5.0 Environmental Consequences

The results of analyses performed to assess potential environmental consequences or impacts of implementing any of the alternative groups are presented in the following sections. For each category of potential environmental impacts considered, brief descriptions of the impact analysis method and the analysis results are given. Details of analytical methods, where applicable, are provided in Volume II (appendixes), as noted within each section. Because the type and level of analysis typically needed for each environmental aspect of interest vary widely, the level of detail in the results presented in the following sections varies commensurate with the nature of the analysis and the potential for consequences associated with that environmental aspect.

In Section 3, Description and Comparison of Alternatives, various alternatives were described for storage, treatment, and disposal of low-level waste (LLW), mixed low-level waste (MLLW), transuranic (TRU) waste, and immobilized low-activity waste (ILAW, the low-activity fraction of tank waste). For purposes of analysis in this section, consequences associated with the alternative actions for each waste type have been combined to provide a consolidated analysis of waste management operations. In the following sections, these consolidated analyses, while retaining the designations corresponding to the various alternatives for each waste type described in Section 3, are analyzed by groups of alternatives. This approach facilitates presentation of impacts for all Hanford Solid Waste Program operations and also is necessary to evaluate facilities that are used to manage more than one type of waste. In these latter consolidated alternative groups, each of the waste types is considered, and the impacts either are analyzed directly or bounded by analysis of similar activities where appropriate.

Unless stated otherwise, the three waste volumes for which evaluations of environmental consequences of the alternatives were made include:

- a Hanford Only waste volume, including the maximum forecast volume for onsite TRU waste
- a Lower Bound waste volume consisting of
  - the Lower Bound volumes for LLW, MLLW (some of which would be received from offsite generators)[(a)]
  - the maximum forecast volume for onsite TRU waste and a Lower Bound waste volume of TRU waste from offsite generators
  - the ILAW volume as defined in Section 3.

(a) The amount of the Lower Bound waste volume received from offsite generators would consist of 18 percent Category 1 LLW, 4 percent Category 3 LLW, and 0.2 percent MLLW.

- an Upper Bound waste volume consisting of
  - the Upper Bound volumes for LLW and MLLW (some of which would be received from offsite generators)
  - the maximum forecast volume for onsite TRU waste and an Upper Bound volume of TRU waste from offsite generators
  - the Hanford Site ILAW volume, again, as defined in Section 3.

The alternatives analyzed in detail by groups are described in the following paragraphs. The cumulative impacts are discussed in Section 5.14.

Alternative Group A

Actions included in Alternative Group A are:

- modification of the T Plant Complex to treat some MLLW and for processing and certification of some TRU waste for shipment to the Waste Isolation Pilot Plant (WIPP)
- continued use of existing MLLW treatment capabilities at the Waste Receiving and Processing Facility (WRAP) and other onsite facilities, as appropriate
- in-trench treatment (in-trench grouting, macroencapsulation, etc.) of some contact-handled (CH) or remote–handled (RH) MLLW and non-standard MLLW packages
- treatment of other MLLW and some non-conforming LLW at commercial facilities, followed by return to the Hanford Site for disposal
- continued operation of the WRAP to process and certify some TRU waste for shipment to WIPP
- acquisition and operation of mobile TRU waste processing and certification units (accelerated processing lines [APLs])
- shipment of all TRU waste to WIPP following processing and certification
- disposal of LLW in 200 West Area Low Level Burial Grounds (LLBGs) in unlined trenches that would be deeper and wider than those currently employed
- disposal of MLLW in 200 East Area LLBGs in lined trenches that would be deeper and wider than those currently employed

- disposal of melters in a lined trench in a new disposal facility near the Plutonium-Uranium Extraction (PUREX) Plant in the 200 East Area

- disposal of ILAW in multiple lined trenches in a new disposal facility near the PUREX Plant

- capping LLW trenches in the LLBGs with a Modified Resource Conservation and Recovery Act (RCRA) (42 USC 6901) Subtitle C Barrier

- capping MLLW trenches with a Modified RCRA Subtitle C Barrier

- capping the melter trench with a Modified RCRA Subtitle C Barrier

- capping the ILAW disposal facility with a Modified RCRA Subtitle C Barrier.

Alternative Group B

Actions included in Alternative Group B are listed here. Actions that are the same as those in Alternative Group A are presented in *italics*.

- construction of a new waste processing facility in the 200 Areas to provide onsite capability to treat most MLLW and non-conforming LLW, and for processing and certification of TRU waste for shipment to WIPP (rather than modifying T Plant for that purpose)

- treatment of non-conforming LLW onsite

- treatment of a limited quantity of MLLW at commercial facilities, followed by return to the Hanford Site for disposal

- *continued operation of the WRAP to process and certify some TRU waste for shipment to WIPP*

- *acquisition and operation of mobile TRU waste processing and certification units (APLs)*

- *shipment of all TRU waste to WIPP following processing and certification*

- disposal of LLW in 200 West Area LLBGs in unlined trenches of a design similar to those currently employed

- disposal of MLLW in 200 West Area LLBGs in lined trenches of a design similar to those currently employed until permitted lined trenches are full, then disposed of in 200 East Area LLBGs, again in trenches similar to those currently employed

- disposal of melters in the 200 East Area in a lined melter trench

- disposal of ILAW in multiple lined trenches in the 200 West Area
- capping LLW and MLLW trenches in the LLBGs with a Modified RCRA Subtitle C Barrier
- capping the melter trench with a Modified RCRA Subtitle C Barrier
- capping ILAW burial site with a Modified RCRA Subtitle C Barrier.

Alternative Group C

Actions included in Alternative Group C are listed below. Actions that are the same as those in Alternative Group A are presented in *italics*.

- *modification of the T Plant Complex to provide the capability for treating some MLLW and for processing and certification of some TRU waste for shipment to WIPP*
- *treatment of other MLLW and some non-conforming LLW at commercial facilities, followed by return to the Hanford Site for disposal*
- *continued operation of the WRAP to process and certify some TRU waste for shipment to WIPP*
- *acquisition and operation of mobile TRU waste processing and certification units (APLs)*
- *shipment of all TRU waste to WIPP following processing and certification*
- disposal of LLW in 200 West Area LLBGs in a single unlined expandable trench
- disposal of MLLW in 200 East Area LLBGs in a single lined expandable trench
- *disposal of melters in a lined trench near the PUREX Plant in the 200 East Area*
- disposal of ILAW in a single lined expandable trench near the PUREX Plant
- *capping LLW trenches in the LLBGs with a Modified RCRA Subtitle C Barrier*
- *capping MLLW trenches with a Modified RCRA Subtitle C Barrier*
- *capping the melter trench with a Modified RCRA Subtitle C Barrier*
- *capping the ILAW burial site with a Modified RCRA Subtitle C Barrier.*

Alternative Group D

Alternative Group D contains three subalternative groupings that depend on the location of disposal. The groupings are denoted by subscripts.

Actions included in Alternative Group D are listed here. Actions that are the same as those in Alternative Group A are presented in *italics*.

- *modification of the T Plant Complex to provide the capability for treating some MLLW and for processing and certification of some TRU waste for shipment to WIPP*
- *treatment of other MLLW and some non-conforming LLW at commercial facilities, followed by return to the Hanford Site for disposal*
- *continued operation of the WRAP to process and certify some TRU waste for shipment to WIPP*
- *acquisition and operation of mobile TRU waste processing and certification units (APLs)*
- *shipment of all TRU waste to WIPP following processing and certification*
- Alternative Group D_1—disposal of LLW, MLLW, melters, and ILAW in a single, lined, modular combined-use facility in the 200 East Area near the PUREX Plant
- Alternative Group D_2—disposal of the wastes listed above in a single, lined, modular combined-use facility in the 200 East Area LLBGs
- Alternative Group D_3—disposal of the wastes listed above in a single, lined, modular combined-use facility at the Environmental Restoration Disposal Facility (ERDF)
- capping the lined combined-use facility with a Modified RCRA Subtitle C Barrier.

Alternative Group E

Alternative Group E contains three subalternative groupings that depend on the location of disposal and waste type. The groupings are denoted by subscripts.

Actions included in Alternative Group E are as listed below. Actions that are the same as those in Alternative Group A are presented in *italics*.

- *modification of the T Plant Complex to provide the capability for treating some MLLW and for processing and certification of some TRU waste for shipment to WIPP*

- *treatment of other MLLW and some non-conforming LLW at commercial facilities, followed by return to the Hanford Site for disposal*

- *continued operation of the WRAP to process and certify some TRU waste for shipment to WIPP*

- *acquisition and operation of mobile TRU waste processing and certification units (APLs)*

- *shipment of all TRU waste to WIPP following processing and certification*

- Alternative Group E_1—disposal of LLW and MLLW in a lined modular facility in the 200 East Area LLBGs and disposal of melters and ILAW in a lined, modular facility at ERDF

- Alternative Group E_2—disposal of LLW and MLLW in a lined, modular facility near the PUREX Plant and disposal of melters and ILAW at ERDF

- Alternative Group E_3—disposal of LLW and MLLW in a lined, modular facility at ERDF and disposal of melters and ILAW in a lined, modular facility near the PUREX Plant

- capping the lined, modular facilities with a Modified RCRA Subtitle C Barrier.

No Action Alternative

This analysis consists of the combined impacts associated with the No Action Alternative for LLW, MLLW, TRU waste, and ILAW as described in Section 3. The Hanford Only waste volume and the Lower Bound waste volume as defined in Section 3 were used for evaluation purposes. This No Action Alternative consists of continuing current solid waste management practices including implementing the Tank Waste Remediation System (TWRS) Record of Decision (ROD) (62 FR 8693). Actions evaluated as part of the No Action Alternative include those listed below. Actions that are the same as those in Alternative Group A are presented in *italics*.

- treatment of a limited quantity of MLLW at commercial facilities, followed by return to the Hanford Site

- disposal of LLW in the LLBGs in trenches of a design similar to those currently employed

- backfilling LLW trenches to grade with no cap

- disposal of MLLW in the two existing MLLW trenches until full

- capping the two MLLW trenches with a Modified RCRA Subtitle C Barrier

- *processing and certification of some TRU waste at the WRAP for shipment to WIPP*

- *shipment of all TRU waste to WIPP following processing and certification*
- *acquisition and operation of mobile TRU waste processing and certification units (APLs)*
- expansion of the Central Waste Complex (CWC) for storage of some non-conforming LLW, untreated MLLW, treated MLLW that exceeds the capacity of the two existing MLLW trenches, and TRU waste that cannot be certified for shipment to WIPP
- storage of melters on concrete pads at the CWC
- disposal of ILAW as glass cullet in vaults near the PUREX Plant according to the TWRS ROD (62 FR 8693).

Except where otherwise specified, all construction and operations engineering data that form the basis for environmental impact analysis of the alternative groups are provided in the *Hanford Site Solid Waste Management Environmental Impact Statement Technical Information Document* (FH 2004).

A comparison of impacts among the alternative groups appears in Section 3.4.

5.1 Land Use

Impacts on land use are considered in terms of commitment of land for a proposed use to the exclusion of other possible uses. Land occupied by LLBGs or other disposal facilities is considered to be permanently committed to the designated use.

In Alternative Groups A, B, C, D, and E, all LLW, MLLW, ILAW, and melters would be disposed of onsite. TRU waste would be shipped to WIPP for disposal. In the No Action Alternative, a substantial amount of the waste would remain in storage because of the lack of appropriate treatment capabilities to permit disposal.

Except for offsite commercial treatment of some MLLW, treatment, storage, and disposal activities associated with Alternative Groups A through E and the No Action Alternative would occur within or between the 200 East and 200 West Areas.[a] The 200 Areas occupy about 16 km^2 (6 mi^2) on the Central Plateau. This area falls under the Industrial-Exclusive designation as defined in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (HCP EIS) (DOE 1999). In addition, materials for capping the LLBGs at closure would be obtained from borrow pits in Area C located south of State Route (SR) 240 outside of, but adjacent to, the Fitzner/Eberhardt Arid Lands Ecology Reserve (ALE). The ALE boundary as adjusted in the HCP EIS is included within the Hanford Reach National Monument. Area C consists of about 926 ha (2287 ac) and was previously designated for Conservation (Mining) in the Record of Decision (ROD) for the HCP EIS (64 FR 61615). Excavation would occur over up to about 86 ha (210 ac) to provide capping materials for closure of the HSW disposal sites.

In Alternative Group A, use of land in the LLBGs for disposal of LLW and MLLW in trenches of deeper/wider design would range from 6 ha (15 ac) for the Hanford Only waste volume to 15 ha (37 ac) for the Upper Bound waste volume estimate. This use would be in addition to the 130 ha (321 ac) of land within the LLBGs already occupied by LLW and MLLW (and some retrievably stored TRU waste that would be removed). This additional land use would amount to increases of about 5 to 12 percent. Melters would be disposed of in a 6-ha (15-ac) single expandable lined trench near the PUREX Plant. ILAW would be disposed of near the PUREX Plant in a newly constructed facility occupying about 26 ha (62 ac). The total amount of land permanently used for disposal would range from 168 ha (410 ac) for the Hanford Only waste volume to 178 ha (440 ac) for the Upper Bound waste volume. No new support facilities would be built. However, from 69 to 73 ha (170 to 180 ac) would be temporarily used for excavation of capping materials.

In Alternative Group B, use of land in the LLBGs for disposal of LLW and MLLW in trenches of conventional design would range from 30 ha (74 ac) for the Hanford Only waste volume to 54 ha (130 ac) for the Upper Bound waste volume. This use would be in addition to the 130 ha (321 ac) of land within the LLBGs already occupied by LLW and MLLW (and some retrievably stored TRU waste that would be

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(a) Installation of mobile accelerated process lines in conjunction with accelerated TRU waste processing and certification would be temporary and would occur within existing CWC buildings or near the points of receipt of TRU waste and would not constitute an important increment in land use.

removed). This additional land use would amount to an increase of about 23 to 41 percent, respectively. ILAW would be disposed of in a newly constructed facility occupying about 26 ha (62 ac) in the CWC expansion area. The total amount of land permanently used for disposal would range from 187 to 210 ha (460 to 520 ac) for the Hanford Only waste volume to the Upper Bound waste volume. A new facility for processing waste would be built and would occupy about 4 ha. From 77 to 86 ha (190 to 210 ac) would be temporarily used for excavation of capping materials.

In Alternative Group C, use of land in the LLBGs for disposal of LLW and MLLW in single expandable trenches by waste type would range from 6 ha (15 ac) for the Hanford Only waste volume to 15 ha (37 ac) for the Upper Bound waste volume (essentially the same as for Alternative Group A). Melters would be disposed of in a 6-ha (15-ac) single expandable lined melter trench near the PUREX Plant. ILAW would be disposed of in a single expandable trench occupying about 8 ha (20 ac) also near the PUREX Plant. The total amount of land permanently used for disposal would range from 151 to 160 ha (370 to 400 ac) for the Hanford Only waste volume to the Upper Bound waste volume. No new treatment facilities would be built. However, from 62 to 66 ha (150 to 160 ac) would be temporarily used for excavation of capping materials.

In Alternative Group D_1, there would be no use of land in the LLBGs for disposal of LLW and MLLW after the year 2007. LLW, MLLW, ILAW, and melters would be disposed of in a lined modular facility to be built near the PUREX Plant. This facility would occupy from 19 ha (47 ac) for the Hanford Only waste volume to 25 ha (62 ac) for the Upper Bound waste volume estimate. The total amount of land permanently used for disposal would range from 150 to 155 ha (370 to 380 ac) for the Hanford Only waste volume to the Upper Bound waste volume. No new treatment facilities would be built. However, from 62 to 64 ha (150 to 160 ac) would be temporarily used for excavation of capping materials.

In Alternative Group D_2, LLW, MLLW, ILAW, and melters would be disposed of in a lined modular facility to be built in the 200 East Area LLBGs. The amount of land used would be the same as for Alternative Group D_1. However, the location of the land would differ from that of Alternative Group D_1.

In Alternative Group D_3, LLW, MLLW, ILAW, and melters would be disposed of in a lined modular facility to be built at the ERDF. The amount of land used would be the same as that for Alternative Group D_1, but land located in a different place would be used.

In Alternative Group E_1, LLW and MLLW would be disposed of in a lined modular facility to be built in a 200 East Area LLBG. This facility would increase land use in the 200 East Area LLBGs ranging from 5 to 11 ha (12 to 27 ac) for the Hanford Only waste volume to the Upper Bound waste volume. This would represent an increase of from 4 to 8 percent. ILAW and melters would be disposed of in a lined modular facility at the ERDF and would occupy about 14 ha (35 ac). The total amount of land used would be the same as that for Alternative Group D_1.

In Alternative Group E_2, LLW and MLLW would be disposed of in a lined modular facility to be built near the PUREX Plant and would occupy the same amount of land as in Alternative Group E_1. ILAW and melters would be disposed of in a lined modular facility to be built at the ERDF. The size of the latter facility also would be the same as that in Alternative Group E_1.

In Alternative Group E_3, LLW and MLLW would be disposed of in a lined modular facility to be built at the ERDF and would occupy the same amount of land as in Alternative Group E_1. ILAW and melters would be disposed of in a lined modular facility to be built near the PUREX Plant. The size of the latter facility also would be the same as that in Alternative Group E_1.

In the No Action Alternative, LLW that had been certified for disposal would continue to be disposed of in trenches of current design. MLLW would be disposed of until trenches 31 and 34 in 218-W-5 are full and would thereafter be stored along with LLW that could not be certified for disposal in the CWC. ILAW would be disposed of in vaults occupying about 10 ha (25 ac) near the PUREX Plant. The increase in permanent land use would range from 27 to 29 ha (67 to 72 ac), which includes the 10 ha mentioned above for ILAW, for the Hanford Only waste volume and the Lower Bound waste volume (the Upper Bound waste volume would not be considered in this alternative), an increase of about 20 percent over the 130 ha (320 ac) currently occupied. In addition, about 116 ha (287 ac) would be used for storage at the CWC of wastes for which treatment for disposal would not be available.

Details of land use (including new construction) associated with the HSW EIS alternative groups are provided in Table 5.1 for disposal sites and in Table 5.2 for support facilities.

At most, a total of about 210 ha (440 ac), or 4 percent, of the 5000 ha (13,000 ac) of land designated as Industrial-Exclusive in the ROD for the HCP EIS (64 FR 61615) would be permanently committed to disposal of LLW, MLLW, ILAW, and melters within the scope of activities evaluated in this EIS.

Table 5.1. Land Use—Areas Used for Disposal, ha[a]

Low Level Burial Ground or Other Disposal Facility	Area Previously Designated for Disposal of HSW	Area Currently Occupied	Alternative Group A LLW & MLLW (Deeper/Wider Trench Design); Melter Trench and ILAW near the PUREX Plant			Alternative Group B LLW & MLLW (Conventional Trench Design); Melter Trench in the 200 East Area; ILAW in the 200 West Area (near the CWC)			Alternative Group C Single Expandable Trenches, LLW in the 200 West Area; MLLW in the 200 East Area; Melter Trench and ILAW near the PUREX Plant			Alternative Group D_1 Lined Modular Facility near the PUREX Plant			Alternative Group D_2 Lined Modular Facility in the 200 East LLBGs		
			Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume
Disposal – Low Level Burial Grounds																	
218-W-3A[b]	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4
218-W-3AE	20	12.2	12.2	12.2	12.2	20	20	20	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2
218-W-4B[b]	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
218-W-4C[b]	20	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
218-W-5	37.2	26	29.4	30.4	35	33	35	37.2	29.4	30.4	35	26	26	26	26	26	26
218-W-5 Exp.[c]	202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
218-W-6	16	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0
200 West Area Subtotal	319.1	66.8	70.2	71.2	75.8	81.6	83.6	92.8	70.2	71.2	75.8	66.8	66.8	66.8	66.8	66.8	66.8
218-E-10	36.1	22.7	22.7	22.7	22.7	22.7	23.2	25.6	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7
218-E-12B[b,d]	70.1	41	43.6	43.6	47.4	56.3	56.3	65.7	43.6	43.6	47.4	41	41	41	60.0	60.6	65.5
200 East Area Subtotal	106.2	63.7	66.3	66.3	70.1	79	79.5	91.3	66.3	66.3	70.1	63.7	63.7	63.7	82.7	83.3	88.2
LLBG Subtotal	425.3	130.5	136.5	137.5	145.9	160.6	163.1	184.1	136.5	137.5	145.9	130.5	130.5	130.5	149.7	150.2	155
Increase in LLBG Land Use			**6.0**	**7.0**	**15.4**	**30.1**	**32.6**	**53.6**	**6.0**	**7.0**	**15.4**	**0**	**0**	**0**	**19.2**	**19.7**	**24.5**

Table 5.1. (contd)

Low Level Burial Ground or Other Disposal Facility	Area Previously Designated for Disposal of HSW	Area Currently Occupied	Alternative Group A LLW & MLLW (Deeper/Wider Trench Design); Melter Trench and ILAW near the PUREX Plant			Alternative Group B LLW & MLLW (Conventional Trench Design); Melter Trench in the 200 East Area; ILAW in the 200 West Area (near the CWC)			Alternative Group C Single Expandable Trenches, LLW in the 200 West Area; MLLW in the 200 East Area; Melter Trench and ILAW near the PUREX Plant			Alternative Group D_1 Lined Modular Facility near the PUREX Plant			Alternative Group D_2 Lined Modular Facility in the 200 East LLBGs		
			Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume
Disposal – Other Areas																	
At ERDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Near PUREX	41	0	32	32	32	0	0	0	14	14	14	19.2	19.7	24.5	0	0	0
CWC Expansion	30	0	0	0	0	26	26	26	0	0	0	0	0	0	0	0	0
Total Area Used for HSW Disposal		130.5	168.5	169.5	177.9	186.6	189.1	210.1	150.5	151.5	159.9	149.7	150.2	155.0	149.5	150.1	155.0
Total Increase in Land Use			**38.0**	**39.0**	**47.4**	**56.1**	**58.6**	**79.6**	**20.0**	**21.0**	**29.4**	**19.2**	**19.7**	**24.5**	**19.2**	**19.7**	**24.5**

Table 5.1. (contd)

Low Level Burial Ground or Other Disposal Facility	Area Previously Designated for Disposal of HSW	Area Currently Occupied	Alternative Group D_3 Lined Modular Facility at ERDF			Alternative Group E_1 Lined Modular Facilities LLW & MLLW in the 200 East Area LLBGs, ILAW & Melters at ERDF			Alternative Group E_2 Lined Modular Facilities LLW & MLLW near PUREX, ILAW & Melters at ERDF			Alternative Group E_3 Lined Modular Facilities LLW&MLLW at ERDF, ILAW & Melters near PUREX			No Action Alternative. Non-Disposable Waste Stored in the CWC; Melters Stored on Concrete Pads at the CWC	
			Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume
Low Level Burial Grounds																
218-W-3A[(b)]	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4
218-W-3AE	20	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	20	20
218-W-4B[(b)]	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
218-W-4C[(b)]	20	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
218-W-5	37.2	26	26	26	26	26	26	26	26	26	26	26	26	26	30.8	32.2
218-W-5 Exp[(c)]	202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
218-W-6	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200 West Area Subtotal	319.1	66.8	66.8	66.8	66.8	66.8	66.8	66.8	66.8	66.8	66.8	66.8	66.8	66.8	79.4	80.8
218-E-10	36.1	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	23.2	23.2
218-E-12B[(b,d)]	70.1	41	41	41	41	46.2	46.7	51.5	41	41	41	41	41	41	45	45
200 East Area Subtotal	106.2	63.7	63.7	63.7	63.7	68.9	69.4	74.2	63.7	63.7	63.7	63.7	63.7	63.7	68.2	68.2
LLBG Subtotal	425.3	130.5	130.5	130.5	130.5	135.7	136.2	141	130.5	130.5	130.5	130.5	130.5	130.5	147.6	149
Increase in LLBG Land Use			**0**	**0**	**0**	**5.2**	**5.7**	**10.5**	**0**	**0**	**0**	**0**	**0**	**0**	**17.1**	**18.5**

Table 5.1. (contd)

Low Level Burial Ground or Other Disposal Facility	Area Previously Designated for Disposal of HSW	Area Currently Occupied	Alternative Group D_3 Lined Modular Facility at ERDF			Alternative Group E_1 Lined Modular Facilities LLW & MLLW in 200 East Area LLBGs, ILAW & Melters at ERDF			Alternative Group E_2 Lined Modular Facilities LLW & MLLW near PUREX, ILAW & Melters at ERDF			Alternative Group E_3 Lined Modular Facilities LLW&MLLW at ERDF, ILAW & Melters near PUREX			No Action Alternative Non-Disposable Waste Stored in the CWC; Melters Stored on Concrete Pads at the CWC	
			Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume
Other Disposal Areas																
At ERDF	0	0	19.2	19.7	24.5	14	14	14	14	14	14	5.0	5.6	10.5	0	0
Near PUREX	41	0	0	0	0	0	0	0	5.0	5.6	10.5	14	14	14	10	10
CWC Expansion	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Area Used for HSW Disposal			149.7	150.2	155.0	149.7	150.2	155.0	149.5	150.1	155.0	149.5	150.1	155.0	157.6	159.0
Total Increase in Land Used			**19.2**	**19.7**	**24.5**	**19.2**	**19.7**	**24.5**	**19.2**	**19.2**	**24.5**	**19.2**	**19.7**	**24.5**	**27.1**	**28.5**

(a) To obtain areas in acres, multiply hectares (ha) by 2.47. Actual assignment of disposal areas to a particular LLBG would depend on operational efficiency.
(b) Area contains some retrievably stored TRU waste.
(c) 218-W-5 Exp. is a contingency expansion of the 218-W-5 Burial Ground for operational flexibility.
(d) Trench 94 in 218-E-12B consisting of about 7.4 ha (18 ac) is for disposal of decommissioned U.S. Naval reactor compartments and is included in the area designated. A like area is also included for future expansion of reactor compartment disposal (a total of 20.4 ha). Disposal of these reactor compartments was addressed in other NEPA documents (Navy 1984, 1996).

Table 5.2. Land Use—Areas of HSW Treatment and Storage Facilities, ha[a]

Facility	Area Previously Designated for HSW Support Facility	Area Currently Occupied	Alternative Group A[b] LLW &MLLW (Deeper/Wider Trench Design); Melter Trench and ILAW near PUREX			Alternative Group B LLW &MLLW (Conventional Trench Design); Melter Trench in the 200 East Area; ILAW in the 200 West Area (near the CWC)			Alternative Group C Single Expandable Trenches, LLW in the 200 West Area; MLLW in the 200 East Area; Melter Trench and ILAW near PUREX			Alternative Groups D&E Lined Modular Facilities			No Action Alternative[c] Non-Disposable Waste Stored in the CWC; Melters Stored on Concrete Pads at the CWC	
			Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume	Upper Bound Volume	Hanford Only Volume	Lower Bound Volume
CWC	86	50	50	50	50	50	50	50	50	50	50	50	50	50	86	86
CWC Expansion Area	30	0	0	0	0	0	0	0	0	0	0	0	0	0	23	30
WRAP	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
NWPF[d]	0	0	0	0	0	4	4	4	0	0	0	0	0	0	0	0
T Plant Complex	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
ETF[e]	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
LERF[f]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Area C (Borrow Pit)	926	3	69.2	69.7	73.1	76.7	77.7	86.3	61.8	62.3	65.7	61.5	61.7	63.7	13.6	13.6
Total for Facilities	**1119**	**130**	**196**	**197**	**200**	**208**	**209**	**217**	**189**	**189**	**193**	**189**	**189**	**191**	**200**	**207**

(a) To obtain areas in acres, multiply hectares (ha) by 2.47.
(b) Treatment and Storage Facility requirements would be the same for the following as for Alternative Group A (capping resource area same as for Alternative Group D_1):
Alternative Group D_1: Disposal in a lined modular facility near PUREX Plant
Alternative Group D_2: Disposal in a lined modular facility in 200 East Area LLBGs
Alternative Group D_3: Disposal in a lined modular facility at ERDF
Alternative Group E_1: Disposal in lined modular facilities: LLW and MLLW in the 200 East Area LLBGs; ILAW and melters at ERDF
Alternative Group E_2: Disposal in lined modular facilities: LLW and MLLW near PUREX; ILAW and melters at ERDF
Alternative Group E_3: Disposal in lined modular facilities: LLW and MLLW at ERDF; ILAW and melters near PUREX
(c) Storage of waste in the CWC in the No Action Alternative would continue after 2046.
(d) NWPF = new waste processing facility.
(e) ETF = 200 Area Effluent Treatment Facility.
(f) LERF = Liquid Effluent Retention Facility.

5.2 Air Quality

Air quality impacts covered in this section focus on four criteria pollutants[a]—nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), and particulate matter with aerodynamic diameters of 10 µm or smaller (PM_{10}). Hanford Solid Waste (HSW) Program activities would emit criteria pollutants as a result of the operation of diesel-fired and propane-fueled equipment. Construction, earthmoving, and transportation activities also would result in fugitive dust emissions. Major program activities that would be substantial sources of criteria pollutants include:

- construction of waste-disposal trenches (for example, LLW, MLLW, ILAW)
- waste-disposal operations
- excavation of backfill and capping materials at the borrow pit
- transportation of backfill and capping materials from the borrow pit to the disposal trenches
- backfill and capping activities at the disposal trenches
- leachate drying operations.

The air quality impacts to the public from these and related program activities are presented in this section, and additional supporting information is provided in Volume II, Appendix E. The air quality impacts from criteria pollutants emitted during the transportation of waste materials are not included in this section, but are instead addressed in Section 5.8. The potential consequences to workers and the public of the releases from radiological and hazardous chemicals are addressed in Section 5.11.

In calculating air quality impacts for criteria pollutants, data on pollutant emissions were derived from the Hanford Solid Waste Technical Information Document (FH 2004). Detailed assessments of pollutant emissions were developed for each major program element. To compute maximum air quality impacts, emissions were combined from all activities that could potentially occur at the same time. Because only 22 percent of the LLW and essentially none of the MLLW would be from offsite sources, the air quality impacts for the Hanford Only waste volume under each alternative group were conservatively modeled as being equivalent to those for the Lower Bound waste volume under the same alternative group.

The approach used to estimate pollutant emission rates and emission schedules for all HSW Program activities are addressed in detail in Volume II, Appendix E.[b]

The maximum air quality impacts that would result from the emission of criteria pollutants from HSW Program activities were calculated using the Industrial Source Complex Short-Term (ISCST3)

(a) The Clean Air Act (42 USC 7401) authorizes the U.S. Environmental Protection Agency to set permissible levels of exposure for selected air pollutants using health-based criteria. These selected pollutants are called “criteria pollutants,” and their permissible exposure levels are defined in 40 CFR 50, “National Primary and Secondary Ambient Air Quality Standards.”

(b) Consequences of operating accelerated process lines would be similar to those from processing TRU waste at WRAP, although timing of the consequences may vary from assumptions based on operation of WRAP with APLs.

Dispersion Model (EPA 1995). The ISCST3 model has been approved by the U.S. Environmental Protection Agency (EPA) for the calculation of the maximum, time-averaged air concentrations at user-specified receptor locations. The model provides results for averaging periods of 1 hour, 3 hours, 8 hours, 24 hours, and 1 year to correspond to the time periods specified in national and state ambient air quality standards. Four years of hourly Hanford Site meteorological data were used in modeling atmospheric dispersion. The ISCST3 model and the data used in model runs are discussed in more detail in Volume II, Appendix E.

In modeling air quality impacts for the public, the following conservative assumptions were made to maximize impact estimates:

- Although HSW Program activities would occur at numerous locations in and around the 200 Areas and Area C, program activities were conservatively modeled by collocating their emissions into three small area sources. These area sources were situated in the 200 West Area (near the southwestern edge of project activities), 200 East Area (near the northwestern edge of project activities), and Area C (at a site close to State Route [SR] 240). The location of each area source was set to correspond to the project work site in the associated major operating area that could generate the greatest air quality impacts to the public.

- When a project activity could potentially occur at more than one source location, the activity was conservatively assumed to occur at the location that would generate the greatest air quality impact. For example, the lined modular facility proposed in Alternative Group D could be sited at locations in or near the 200 East or 200 West Areas, depending on the subalternative selected. After assessing impacts from both potential source locations, the 200 West Area source location was used in the air quality analysis because it generated the greatest air quality impacts.

- Even though the maximum air quality impacts to the public from the 200 East and 200 West source locations would occur at markedly different locations (as discussed later in this section), it was conservatively assumed that the maximum pollutant concentrations associated with these two source locations could be summed to compute total maximum air quality impacts for emissions from both 200 Area source locations.

- Chemical decay and deposition processes were not explicitly modeled for any criteria pollutant. Neglecting these removal mechanisms would increase estimates of maximum pollutant concentrations (especially in the case of particulate matter) at publicly accessible locations.

- Pollutant emission rates from diesel-fueled engines were only assumed to comply with current emissions standards. No credit was taken for the substantial reduction in the sulfur content of diesel fuel (from a 500-ppm to a 15-ppm limit) scheduled to be phased in beginning June 2006 or a tightening of the emission standards for nitrogen dioxide and particulate matter scheduled to be phased in beginning 2007 (EPA 2000b).

As a result of these and other conservative assumptions, the estimates of short-term and long-term maximum air quality impacts presented in this section should be substantially greater than what would actually be experienced during program implementation.

To meet regulatory requirements, emissions from program activities must not result in air concentrations of criteria pollutants that exceed regulatory limits. The ISCST3 model predicted the locations of the maximum air quality impacts to the public from emissions at the 200 East Area, 200 West Area, and Area C source locations. These are provided in Table 5.3 for the 200 East and 200 West Areas and in Table 5.4 for Area C. The location of maximum impact varies based on the averaging period of exposure. The maximum shorter-term air quality impacts (for example, 1 hour and 3 hours) generally occur at or near the closest point of public access. The locations of the longer-term maximum air quality impacts (for example, 24 hours and annual) are heavily dependent on local, prevailing wind directions and other meteorological conditions. Dispersion factors also are provided in Tables 5.3 and 5.4 to provide relative estimates of the maximum impacts from a unit release (for example, one unit of mass emitted per second) of a generic pollutant.

In the following sections, the results of the air quality analysis are presented for Alternative Groups A through E and the No Action Alternative. Separate results are provided for the maximum air quality impacts to the public from emissions in the 200 Areas and emissions in Area C.

Table 5.3. 200 East and 200 West Area Emissions: Location and Dispersion Factors Used to Determine Maximum Air Quality Impacts to the Public

Area	Averaging Time Period	Maximum Impact Location and Corresponding Public Access	Distance and Direction from Pollutant Release Location to Maximum Public Impact Location[(a)]	Dispersion Factor for Maximum Impact Location (s/m^3)[(b)]
200E	1 hr	SR 240	8.5 km–SW	8.4E-05
	3 hr	SR 240	9.0 km–SSW	3.3E-05
	8 hr	SR 240	9.0 km–SSW	2.2E-05
	24 hr	Hanford Site boundary	15.3 km–WNW	9.3E-06
	Annual	Hanford Site boundary	13.9 km–WNW	8.9E-08
200W	1 hr	SR 240	4.0 km–S	1.6E-04
	3 hr	SR 240	4.0 km–S	7.4E-05
	8 hr	SR 240	4.0 km–S	5.1E-05
	24 hr	Hanford Site boundary	8.5 km–WNW	1.6E-05
	Annual	Hanford Site boundary	11.5 km–W	1.5E-07

(a) Distance and direction determined by dispersion modeling. Pollutant transport direction is reported using 16 compass sectors—starting with N (North) and continuing clockwise with NNE, NE, ENE, E (East), ESE, SE, SSE, S (South), SSW, SW, WSW, W (West), WNW, NW, and NNW.

(b) Values computed by the ISCST3 model. To convert to a concentration estimate ($\mu g/m^3$), a dispersion factor (s/m^3) is multiplied by the estimated pollutant release rate ($\mu g/s$).

Table 5.4. Area C (Borrow Pit) Emissions: Location and Dispersion Factors Used to Determine Maximum Air Quality Impacts to the Public

Averaging Time Period	Maximum Impact Location and Corresponding Public Access	Distance and Direction from Pollutant Release Location to Maximum Public Impact Location[(a)]	Dispersion Factors for Maximum Impact Location (s/m^3)[(b)]
1 hr	SR 240	<150 m NE	3.3E-03
3 hr	SR 240	<150 m NE	2.5E-03
8 hr	SR 240	<150 m NE	1.9E-03
24 hr	Hanford Site boundary	14.4 km WNW	1.0E-05
Annual	Hanford Site boundary	13.8 km WNW	9.2E-08

(a) Distance determined by dispersion modeling. Pollutant transport direction is reported using 16 compass sectors—starting with N (North) and continuing clockwise with NNE, NE, ENE, E (East), ESE, SE, SSE, S (South), SSW, SW, WSW, W (West), WNW, NW, and NNW.

(b) Values computed by the ISCST3 model. To convert to a concentration estimate ($\mu g/m^3$), the dispersion factor (s/m^3) is multiplied by the estimated pollutant release rate (μg/s).

A Clean Air Act General Conformity Review analysis is presented in Volume II, Appendix E. Based on this analysis, it was concluded that a Conformity Determination would not be needed.

5.2.1 Alternative Group A

Project activities that would generate air quality impacts under Alternative Group A include the use of diesel-fueled equipment to construct new trenches of deeper and wider design than current trenches, construction of the ILAW and melter trenches, backfilling of trenches, capping the LLBGs and the ILAW trench at closure, performing routine CWC and T Plant operations, modifying the T Plant to achieve a waste processing capability, and the excavation and transportation of materials from the borrow pit. In addition, propane-fueled pulse driers would be used to treat leachate from the MLLW trenches beginning in 2026. Fugitive dust emissions would be associated with many major construction and operation activities.

For Alternative Group A (Hanford Only and Lower Bound waste volumes), the largest air quality impacts would occur during two different periods of project operation. In 2006, ILAW trench construction and MLLW capping and backfill operations would be underway. The heavy use of construction equipment for short periods of time would produce the maximum 24-hour and shorter-term average concentrations for SO_2 and CO. After disposal operations cease, LLBG and ILAW capping operations would be in full swing. This sustained activity would produce the maximum 24-hour and annual concentrations of PM_{10} and maximum annual concentrations of NO_2 and SO_2.

For Alternative Group A (Upper Bound waste volume), the largest air quality impacts would occur during three different periods of project operation. In 2006, the heavy use of construction equipment would produce the maximum concentrations over all averaging periods for CO, SO_2, and NO_2. In 2018, LLW and ILAW trench construction, coupled with MLLW melter capping and backfilling operations, would generate the maximum 24-hour PM_{10} concentrations. After disposal operations cease, LLBG and ILAW capping operations would be in full swing. This sustained activity would produce the maximum annual concentrations of PM_{10}.

Estimates of the maximum air quality impacts to the public from activities in the 200 Areas under Alternative Group A are summarized in Table 5.5. Estimates of the maximum air quality impacts from Area C activities are presented in Table 5.6. The maximum air quality impacts from Area C activities are the same for all alternative groups. The impacts from the single activity undertaken in Area C are less than the maximum impacts from the multiple activities undertaken in Alternative Group A.

Even in the years with the largest potential air quality impacts, ambient air quality standards (see Table 4.6, Section 4.3.3) would not be exceeded under Alternative Group A. The largest potential impacts to the public from activities at Area C would result from SO_2 and CO emissions. Maximum air

Table 5.5. Alternative Group A: Maximum Air Quality Impacts to the Public from Activities in the 200 Areas

Pollutant	Averaging Time	Ambient Air Quality Standard (μg/m³)	Hanford Only & Lower Bound Waste Volumes		Upper Bound Waste Volume	
			Maximum Air Quality Impacts (μg/m³)	Percent of Standard	Maximum Air Quality Impacts (μg/m³)	Percent of Standard
PM_{10}	24 hr	150	69	46	74	49
	Annual	50	0.61	1.2	0.62	1.2
SO_2	1 hr	1,000	81	8.1	98	9.8
	3 hr	1,300	38	2.9	45	3.5
	24 hr	260	2.7	1.0	3.5	1.3
	Annual	50	0.017	0.034	0.019	0.038
CO	1 hr	40,000	1,500	3.8	900	4.6
	8 hr	10,000	470	4.7	590	5.9
NO_2	Annual	100	0.72	0.72	0.80	0.80

Table 5.6. All Alternative Groups: Maximum Air Quality Impacts to the Public from Area C (Borrow Pit) Activities

Pollutant	Averaging Time	Ambient Air Quality Standard (μg/m³)	Maximum Air Quality Impacts	
			Maximum Pollutant Concentration (μg/m³)	Percent of Standard
PM_{10}	24 hr	150	21	14
	Annual	50	0.19	0.38
SO_2	1 hr	1,000	260	26
	3 hr	1,300	200	15
	24 hr	260	0.44	0.17
	Annual	50	0.0035	0.0070
CO	1 hr	40,000	6,300	16
	8 hr	10,000	3,600	36
NO_2	Annual	100	0.16	0.16

quality impacts to the public are conservatively estimated to be about 26 percent of the 1-hour SO_2 standard and 36 percent of the 8-hour CO standard. The largest potential impacts to the public from activities within the 200 Areas would involve the 24-hour PM_{10} standard. Using the series of conservative assumptions employed in the air-dispersion modeling, this maximum air quality impact would be about half of the 24-hour PM_{10} standard.

5.2.2 Alternative Group B

Project activities that would generate air quality impacts under Alternative Group B include the use of diesel-fueled equipment to construct additional trenches of current design and the ILAW and melter trenches, backfilling and capping activities in the LLBGs, construction of a new waste processing facility, and the excavation of materials at the borrow pit. In addition, propane would be used to fuel vehicles at the CWC and to operate pulse driers used to treat leachate from the MLLW trenches. Fugitive dust would be associated with all major construction and operation activities.

For Alternative Group B (Hanford Only and Lower Bound waste volumes), the largest air quality impacts would occur during two different periods of project operation. In 2011, ILAW trench construction, LLW trench construction, and MLLW capping and backfill operations would be underway. The heavy use of construction equipment for short periods of time would produce the maximum pollutant concentrations for CO, SO_2, and NO_2. After disposal operations cease, LLBG and ILAW capping operations would be in full swing. This sustained activity would produce maximum 24-hour and annual concentrations of PM_{10} that would be slightly greater than in 2011.

For Alternative Group B (Upper Bound waste volume), the largest air quality impacts would occur during three different periods of project operation. In 2006, the heavy use of construction equipment would produce the maximum pollutant concentrations over the relevant 1-hour, 3-hours, 8-hours, and 24-hour averaging periods for CO and SO_2. In 2011, LLW and ILAW trench construction, coupled with MLLW melter capping and backfilling operations, would generate the maximum annual SO_2 and NO_2 concentrations. After disposal operations cease, LLBG and ILAW capping operations would be in full swing. This sustained activity would produce the maximum 24-hour and annual concentrations of PM_{10}.

Estimates of the maximum air quality impacts to the public from activities in the 200 Areas under Alternative Group B are summarized in Table 5.7. Estimates of the maximum air quality impacts from Area C activities are the same for all alternative groups (see Table 5.6).

All air quality impacts to the public under Alternative Group B would be within ambient air quality standards (see Table 4.6, Section 4.3.3). The largest potential impact to the public from activities at Area C would result from SO_2 and CO emissions. The largest potential air quality impacts to the public from 200 Area emissions would involve the 24-hour PM_{10} air concentration. Even using the series of conservative assumptions employed in the dispersion modeling, the maximum air quality impact to the public for the Upper Bound waste volume would be about 60 percent of the applicable air quality standard. Maximum impacts for the Hanford Only and Lower Bound waste volumes would be less than 47 percent of the applicable standards.

Table 5.7. Alternative Group B: Maximum Air Quality Impacts to the Public from Activities in the 200 Areas

			Hanford Only & Lower Bound Waste Volumes		Upper Bound Waste Volume	
Pollutant	**Averaging Time**	**Ambient Air Quality Standard ($\mu g/m^3$)**	**Maximum Air Quality Impacts ($\mu g/m^3$)**	**Percent of Standard**	**Maximum Air Quality Impacts ($\mu g/m^3$)**	**Percent of Standard**
PM_{10}	24 hr	150	71	47	90	60
	Annual	50	0.62	1.2	0.65	1.3
SO_2	1 hr	1,000	130	13	180	18
	3 hr	1,300	61	4.7	85	6.5
	24 hr	260	4.7	1.8	6.4	2.5
	Annual	50	0.021	0.042	0.021	0.042
CO	1 hr	40,000	2,500	6.3	3,400	8.5
	8 hr	10,000	800	8.0	1,100	11
NO_2	Annual	100	1.0	1.0	1.1	1.1

5.2.3 Alternative Group C

Project activities that would generate air quality impacts under Alternative Group C include the use of diesel-fueled equipment to construct new expandable trenches for LLW and for MLLW, construction of the ILAW and melter trenches, backfilling of trenches, capping the LLBGs and the ILAW trench at closure, performing routine CWC and T Plant operations, modifying the T Plant for a new waste processing capability, and the excavation and transportation of materials from the borrow pit. In addition, propane engines would be used at the CWC and to operate pulse driers used to treat leachate from the MLLW trenches. Fugitive dust would be associated with all major construction and operation activities.

For Alternative Group C (Hanford Only and Lower Bound waste volumes), the largest air quality impacts would occur during three different periods of project operation. In 2007, the heavy use of construction equipment would produce the maximum pollutant concentrations over 1-hour and 3-hour averaging periods for SO_2. In 2018, ILAW trench construction and MLLW capping and backfill operations would be under way. This use of construction equipment for long periods of time would produce the maximum 24-hour and annual concentrations for SO_2, the maximum 1-hour and 8-hour pollutant concentrations for CO, and the maximum annual concentration of NO_2. After disposal operations cease, LLBG and ILAW capping operations would be in full swing. This sustained activity would produce the maximum 24-hour and annual concentrations of PM_{10}.

For Alternative Group C (Upper Bound waste volume), the largest air quality impacts would occur during four different periods of project operation. In 2007, the construction of ILAW, LLW, and MLLW trenches would produce the maximum concentrations over 1-hour and 3-hour averaging periods for SO_2 and an 8-hour averaging period for CO. In 2018, ILAW trench construction, coupled with MLLW melter capping and backfilling operations, would generate the maximum 24-hour and annual concentrations of

SO_2, annual concentrations of NO_2, and 1-hour concentrations of CO. After disposal operations cease, LLBG and ILAW capping operations would be in full swing. This sustained activity would produce the maximum 24-hour and annual concentrations of PM_{10}.

Estimates of the maximum air quality impacts to the public from activities in the 200 Areas under Alternative Group C are summarized in Table 5.8. Estimates of the maximum air quality impacts from Area C activities are the same for all alternative groups (see Table 5.6).

All air quality impacts to the public from Alternative Group C would be within ambient air quality standards (see Table 4.6, Section 4.3.3). The largest potential impacts to the public from activities at Area C would result from SO_2 and CO emissions. The largest potential air quality impacts to the public from activities in the 200 Areas would involve the 24-hour PM_{10} concentration. Even using the series of conservative assumptions employed in the dispersion modeling, this maximum air quality impact would be about 40 percent of the applicable air quality standard.

5.2.4 Alternative Groups D_1, D_2, and D_3

Project activities that would generate air quality impacts under Alternative Groups D_1, D_2, and D_3 (collectively referred to in this section as Alternative Group D) include the use of diesel-fueled equipment to construct a lined modular facility to hold the LLW, MLLW, ILAW and melters, backfilling and capping activities in the LLBGs, the modification of T Plant, and the excavation of materials at the borrow pit. In addition, propane would be used at the CWC and to operate pulse driers used to treat leachate from the MLLW trenches. Fugitive dust would be associated with all major construction and operation activities. Alternative Groups D_1, D_2, and D_3 postulate different locations for the lined modular

Table 5.8. Alternative Group C: Maximum Air Quality Impacts to the Public from Activities in the 200 Areas

			Hanford Only & Lower Bound Waste Volumes		Upper Bound Waste Volume	
Pollutant	**Averaging Time**	**Ambient Air Quality Standard ($\mu g/m^3$)**	**Maximum Air Quality Impacts ($\mu g/m^3$)**	**Percent of Standard**	**Maximum Air Quality Impacts ($\mu g/m^3$)**	**Percent of Standard**
PM_{10}	24 hr	150	60	40	61	41
	Annual	50	0.53	1.1	0.54	1.1
SO_2	1 hr	1,000	79	7.9	80	8.0
	3 hr	1,300	36	2.8	37	2.8
	24 hr	260	2.9	1.1	2.9	1.1
	Annual	50	0.018	0.036	0.018	0.036
CO	1 hr	40,000	1,500	3.8	1,500	3.8
	8 hr	10,000	460	4.6	470	4.7
NO_2	Annual	100	0.77	0.77	0.77	0.77

facility. In conducting air quality modeling, a conservative 200 West Area source location was assumed in all cases for the lined modular facility. As a result, the air quality estimates for Alternative Groups D_1, D_2, and D_3 are equivalent.

For Alternative Group D (Hanford Only, Lower Bound, and Upper Bound waste volumes), the largest air quality impacts would occur during two different periods of project operation. In 2006, the lined modular facility construction and capping of an existing MLLW trench would be under way. The heavy use of construction equipment for short periods of time would produce the maximum average pollutant concentrations for CO, SO_2, and NO_2. After disposal operations cease, the lined modular facility capping operations would be in full swing. This sustained activity would produce the maximum 24-hour and annual concentrations of PM_{10}.

Estimates of the maximum air quality impacts to the public from activities in the 200 Areas under Alternative Group D are summarized in Table 5.9. Estimates of the maximum air quality impacts from Area C activities are the same for all alternative groups (see Table 5.6).

All air quality impacts from Alternative Group D would be within ambient air quality standards. The largest potential impacts to the public from Area C activities would result from SO_2 and CO emissions. The largest potential air quality impacts to the public from activities in the 200 Areas would involve the 24-hour PM_{10} air concentration. Using the series of conservative assumptions employed in the dispersion modeling, this maximum air quality impact would be about 41 percent of the applicable air quality standard.

Table 5.9. Alternative Group D: Maximum Air Quality Impacts to the Public from Activities in the 200 Areas

			Hanford Only & Lower Bound Waste Volumes		**Upper Bound Waste Volume**	
Pollutant	**Averaging Time**	**Ambient Air Quality Standard ($\mu g/m^3$)**	**Maximum Air Quality Impacts ($\mu g/m^3$)**	**Percent of Standard**	**Maximum Air Quality Impacts ($\mu g/m^3$)**	**Percent of Standard**
PM_{10}	24 hr	150	61	41	62	41
	Annual	50	0.53	1.1	0.54	1.1
SO_2	1 hr	1,000	84	8.4	84	8.4
	3 hr	1,300	38	2.9	38	2.9
	24 hr	260	3.1	1.2	3.1	1.2
	Annual	50	0.019	0.038	0.019	0.038
CO	1 hr	40,000	1,590	4.0	1,590	4.0
	8 hr	10,000	500	5.0	500	5.0
NO_2	Annual	100	0.79	0.79	0.85	0.85

5.2.5 Alternative Groups E_1, E_2, and E_3

Project activities that would generate air quality impacts under Alternative Groups E_1, E_2, and E_3 (collectively referred to in this section as Alternative Group E) include the use of diesel-fueled equipment to construct a lined modular facility for LLW and MLLW, construction of the ILAW and melter trenches, backfilling and capping activities in the LLBGs, modification of T Plant, and the excavation of materials at the borrow pit. In addition, propane engines would be used at the CWC and to operate pulse driers used to treat leachate from the MLLW trenches. Fugitive dust would be associated with all major construction and operation activities. Alternative Groups E_1, E_2, and E_3 postulate different locations for the lined modular facility. In conducting air quality modeling, a conservative 200 West Area source location was assumed in all cases for the lined modular facility. As a result, the air quality estimates for Alternative Groups E_1, E_2, and E_3 are equivalent.

For Alternative Group E (Hanford Only, Lower Bound, and Upper Bound waste volumes), the largest air quality impacts would occur during three different periods of project operation. In 2006, the heavy use of construction equipment for concurrent construction of LLW, MLLW, and ILAW trenches and the capping of an existing MLLW trench would produce the maximum 24-hour and annual concentrations of SO_2. In 2007, trench construction activities would be underway, which would produce the maximum 1- and 8-hour concentrations of CO, the maximum 1- and 3-hour concentrations of SO_2, and the maximum annual NO_2 concentrations. After disposal operations cease, LLBG and ILAW capping operations would be in full swing. This sustained activity would produce the maximum 24-hour and annual concentrations of PM_{10}.

Estimates of the maximum air quality impacts to the public from activities in the 200 Areas under Alternative Group E are summarized in Table 5.10. Estimates of the maximum air quality impacts to the public from Area C activities are the same for all alternative groups (see Table 5.6).

All air quality impacts from Alternative Group E would be within ambient air quality standards (see Table 4.6, Section 4.3.3). The largest potential impacts to the public from activities at Area C would result from SO_2 and CO emissions. The largest potential air quality impact to the public from activities in the 200 Areas would involve the 24-hour PM_{10} air concentration. Using the series of conservative assumptions employed in the dispersion modeling, this maximum air quality impact would be about 41 percent of the applicable air quality standard.

5.2.6 No Action Alternative

Project activities that would generate air quality impacts under the No Action Alternative include the use of diesel-fueled equipment during construction of additional trenches of current design, construction of the ILAW trench and 66 CWC buildings, backfilling the LLW and MLLW trenches, capping two existing MLLW trenches, and excavation of materials at the borrow pits. A propane-fueled pulse drier would be used to treat MLLW trench leachate, beginning in 2026. Fugitive dust would be associated with all major construction and operation activities.

Table 5.10. Alternative Group E: Maximum Air Quality Impacts to the Public from Activities in the 200 Areas

			Hanford Only & Lower Bound Waste Volumes		Upper Bound Waste Volume	
Pollutant	**Averaging Time**	**Ambient Air Quality Standard ($\mu g/m^3$)**	**Maximum Air Quality Impacts ($\mu g/m^3$)**	**Percent of Standard**	**Maximum Air Quality Impacts ($\mu g/m^3$)**	**Percent of Standard**
PM_{10}	24 hr	150	60	40	62	41
	Annual	50	0.53	1.1	0.54	1.1
SO_2	1 hr	1,000	93	9.3	95	9.5
	3 hr	1,300	42	3.2	42	3.2
	24 hr	260	3.1	1.2	3.2	1.2
	Annual	50	0.019	0.038	0.020	0.040
CO	1 hr	40,000	1,700	4.3	1,700	4.3
	8 hr	10,000	530	5.3	530	5.3
NO_2	Annual	100	0.89	0.89	0.89	0.89

For the No Action Alternative (Hanford Only and Lower Bound waste volumes), the largest air quality impacts would occur during two different periods of project operation. In 2007, the heavy use of construction equipment to construct LLW trenches and CWC buildings, the capping of existing MLLW trenches, and propane use at CWC would produce the maximum 24-hour and annual concentrations of PM_{10}. In 2034, ILAW vault and final LLW trench construction would be underway, and propane for CWC and pulse drier operations would be at their peak. These activities would produce the maximum concentrations of SO_2 over all averaging periods, the maximum annual concentrations of NO_2, and the maximum 1- and 8-hour concentrations of CO.

Estimates of the maximum air quality impacts to the public from activities in the 200 Areas under the No Action Alternative are presented in Table 5.11. Estimates of the maximum air quality impacts to the public from Area C activities are the same for all alternative groups (see Table 5.6).

All air quality impacts from the No Action Alternative would be within ambient air quality standards (see Table 4.6, Section 4.3.3). The largest potential impacts to the public from Area C activities would result from SO_2 and CO emissions. The largest potential air quality impact from emissions in the 200 Areas would involve the 24-hour PM_{10} air concentration. Using the series of conservative assumptions employed in the dispersion modeling, this maximum air quality impact would be about 38 percent of the applicable air quality standard.

Table 5.11. No Action Alternative: Maximum Air Quality Impacts to the Public from Activities in the 200 Areas

Pollutant	Averaging Time	Ambient Air Quality Standard ($\mu g/m^3$)	Maximum Air Quality Impacts	
			Maximum Pollutant Concentration ($\mu g/m^3$)	Percent of Standard
PM_{10}	24 hr	150	57	38
	Annual	50	0.37	0.74
SO_2	1 hr	1,000	86	8.6
	3 hr	1,300	35	2.7
	24 hr	260	3.4	1.3
	Annual	50	0.019	0.038
CO	1 hr	40,000	1,600	4.0
	8 hr	10,000	460	4.6
NO_2	Annual	100	0.85	0.85

5.2.7 Comparison of the Alternative Groups

Table 5.12 presents a summary comparison across all alternative groups of maximum ambient air quality impacts to the public from activities in the 200 Areas. The greatest air quality impacts are experienced under Alternative Group B–Upper Bound waste volume. Depending on the pollutant and averaging period, the lowest air quality impacts are experienced under Alternative Group A–Hanford Only and Lower Bound waste volumes, Alternative Group C–Hanford Only and Lower Bound waste volumes, Alternative Group C–Upper Bound waste volume, and the No Action Alternative.

The only air quality impacts to the public from activities in the 200 Areas that would exceed 10 percent of their applicable ambient air quality standards would be the maximum 24-hour concentration of PM_{10}, 1-hour concentration of SO_2, and 8-hour concentration of CO. Only the maximum 24-hour concentration of PM_{10} under Alternative Group B–Upper Bound waste volume would exceed 50 percent of the applicable air quality standard. For activities in Area C, the maximum 1- and 8-hour concentrations of CO, 1- and 3-hour concentrations of SO_2, and 24-hour concentration of PM_{10} would be greater than 10 percent of the applicable ambient air quality standards (see Table 5.6). None of these impacts would exceed 50 percent of the applicable air quality standard.

It should be re-emphasized that the air quality impacts presented above are all based on a series of conservative assumptions. In particular, the incorporation of particulate deposition processes in the air quality modeling or the consideration of more stringent vehicle pollutant emission standards that are currently scheduled for future implementation would substantially reduce estimates of many maximum air quality impacts.

It is important to note that the maximum short-term air quality impacts to the public from activities in the 200 East and 200 West Areas and Area C should not be summed to come up with a combined air quality impact. For averaging periods of 24 hours and less, the maximum air quality impacts to the public from emissions in the 200 Areas and Area C would occur under markedly different flow regimes and would therefore occur at different times and have different impact locations. As a result, the maximum short-term air quality impacts to the public from emissions at one source location would not be appreciably impacted by emissions from the other source location. For annual air quality impacts to the public, it is extremely conservative to sum maximum annual impacts from different source locations to estimate the maximum cumulative impact. For the HSW Program, the combined maximum annual air quality impacts from emissions in each source location would be very small (that is, less than 2 percent of any annual air quality standard).

Table 5.12. Comparison Across all Alternative Groups of Maximum Air Quality Impacts to the Public from Activities in the 200 Areas

		Maximum Air Quality Impacts in Terms of Percent of the Associated Ambient Air Quality Standard										
		Alternative Group A		**Alternative Group B**		**Alternative Group C**		**Alternative Group D**		**Alternative Group E**		**No Action**
Pollutant	**Averaging Time**	**Hanford & Lower Bound Waste Volumes**	**Upper Bound Waste Volume**	**Hanford & Lower Bound Waste Volumes**	**Upper Bound Waste Volume**	**Hanford & Lower Bound Waste Volumes**	**Upper Bound Waste Volume**	**Hanford & Lower Bound Waste Volumes**	**Upper Bound Waste Volume**	**Hanford & Lower Bound Waste Volumes**	**Upper Bound Waste Volume**	**Hanford & Lower Bound Waste Volumes**
PM_{10}	24 hr	46	49	47	60	40	41	41	41	40	41	38
	Annual	1.2	1.2	1.2	1.3	1.1	1.1	1.1	1.1	1.1	1.1	0.74
SO_2	1 hr	8.1	9.8	13	18	7.9	8.0	8.4	8.4	9.3	9.5	8.6
	3 hr	2.9	3.5	4.7	6.5	2.8	2.8	2.9	2.9	3.2	3.2	2.7
	24 hr	1.0	1.3	1.8	2.5	1.1	1.1	1.2	1.2	1.2	1.2	1.3
	Annual	0.034	0.038	0.042	0.042	0.036	0.036	0.038	0.038	0.038	0.040	0.038
CO	1 hr	3.8	4.6	6.3	8.5	3.8	3.8	4.0	4.0	4.3	4.3	4.0
	8 hr	4.8	5.9	8.0	11	4.6	4.7	5.0	5.0	5.3	5.3	4.6
NO_2	Annual	0.72	0.80	1.0	1.1	0.77	0.77	0.79	0.85	0.89	0.89	0.85

5.3 Water Quality

This section discusses potential short-term impacts on groundwater quality from operations and construction of Hanford solid waste (HSW) disposal sites and related facilities and potential long-term impacts on groundwater and the Columbia River from contaminant releases from HSW disposal facilities after site closure in 2046 based on conservative assumptions used in this HSW EIS. Potential short-term impacts during the period of operations and construction are discussed in Section 5.3.1. An overview of assessment methods used to determine the potential long-term impacts to groundwater and the Columbia River are presented in Section 5.3.2. Detailed information on the long-term assessment methods and results are provided in Volume II, Appendix G. Section 5.3.3 discusses the use of immobilized low-activity waste (ILAW) performance assessment calculations to support this EIS. Details from the water quality analysis presented in Section 5.3.4 and in Volume II, Appendix G are used in the preparation of estimates of potential impacts on public health and safety, as provided in Section 5.11.

As a result of wastewater management activities during past Hanford Site operations, groundwater beneath the 200 Areas has been contaminated with radionuclides and non-radioactive chemicals. The contaminants emanating from the 200 Areas are moving toward the Columbia River. Radioactive contaminants present in groundwater beneath the 200 Areas that exceed values cited in Table 4.10 (see Section 4.5.3) are tritium, strontium-90, technetium-99, iodine-129, plutonium, cesium-137, total alpha, total beta, and uranium. Hazardous chemical contaminants present at levels exceeding values in Table 4.10 include nitrate, fluoride, chromium, carbon tetrachloride, trichloroethene, cyanide, tetrachloroethene, and cis-1, 2-dichloroethene. None of these contaminants is thought to have originated from the LLBGs being considered in this EIS (Hartman et al. 2002).

5.3.1 Potential Short-Term Impacts of Operations and Construction Activities

In the HSW management facilities, water is derived from the Hanford Site Export Water System is used for dust suppression during operations and construction. The Hanford Site Export Water System extracts potable water for fire suppression and industrial use in the Central Plateau from the Columbia River intake locations in the 100 D Area. Water from the export system also is expected to be used at existing sanitary facilities and would be disposed of after treatment. Because most of these operational water discharges would occur in uncontaminated areas, the discharges would not be expected to have a substantial effect on the groundwater system from leaching or the driving force of the wastes. Potential groundwater quality impacts would not be expected. In the case of capping the HSW disposal facilities at closure where water is used for short-term dust suppression, the 25-cm (10-in) layer of asphalt at the base of the cap is expected to divert water away from the waste and is not expected to result in impacts to groundwater quality. Use of process water is not anticipated for any of the HSW management facilities and is not considered further in terms of water quality.

Solid LLW disposed of after 1988 in the HSW disposal facilities is largely dry solid waste with limited amounts of free liquid that could otherwise result in waste leaching and release through the vadose zone and into the groundwater. Since that time, LLW has been categorized into Category (Cat) 1 and Cat 3 LLW based on stringent waste acceptance criteria for radionuclide inventory content. Further, beginning in 1995, systematic use of waste containment and containers, such as emplacing all wastes in steel boxes, drums, high-integrity containers (HIC), and grouted waste forms, was implemented to minimize leaching and release of contaminants during the period of operations. In addition, MLLW is being disposed of in RCRA-compliant trenches with a liner system to facilitate monitoring, management, and treatment of leachate during operations (see Section 3.1).

Because waste containment using containers described above was not systemically used prior to 1995, contaminants contained in solid LLW disposed of in LLBGs prior to 1995 offer the highest potential for leaching and release into the vadose zone prior to site closure. The analysis conducted for this HSW EIS conservatively evaluated the potential impacts of these earlier disposals by evaluating the effect of higher infiltration rates during operations. Results of analyses of earlier disposal facilities used release and vadose zone infiltration rates of 5 cm/yr, a rate reflective of managed bare surface soil conditions over the older disposal areas during the operations phase. Mobile contaminants (such as technetium-99 and iodine-129) disposed of before 1995 were estimated to arrive several hundred years before mobile contaminants disposed of after 1995. Peak concentrations of technetium-99 and iodine-129 were estimated to arrive at downgradient locations between years 2050 and 2100 from 200 East Area locations and year 2150 and 2200 from 200 West Area locations. Descriptions of the underlying assumptions and resulting estimated impacts (that is, contaminant concentration levels and peak arrival times) from these analyses are provided in detail in Volume II, Appendix G.

5.3.2 Methods for Assessment of Potential Long-Term Impacts

The groundwater exposure pathway considers the long-term release of contaminants from a variety of LLW and MLLW downward through the vadose zone underlying the HSW disposal facilities and laterally through the unconfined aquifer immediately underlying the vadose zone to the Columbia River. The LLBG are all located in the 200 Areas, and the physical area of potential groundwater impact is the unconfined aquifer bounded laterally by the Rattlesnake Hills to the west and southwest, by the Columbia River to the north and east, and by the Yakima River to the south (see Section 4.5.3, Figure 4.17).

The sequence of calculations used in the long-term assessment required using a suite of process models that estimated source-term release, vadose zone flow and transport, and groundwater flow and transport. The computational framework for these process models and relationship of software elements is schematically illustrated in Figure 5.1.

Wastes considered in this assessment include previously disposed of wastes and wastes to be disposed of in the HSW disposal facilities (for purposes of analysis, year 2007 was assumed to be the date when new disposal facilities would be operational):

- Previously disposed of LLW, which includes:
  - LLW disposed of in LLBGs between 1962 and 1970 (referred to as pre-1970 LLW in this section).
  - LLW disposed of in LLBGs after 1970, but before October 1987 (referred to as 1970–1987 LLW in this section).

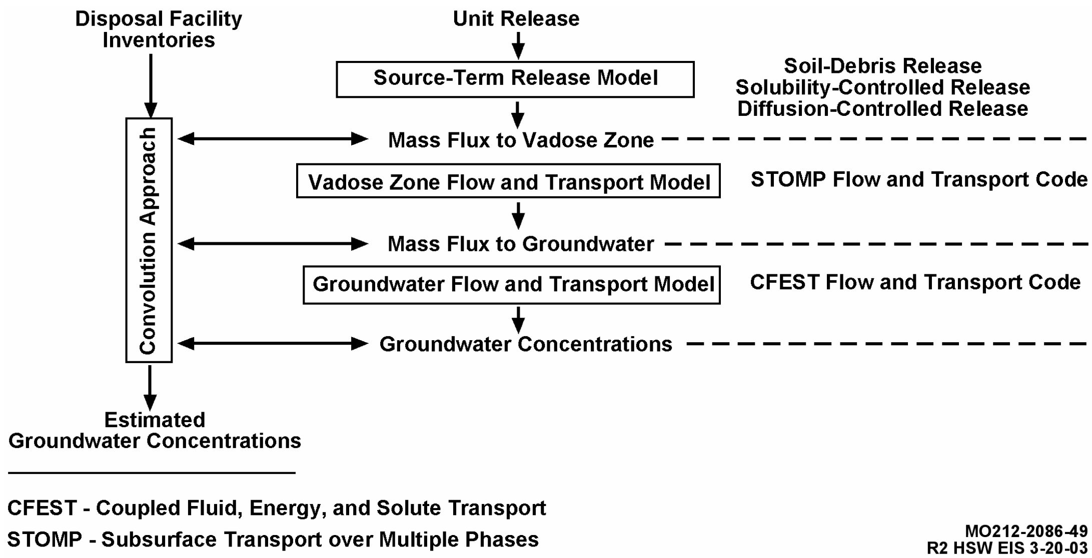


Figure 5.1. Schematic Representation of Computational Framework and Codes Used in the HSW EIS

  - LLW disposed of in LLBGs after October 1987, but before 1995 (referred to as 1988–1995 LLW in this section).

- Cat 1 LLW, which includes:
  - Cat 1 LLW disposed of in the LLBGs after 1995 including Cat 1 LLW forecasted to be disposed of through 2007 (referred to as Cat 1 LLW [1996–2007] in this section).
  - Cat 1 LLW disposed of after 2007 including Cat 1 LLW forecasted to be disposed of through 2046 (referred to as Cat 1 LLW disposed of after 2007 in this section). For purposes of analysis, year 2007 was assumed to be the date when new disposal facilities would be operational.

- Cat 3 LLW, which includes:
  - Cat 3 and greater than Cat 3 (GTC3) LLW disposed of in the LLBGs after 1995 including Cat 3 LLW forecasted to be disposed of through 2007 (referred to as Cat 3 LLW [1996–2007] in this section).
  - Cat 3 and GTC3 LLW disposed of after 2007 including Cat 3 LLW forecasted to be disposed of through 2046 (referred to as Cat 3 LLW disposed of after 2007 in this section).

- MLLW, which includes:
  - MLLW disposed of after 1996 including MLLW forecasted to be disposed of through 2007 (referred to as MLLW [1996–2007] in this section). MLLW received since 1988 has been in storage awaiting final treatment.

- MLLW disposed of after 2007 including MLLW forecasted to be disposed of through 2046 (referred to as MLLW disposed of after 2007 in this section).

- Melters from the tank waste treatment program.

- ILAW from the tank waste treatment program.

Inventories of retrievably stored transuranic (TRU) waste in trenches and caissons located in the LLBGs were not evaluated for their potential groundwater quality impacts because the TRU waste will be retrieved and sent to the Waste Isolation Pilot Plant for disposal. TRU waste is stored in containers, and the configuration in which the TRU waste containers are stored (including coverings to prevent intrusion of water and asphalt storage pads) provides additional protection from releases. Procedures require that waste container integrity and containment inspections be performed during the retrieval. Any releases would be characterized and addressed consistent with existing procedures and plans.

Although not specifically required by current DOE standards for LLW management, this assessment examined potential groundwater quality impacts for up to 10,000 years after the operational period. Current requirements under the guidelines for a performance assessment of LLW disposal facilities, as prescribed in (DOE 2001b), focus on potential impacts during the first 1,000 years after disposal.

This groundwater assessment was performed using a combination of screening techniques and numerical modeling. The groundwater modeling results estimate contaminant concentrations in the groundwater associated with selected alternatives evaluated in this HSW EIS from the end of waste operations in 2046 up to 10,000 years from 2046. This analysis also evaluates potential early waste release and contaminant transport from wastes disposed of before 1996, including pre-1970 LLW, 1970-1987 LLW, and 1988–1995 LLW, and examines the potential for release and vadose zone transport during the operational period.

The lines of analysis (LOAs) used in this comparative assessment were located on the Hanford Site along lines approximately 1 km (0.6 mi) downgradient from the 200 East and West Areas, at ERDF, and near the Columbia River, as shown in Figure 5.2. Additional analyses of potential groundwater quality impacts for a new combined-use facility (as presented for Alternative Groups D_1, D_2, and D_3), are presented in Section 5.3.6 and in Volume II, Appendix G, Section G.5, and provide a perspective on the relative impact at waste management boundaries immediately downgradient of the aggregate waste disposal area versus potential impacts at the 1-km LOAs. A similar impact analysis is provided for LLW and MLLW disposed of before 2007 for another perspective.

All locations were selected based on simulated transport results of unit releases at selected HSW disposal facilities. These LOAs in each area are not meant to represent points of regulatory compliance, but rather common locations to facilitate a comparison of the waste management activities and locations defined for each alternative group. Constituent concentrations presented for each alternative group from specific waste category releases represent maximum concentrations estimated along these LOAs. Because of the variation in the location of the different waste types and category releases for a given alternative group, the estimated maximum concentrations calculated from a specific waste category release may not correspond to the same point on the line of analysis for every waste category and

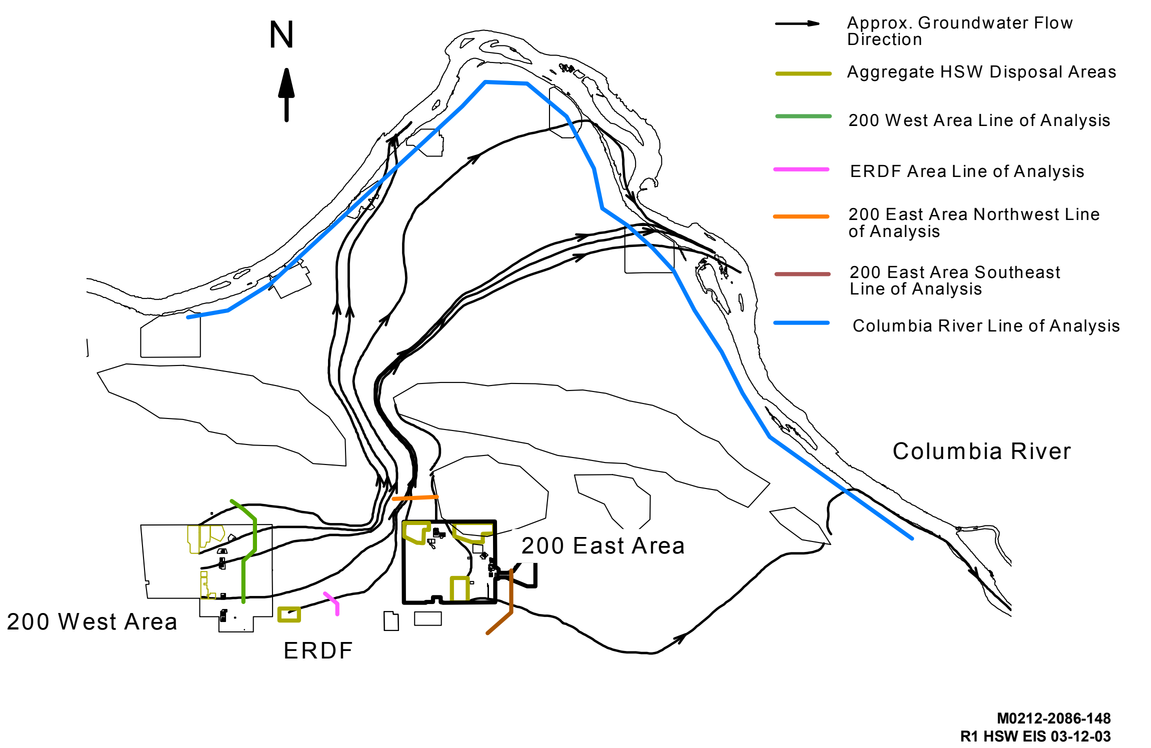


Figure 5.2. LOAs Used in Comparing Potential Long-Term Groundwater Quality Impacts

alternative group. Combined concentration levels presented for each LOA and alternative group reflect the summation of estimated concentration levels regardless of their position on the LOA. As a consequence, the actual maximum concentrations at a given point along the LOA would be overestimated when combining concentration levels.

Delineation of potential waste impacts in the 200 East Area required two different LOAs. One LOA, designated as the 200 East Northwest (NW) LOA, is used to evaluate concentrations in groundwater migrating northwest from the 200 East Area. Another LOA, designated as the 200 East Southeast (SE) LOA, is used to evaluate concentrations in groundwater migrating southeast from the 200 East Area.

The HSW disposal facilities contain over 100 radioactive and non-radioactive waste constituents. Potential impacts to groundwater within the 10,000-year period of analysis were based primarily on the overall mobility of the constituents. To establish their relative mobility, the constituents were grouped based on their mobility in the vadose zone and underlying unconfined aquifer. Contaminant mobility classes were used rather than the individual mobility of each contaminant because of the uncertainty involved in determining the mobility of individual constituents. The mobility classes were selected based on relatively narrow ranges of mobility. Some of the constituents, such as iodine and technetium, would move at the same rate as water whether in the vadose zone or underlying groundwater. The movement of other constituents in water, such as americium, cesium, plutonium, and strontium, would be retarded by interaction with soil and rock.

The constituents considered in this assessment have a broad range of mobility when their affinity to being sorbed during transport in the vadose zone and groundwater environment is considered. The flow and transport models used in this analysis account for these differences in mobility by the use of a factor commonly referred to as the retardation factor (Rf). This factor, which relates the velocity of the contaminant to the velocity of pore water, is typically calculated using a distribution coefficient, or K_d, which has units of mL/g. This parameter is a measure of sorption and is the ratio of the quantity of the solute adsorbed per gram of solid to the amount of solute remaining in solution (Kaplan et al. 1995). Values of K_d for the constituents range from 0 mL/g (in which the contaminant movement in water is not retarded) to more than 40 mL/g (in which the contaminant moves at a much slower rate than water).

The constituents in the LLW inventory were grouped and modeled according to well-established K_ds for each constituent, or a conservative K_d where a range of K_ds is known for a particular constituent. The constituent mobility classes, based on mobility and examples of common or potential constituents of concern, are described in the following text. A complete list of solid LLW constituents by K_d is provided in Volume II, Appendix G. The constituent mobility classes used for modeling include:

- **Mobility Class 1** – Contaminants were modeled as non-sorbing (that is, $K_d = 0$) and would not be retarded in the soil-water system. Contaminant K_d values in this group are within the range of 0 to 0.59 mL/g and include all the isotopes of iodine, technetium, selenium, chlorine, and tritium.

- **Mobility Class 2** – Contaminants were modeled as slightly sorbing (that is, $K_d = 0.6$) and would be slightly retarded in the soil-water system. Contaminant K_d values in this group are within the range of 0.6 to 0.99 mL/g and include all the isotopes of uranium and carbon.

- **Mobility Class 3** – Contaminants were modeled as slightly more sorbing (that is, $K_d = 1$). Contaminant K_d values in this group are within the range of 1.0 to 9.9 mL/g and include all the isotopes of barium.

- **Mobility Class 4** – Contaminants were modeled as moderately sorbing (that is, $K_d = 10$). Contaminant K_d values in this group are within the range of 10 to 39.9 mL/g and include all the isotopes of neptunium, palladium, protactinium, radium, and strontium.

- **Mobility Class 5** – Contaminants were modeled as strongly sorbing (that is, $K_d = 40$). Contaminant K_d values in this group are 40 mL/g or greater and include all the isotopes of actinium, americium, cobalt, curium, cesium, iron, europium, gallium, niobium, nickel, lead, plutonium, samarium, tin, thorium, and zirconium.

Estimated inventories of hazardous chemical constituents associated with LLW and MLLW disposed of after 1988 being considered under each alternative group would be expected to be found at trace levels. MLLW, which would be expected to contain the majority of hazardous chemical constituents, would undergo predisposal solidification to stabilize waste forms and containment and thermal treatment to remove organic chemical components of the MLLW. This waste treatment would be done to meet current waste acceptance criteria and land disposal restrictions before being disposed of in permitted MLLW facilities. Consequently, potential groundwater quality impacts from these constituents would not be expected to be substantial.

Analysis of MLLW inventories for this assessment did identify two exceptions that included lead and mercury inventories associated with the projected MLLW that were estimated at 336 kg (741 lb) and 2.5 kg (5.5 lb), respectively. Because of its affinity to be sorbed into Hanford sediments, lead falls within Mobility Class 5 (K_d = 40 mL/g) and would not release to groundwater within the 10,000-year period of interest. The inventory estimated for mercury is assumed to be small enough that it would not release to groundwater in substantial concentrations. Even the most conservative estimates of release would yield estimated groundwater concentrations at levels of two orders of magnitude below the current drinking water standard for mercury of 0.002 mg/L.

LLW disposed of prior to October 1987 may contain hazardous chemical constituents, but no specific requirements existed to account for or report the content of hazardous chemical constituents in this category of LLW. As a consequence, analysis of these constituents and estimated impacts based on the limited amount of information on estimated inventories and waste disposal locations would be subject to uncertainty at this time. (Additional discussion on uncertainties is presented in Section 3.5.) These facilities are part of the LLW and MLLW facilities in the LLW management Areas (LLWMAs) 1 through 4 that currently are being monitored under RCRA interim status programs. Final closure or remedial investigation of these facilities under RCRA (42 USC 6901) and/or CERCLA (42 USC 9601) guidelines could involve further analysis of the potential impacts of the chemical components of these inventories.

In response to comments received during the public comment periods on the drafts of the HSW EIS, efforts were made to develop an estimate of quantities of potentially hazardous chemicals in previously buried LLW so that an initial analysis of potential impacts of such chemicals on groundwater quality could be evaluated. The estimation of these inventories, which used a waste stream analysis estimation method, is summarized in the Technical Information Document (FH 2004). This initial assessment of the estimated hazardous chemical inventory in pre-1988 buried wastes is provided in Section 5.3.7 and Section G.6 in Volume II, Appendix G.

The source term is the quantification of when and which constituents (by mass or activity) would be released. This source term includes the water flux into the vadose zone that results from precipitation infiltrating the waste and mass or activity solubilized from dissolution of waste in the HSW disposal facilities. A detailed description of the source term and the rates of release of constituents into the groundwater can be found in Volume II, Appendix G. Methods used for calculating source release and transport of constituents in the vadose zone and groundwater also are described in Volume II, Appendix G.

5.3.2.1 Previously Disposed of Waste and Category 1 Low-Level Waste

Previously disposed of LLW and Cat 1 LLW were evaluated using similar modeling approaches. Previously disposed of LLW consists of waste emplaced in the HSW disposal facilities from 1962 to 1970 and between 1970 and 1987; Cat 1 LLW consists of waste emplaced since 1988 and forecasted to be emplaced in the future in the 200 East Area and the 200 West Area.

Assumptions for analysis of these LLW types include:

- All LLW would be buried by 2046. At the beginning of the analysis period, all constituents of concern were assumed to be available for transport via infiltrating precipitation to the vadose zone and for eventual arrival at the groundwater.

- The start of release is variable and dependent on the waste category. Because of uncertainties in the use of waste containers and containment prior to 1995, releases for the pre-1970 LLW, 1970-1987 LLW, and 1988–1995 LLW were conservatively approximated by initiating waste releases in 1966, 1976, and 1996, respectively. Since 1995, the use of more robust waste containment and waste forms (that is, the use of steel drums and steel boxes for Cat 1 LLW and the use of macroencapsulated grouting and high-integrity containers for Cat 3 LLW) has become a standard practice. Thus the start of release of all LLW and MLLW disposed of after 1995 was assumed to be delayed at least until the time of site closure in 2046.

- Source-term release for the LLW was estimated using the soil-debris release model. In this model, the waste, itself, was assumed to have the same hydraulic characteristics of the surrounding soil materials. The inventory in the LLW was conservatively assumed to be immediately available for leaching and would be leached out of the HSW disposal facilities at the assumed infiltration rate.

- For all alternatives involving LLW previously disposed of before 1996, the soil-debris release model assumed an infiltration rate of 5 cm/yr during the period of operations before year 2046. This assumption of infiltration provides conservative estimates of waste release to groundwater for earlier disposals (prior to 1995) when waste containment was not as robust. This assumed release model infiltration rate was used for the pre-1970 LLW, the 1970–1988 LLW, and the 1988–1995 LLW.

- For all alternatives involving wastes disposed of after 1995, the soil-debris release model assumed sufficient waste containment to delay release until after site closure.

- For Alternative Groups A through E, all waste disposal sites were assumed to be covered with a Modified RCRA Subtitle C Cover system. To approximate the effect of the cover on waste release, the following assumed infiltration rates were used in the waste release modeling. For 500 years after site closure, an infiltration rate of 0.01 cm/yr was used to approximate the effect of cover emplacement over the wastes and its potential impact on reducing infiltration. After 500 years, it was assumed that the cover would begin to degrade. Between 500 and 1000 years after site closure, infiltration rates were increased from 0.01 cm/yr to 0.5 cm/yr to approximate a 500-year period of cover degradation and return to an infiltration rate reflective of natural vegetated surface soil conditions over the wastes. The final rate of 0.5 cm/yr was used for the remaining 9,000-year period of analysis. For the No Action Alternative, the release modeling from these wastes used an infiltration rate of 0.5 cm/yr, which was assumed to be an appropriate infiltration rate for naturally vegetated surface soil conditions that would persist under this alternative after site closure.

Additional analyses were performed to provide perspective on potential impacts using two additional assumptions: 1) no cover system is installed and 2) a cover system is used and remains intact for the entire period of analysis (see Section 5.3.5.).

- A specific case of leaching was used to estimate the release of uranium from the LLW. For uranium, the release was controlled at a solubility limit of 64 mg/L, a conservative estimate of uranium solubility at Hanford estimated by Wood et al. (1995) for LLW in the 200 West Area.

- During the post-closure period (that is, after 2046), the infiltration rate used for vadose zone flow was assumed to be 0.5 cm/yr to reflect natural recharge in the surrounding environment of naturally vegetated surface soil conditions. In the absence of artificial recharge, vadose simulation results based on this assumed infiltration rate indicated a travel time to the water table of about 560 years in the 200 East Area and 900 years in the 200 West Area.

- The thickness of the LLW was assumed to be 6 m (20 ft) for disposal in the existing trenches and 15.6 m (51 ft) for the enhanced design waste trenches (deeper, wider trenches in Alternative Group A; single expandable trenches in Alternative Group C; and in the lined modular facility in Alternative Groups D_1, D_2, D_3, E_1, E_2, and E_3).

- For a number of the alternative groups, the analysis considered the use of liner systems to control waste release during the period of operations. However, no specific credit for the effect of these liner systems was considered in this long-term analysis. Although the liner systems, as described in Section 3.1, might last (contain leachate for removal) for several hundreds of years if properly managed, this analysis assumed that the emplaced liners would fail during the 100-year active institutional control period and would have little effect on the long-term waste release during the 10,000-year period of analysis.

5.3.2.2 Cat 3 Low-Level Waste

Assumptions for analysis of Cat 3 LLW that differs from those of Cat 1 LLW follow:

- Because all Cat 3 LLW is either buried in high-integrity containers (HICs) constructed of concrete or disposed of by in-trench grouting, the calculations assumed a delay in contaminant release (the design lifetime of an individual HIC). Source-term releases of carbon-14 and iodine-129 were estimated using the soil-debris release model with the assumed delay in release to account for containment of the LLW in either HIC or in-trench grouting. In this model, the inventory in the LLW was conservatively assumed to be immediately available for leaching. The exception to this approach was technetium-99 and uranium in LLW. The technetium-99 LLW was assumed to be disposed of within the HIC in a macroencapsulated grout form, and the release of technetium-99 was assumed to be controlled by diffusion through the grout.

- The leaching of uranium disposed of in cementitious waste forms (that is, in macroencapsulated grout or HICs) was based on a solubility controlled release model that used an assumed lower uranium solubility limit of 0.2 mg/L (Wood et al. 1996). This solubility limit, which is lower than the 64 mg/L used for leaching of uranium in non-cemented wastes, is a conservative representation of uranium solubility in the alkaline geochemical conditions created by the presence of cement in the disposal environment. Additional information on recent studies of leaching of uranium from cementitious waste forms is available from Krupka and Serne (1996) and Serne et al. (1996).

5.3.2.3 Mixed Low-Level Waste

MLLW analyzed in this section includes waste emplaced since 1988 and waste forecasted to be emplaced in the future. Trenches 31 and 34 in LLBG 218-W-5 in the 200 West Area were constructed specifically for disposal of MLLW. MLLW in excess of the capacity of these trenches is assumed to be disposed of in newly constructed MLLW trenches in designated locations defined in Alternative Groups A through E.

Assumptions for analysis of MLLW that differs from those of Cat 1 LLW follow:

- Some of the MLLW would be disposed of in a matrix of macroencapsulated grout similar to Cat 3 LLW.

- The thickness of the MLLW disposed of in the 200 West Area in Trenches 31 and 34 within LLBG 218-W-5 was assumed to be 6 m (20 ft). Depth of the MLLW disposed of in the 200 East Area in the enhanced trench at other LLBG locations was assumed to be 15.6 m (51 ft).

5.3.2.4 Melters from the Waste Treatment Program

Melters analyzed in this section are forecasted to be emplaced in a new 21-m (69-ft) deep disposal facility, which would be constructed in locations designated in Alternative Groups A through E.

Assumptions for analysis of melters that differ from those of MLLW follow:

- The depth of the melter disposal facility, wherever constructed, was assumed to be 21 m (69 ft), and the waste thickness was assumed to be 18.6 m (61 ft).

- The melters were assumed to be macroencapsulated in grout. Thus, the release of inventories of constituents contained within this waste was assumed to be controlled by the presence of grout. The release of technetium-99 was assumed to be controlled by diffusion using the diffusion-controlled release model. The release of uranium isotopes was assumed to be controlled by a solubility-controlled release models using a solubility limit of 0.2 mg/L. (This value is used for uranium release from other waste categories that use cementitious waste forms.) All of these waste release assumptions would represent a conservative treatment of waste release for these melters since constituents contained within these wastes would be contained in thick heavy gauge steel and encapsulated and incorporated in a vitrified waste mass and would likely be controlled by a much lower release rate related to steel corrosion and glass degradation.

5.3.3 Use of ILAW Performance Assessment Calculations to Support the HSW EIS

Potential impact results presented for ILAW disposal in this assessment were not based on independent calculations used in the previously described methodology, but rather on recent performance assessment (PA) calculations made for siting the ILAW HSW in the vicinity of the PUREX Plant, as summarized in Mann et al. (2001).

Under Alternative Groups A, C, D_1, and E_3, where ILAW disposal is sited near the PUREX facility, results of a sensitivity case in Mann et al. (2001) that analyzed the effect of 25,550 Ci of technetium-99 was used. This case reflected no technetium-99 removal from low-activity waste in the separation processes from the Waste Treatment Plant.

In this analysis, the results for the ILAW were superimposed directly onto the results of other waste categories calculated for this analysis at the operational area (the 200 East and West Areas and ERDF) and Columbia River LOAs, as appropriate for each alternative group. Thus where ILAW may be disposed of near the PUREX Plant (Alternative Groups A, C, D_1, and E_3), ILAW results were superimposed onto other potential waste category impacts at the 200 East Area SE LOA. Where ILAW is disposed of in the 200 East Area LLBGs (Alternative Group D_2), ILAW results were superimposed onto other potential waste category impacts at the 200 East Area SE LOA.

For purposes of this analysis, water quality and associated human health impact results presented in Section 5.11 and Volume II, Appendix F for Alternative Group B (where the ILAW disposal facility is sited in an area south of the CWC) and Alternative Groups D_3, E_1, and E_2 (where the ILAW disposal facility is sited at ERDF) are based on simple scaling of comparative simulation results of source releases in these areas using the sitewide groundwater flow and transport model (see Section G.3.3.2 in Appendix G, Volume II). Groundwater concentrations and results of human health impacts summarized in the original performance assessment calculations described in Mann et al. (2001) were based on well intercept factors (WIFs) or dilution factors from a given areal flux of a hypothetical contaminant released to the unconfined aquifer from the ILAW disposal facility (Bergeron and Wurstner 2000). The WIF is defined as the ratio of the concentration at a well location in the aquifer to the concentration of infiltrating water entering the aquifer. These WIFs are being used in conjunction with calculations of released contaminant fluxes through the vadose zone to estimate potential impacts from radiological and hazardous chemical contaminants within the ILAW disposal facility at LOAs.

Results of applying WIFs for the three postulated ILAW disposal locations (see Section 3.3.2 in Appendix G, Volume II) suggest that predicted groundwater concentrations would be a factor of about 3 higher at the 1-km (0.6-mi) LOA downgradient of the HSW disposal site locations (south of CWC and at

ERDF) relative to a comparable location downgradient from the PUREX location. These higher-predicted concentrations would be consistent with differences in hydrogeology at these two locations relative to conditions found near the PUREX Plant. Near the PUREX Plant, the upper part of the unconfined aquifer is largely composed of very permeable sediments associated with the Hanford formation. Whereas, at the ERDF and CWC locations, the upper part of the unconfined aquifer is made up of less permeable sand and gravel sediments associated with the Ringold sediments.

These scaling factors would apply for both the Lower Bound and Upper Bound waste volumes since the ILAW volume and inventory is assumed to be the same for both cases. Peak concentrations estimated near the Columbia River from these alternative locations of disposal would be about 20 and 10 percent lower, respectively, than was calculated from releases near the PUREX location. The reductions in concentrations levels would be consistent with the longer flow path to the Columbia River.

The methods used to adapt the PA results to the analysis in the HSW EIS are provided in Volume II, Appendix G, Section G.3.

The technetium-99 inventory (25,550 Ci) used in the HSW EIS is a factor of 4.4 higher than the estimated inventory (about 5,790 Ci) if technetium-99 removal occurred in the separation process. Potential groundwater impacts attributable to technetium-99 in ILAW based on the higher estimated inventory would be reduced to about 23 percent of estimated levels presented in the HSW EIS alternative groups analyses if the lower inventory were assumed.

5.3.4 Potential Long-Term Impacts on Groundwater Quality

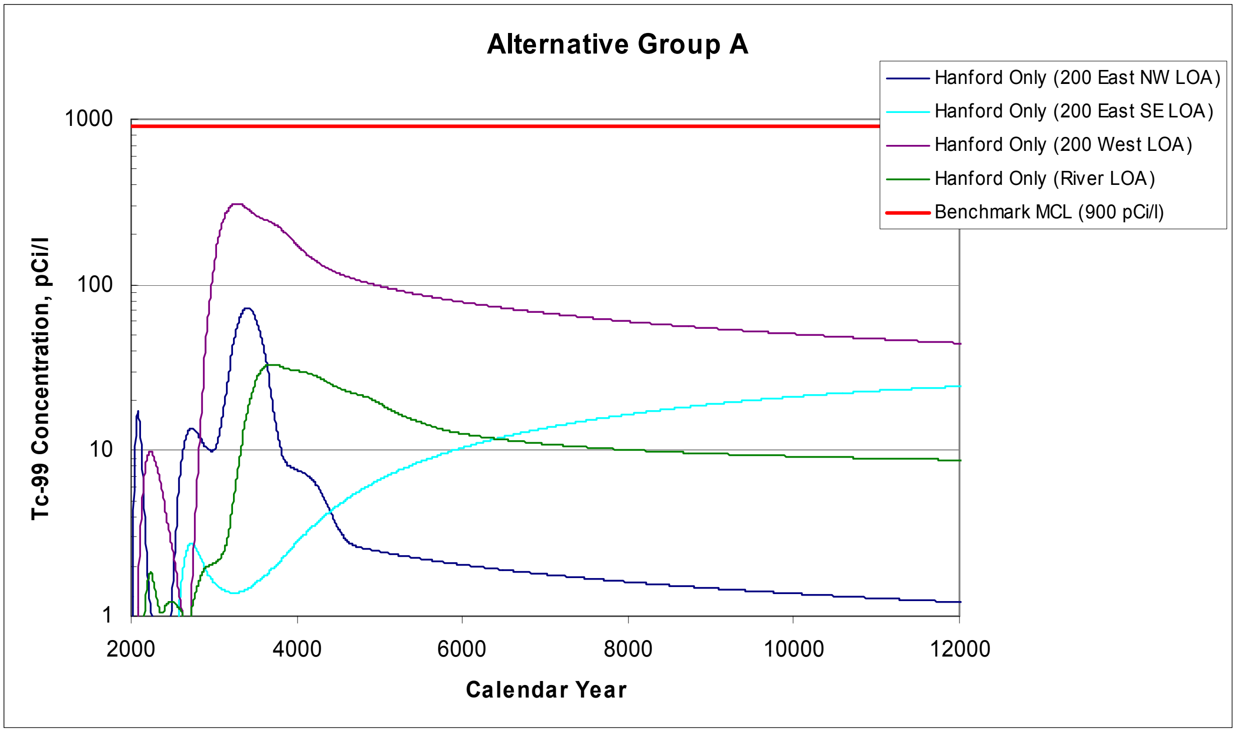
Of the suite of LLW constituents disposed of in the HSW disposal facilities, only technetium-99 and iodine-129 in Mobility Class 1 and carbon-14 and the uranium isotopes in Mobility Class 2 were considered to be in sufficient quantity, long-lived, and mobile enough to warrant detailed analysis of potential groundwater quality impacts. Although three of the constituents in Mobility Class 1—selenium, chlorine, and tritium—are considered to be very mobile, they were excluded from analysis because the total inventories for selenium and chlorine were considered negligible (less than 1×10^{-2} Ci); tritium was excluded because it has a relatively short half-life and would reach the groundwater from the HSW disposal facilities in very small quantities.

Estimates of transport times of constituents in Mobility Classes 3, 4, and 5 indicated their release through the thick vadose zone to the unconfined aquifer beneath the HSW disposal facilities would be beyond the 10,000-year period of analysis. Thus all constituents in these mobility classes were eliminated from further analysis.

Federal drinking water standards are used as benchmarks against which potential contamination levels may be compared. For the contaminants of interest, the Federal Drinking Water Standards (40 CFR 141.16) are based on EPA's calculated dose equivalent of 4 mrem/yr to the maximally exposed internal organ or total body. Effective December 8, 2003, however, the uranium standard is 30 μg/L, based on chemical toxicity that is more restrictive than the radiological dose standard (65 FR 76708). Drinking water standards for Washington state are stated in WAC 246-290. Federal standards are given in 40 CFR 141 and 40 CFR 143.

Concentrations of key constituents (primarily technetium-99 and iodine-129) for all Hanford solid waste types disposed of in the 200 Areas, at ERDF, and near the PUREX Plant for the LOAs by alternative group over 10,000 years for the Hanford Only and Upper Bound waste volumes are provided in Figures 5.3 to 5.21. These results represent the incremental potential impacts from wastes considered in this EIS (potential cumulative impacts of these wastes combined with other Hanford sources are presented in Section 5.14). For reference, benchmark maximum contaminant levels (MCLs) for technetium-99 and iodine-129 are 900 pCi/L and 1 pCi/L, respectively. Because of the variation in the location of the different waste types and category releases for a given alternative group, the estimated maximum concentrations calculated from a specific waste category release may not correspond to the same point on the LOA for every waste category and alternative group. Combined concentration levels presented in the following sections for each LOA and alternative group reflect the summation of estimated concentration levels regardless of their position on the LOA. As indicated in the following figures, most of the variation in groundwater radionuclide concentrations among the alternative groups resulted from proposed locations and configurations for new disposal facilities; differences between the Hanford Only and Upper Bound waste volumes were minimal.

Summary level discussions of potential impacts on groundwater quality for each alternative group are presented in the following sections. These discussions primarily focus on quantitative estimates of potential impacts related to releases of technetium-99 and iodine-129. Qualitative discussion of the potential impacts from carbon-14 and the uranium isotopes also is provided. Potential human health impacts are presented in Section 5.11.



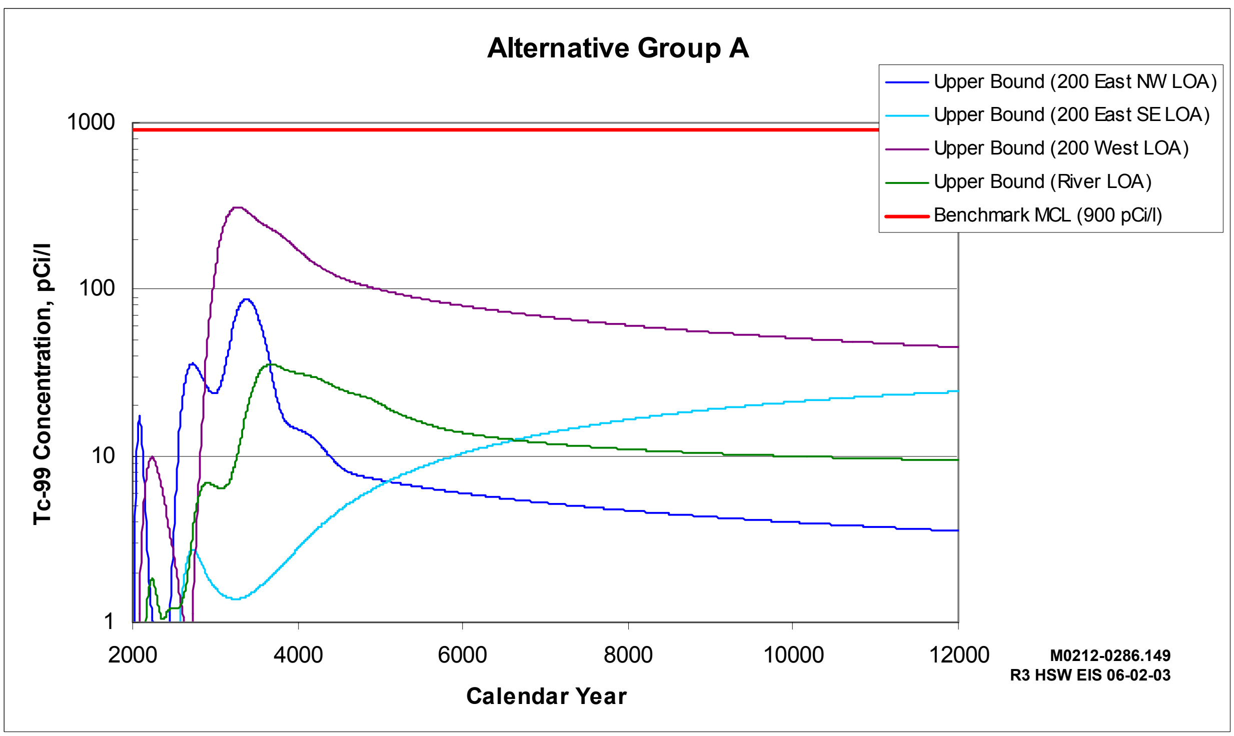


Figure 5.3. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group A – Hanford Only and Upper Bound Waste Volumes)

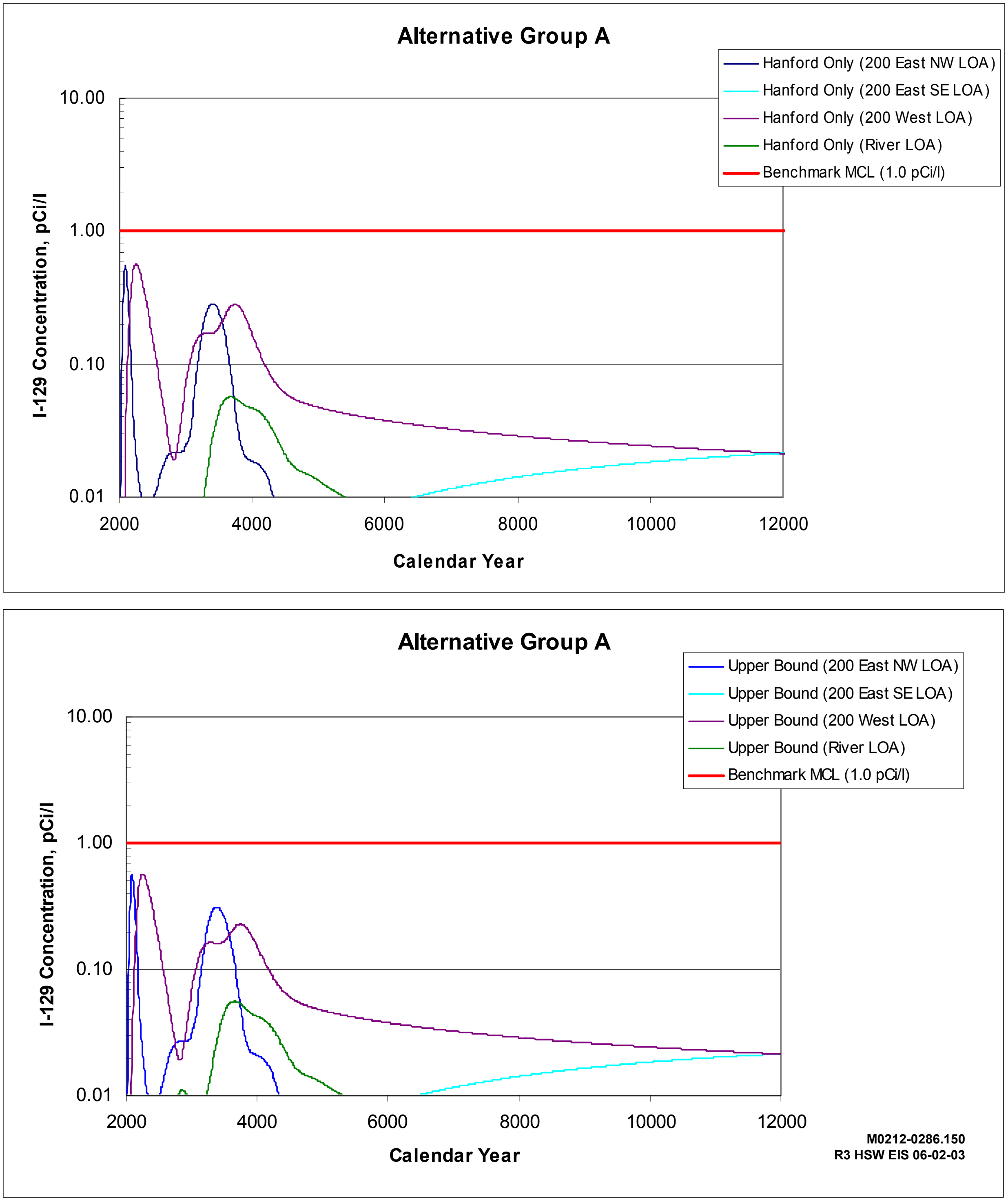


Figure 5.4. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group A – Hanford Only and Upper Bound Waste Volumes)

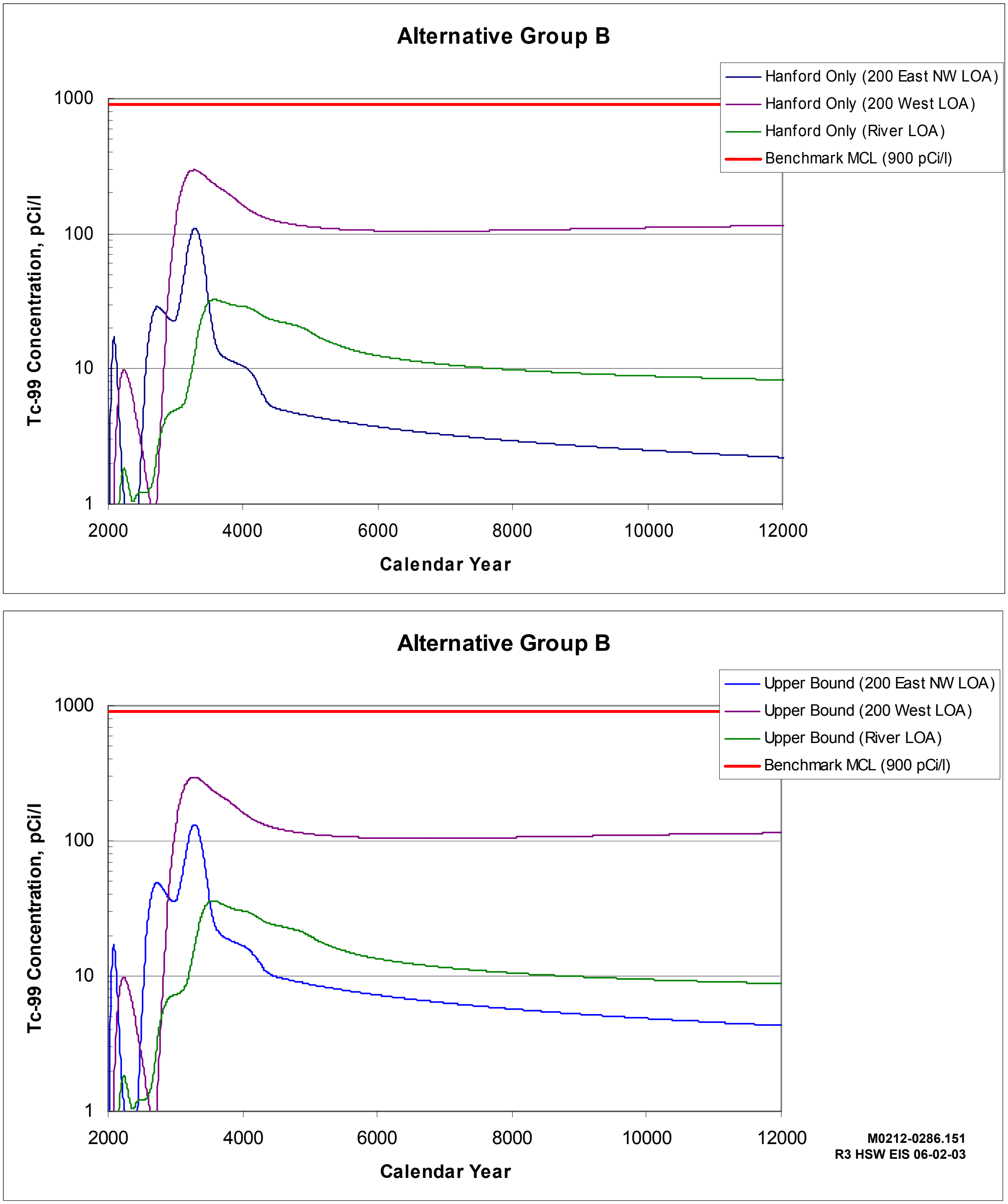


Figure 5.5. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group B – Hanford Only and Upper Bound Waste Volumes)

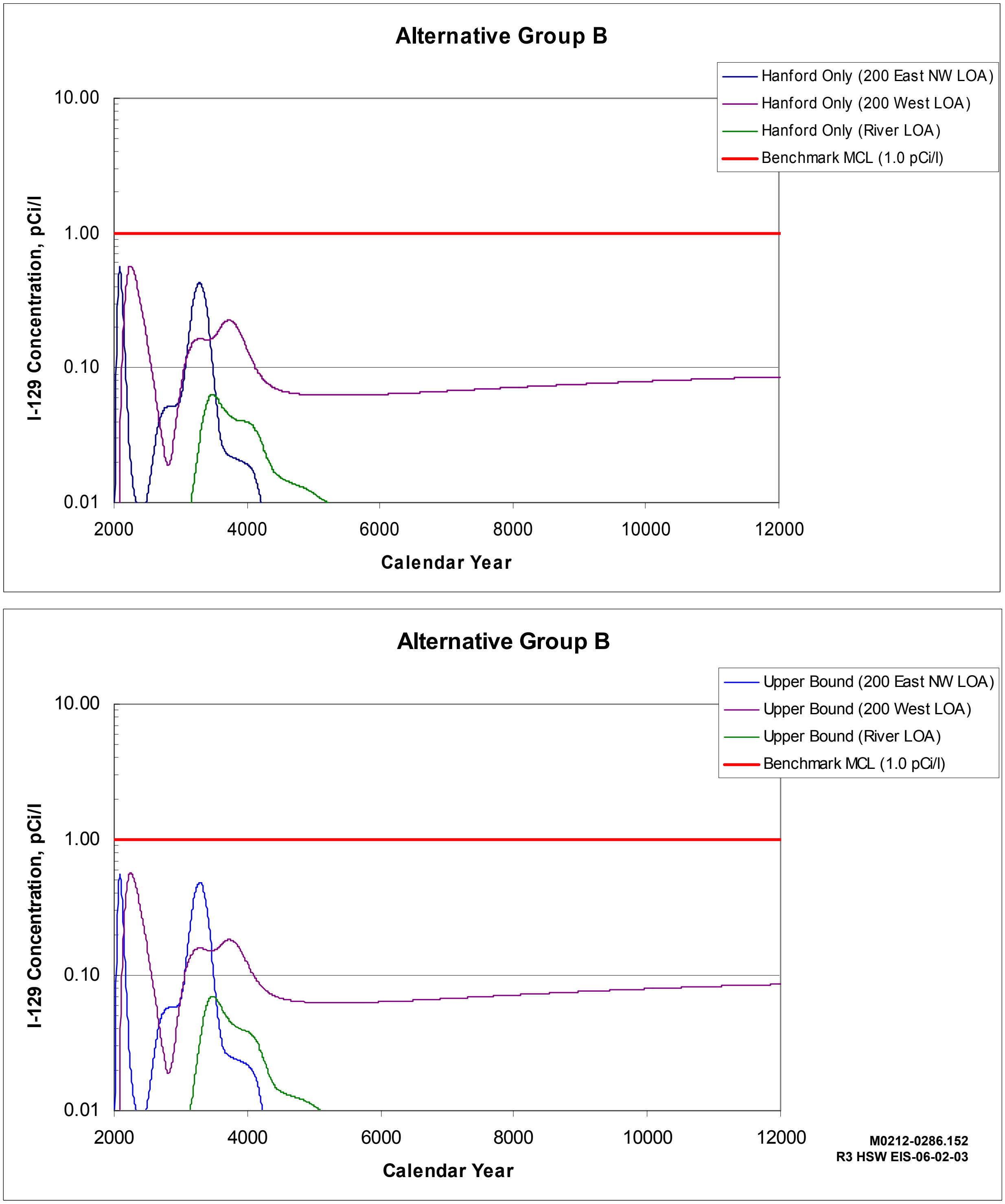


Figure 5.6. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group B – Hanford Only and Upper Bound Waste Volumes)

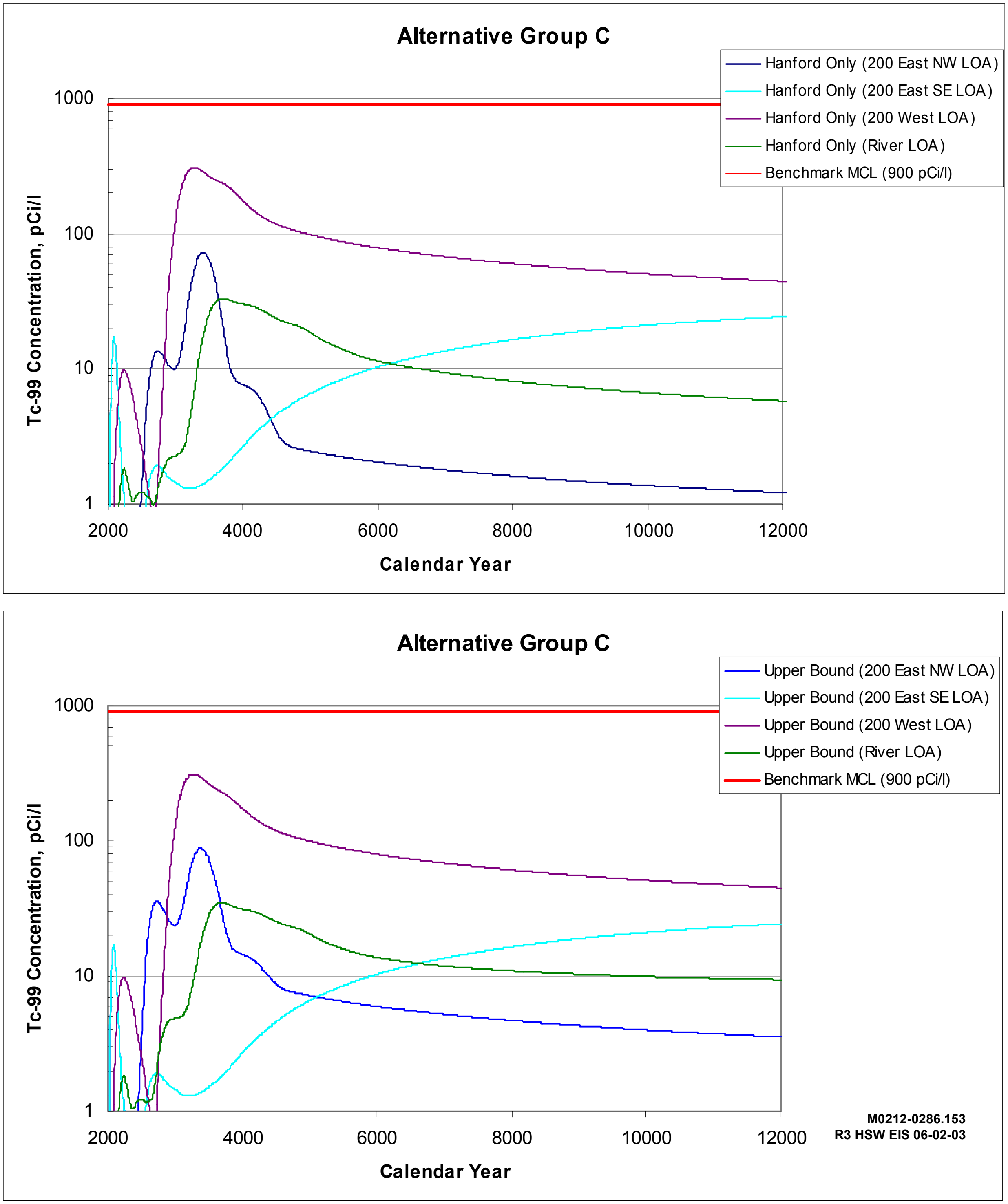


Figure 5.7. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group C – Hanford Only and Upper Bound Waste Volumes)

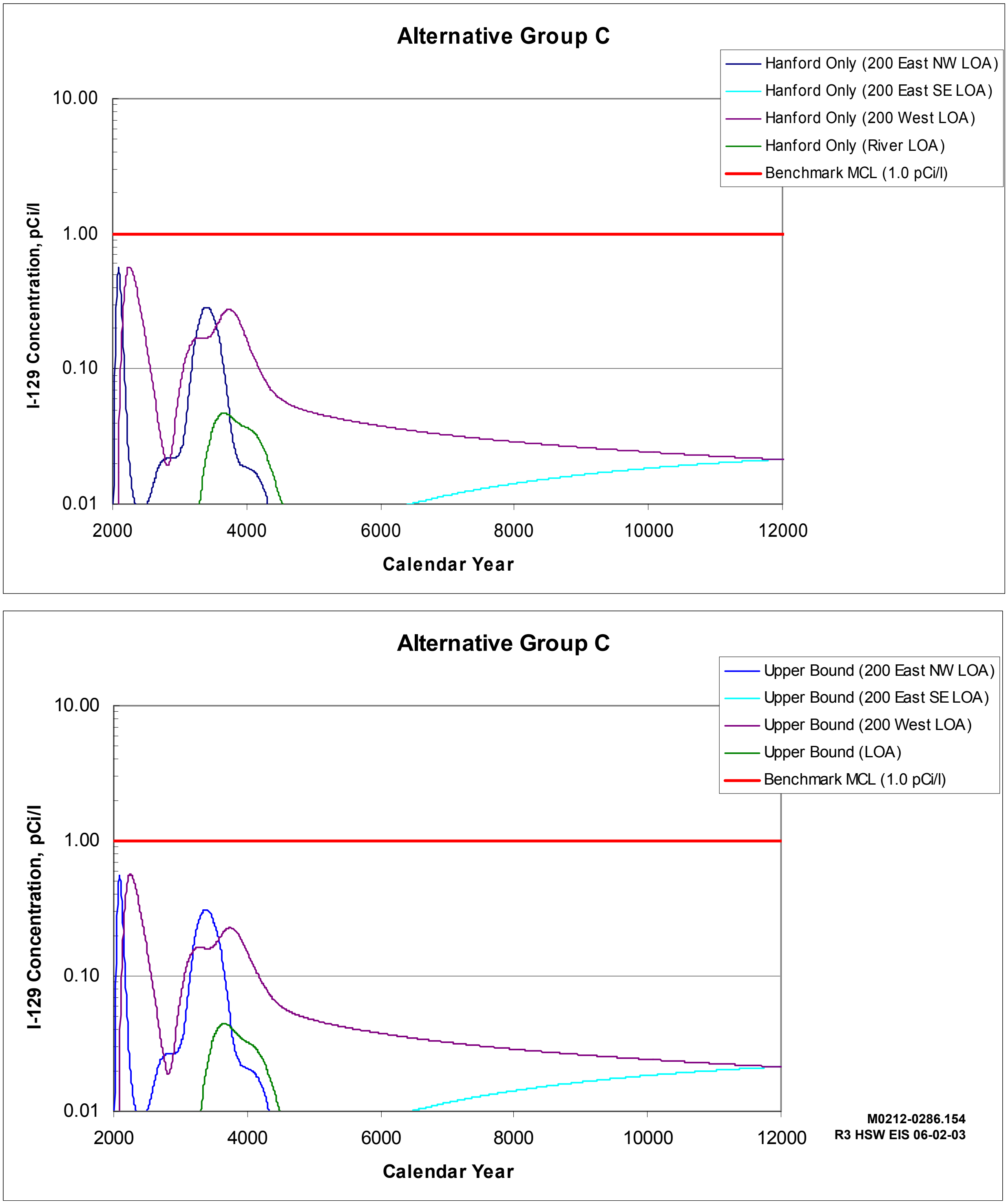
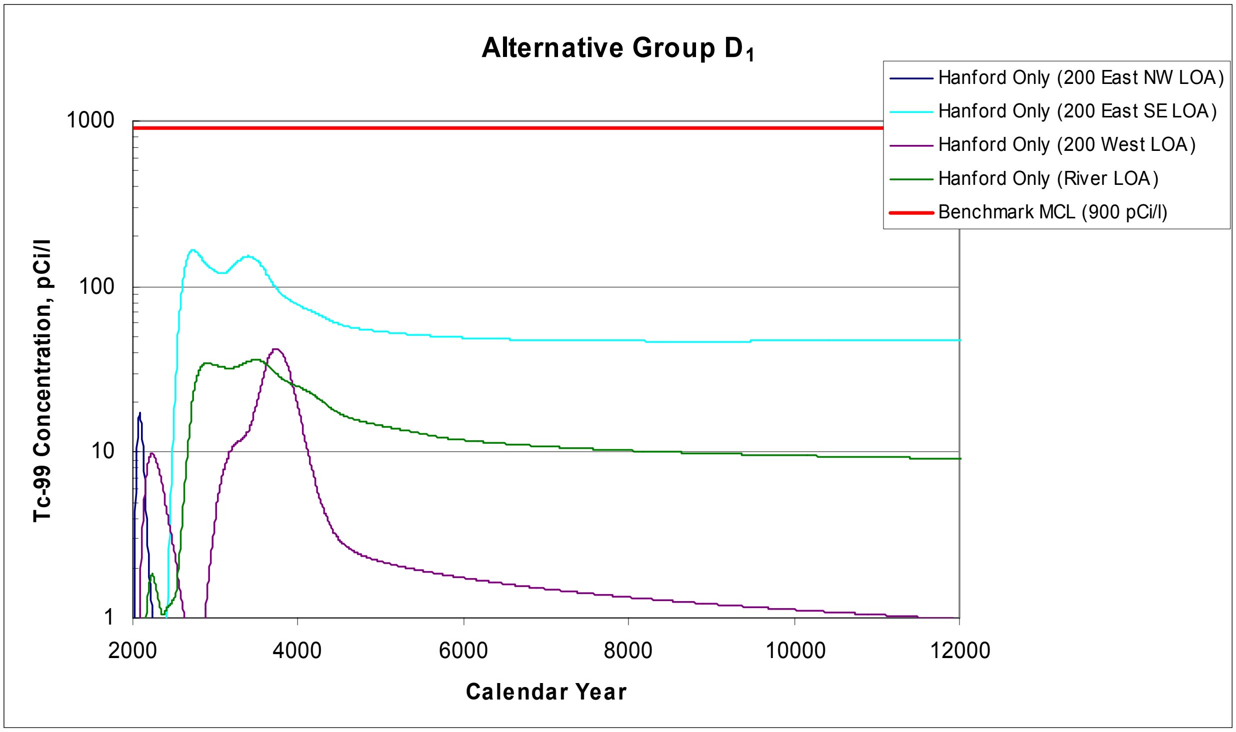


Figure 5.8. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group C – Hanford Only and Upper Bound Waste Volumes)



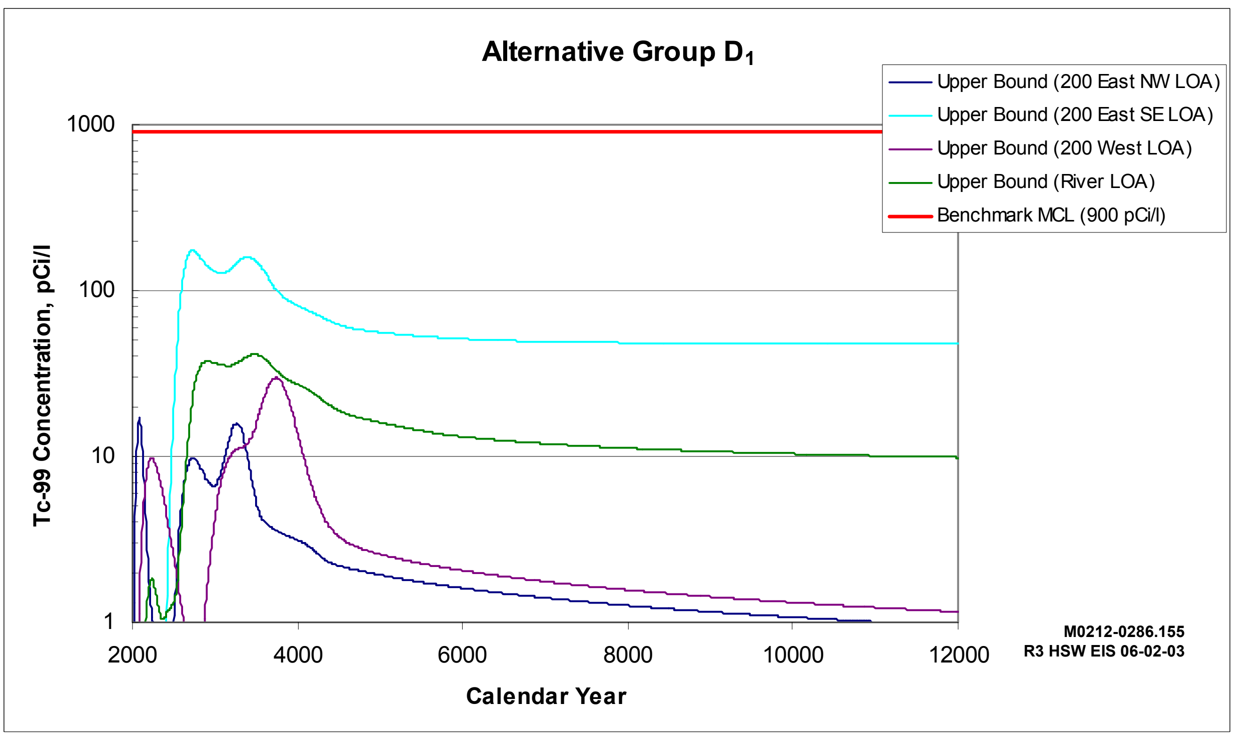
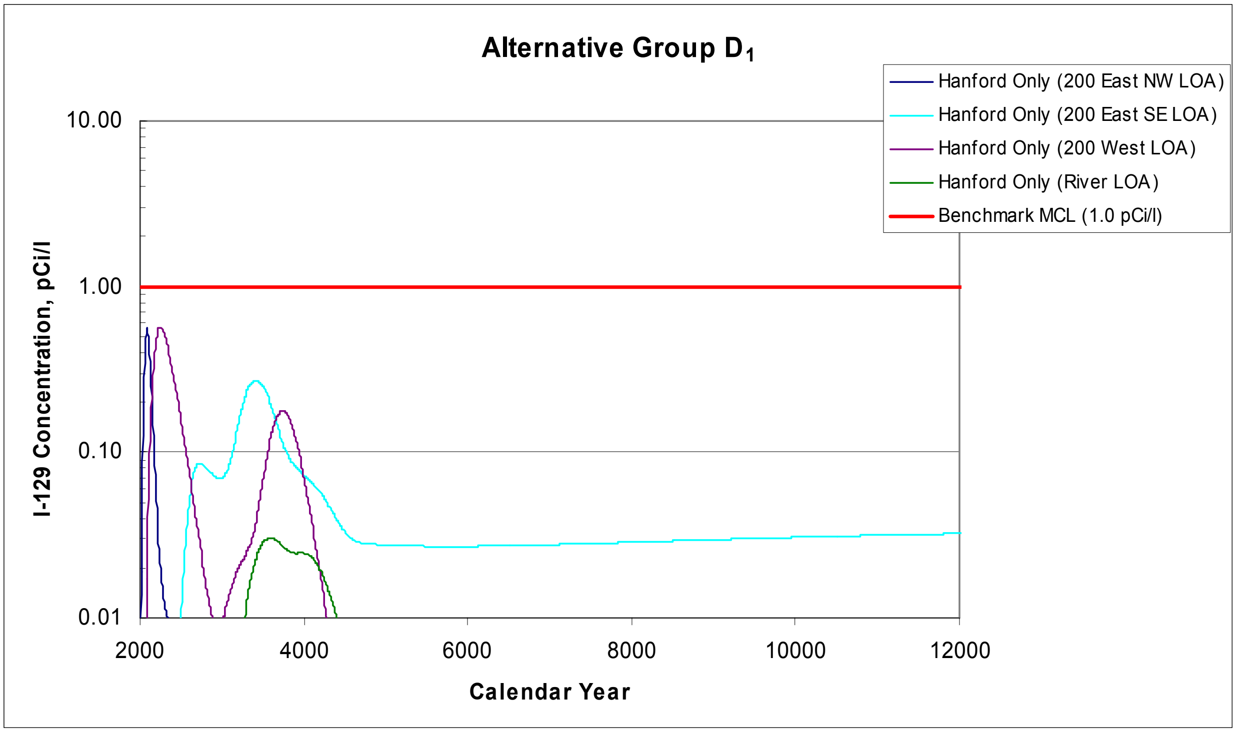


Figure 5.9. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group D_1 – Hanford Only and Upper Bound Waste Volumes)



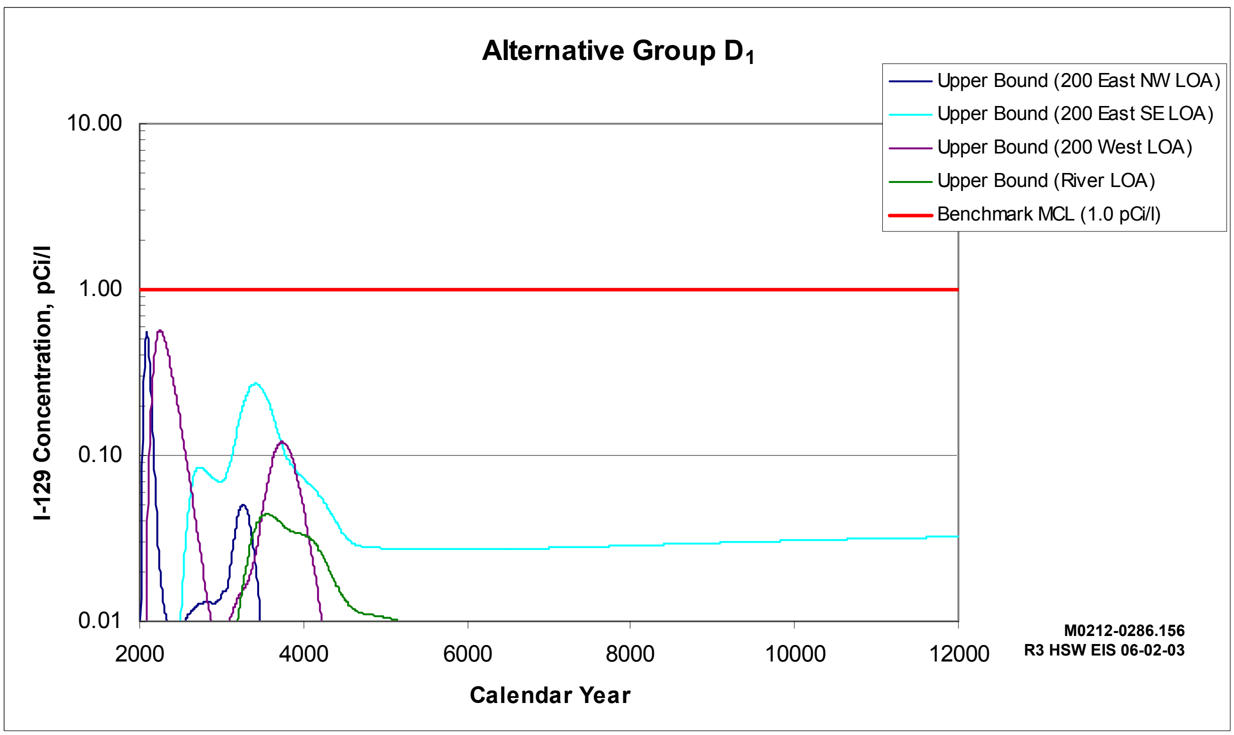
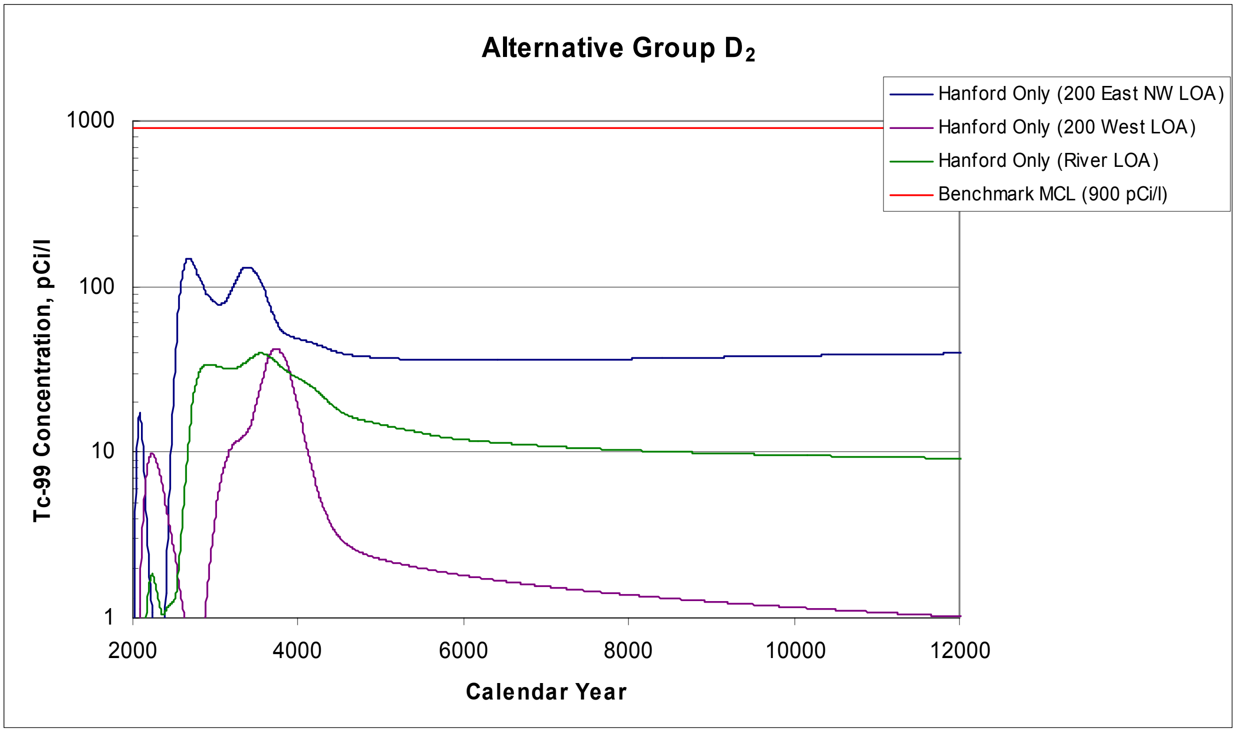


Figure 5.10. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group D_1 – Hanford Only and Upper Bound Waste Volumes)



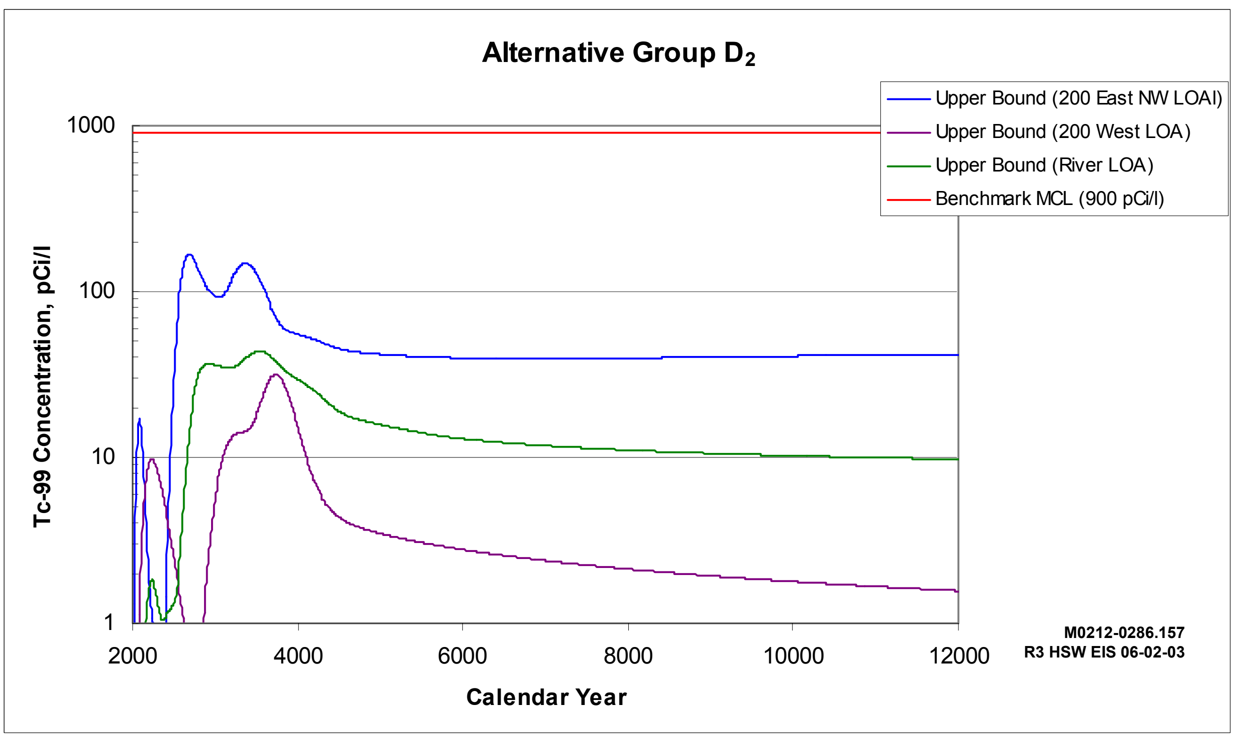


Figure 5.11. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group D_2 – Hanford Only and Upper Bound Waste Volumes)

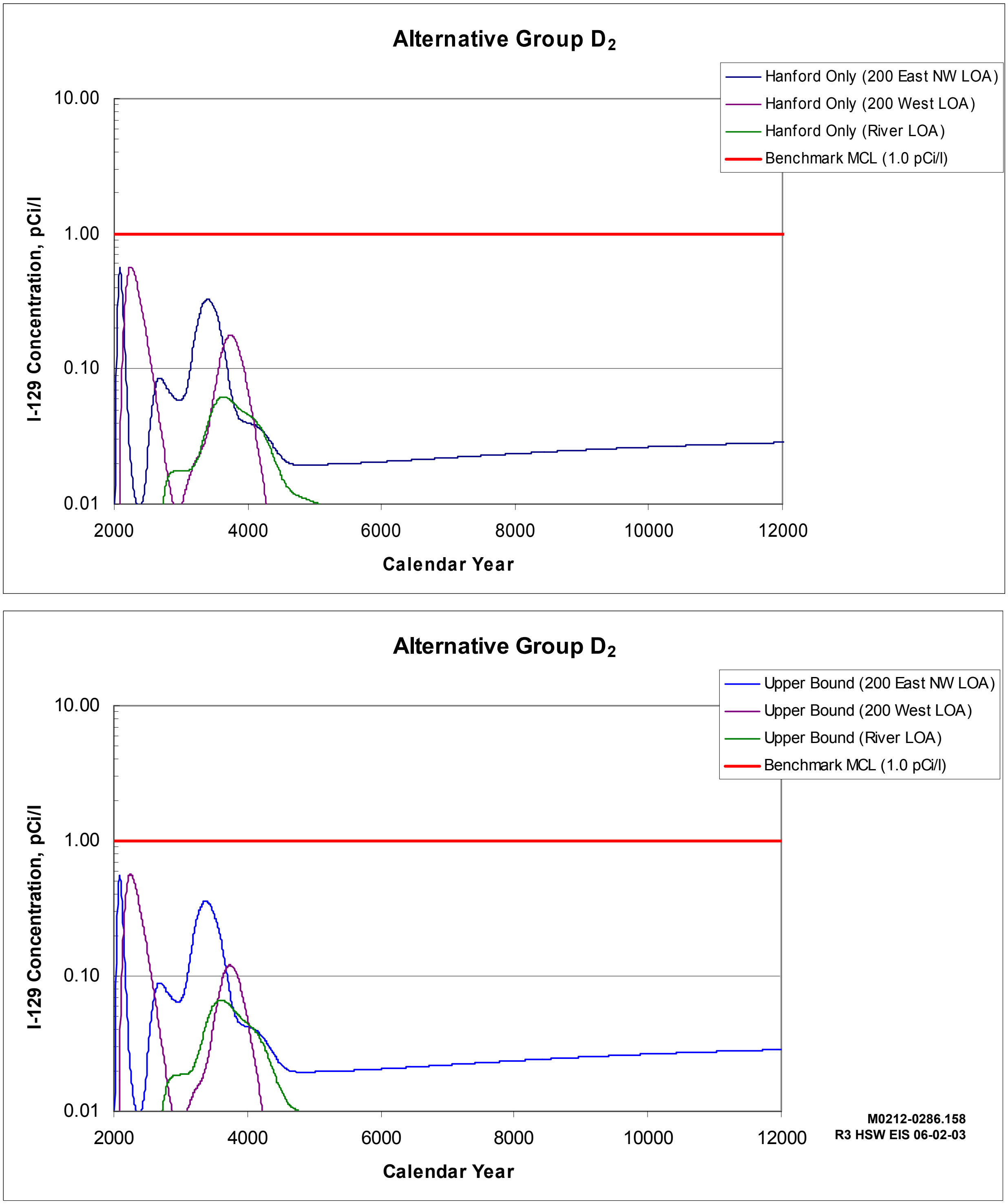


Figure 5.12. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group D_2 – Hanford Only and Upper Bound Waste Volumes)

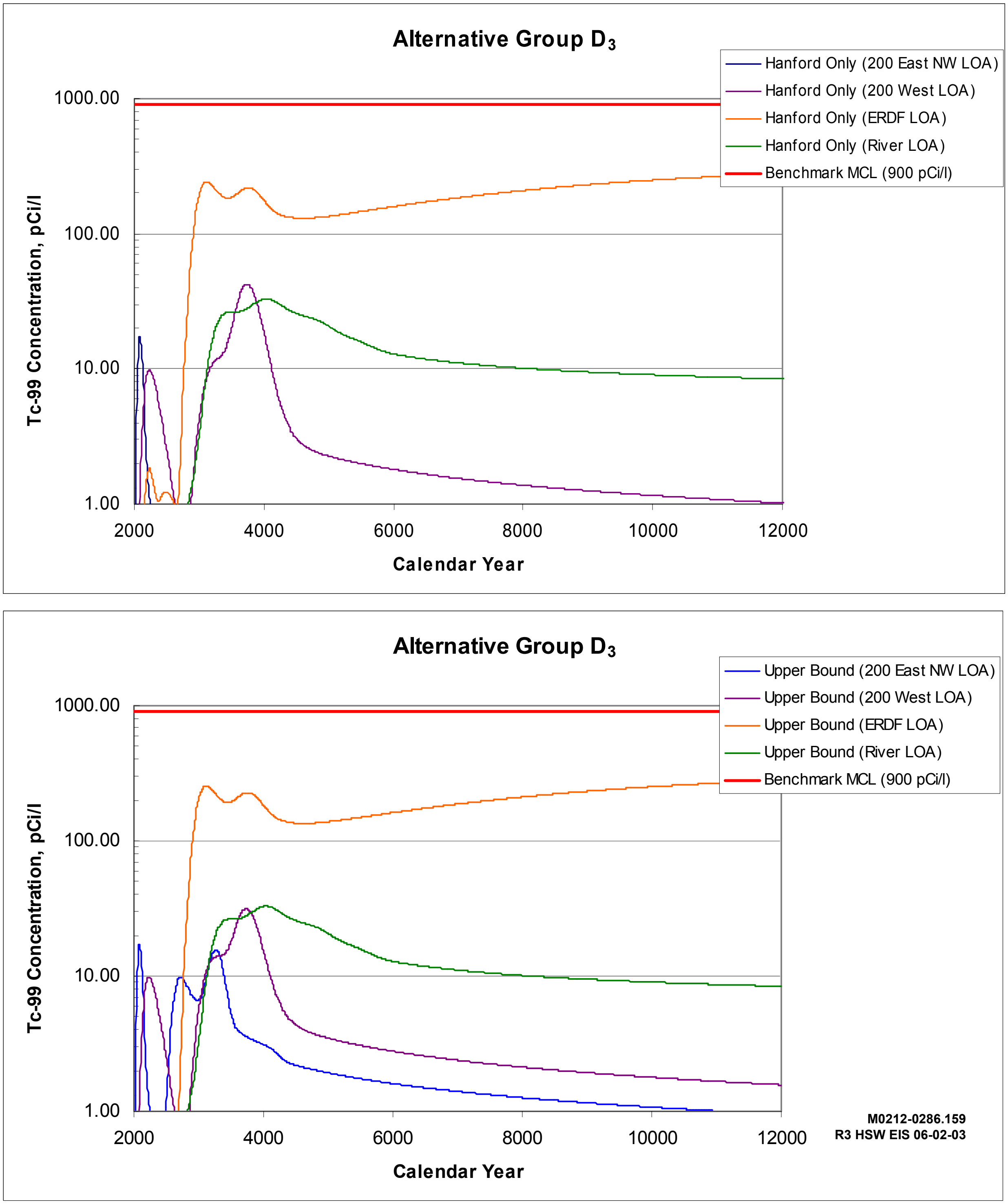


Figure 5.13. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group D_3 – Hanford Only and Upper Bound Waste Volumes)

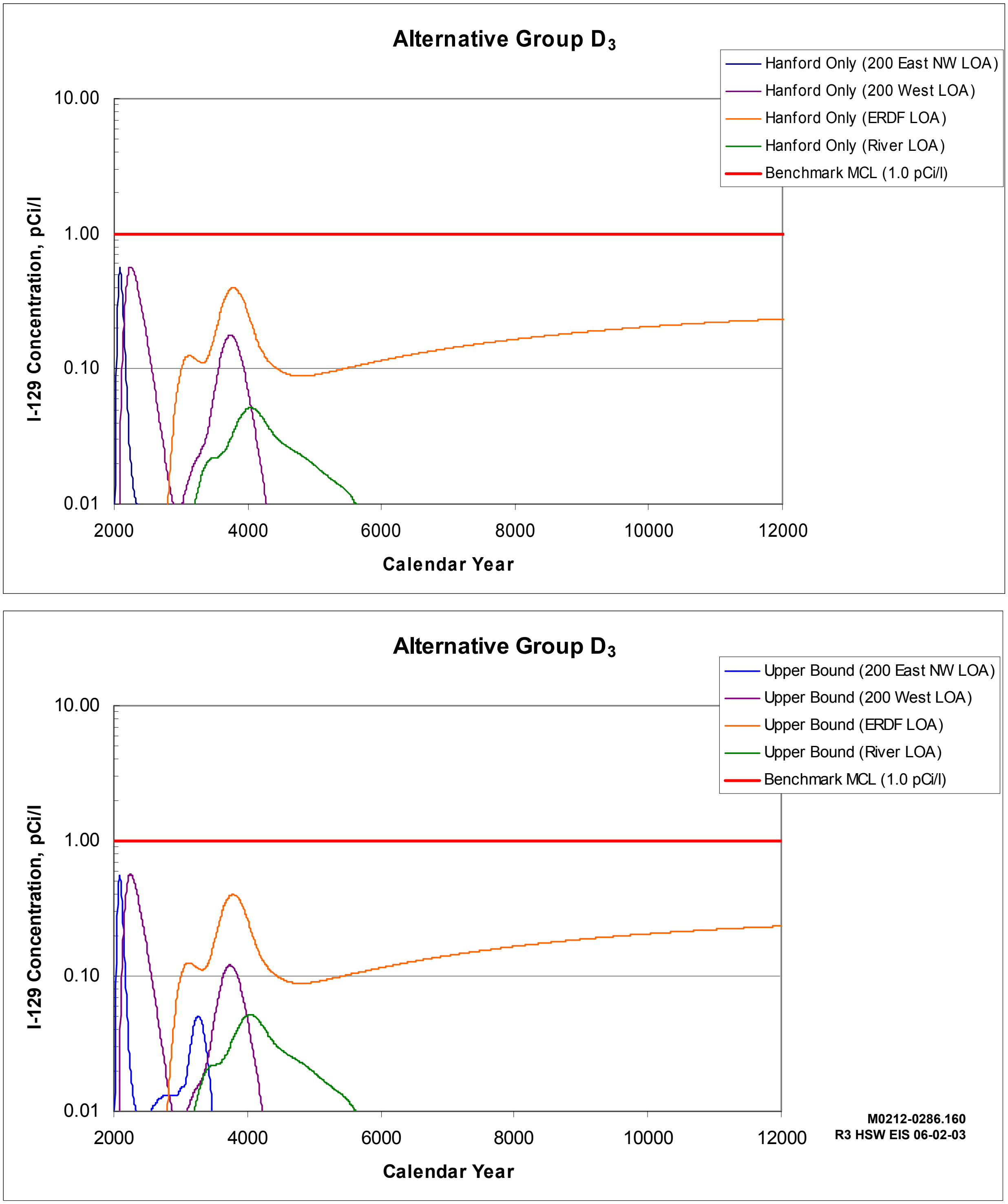


Figure 5.14. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group D$_3$ – Hanford Only and Upper Bound Waste Volumes)

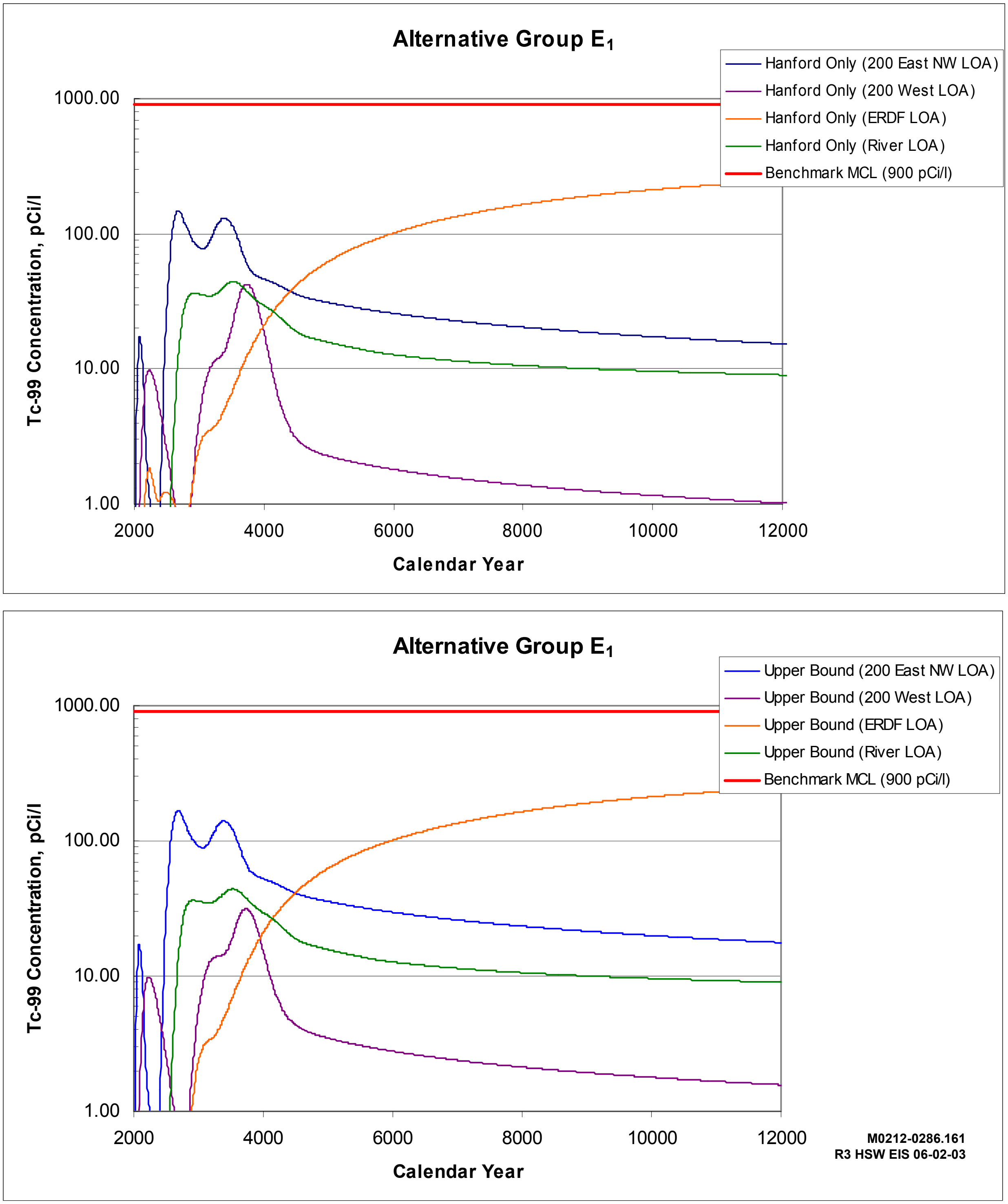


Figure 5.15. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group E_1 – Hanford Only and Upper Bound Waste Volumes)

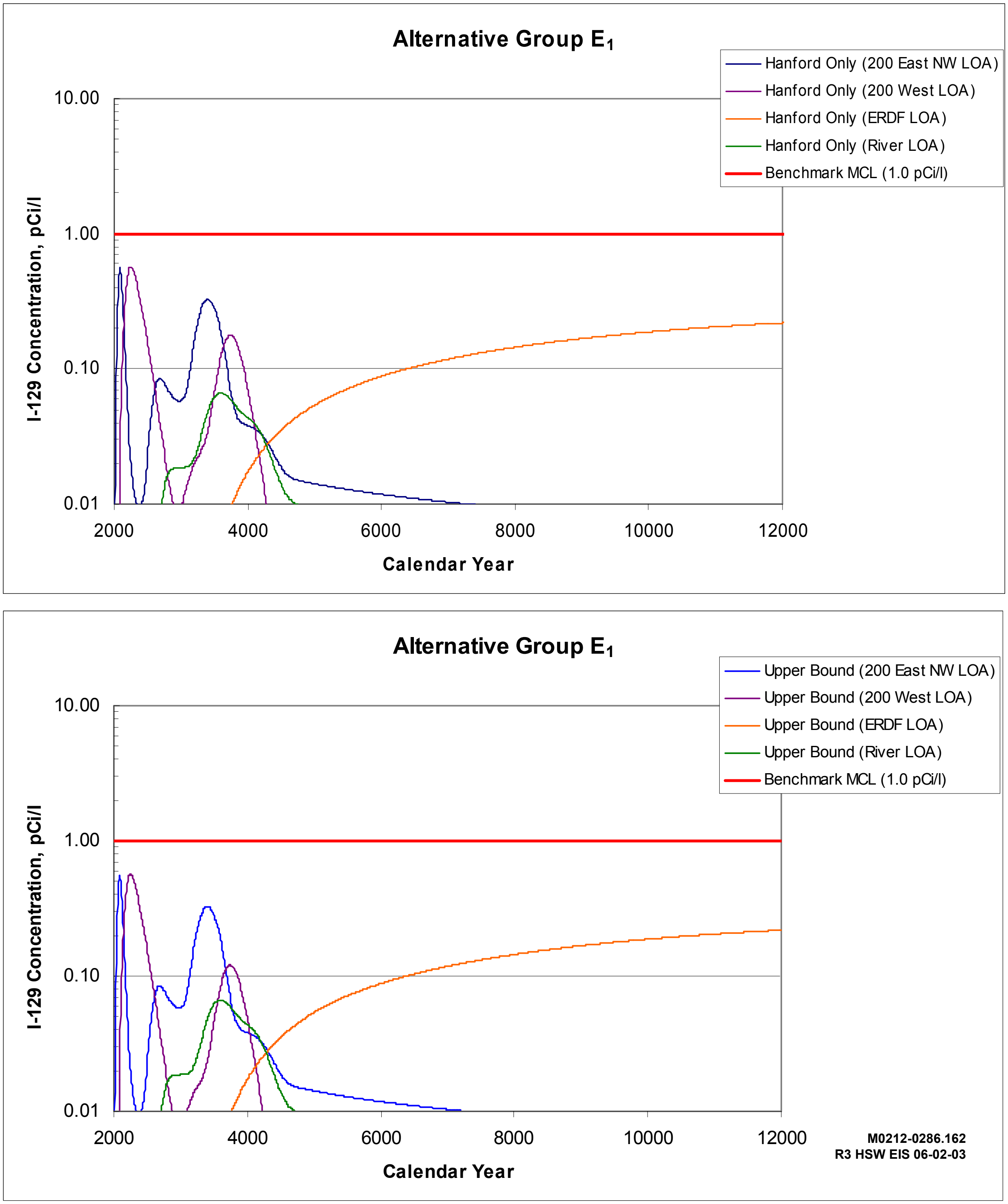


Figure 5.16. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group E_1 – Hanford Only and Upper Bound Waste Volumes)

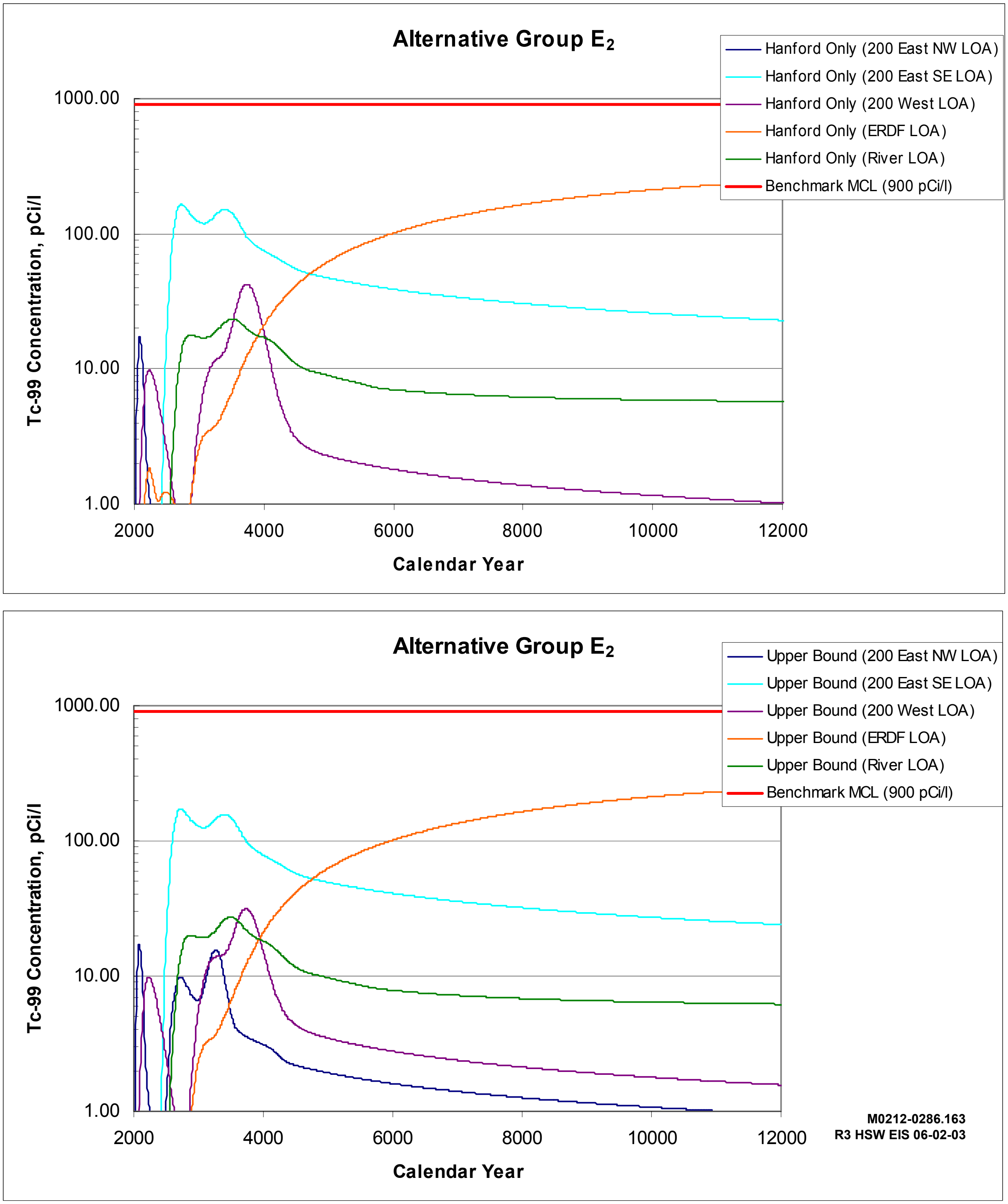


Figure 5.17. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group E_2 – Hanford Only and Upper Bound Waste Volumes)

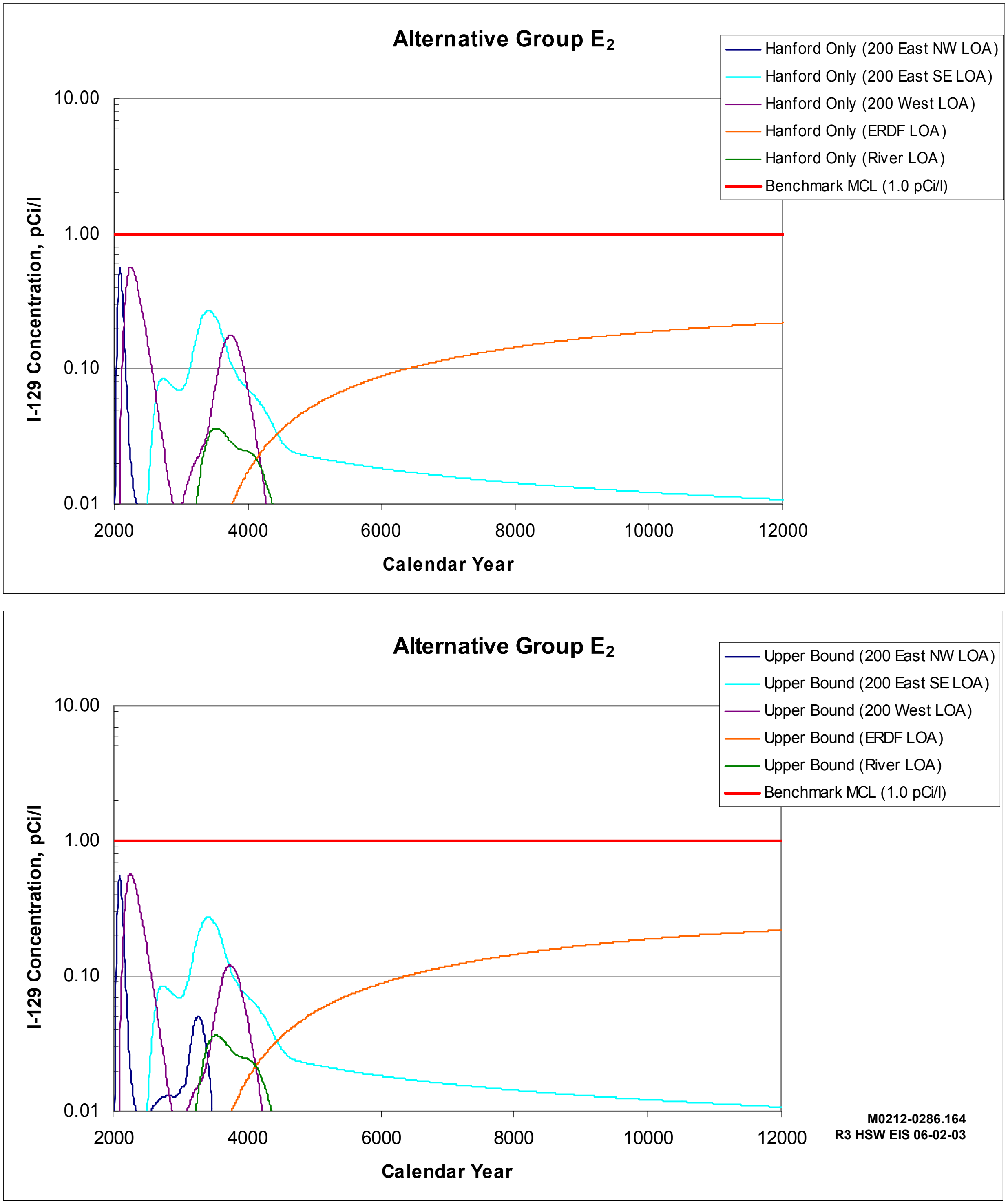


Figure 5.18. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group E_2 – Hanford Only and Upper Bound Waste Volumes)

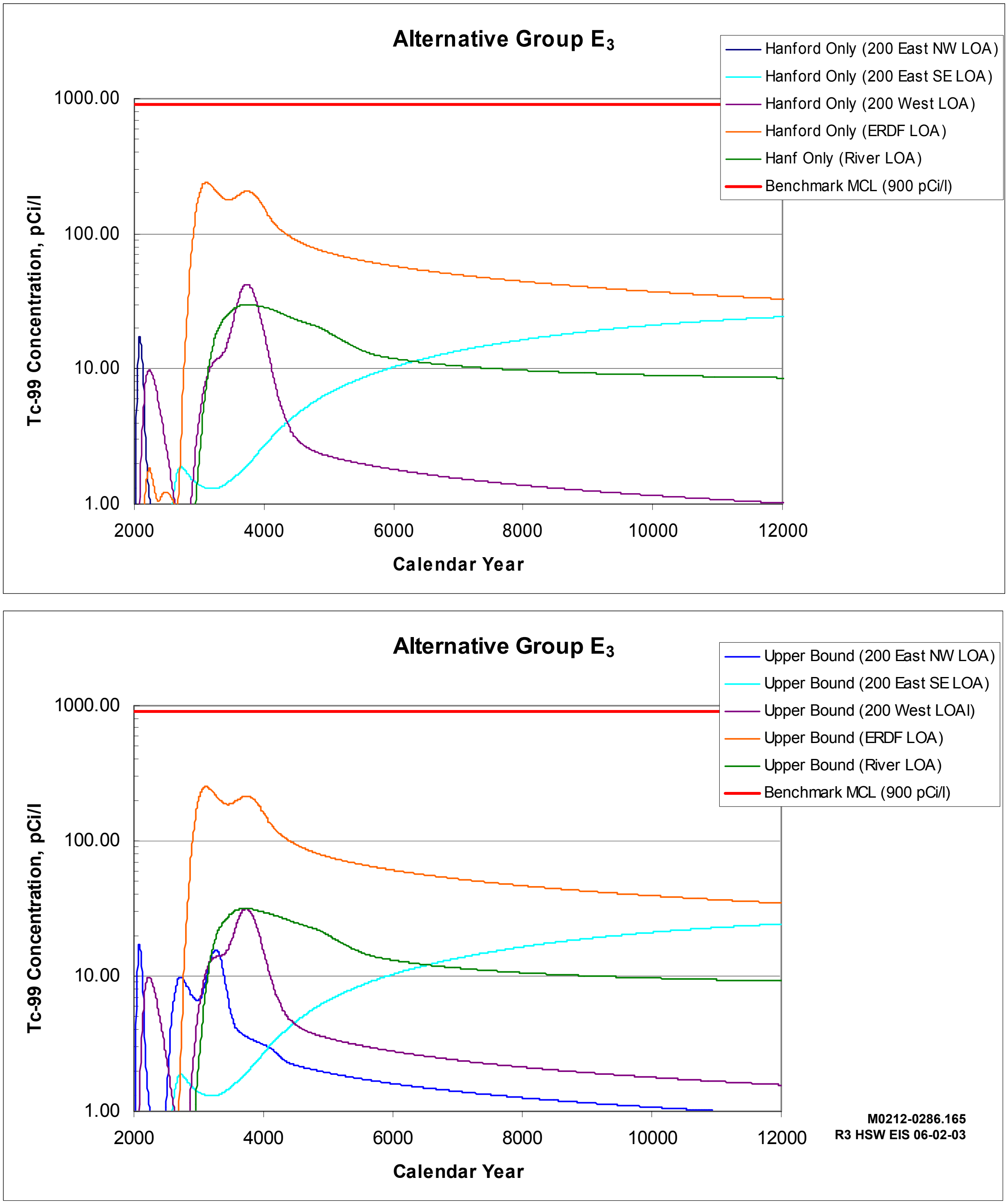
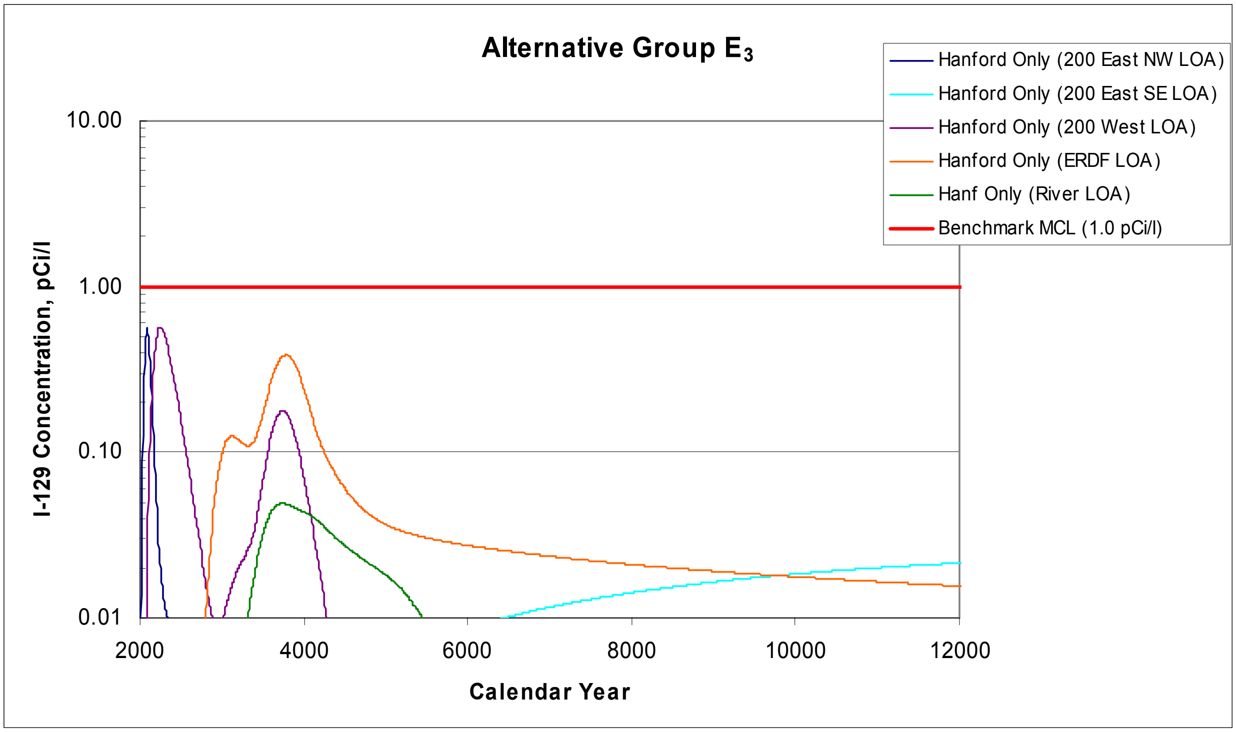


Figure 5.19. Technetium-99 Concentration Profiles at Various Lines of Analysis (Alternative Group E_3 – Hanford Only and Upper Bound Waste Volumes)



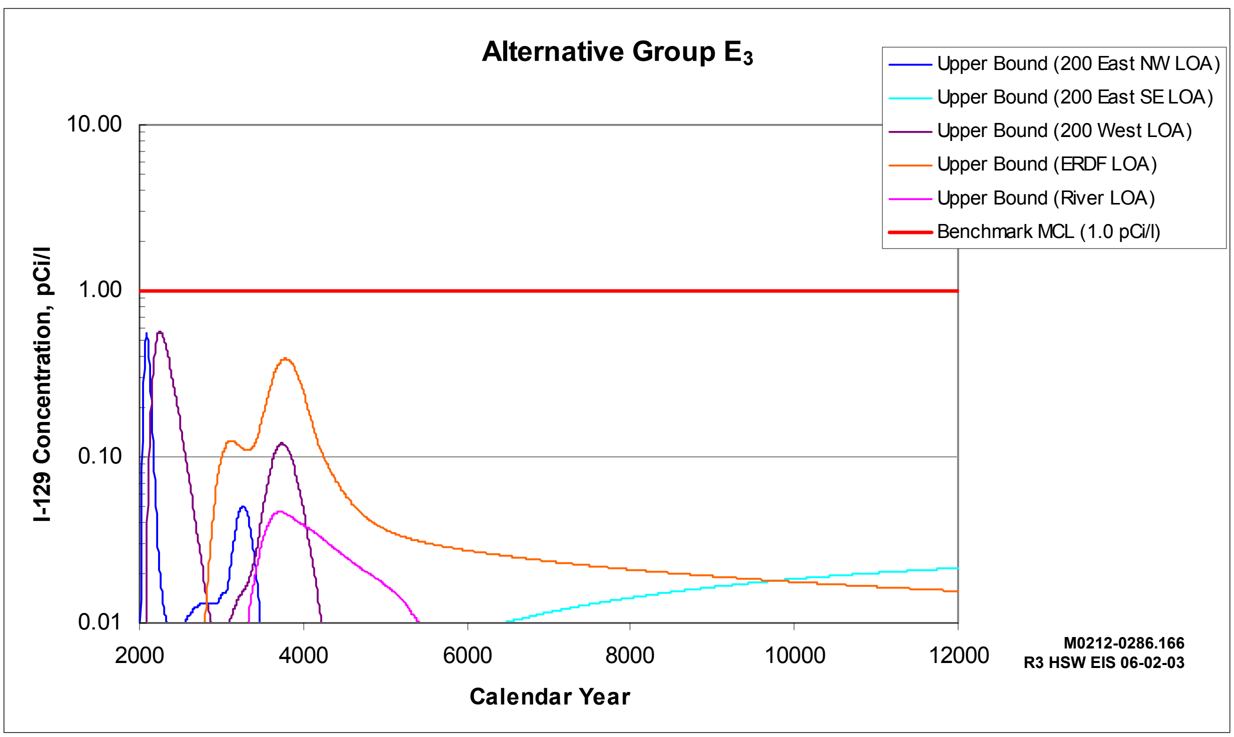
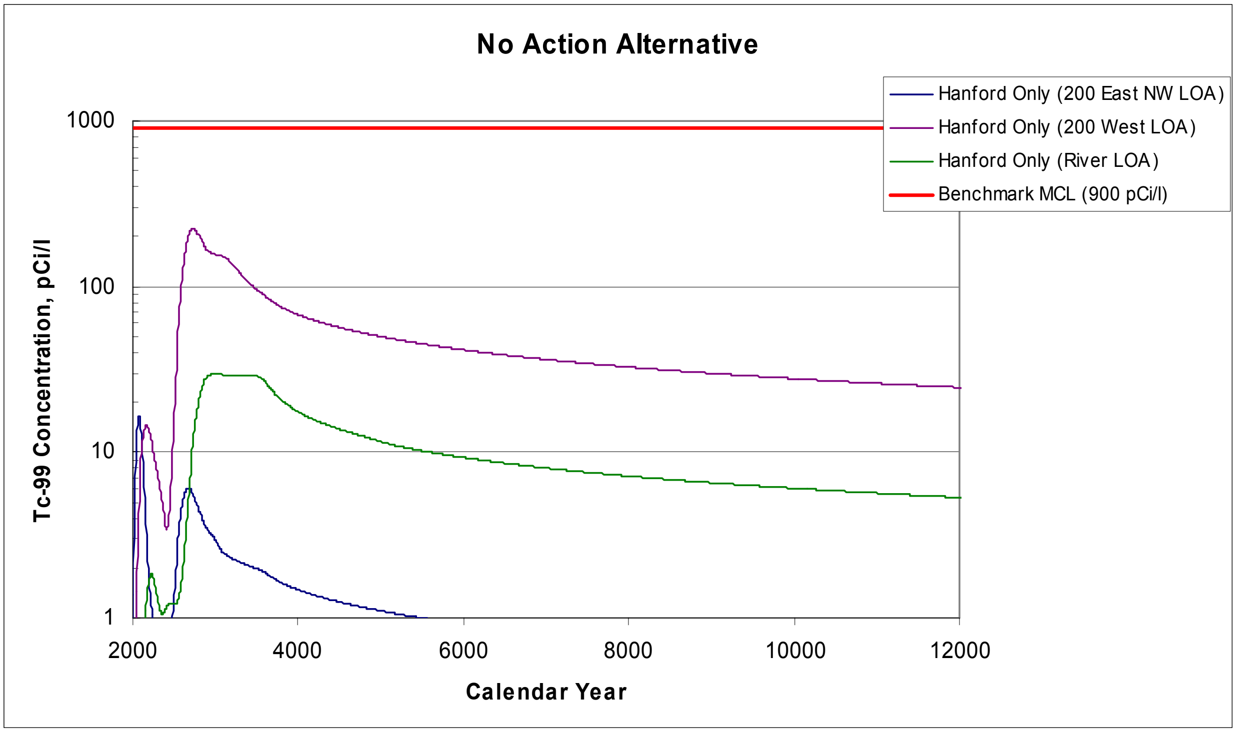


Figure 5.20. Iodine-129 Concentration Profiles at Various Lines of Analysis (Alternative Group E_3 – Hanford Only and Upper Bound Waste Volumes)



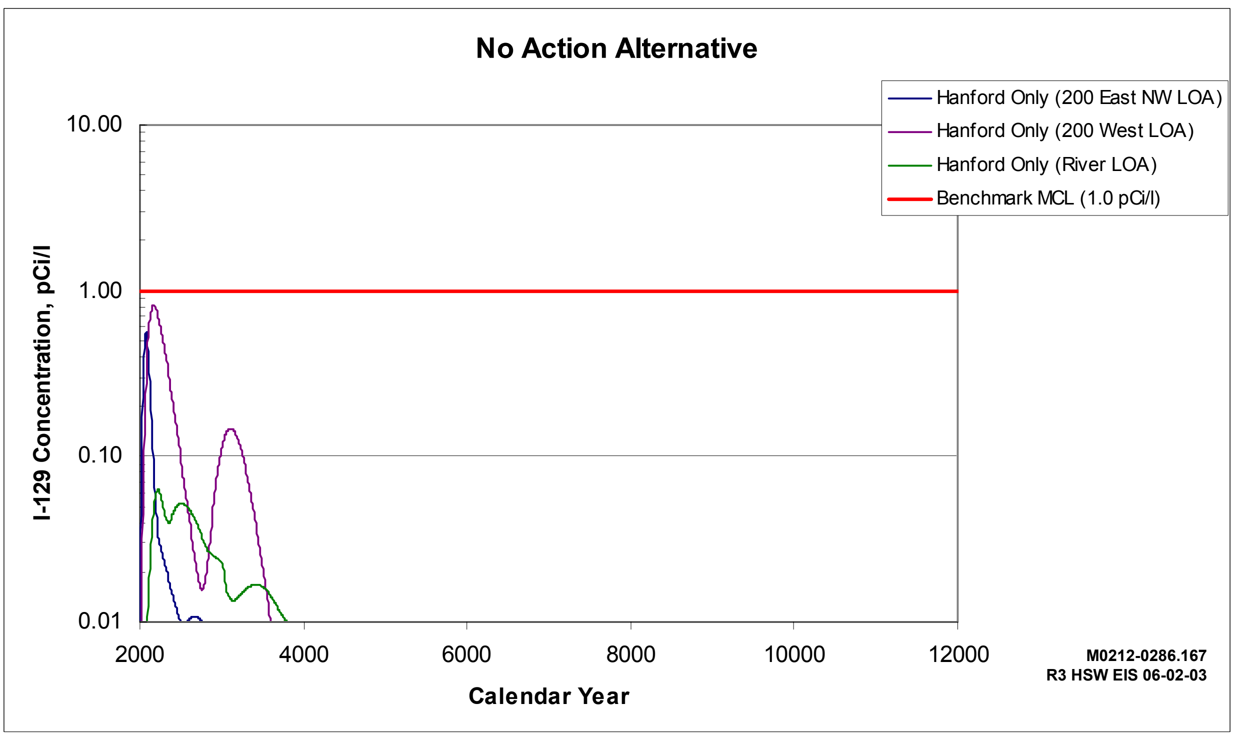


Figure 5.21. Technetium-99 and Iodine-129 Concentration Profiles at Various Lines of Analysis (No Action Alternative – Hanford Only Waste Volume)

5.3.4.1 Alternative Group A

LLW considered in Alternative Group A includes several different waste categories for disposal:

- pre-1970 LLW
- 1970–1987 LLW
- 1988–1995 LLW
- 1996–2007 Cat 1 and Cat 3 LLW and MLLW
- Cat 1 and Cat 3 LLW and MLLW disposed of after 2007 in deeper (18 m) (59 ft) and wider trenches in existing LLBGs 218-E-12B and 218-W-5
- melters disposed of after 2007 in a 21-m (69-ft) deep facility near the PUREX Plant
- ILAW disposed of after 2007 in a HSW disposal facility near the PUREX Plant.

Alternative Group A results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.3 and 5.4. These results show the potential impacts to groundwater quality at various lines of analysis starting in the year 2000. The potential impacts shown reflect: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.1.

5.3.4.1.1 Wastes Disposed of Before 1996

Constituents released from wastes disposed of before 1996 in the LLBGs that have the highest potential impact on groundwater quality are technetium-99 and iodine-129. Estimated combined technetium-99 and iodine-129 levels at the 200 East Area NW LOA peaked at about 110 years after the assumed start of release and at about 220 years after the assumed start of release at the 200 West Area LOA. Combined concentration levels of technetium-99 were relatively low (less than 20 pCi/L) at these 1-km LOAs and reflect about 2 percent of the benchmark maximum contaminant level for technetium-99 (900 pCi/L). The combined concentration level of iodine-129 at the 200 East NW LOA was about 60 percent (0.6 pCi/L) of the benchmark MCL. This concentration level resulted from releases of the iodine-129 inventory in the 1970–1987 LLW. The combined concentration level of iodine-129 at the 200 West Area LOA was about 50 percent (0.5 pCi/L) of the benchmark MCL. This concentration level also resulted from releases of the iodine-129 inventory in the 1970–1987 LLW.

Technetium-99 and iodine-129 combined concentrations were well below benchmark MCLs by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA reached their peaks in about 260 years after the assumed start of release. Contaminant levels from sources in the 200 West Area reached their peaks along the Columbia River LOA between 500 and 600 years after the assumed start of release.

Carbon-14 and the uranium isotopes combined concentrations were found to peak at about or beyond the 10,000-year period of analysis. Carbon-14 concentrations at all LOAs were well below the benchmark MCL of 2000 pCi/L. Combined concentration levels of uranium-238, the dominant uranium isotope, also were well below the benchmark MCL at the 200 East and West Area LOAs at 10,000 years after site closure.

5.3.4.1.2 Wastes Disposed of After 1995

Potential groundwater quality impacts from wastes disposed of after 1995 also were highest for technetium-99 and iodine-129. Technetium-99 levels at the 200 East Area NW LOA were about 8 percent (75 pCi/L) of the benchmark MCL for the Hanford Only waste volume. The source for these elevated levels is from technetium-99 released from the MLLW disposed of after 2007. Technetium-99 levels at the 200 West Area LOA were about 33 percent (300 pCi/L) of the benchmark MCL. The source of these potential impacts was primarily from the technetium-99 released from the Cat 3 LLW disposed of after 2007. Predicted technetium-99 releases were very similar for all waste volumes but were slightly higher for the Upper Bound waste volume.

Combined iodine-129 levels at the 200 East Area NW LOA were about 30 percent of the benchmark MCL of 1 pCi/L for the Hanford Only waste volume. The main contributor to these concentration levels was the release of iodine-129 inventories in ungrouted parts of MLLW disposed of after 2007. Iodine-129 levels at the 200 West Area LOA were about 15 percent of the benchmark MCL of 1 pCi/L for the Hanford Only waste volume. The main contributor to these concentration levels was the release of iodine-129 inventories in ungrouted parts of MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels were slightly higher at the 200 East Area NW LOA and slightly lower at the 200 West Area LOA for the Upper Bound waste volume. This result is reflective of changes in partitioning the iodine-129 inventory for the MLLW (1996–2007) waste category between the 200 East and West Areas for the Upper Bound inventory.

Combined technetium-99 and iodine-129 concentrations were well below benchmark MCLs by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks between 1550 and 1600 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks near the river between 1600 and 2100 years after site closure.

Concentration levels of carbon-14 and the uranium isotopes at the LOAs did not reach their peak values until after the 10,000-year period of analysis and were well below benchmark MCLs at 10,000 years after site closure.

5.3.4.2 Alternative Group B

LLW considered in Alternative Group B includes the same waste considered in Alternative Group A but disposes of Cat 1 and Cat 3 LLW and MLLW in conventional trenches after 2007 in LLBGs 218-E-12B and 218-W-5 and in the ILAW disposal facility located just south of the CWC.

Alternative Group B results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.5 and 5.6. As in Alternative Group A, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information is found in several tables and figures in Volume II, Appendix G, Volume II.

5.3.4.2.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.2.2 Wastes Disposed of After 1995

Under this alternative group, groundwater quality was most impacted by releases of technetium-99 and iodine-129 from disposed LLW and MLLW. Technetium-99 levels at the 200 East Area NW LOA were about 11 and 13 percent of the benchmark MCLs (95 and 116 pCi/L) for the Hanford Only and Upper Bound waste volumes, respectively. The primary source for these elevated levels was from inventories in MLLW disposed of after 2007. These higher concentration levels are generally consistent with the broader surface area of releases associated with the use of conventional trenches under this alternative group.

Combined technetium-99 levels at the 200 West Area LOA were estimated to be about 33 percent (300 pCi/L) of the benchmark MCL of 900 pCi/L for the Hanford Only and Upper Bound waste volumes. These values are slightly less than levels estimated for Alternative Group A. However, this would be expected since the source of these potential impacts was primarily from the technetium-99 inventories in the Cat 3 LLW disposed of after 2007. Additionally, the use of conventional trenches under this alternative group would result in some of the inventory associated with Cat 1 and Cat 3 LLW disposed of after 2007 being emplaced in the 200 East Area.

Combined iodine-129 levels at the 200 East Area NW LOA were 42 and 47 percent (0.42 and 0.47 pCi/L) of the benchmark MCL of 1 pCi/L for the Hanford Only and Upper Bound waste volumes, respectively. The main contributor to these concentration levels was the release of iodine-129 inventories in ungrouted parts of the MLLW disposed of after 2007. Iodine-129 levels at the 200 West Area LOA were less than 8 percent (0.08 pCi/L) of the benchmark MCL for the Hanford Only waste volume. The main contributor to these concentration levels was from iodine-129 inventories in the ungrouted part of the MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels were slightly higher at the 200 East Area NW LOA and slightly lower at the 200 West Area LOA for the Upper Bound waste volume. This impact is reflective of changes in partitioning the iodine-129 inventory for the MLLW (1996–2007) waste category between the 200 East and West Areas for the Upper Bound waste volume.

Concentration levels of carbon-14 and the uranium isotopes at the LOAs downgradient from source areas of projected LLW and MLLW did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below benchmark MCLs at 10,000 years after site closure.

Concentrations of all constituents were well below benchmark MCLs by the time they reached the Columbia River LOA. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks at about 1400 years after site closure. Contaminant levels from sources in the 200 West Area sources reached their peaks near the river at about 1500 years after site closure.

5.3.4.3 Alternative Group C

LLW considered in Alternative Group C includes the same wastes considered in Alternative Group A but disposes of Cat 1 and Cat 3 LLW in a single, lined expandable trench and MLLW in another single, lined expandable trench after 2007 in LLBGs 218-E-12B and 218-W-5. The melters would be placed in a lined trench and ILAW would be placed in a single, expandable, lined trench near the PUREX Plant.

Alternative Group C results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.7 and 5.8. As in Alternative Groups A and B, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information is provided in several tables and figures in Volume II, Appendix G, Section G.2.3.

5.3.4.3.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.3.2 Wastes Disposed of After 1995

Because of assumptions in the source-term release and vadose zone modeling used for previously buried LLW and LLW and MLLW disposed of between 1996 and 2007 for Alternative Group C, results for this alternative group were the same for those waste categories calculated for Alternative Group A. Results for LLW and MLLW disposed of after 2007 for this alternative group were essentially the same as those presented in the figures for Alternative Group A. These results are consistent since the analysis assumption about waste depth and projected land use for waste disposed of after 2007 are the same for both alternative groups.

5.3.4.4 Alternative Group D_1

Wastes considered in Alternative Group D_1 are the same as those described for Alternative Group A. However, in this alternative group, all wastes received after 2007 would be disposed of in a single, lined, modular combined-use facility near the PUREX Plant.

Alternative Group D_1 results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.9 and 5.10. As was provided in the previous alternatives groups, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.4.

5.3.4.4.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.4.2 Wastes Disposed of After 1995

The highest potential impacts for this alternative group reflect the emplacement of all wastes disposed of after 2007 in the vicinity of the PUREX Plant. Potential impacts from LLW and MLLW are dominated by technetium-99 and iodine-129.

Combined concentration levels for technetium-99 were about 18 and 20 percent (167 and 185 pCi/L) of the benchmark MCL at the 200 East SE LOA for the Hanford Only and Upper Bound waste volumes, respectively. The primary source for these elevated levels was from inventories in MLLW disposed of after 2007. Two peaks reflect technetium-99 inventories in both Cat 3 LLW and MLLW disposed of after 2007 near the PUREX area.

Combined technetium-99 concentration levels at the 200 West Area LOA were about 5 and 3 percent (42 and 31 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. These values are slightly less than levels estimated for Alternative Group A. The source of these potential impacts was primarily from the technetium-99 inventory in MLLW disposed of between 1996 and 2007. Decreased concentrations for the Upper Bound waste volume reflect the emplacement of some of the MLLW inventory in the 200 East Area.

Combined iodine-129 concentration levels at the 200 East SE LOA were about 28 percent (0.28 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes. The main contributor to these concentration levels was iodine-129 inventories in ungrouted parts of the MLLW disposed of after 2007.

Combined iodine-129 levels at the 200 West Area LOA were about 15 and 8 percent (0.15 and 0.08 pCi/L) of the benchmark MCL for the for the Hanford Only and Upper Bound waste volumes, respectively. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels were slightly higher at the 200 East Area SE LOA and slightly lower at the 200 West Area LOA for the Upper Bound waste volume. These results are reflective of changes in partitioning of iodine-129 inventory for the MLLW (1996–2007) waste category between the 200 East and West Areas for the Upper Bound waste volume.

Combined concentration levels of carbon-14 and the uranium isotopes at the 200 East and West Area LOAs from source areas of projected LLW and MLLW did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below the benchmark MCLs at 10,000 years after site closure.

Combined technetium-99 and iodine-129 concentrations were well below benchmark MCLs by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks near the river between 1400 and 1500 years after site closure. Contaminant levels at the same LOA from sources in the 200 West Area reached their peaks between 2100 and 2200 years after site closure.

5.3.4.5 Alternative Group D_2

Wastes considered in Alternative Group D_2 are the same as those described for Alternative Group A. However, in this alternative group, all wastes received after 2007 would be disposed of in a single, lined, modular combined-use facility in LLBG 218-E-12B.

Alternative Group D_2 results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.11 and 5.12. As was provided in the previous alternative groups, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.5.

5.3.4.5.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.5.2 Wastes Disposed of After 1995

The highest potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 in the 218-E-12B LLBG. These potential impacts were primarily from technetium-99 and iodine-129.

Combined technetium-99 levels at the 200 East Area NW LOA were about 16 and 19 percent (148 and 169 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. The primary source for these elevated levels was from inventories in Cat 3 LLW and MLLW disposed of after 2007.

Combined concentration levels of technetium-99 at the 200 West Area LOA were about 5 and 3 percent (42 and 31 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. These values are slightly less than levels estimated for Alternative Group A. The source of these potential impacts was primarily from the technetium-99 inventory in MLLW disposed of between 1996 and 2007. Decreased concentrations for the Upper Bound waste volume reflect the emplacement of some of the MLLW inventory in the 200 East Area.

The highest combined iodine-129 levels at the 200 East Area NW LOAs were about 28 percent (0.28 pCi/L) of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. The main contributor to these concentration levels was ungrouted iodine-129 inventories in MLLW disposed of after 2007.

The highest combined iodine-129 levels were about 15 and 8 percent (0.15 and 0.08 pCi/L) of the benchmark MCL at the 200 West Area LOA for the Hanford Only and Upper Bound waste volumes, respectively. The main contributor to these concentration levels was ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

The highest combined iodine-129 levels were slightly higher at the 200 East Area NW LOA and slightly lower at the 200 West Area LOA for the Upper Bound waste volume. This is reflective of changes in partitioning of the iodine-129 inventory for the MLLW (1996–2007) waste category between the 200 East and West Areas for the Upper Bound waste volume.

Concentration levels of carbon-14 and the uranium isotopes at all LOAs did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below the benchmark MCLs at 10,000 years after site closure.

Combined technetium-99 and iodine-129 concentrations were well below the benchmark MCLs by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks between 1500 and 1600 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks near the river at about 2000 years after site closure.

5.3.4.6 Alternative Group D_3

Wastes considered in Alternative Group D_3 are the same as those described for Alternative Group A. However, in this alternative group, all wastes received after 2007 would be disposed of in a single, lined, modular combined-use facility at ERDF.

Alternative Group D_3 results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.13 and 5.14. As was provided in the previous alternative groups, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.6.

5.3.4.6.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.6.2 Wastes Disposed of After 1995

The highest potential groundwater quality impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 at ERDF. Potential impacts were primarily from technetium-99 and iodine-129.

No LLW and MLLW were disposed of after 1996 in the 200 East Area for the Hanford Only waste volume under this alternative group. Combined technetium-99 levels at the 200 East Area NW LOA were about 2 percent (15.7 pCi/L) of the benchmark MCL for the Upper Bound waste volume. The primary source for these elevated levels was from inventories in MLLW disposed of between 1996 and 2007.

Combined technetium-99 levels at the 200 West Area LOA were about 5 and 3 percent (42 and 31 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. These values are slightly less than levels estimated for Alternative Group A. The source of these potential impacts was primarily from the technetium-99 inventory in MLLW disposed of between 1996 and 2007. Decreased concentrations for the Upper Bound waste volume reflect the emplacement of some of the MLLW inventory in the 200 East Area.

Combined technetium-99 levels at the ERDF LOA were about 27 and 28 percent (242 and 253 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. The primary source for these elevated levels was from inventories in the Cat 3 LLW disposed of after 2007.

No LLW and MLLW were disposed of after 1996 in the 200 East Area for the Hanford Only waste volume under this alternative group. Combined iodine-129 levels at the 200 East Area NW LOA were about 5 percent (0.05 pCi/L) of the benchmark MCL for the Upper Bound waste volume. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels at the 200 West Area LOA were about 15 and 8 percent (0.15 and 0.08 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels at the 200 West Area LOA were slightly higher at the 200 East Area NW LOA and slightly lower for the Upper Bound waste volume. This result reflects assumed changes in partitioning of the iodine-129 inventory for the MLLW (1996–2007) waste category between the 200 East and West Areas for the Upper Bound inventory.

Combined iodine-129 levels at the ERDF LOA were 92 and 94 percent (0.92 and 0.94 pCi/L) of the benchmark MCL for the Hanford Only waste volume. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of after 2007.

Concentration levels of carbon-14 and the uranium isotopes at all LOAs downgradient from source areas of projected LLW and MLLW did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below benchmark MCLs at 10,000 years after site closure.

Combined technetium-99 and iodine-129 concentrations were well below benchmark MCLs by the time they reached the Columbia River. Overall concentration levels from sources in the 200 East Area reached their peaks near the river at about 1400 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks near the river at about 2000 years after site closure.

5.3.4.7 Alternative Group E_1

Alternative Group E_1 results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.15 and 5.16. As was provided in the previous alternative groups, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.7.

5.3.4.7.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.7.2 Wastes Disposed of After 1995

Potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 in LLBG 218-E-12B and disposal of melters and ILAW at ERDF. Results for LLW and MLLW disposed of after 2007 are identical to results for the same wastes in Alternative D_2. The highest potential impacts resulted from releases of technetium-99 and iodine-129.

Combined technetium-99 levels at the 200 East Area NW LOA were about 16 and 19 percent (148 and 169 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes. The primary source for these elevated levels was from inventories in Cat 3 LLW and MLLW disposed of after 2007.

Combined technetium-99 levels at the 200 West Area LOA were about 5 and 3 percent (42 and 31 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. These values are slightly less than levels estimated for Alternative Group A. The source of these potential impacts was primarily from the technetium-99 inventory in MLLW disposed of between 1996 and 2007. Decreased concentrations for the Upper Bound waste volume reflect the emplacement of some of the MLLW inventory in the 200 East Area.

Combined technetium-99 levels at the ERDF LOA were about 0.3 percent (2.7 pCi/L) of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. The primary source for these elevated levels was from inventories in the melters disposed of after 2007.

No LLW and MLLW were disposed of after 1996 in the 200 East Area for the Hanford Only waste volume under this alternative group. Combined iodine-129 levels at the 200 East Area NW LOA were about 5 percent (0.04 pCi/L) of the benchmark MCL for the Upper Bound waste volume. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels at the 200 West Area LOA were 15 and 8 percent (0.15 and 0.08 pCi/L) of the benchmark MCL for the Hanford Only and Upper Bound waste volumes, respectively. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels at the 200 West Area LOA were slightly higher at the 200 East Area NW LOA and slightly lower for the Upper Bound waste volume, which is reflective of changes in partitioning of the iodine-129 inventory for the MLLW (1996–2007) waste category between the 200 East and West Areas for the Upper Bound inventory.

Combined iodine-129 levels were 22 percent (0.22 pCi/L) at the ERDF LOA for both the Hanford Only and Upper Bound waste volumes. No iodine-129 inventory was estimated for melters disposed of at ERDF after 2007 for this alternative group.

Concentration levels of carbon-14 and the uranium isotopes at the LOA downgradient from source areas of projected LLW and MLLW did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below benchmark MCLs at 10,000 years after site closure.

Combined technetium-99 and iodine-129 concentrations were well below benchmark MCLs by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks near the river at about 1400 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks near the river at about 2000 years after site closure.

5.3.4.8 Alternative Group E_2

Results for Alternative Group E_2 for combined technetium-99 and iodine-129 concentration levels for Hanford Only and Upper Bound waste volumes are summarized in Figures 5.17 and 5.18. As was provided in the previous alternative groups, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.8.

5.3.4.8.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1.1).

5.3.4.8.2 Wastes Disposed of After 1995

Potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 near the PUREX Plant and the disposal of melters and ILAW at ERDF. Results for LLW and MLLW disposed of after 2007 are identical to results for the same wastes in Alternative Group D_1 (see Section 5.3.4.4.2). Results for the melters and ILAW were the same as those calculated for Alternative Group E_1 (See Section 5.3.4.7.2).

5.3.4.9 Alternative Group E_3

Alternative Group E_3 results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.19 and 5.20. Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.9.

5.3.4.9.1 Wastes Disposed of Before 1996

Potential impacts from wastes disposed of before 1996 were the same for all alternative groups. This discussion is presented under results for Alternative Group A results in (see Section 5.3.4.1.1).

5.3.4.9.2 Wastes Disposed of After 1995

Potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 at ERDF and the disposal of melters and ILAW near the PUREX Plant. Results for LLW and MLLW disposed of after 2007 are identical to results for the same wastes in Alternative Group D_3 (see Section 5.3.4.6.2). Results for the melters and ILAW were the same as those calculated for Alternative Group D_1 (see Section 5.3.4.4.2).

Combined technetium-99 levels were slightly less than 2.5 percent (22 pCi/L) of the benchmark MCL at the 200 East Area SE LOA for the Hanford Only waste volume. The potential impact for the Hanford Only waste volume reflects the potential impact of the melter and ILAW disposal near the PUREX Plant. The highest combined iodine-129 levels at the 200 East Area SE LOA were about 20 percent (0.2 pCi/L) of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes as a result of the ILAW disposal near the PUREX area.

5.3.4.10 No Action Alternative

The No Action Alternative for combined technetium-99 and iodine-129 concentration levels are summarized in Figure 5.21. As was provided in the previous alternative groups, these results show the potential impacts to groundwater quality at various lines of analysis from: 1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, 2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, the year 12,046 A.D.). Additional information can be found in several tables and figures in Volume II, Appendix G, Section G.2.10.

5.3.4.10.1 Wastes Disposed of Before 1996

The highest potential groundwater quality impacts from wastes disposed of before 1996 are related to technetium-99 and iodine-129 releases. Estimated concentrations of technetium-99 and iodine-129 peaked at about 110 years after the assumed start of release at the 200 East Area NW LOA and about 220 years after the assumed start of release at the 200 West Area LOA. Combined levels of technetium-99 were less than 2 percent (18 pCi/L) at the 200 East Area NW and the 200 West Area LOAs. Combined levels of iodine-129 at the 200 East Area NW LOA were less than 0.1 percent (0.09 pCi/L) of the benchmark MCL.

Combined levels of iodine-129 at the 200 West Area LOA were about 50 percent (0.5 pCi/L) of the benchmark MCL. This concentration level resulted from releases of the iodine-129 inventory in 1970-1987 LLW.

Concentration levels of carbon-14 and the uranium isotopes were found to peak at about or beyond 10,000 years after site closure. Carbon-14 concentrations were well below the benchmark MCL of 2000 pCi/L at the 200 East and West Area LOAs. Concentration levels of uranium-238, the dominant uranium isotope, were also well below the benchmark MCL of 30 pCi/L at the 200 East and West Area LOAs at 10,000 years after site closure. Uranium-238 concentrations reached a peak of about 3 pCi/L at their peak (between 14,000 and 16,000 years after site closure) at the 200 West Area LOA.

Combined technetium-99 and iodine-129 concentrations were well below benchmark MCLs by the time they reached the Columbia River. Overall concentration levels from sources in the 200 East Area reached their peaks at the Columbia River LOA at about 260 years after the assumed start of release. Contaminant levels from sources in the 200 West Area reached their peaks at the Columbia River LOA between 500 and 600 years after the assumed start of release.

5.3.4.10.2 Wastes Disposed of After 1995

The highest potential groundwater quality impacts from LLW and MLLW disposed of after 1995 resulted from releases of technetium-99 and iodine-129. Combined technetium-99 levels at the 200 East Area NW LOA were about 8 percent (77 pCi/L) of the benchmark MCL for the Hanford Only waste volume. The primary source for these elevated levels was from inventories in MLLW disposed of after 1995.

Combined technetium-99 levels were about 25 percent (225 pCi/L) of the benchmark MCL at the 200 West Area LOA. The source of these potential impacts was primarily from the technetium-99 inventory in Cat 3 LLW disposed of after 1995.

The highest combined iodine-129 levels were about 6 percent (0.06 pCi/L) of the benchmark MCL at the 200 West Area LOA for the Hanford Only waste volume. The main contributor to these concentration levels was from inventories in MLLW disposed of after 1995.

Concentration levels of carbon-14 and the uranium isotopes at the LOAs downgradient from source areas of LLW and MLLW disposed of after 1995 did not reach their peak values until after the

10,000-year period of analysis. Concentration levels for both constituents were well below the benchmark MCLs at 10,000 years after site closure.

Combined technetium-99 and iodine-129 concentrations were well below the benchmark MCL by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks at about 850 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks near the river between 1660 and 1820 years after site closure.

5.3.5 Effect of Long-Term Cover System Performance Assumptions

This section presents results from a set of cases that was evaluated to examine and illustrate the effect of changing assumptions related to cover system performance on predicted groundwater quality impacts. The cases evaluated were related to groundwater impacts from selected waste categories and configurations proposed under Alternative Group D_1. Two specific assumptions evaluated were as follows:

- No cover is assumed to exist and waste release is controlled by infiltration through natural vegetated surface conditions that likely would persist following site closure. The assumed infiltration rate for these conditions is 0.5 cm/yr.

- The Modified RCRA Subtitle C Cover system is assumed to persist for the entire period of analysis and waste release is assumed to be controlled by the cover design infiltration rate of 0.01 cm/yr.

The specific contaminants and waste categories evaluated in these sensitivity cases included ungrouted Upper Bound inventories of technetium-99 and iodine-129 contained in MLLW and ungrouted and grouted Upper Bound inventories of uranium-238 contained in MLLW (see Figures 5.22 and 5.23). These specific examples illustrate the effect of the cover assumptions for contaminants from Mobility Class 1 (K_d = 0.0 mL/g) and Mobility Class 2 (K_d=0.6 mL/g).

A comparison of results based on the current conservative cover system assumption of failure after 500 years and a return to natural infiltration within 500 years after failure produces very similar potential impacts to those predicted with the assumption that no cover system is used. For all cases examined, differences in the results show predicted peak concentrations at the 1-km LOA, based on the 500-year cover system assumption, to be slightly lower and to arrive about 600 to 700 years later than the calculated peak concentrations at the 1-km LOA for the no-cover assumption. The delay in arrival time is reflective of the effect of the lower infiltration and release rate that would be expected to occur when the cover system is assumed to operate at or near its design infiltration of 0.01 cm/yr for the first 600 to 700 years after closure.

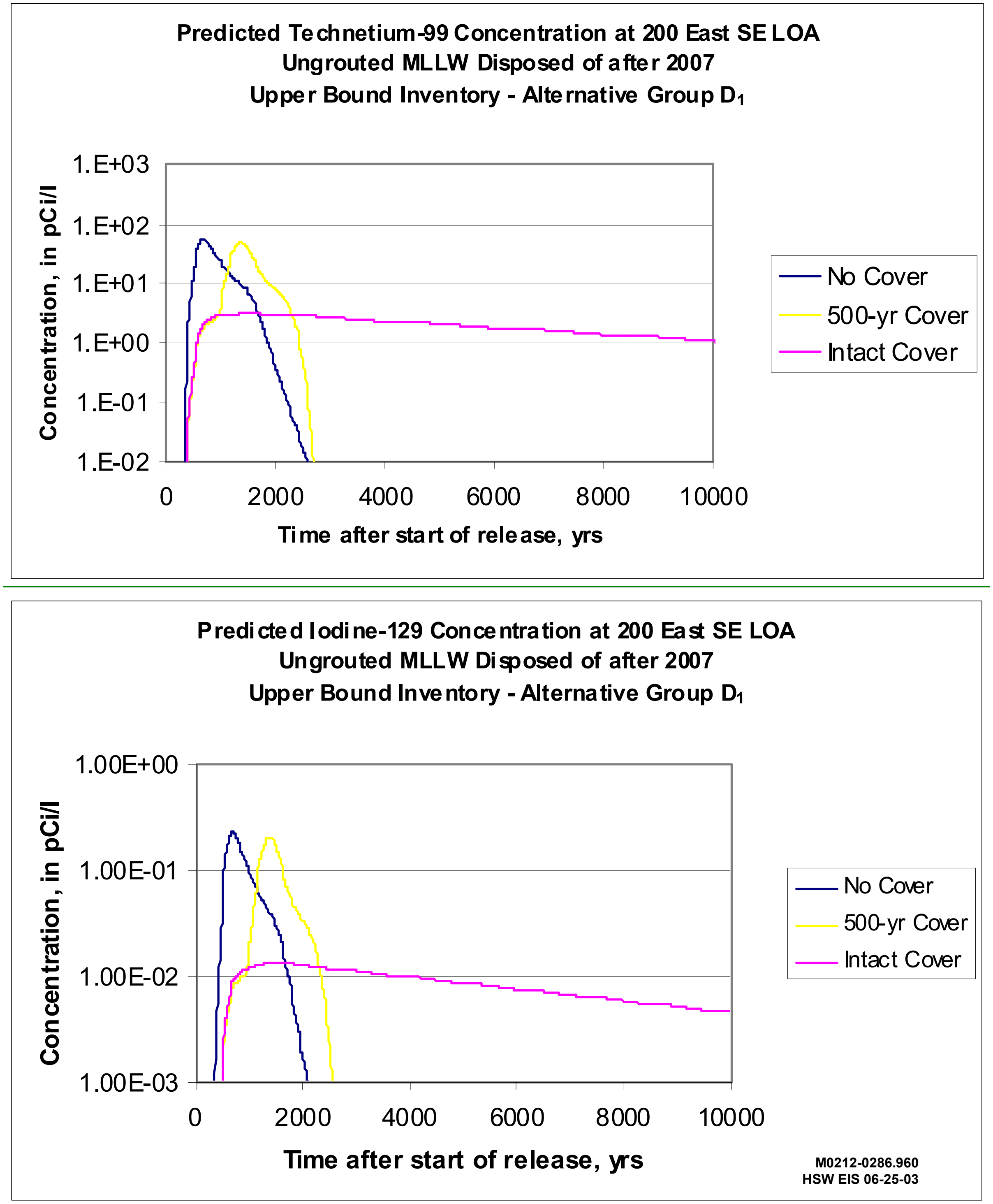
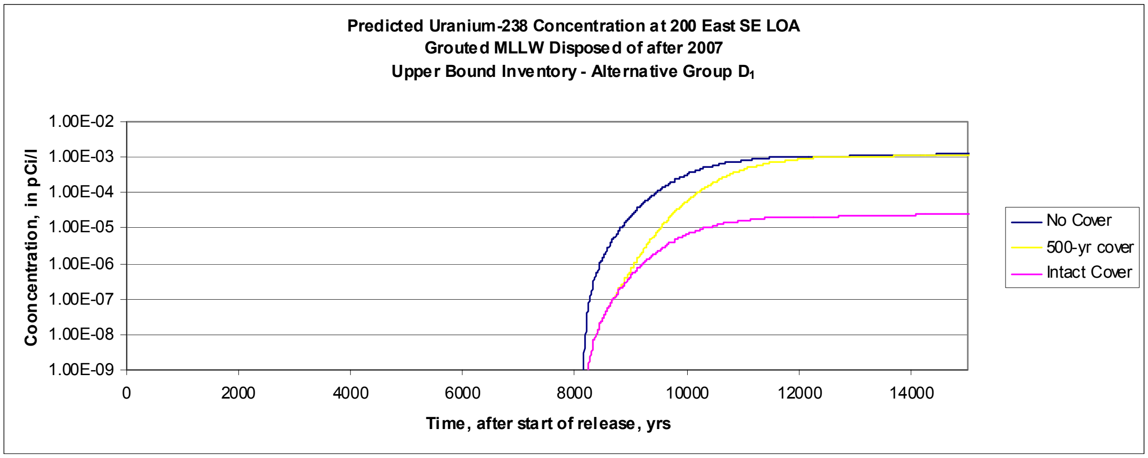


Figure 5.22. Comparison of Predicted Peak Concentrations of Technetium-99 and Iodine-129 at 200 East SE LOA from Upper Bound Inventories in Ungrouted MLLW Disposed of After 2007



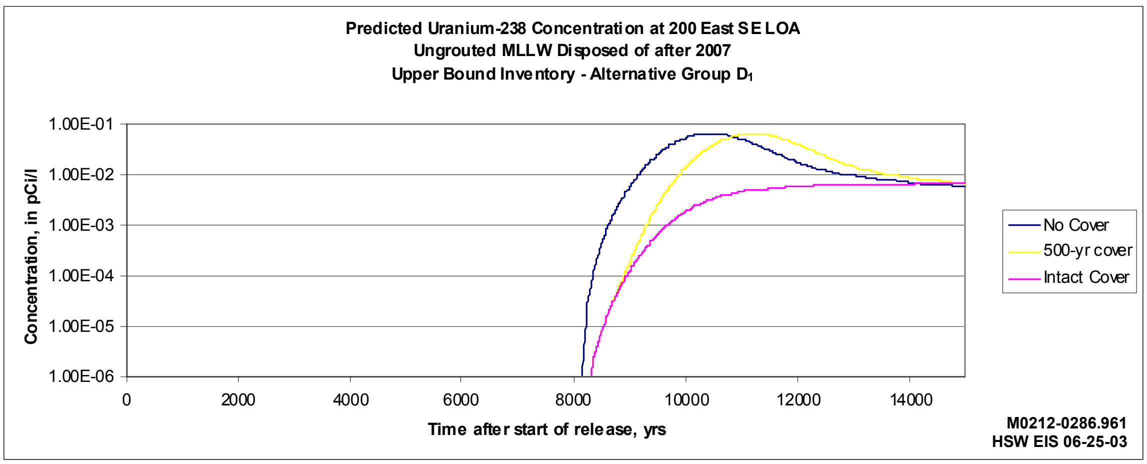


Figure 5.23. Comparison of Predicted Peak Concentrations of Uranium-238 at 200 East SE LOA from Upper Bound Inventories in Ungrouted and Grouted MLLW Disposed of After 2007

Figures 5.22 and 5.23 also compare resulting potential impacts using a calculational assumption where the cover system remains intact and does not fail during the period of analysis. For all cases examined, predicted peak concentrations at the 1-km LOA consistent with the intact cover system assumption are calculated to be about 7 percent of the peak and to arrive over a much longer period of time than the peak concentration arrival time at the 1-km LOA for the 500-year cover scenario (see Table 5.13). Results based on this assumption reflect the effect of the expected reduced infiltration and waste release from the waste disposal zone while the cover system is assumed to be intact and operating at its design infiltration rate of 0.01 cm/yr.

Table 5.13. Comparison of Predicted Peak Concentrations of Selected Constituents at the 200 East SE LOA from Upper Bound Inventories in Ungrouted MLLW Disposed of After 2007

	500-Year Cover		No Cover		Intact Cover	
	Peak Concentration (pCi/L)	**Peak Arrival Time (yrs)**	**Peak Concentration (pCi/L)**	**Peak Arrival Time (yrs)**	**Peak Concentration (pCi/L)**	**Peak Arrival Time (yrs)**
Ungrouted MLLW						
Tc-99	48.9	1,370	54.6	680	3.2	1,530
Iodine-129	0.21	1,370	0.23	680	1.3E-02	1,530
U-238	6.7E-02	11,200	6.7E-02	10,450	7.9E-03	20,000
Grouted MLLW						
U-238	1.42E-03	20,000	1.43E-03	20,000	2.8E-05	20,000

5.3.6 Potential Groundwater Quality Impacts at Waste Management Area Boundaries for Selected Alternatives

Potential impacts on groundwater for Alternative Groups D_1, D_2, and D_3 within 100 meters of the aggregate low-level waste management areas (LLWMAs) (see Volume II, Appendix G) are provided in this section. The alternative groups, waste types, and disposal conditions are briefly restated to establish the framework for comparing the results. These additional analyses of potential groundwater quality impacts for the new combined-use facility (as presented for Alternative Groups D_1, D_2, and D_3), also are presented in Section G.5 and provide a perspective on the relative potential impact at LLWMA boundaries about 100 meters downgradient of the aggregate waste disposal area versus potential impacts at the 1-km LOAs. A similar impact analysis is provided for LLW and MLLW disposed of before 2007 for another perspective. At the end of this section (Section 5.3.6.5), a qualitative discussion of estimates of impacts at LLWMA boundaries for Alternative Groups A, B, C, E, and the No Action Alternative are also provided.

Because of assumptions used in waste release, vadose zone transport, and introduction of constituent release to underlying groundwater, these analyses represent a very conservative evaluation, that is, an overestimate of potential water quality impacts in the vicinity of aggregate LLWMA boundaries (100 meters), and these analyses should not be considered a compliance analysis as required by DOE Order 435.1, RCRA closure, or CERCLA. The conservatism used in this analysis is particularly evident in the analysis of waste contained in LLBG 218-E-12B, where the aquifer system is predicted to become dry over the period of interest (see Volume II, Appendix G, Section G.5). Specific unit releases used to approximate potential impacts from waste categories and associated disposal areas were represented as a linear source just inside the aquifer system down-slope relative to the top of the basalt bedrock underlying this LLBG. This representation is a simplistic representation of the complex future migration of contaminants from this burial ground and resulting concentration levels estimated downgradient of LLWMA 2 likely would be substantially less than those reported here.

The broader comparative analysis of impacts at the 1-km LOAs presented in the previous section reflect a summation of predicted maximum concentrations for several waste categories regardless of their position on the LOA. These resulting concentrations also were used to provide a determination of the sum-of-fractions of benchmark MCLs for key constituents (that is, technetium-99 and iodine-129) for each alternative group. These results are presented in Section 5.3.6.4 and are also provided in Section 3.4 and the Summary of this HSW EIS. That approach, combining groundwater concentrations from separate waste sources, would not be appropriate for results of the LLWMA boundary analyses presented in this section because of differences in locations of the wastes in question within each LLWMA, the associated locations of estimated potential maximum concentration, and the timing of arrival for maximum potential concentrations from each waste category.

A discussion and summary of ratios to benchmark MCLs for technetium-99 and iodine-129 for each waste category in the three alternative groups (D_1, D_2, and D_3) are presented in Section 5.3.6.4.

5.3.6.1 Alternative Group D_1

Wastes considered in Alternative Group D_1 are the same as those described for Alternative Group A. However, in Alternative Group D_1, all wastes disposed of after 2007 would be placed in a single, lined, modular combined-use facility near the PUREX Plant. Results for waste disposed of before 2008 in Alternative Group D_1 are summarized in Table G.42 in Volume II, Appendix G. Waste disposed of after 2007 are summarized in Table G.43 in Volume II, Appendix G.

5.3.6.1.1 Wastes Disposed of Before 2008

Waste disposed of before 2008 consists of four categories: 1) pre-1970 LLW, 2) 1970–1987 LLW, 3) 1988–1995 LLW, and 4) 1996–2007 LLW and MLLW. The following sections provide brief summaries of potential groundwater quality impacts at about 100 meters downgradient from aggregate LLWMAs for each of these waste categories.

Pre-1970 Low-Level Waste

Pre-1970 LLW was primarily disposed of in LLBGs 218-E-10 (LLWMA 1) and 218-E-12B (LLWMA 2) in the 200 East Area and in LLBG 218-W-4C (LLWMA 4) in the 200 West Area. For these wastes, technetium-99 and iodine-129 released from the LLBGs would have the highest potential impact on groundwater quality.

Iodine-129 is estimated to be about 80 percent of the benchmark MCL and technetium-99, about 30 percent of the benchmark MCL 100 meters downgradient of LLWMA 2 in the 200 East Area. These resulting concentration levels estimated 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Volume II, Appendix G, Section G.5.3).

1970–1987 Low-Level Waste

1970–1987 LLW was primarily disposed of in LLBGs 218-E-10 (LLWMAB (LLWMA 2) in the 200 East Area and in LLBG 218-W-4A (LLWMA 4), 218-W-3A, and 218-W-3E (LLWMA 3) in the 200 West Area. For these wastes, iodine-129 released from the LLBGs has the highest potential impact on groundwater quality.

Iodine-129 is estimated to be about 7 times higher than the benchmark MCL of 1 pCi/l 100 meters downgradient of LLWMA 2 in the 200 East Area. As in the case of pre-1970 LLW, these resulting concentration levels estimated 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Volume II. Appendix G, Section G.5.3).

1988–1995 Low-Level Waste

1988–1995 LLW is primarily disposed of in LLBGs 218-E-10 (LLWMA 1) and 218-E-12B (LLWMA 2) in the 200 East Area, and in LLBG 218-W-3A and 218-W-5 (LLWMA 3) in the 200 West Area. For these wastes, technetium-99 and iodine-129 released from the LLBGs would have the highest potential impact on groundwater quality.

Iodine-129 is estimated to be about 5 percent of the benchmark MCL 100 meters downgradient of LLWMA 2 in the 200 East Area. Technetium-99 is estimated to be about 7 percent of the benchmark MCL 100 meters downgradient of LLWMA 2 in the 200 East Area and about 9 percent of the benchmark MCL 100 downgradient of LLWMA 3 in the 200 West Area.

As in the case of pre-1970 LLW, concentration levels estimated 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Volume II, Appendix G, Section G.5.3).

1996–2007 LLW and MLLW

1996–2007 wastes are and will be primarily disposed of in LLBGs 218-E-10 (LLWMA 1) and 218-E-12B (LLWMA 2) in the 200 East Area and in LLBG 218-W-3A and 218-W-5 (LLWMA 3) in the 200 West Area. Following is a brief summary of potential groundwater quality impacts from the three main components of these wastes, including Cat 1 LLW, Cat 3 LLW, and MLLW, as follows:

Category 1 LLW – Iodine-129 and technetium-99 released from 1996–2007 Cat 1 LLW primarily located in LLBG 218-W-5 within LLWMA 3 would have the highest potential impact on groundwater quality. Iodine-129 levels are estimated to be about 15 to 18 percent of the benchmark MCL 100 meters downgradient of LLWMA 3 in the 200 West Area for the Hanford Only and Upper Bound waste volumes. Technetium-99 levels are estimated to be about 1 and 2 percent of the benchmark MCL 100 meters downgradient of LLWMA 3 in the 200 West Area.

Category 3 LLW – Technetium-99 released from 1996–2007 Cat 3 LLW primarily located in LLBG 218-W-5 within LLWMA 3 would have the highest potential impact on groundwater quality. Technetium-99 levels are estimated to be about 2 percent of the benchmark MCL 100 meters downgradient of LLWMA 3 in the 200 West Area.

MLLW – Technetium-99 and iodine-129 released from ungrouted 1996–2007 MLLW would have the highest potential impact on groundwater quality. Concentration levels of all constituents are below benchmark MCLs for grouted 1996–2007 MLLW.

Estimated technetium-99 concentrations are about 21 percent of the benchmark MCL 100 meters downgradient of LLWMA 3 for all waste volumes. Estimated iodine-129 concentrations are about 48 and 80 percent of the benchmark MCL 100 meters downgradient of LLWMA 3 for the Hanford Only and Upper Bound waste volumes and about equal to the benchmark MCL 100 meters downgradient of LLWMA 2 for the Upper Bound waste volume.

As in the case of pre-1970 LLW, concentration levels estimated 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Volume II, Appendix G, Section G.5.3).

5.3.6.1.2 Waste Disposed of After 2007 Near the PUREX Plant

The potential impact for waste disposed of after 2007 reflects the emplacement of all wastes in the vicinity of the PUREX Plant. Potential impacts from LLW and MLLW would be dominated by technetium-99 and iodine-129.

The maximum potential impact from technetium-99 would be from Cat 3 LLW, where estimated concentration levels are about 21 percent of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. The maximum potential impact from iodine-129 would be from ungrouted MLLW, where estimated concentration levels are about 29 and 26 percent of the benchmark MCL for the Hanford Only and Upper Bound waste volumes.

Estimated concentration levels of all other constituents in these waste categories and all constituents in other waste categories are well below benchmark MCLs.

5.3.6.2 Alternative Group D_2

Wastes considered in Alternative Group D_2 are the same as those described for Alternative Group D_1. However, in Alternative Group D_2, all wastes disposed of after 2007 would be placed in a single, lined, modular combined-use facility at LLBG 218-E-12B. Results for waste disposed of before 2008 in Alternative Group D_2 are summarized in Table G.42 in Volume II, Appendix G. Waste disposed of after 2007 are summarized in Table G.44 in Volume II, Appendix G.

5.3.6.2.1 Wastes Disposed of Before 2008

Because of assumptions in the source-term release and vadose zone modeling used for LLW disposed of before 2008 for Alternative Group D, results for Alternative Group D_2 are the same as those for waste categories calculated for Alternative Group D_1. These results are summarized in Table G.42 of Volume II, Appendix G.

5.3.6.2.2 Waste Disposed of After 2007 in LLBG 218-E-12B

The highest potential impact for this alternative group reflects the emplacement of all wastes disposed of after 2007 in LLBG 218-E-12B. Potential impacts from LLW and MLLW would be dominated by technetium-99 and iodine-129 (see Volume II, Appendix G, Table G.44).

The maximum potential impact from technetium-99 would be from Cat 3 LLW, where estimated concentration levels are about 86 percent of the benchmark MCL for all waste volumes. The maximum potential impact from iodine-129 would be from ungrouted MLLW, where estimated concentration levels are about 94 and 95 percent of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. In addition, the potential impact from iodine-129 would be from Cat 3 LLW, where estimated concentration levels are about 38 percent of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes. These higher levels of potential groundwater quality impacts relative to those calculated for similar waste inventories in Alternative Group D_1 reflect differences in aquifer conditions found beneath the near PUREX location (that is, high permeability and moderate saturated thickness of the Hanford formation at the water table) and the 218-E-12B LLBG (that is, slightly lower hydraulic conductivities and thinner saturated thicknesses of the Hanford formation at the water table).

Estimated concentrations of all other constituents in these waste categories and all constituents in other waste categories would be below benchmark MCLs.

As in the case of other wastes disposed of in LLBG 218-E-12B, the resulting concentration levels estimated about 100 meters downgradient of LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Volume II, Appendix G, Section G.5.3).

5.3.6.3 Alternative Group D_3

Wastes considered in Alternative Group D_3 are the same as those described for Alternative Group D_1. However, in Alternative Group D_3, all wastes received after 2007 would be disposed of in a single, lined, modular combined-use facility at ERDF. Results for waste disposed of before 2008 in Alternative Group D_3 are summarized in Table G.42 in Volume II, Appendix G. Waste disposed of after 2007 are summarized in Table G.45 in Volume II, Appendix G.

5.3.6.3.1 Wastes Disposed of Before 2008

Because of assumptions in the source-term release and vadose zone modeling used for LLW previously disposed of before 2008 for Alternative Group D, results for Alternative Group D_3 are the same as for those for waste categories calculated for Alternative Group D_1. These results are summarized in Table G.45 of Volume II, Appendix G.

5.3.6.3.2 Waste Disposed of After 2007

The highest potential impact for this alternative group reflects the emplacement of all wastes disposed of after 2007 at ERDF. Potential impacts from LLW and MLLW would be dominated by technetium-99 and iodine-129 (see Volume II, Appendix G, Table G.45).

The maximum potential impact from technetium-99 would be from Cat 3 LLW, where estimated concentration levels are about 81 and 58 percent of the benchmark MCL for the Hanford Only and Upper Bound waste volumes. The maximum potential impact from iodine-129 would be from ungrouted MLLW, where estimated concentration levels are about 94 and 74 percent of the benchmark MCL for both the Hanford Only and Upper Bound waste volumes, respectively. In addition, the potential impact from iodine-129 from Cat 3 LLW would be about 36 and 28 percent of the benchmark MCL for the Hanford Only and Upper Bound waste volumes. These higher levels of potential groundwater quality impacts relative to those calculated for similar waste inventories in Alternative Group D_1 reflect differences between aquifer conditions found beneath the near PUREX location (that is, high permeability and moderate saturated thickness of the Hanford formation at the water table) and at ERDF (that is, lower hydraulic conductivities associated with the Ringold Formation at the water table).

Estimated concentrations of all other constituents in these waste categories and all constituents in other waste categories would well be below benchmark MCLs.

5.3.6.4 Summary of Ratios to Benchmark MCLs for Technetium-99 and Iodine-129

This section presents a discussion of the combined ratios of maximum potential concentrations to benchmark MCLs for technetium-99 and iodine-129 using the sum-of-fractions rule for all wastes considered in the three alternative groups. The breakdown is provided in two broad categories—1) waste disposed of before 2008 and 2) waste disposed of after 2007—and includes results for the Hanford Only and Upper Bound waste volumes.

5.3.6.4.1 Waste Disposed of Before 2008

The sum-of-fractions of maximum potential concentrations as compared with benchmark MCLs for technetium-99 and iodine-129 for waste disposed of before 2008, as presented in Table 5.14, are the same for all three alternative groups. Each waste category was evaluated as a separate entity because of differences in locations of the wastes in question within each LLWMA, the associated locations of estimated potential maximum concentration, and the timing of arrival for maximum potential concentrations from each waste category. Because of the higher waste containment integrity used for waste disposed of

Table 5.14. Sum of MCL Fractions and Drinking Water Doses from Maximum Potential Concentrations at LLWMA Boundaries for Technetium-99 and Iodine-129 for Waste Buried Before 2008

Primary Contributing Waste Category	200 East Area				200 West Area			
	Ratios of Maximum Potential Concentrations to Benchmark MCL			Estimated Dose (mrem/yr)	Ratios of Maximum Potential Concentrations to Benchmark MCL			Estimated Dose (mrem/yr)
	Tc-99	I-129	Sum-of-Fractions[(a)]		Tc-99	I-129	Sum-of-Fractions	
Pre-1970 LLW	0.4	0.8	1.2	0.5	0.03	0.04	0.07	0.04
1970–1987 LLW	NA	7.2	7.2	1.5	NA	0.05	0.05	0.01
1988–1995 LLW	0.1	0.1	0.2	0.1	0.07	4.2	4.3	1.0
1996–2007 Cat 3 LLW								
Hanford Only	NA	NA	NA	NA	0.03	NA	0.03	0.03
Upper Bound	NA	NA	NA	NA	0.03	NA	0.03	0.03
1996–2007 MLLW								
Hanford Only	NA	NA	NA	NA	0.2	0.8	1.0	0.3
Upper Bound	0.3	1	1.3	0.5	0.1	0.5	0.7	0.2

(a) Sum-of-fractions greater than 1.0 would indicate a potential cumulative exceedance of benchmark MCLs.
NA = not applicable.

after 1995, waste releases of mobile constituents (that is, technetium-99 and iodine-129) to groundwater after 1995 would be delayed from release to groundwater from waste disposed of before or during 1995 by several hundred years.

As in the case for LLW disposed of in LLWMA 2 for Alternative Groups D_1 and D_2 (see Sections 5.3.6.1.1 and 5.3.6.2.1), concentration levels estimated 100 meters downgradient for LLW disposed of in LLWMA 2 are deemed to be very conservative because of the approximation of release to groundwater in this area used in the current approach (see Volume II, Appendix G, Section G.5.3).

The largest sum-of-fractions were calculated from maximum potential concentrations estimated for iodine-129 contained in 1970–1987 wastes disposed of in LLBGs in the 200 East Area and in 1988–1995 LLW disposed of in LLBGs (mainly 218-W-5 and 218-W-3A) in the 200 West Area. The arrival of maximum concentration levels at the given LLWMA boundary were estimated to occur at about 90 years from the start of release in the 200 East Area and at about 150 years from the start of release for wastes in the 200 West Area. The assumed start of release for both areas was 1966. These relatively short arrival times of maximum concentrations reflect the assumptions used in the release of waste disposed of before 1995, that is, using a relatively high infiltration rate of 5.0 cm/yr in waste release and vadose zone transport. The maximum concentration would be expected to persist at the LLWMA boundary for a relatively short period of time (a few decades) after initial arrival and would dissipate within the period of active institutional control (that is, 100 years after site closure), during which time ground water use within the Central Plateau would be restricted.

As may be seen from Table 5.14, potential exceedances of benchmark MCLs using the sum-of-fractions rule (that is, sum-of-fractions greater than 1.0) are evident; however, it may also be noted that drinking water doses are below the benchmark DOE drinking water standard of 4 mrem/yr at the LLWMA boundary points of analysis.

5.3.6.4.2 Waste Disposed of After 2007

Combined ratios of maximum potential concentrations to benchmark MCLs for technetium-99 and iodine-129 for waste disposed of after 2007 are presented in Table 5.15 for all three alternative groups. In this case, the wastes would be disposed of within a combined-use facility. They are evaluated separately from the wastes disposed of before 2008 because of differences in locations of the wastes in question within each LLWMA, the associated locations of estimated potential maximum concentration, and the timing of arrival for maximum potential concentrations from each waste category. Because of the improved waste isolation and containment used in disposal of waste between 1996 and 2007, releases of mobile constituents (that is, technetium-99 and iodine-129) from these wastes to groundwater would be separated from releases to groundwater from waste disposed of before 1996 by several hundred years. In addition, the use of a glass waste form for waste in ILAW would cause releases of mobile constituents from these wastes to groundwater to be separated from releases to groundwater from waste disposed of before 1996 by several thousand years.

For the three alternative groups considered, the calculated sum-of-fractions would be lowest if the combined-use facility were sited near the PUREX Plant location (Alternative Group D_1). The higher levels of potential groundwater quality impacts at the 218-E-12B (Alternative Group D_2) and the ERDF (Alternative Group D_3) locations relative to the near-PUREX location reflect differences in aquifer conditions found beneath the 218-E-12B LLBG (slightly lower hydraulic conductivities and thinner saturated thicknesses of the Hanford formation at the water table) and the ERDF (lower hydraulic conductivities associated with the Ringold Formation at the water table) locations.

For a combined-use facility near the PUREX Plant (Alternative Group D_1), Table 5.15 shows that the benchmark MCLs using the sum-of fractions rule would not be exceeded. For combined-use facilities at other LLWMA locations, potential exceedances of benchmark MCLs using the sum-of-fractions rule are evident; however, it should be noted that drinking water doses are below the DOE benchmark drinking water standard of 4 mrem/yr at the LLWMA boundary points of analysis.

Table 5.15. Sum of MCL Fractions and Drinking Water Doses from Maximum Potential Concentrations at Combined-Use Facility Boundaries for Technetium-99 and Iodine-129 for Waste Buried After 2007

Primary Contributing Waste Category	Ratios of Maximum Potential Concentrations to Benchmark MCL			Estimated Dose (mrem/yr)
	Technetium-99	Iodine-129	Sum-of-Fractions[(a)]	
Near the PUREX Plant (Alternative Group D_1)				
Cat 3 LLW				
Hanford Only	0.2	0.1	0.3	0.2
Upper Bound	0.2	0.1	0.3	0.2
MLLW				
Hanford Only	0.1	0.2	0.3	0.1
Upper Bound	0.1	0.2	0.3	0.1
Overall Totals				
Hanford Only	0.3	0.3	0.6	0.4
Upper Bound	0.3	0.3	0.6	0.4
218-E-12B LLBG (Alternative Group D_2)				
Cat 3 LLW				
Hanford Only	0.8	0.4	1.2	0.9
Upper Bound	0.8	0.4	1.2	0.9
MLLW				
Hanford Only	0.3	1.0	1.2	0.5
Upper Bound	0.3	1.0	1.2	0.5
Overall Totals				
Hanford Only	1.1	1.3	2.4	1.3
Upper Bound	1.1	1.3	2.4	1.3
ERDF (Alternative Group D_3)				
Cat 3 LLW				
Hanford Only	0.9	0.4	1.2	0.9
Upper Bound	0.9	0.4	1.2	0.9
MLLW				
Hanford Only	0.3	0.9	1.2	0.5
Upper Bound	0.3	0.9	1.2	0.5
Overall Totals				
Hanford Only	1.1	1.2	2.3	1.3
Upper Bound	1.1	1.2	2.3	1.3

(a) Sum-of-fractions greater than 1.0 would indicate a potential cumulative exceedance of benchmark MCLs.

5.3.6.5 Qualitative Estimates of Impacts at LLWMA Boundaries for Alternative Groups A, B, C, E, and the No Action Alternative

Although quantitative estimates of the impacts at the LLWMA boundaries were made only for Alternative Groups D_1, D_2, and D_3, those results were used to make qualitative estimates of impacts that might be expected from the other action alternative groups (that is, A, B, C, E_1, E_2, and E_3) and the No Action Alternative. The inferences are made based on evaluation of a combination of factors, including:

- similarities in assumed disposal configuration, mainly related to assumed waste depth
- similarities in hydrogeologic conditions at assumed disposal facility locations
- calculated ratios of predicted concentrations at the LLWMA boundaries and 1-km LOAs from similar source areas.

Ratios of predicted concentrations of the technetium-99 and iodine-129 calculated at the LLWMA boundaries and the 1-km LOAs were found to vary by waste category and disposal location. These ratios also vary within each LLWMA as a function of distance from the assumed disposal site to the LLWMA boundary. Calculated ratios for waste considered in Alternative Group D were found to vary as follows:

- Ratios for waste disposed of before 2008 varied from about 14 to 23 in the 200 East Area and from about 2 to 11 in the 200 West Area.
- Ratios for waste disposed of after 2007 varied from a low of 1.1 for waste assumed to be disposed of at the proposed facility near PUREX to a high of about 6 for waste assumed to be disposed of within the 218-E-12B LLBG.

The following sections provide a qualitative summary of impacts for the other action alternative groups (A, B, C, and E_1, E_2, and E_3) and the No Action Alternative for all wastes postulated to be disposed of before 2008 and wastes that would be disposed of after 2007. The primary focus of this discussion is on the impacts from technetium-99 and iodine-129, because these constituents are associated with potential maximum impacts.

5.3.6.5.1 Waste Disposed of Before 2008

Because the assumptions used in the source-term release and vadose zone modeling for LLW and MLLW postulated to be disposed of before 2008 were the same for all the action alternative groups, potential concentration levels of technetium-99 and iodine-129 estimated for Alternative Group D (see Table G.42 in Volume II, Appendix G) for waste disposed of before 2008 would be directly applicable for all the action alternative groups.

The impacts at the LLWMA boundaries presented in Table G.42 in Volume II, Appendix G for waste disposed of before 1996 generally would be applicable to concentration levels of technetium-99 and iodine-129 estimated for the No Action Alternative. Because of the assumptions used in the surface cover conditions, source release, and vadose zone transport for waste disposed of before 1996, the estimated maximum concentrations of technetium-99 and iodine-129 from these waste categories for the No Action Alternative were found to be similar to those estimated for the action alternative groups.

The impacts at the LLWMA boundaries presented in Table G.42 in Volume II, Appendix G for LLW and MLLW assumed to be disposed of between 1996 and 2007 also would be generally applicable to concentration levels of technetium-99 and iodine-129 estimated for LLW and MLLW assumed to be disposed of after 1995 in the No Action Alternative. However, maximum concentrations for technetium-99 and iodine-129 from waste disposed of after 1995 in the No Action Alternative would be expected to be higher for LLW and lower for MLLW due to the differences in assumed inventories of technetium-99 and iodine-129 between the No Action Alternative and the action alternative groups.

5.3.6.5.2 Waste Disposed of After 2007

The following sections provide a qualitative summary of potential groundwater quality impacts for LLW and MLLW assumed to be disposed of after 2007 with respect to Alternative Groups A, B, C, E_1, E_2, and E_3. The potential impacts for LLW and MLLW assumed to be disposed of after 2007 in the No Action Alternative were discussed in the previous section.

Alternative Group A

This alternative group evaluates the following disposal options:

- Cat 1 and Cat 3 LLW and MLLW disposed of after 2007 in deeper (18 m) (59 ft) and wider trenches in existing LLBGs 218-W-5 and 218-E-12B
- melters disposed of after 2007 in a 21-m (69-ft) deep facility near PUREX
- ILAW disposed of after 2007 in a new HSW disposal facility near PUREX.

For LLW disposed of after 2007 in LLBG 218-W-5 within the 200 West Area, the increase in concentrations from the 1-km LOA to those calculated at the LLWMA 3 boundary for technetium-99 and iodine-129 would be expected to be similar to results for the Cat 1 and Cat 3 wastes disposed of between 1996 and 2007 in LLBG 218-W-5 in the 200 West Area in all the alternative groups. The ratio of results for technetium-99 and iodine-129 for LLW disposed of between 1996 and 2007 calculated at the LLWMA 3 boundary, shown in Table G.42 (see Volume II, Appendix G), and results at the 1-km LOA given for the same waste category (see Table G.7 in Volume II, Appendix G) suggest that concentrations at the LLWMA 3 boundary would be about a factor of 6 greater than those presented for the 1-km LOA.

For MLLW disposed of after 2007 in LLBG 218-E-12B within the 200 East Area, the increase in concentrations from the 1-km LOA to those calculated at the LLWMA 2 boundary for technetium-99 and iodine-129 would be expected to be similar to results for the MLLW disposed of after 2007 in Alternative Group D_2. The ratio of results for technetium-99 and iodine-129 calculated at the LLWMA 2 boundary for the MLLW disposed of after 2007 in Alternative Group D_2, shown in Table G.42 (see Volume II,

Appendix G), and results at the 1-km LOA given in Table G.7 (see Volume II, Appendix G) suggest that concentrations at the LLWMA 2 boundary would be about a factor of 6 greater than those presented for the 1-km LOA.

Technetium-99 and iodine-129 results from disposal of melters and ILAW would be expected to be similar to those calculated for these facilities near PUREX in Alternative Group D_3 (see Table G.45 in Volume II, Appendix G).

Alternative Group B

LLW considered in Alternative Group B includes the same waste considered in Alternative Group A but assumes disposal of Cat 1 and Cat 3 LLW and MLLW in conventional trenches after 2007 in LLBGs 218-W-5 and 218-E-12B, melters in a trench in LLBG 218-E-12B, and ILAW in a new disposal facility located just south of the CWC.

For LLW disposed of after 2007 in LLBG 218-W-5 within the 200 West Area, the increase in concentrations from the 1-km LOA to those calculated at the LLWMA 3 boundary for technetium-99 and iodine-129 would be expected to be similar to results for the Cat 1 and Cat 3 wastes disposed of between 1996 and 2007 in LLBG 218-W-5 in the 200 West Area for all the alternative groups. The ratio of results for technetium-99 and iodine-129 for LLW disposed of between 1996 and 2007 calculated at the LLWMA 3 boundary, shown in Table G.42 (see Volume II, Appendix G), and results at the 1-km LOA given for the same waste category (see Table G.7 in Volume II, Appendix G) suggest that concentrations at the LLWMA 3 boundary would be about a factor of 6 greater than those presented for the 1-km LOA.

For MLLW disposed of after 2007 in LLBG 218-E-12B within the 200 East Area, the increase in concentrations from the 1-km LOA to those calculated at the LLWMA 2 boundary for technetium-99 and iodine-129 would be expected to be similar to results for the MLLW disposed of after 2007 in Alternative Group D_2. The ratio of results for technetium-99 and iodine-129 calculated at the LLWMA 2 boundary, shown in Table G.43 (see Volume II, Appendix G), and results at the 1-km LOA, given in Table G.22 (see Volume II, Appendix G), suggest that concentrations at the LLWMA 2 boundary would be about a factor of 6 greater than those presented for the 1-km LOA.

Results for the melters would be expected to be similar to those calculated for Alternative Group D_2 (see Section 5.3.6.2.2 and Table G.44 in Volume II, Appendix G). Results suggest that concentrations at the LLWMA 2 boundary would be about a factor of 5 greater than those presented for the 1-km LOA.

For ILAW disposed of after 2007 south of the CWC, the increase in concentrations at the LLWMA 4 boundary relative to the 1-km LOA for technetium-99 and iodine-129 would be expected to be similar to results for the Cat 1 and Cat 3 LLW disposed of after 2007 at ERDF in Alternative Group D_3. Although the disposal site south of CWC is several kilometers from the ERDF location, both disposal sites are in areas underlain with similar hydrogeologic units (that is, Ringold Formation Unit 5) that exist below the water table. The ratio of results for technetium-99 and iodine-129 calculated for Cat 1 and Cat 3 LLW at the ERDF boundary, shown in Table G.45 (see Volume II, Appendix G), and results at the 1-km LOA for the same waste category, given in Table G.25 (see Volume II, Appendix G), suggest that concentrations at the ERDF boundary would be about a factor of 3 greater than those presented for the 1 km LOA.

Alternative Group C

Because of assumptions in the source-term release and vadose zone modeling used for previously buried LLW and LLW and MLLW disposed of after 2007 for Alternative Group C, results for LLW and MLLW disposed of after 2007 for this alternative group, including the ILAW and melters, would be expected to be similar to those qualitatively discussed for Alternative Group A. These results are consistent because the analysis assumption about waste depth and projected land use for waste disposed of after 2007 are the same for both alternative groups.

Alternative Group E_1

The potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 in LLBG 218-E-12B and disposal of melters and ILAW at ERDF. Results for LLW and MLLW disposed of after 2007 would be expected to be similar to results for the same wastes in Alternative D_2 (see Table G.44 in Volume II, Appendix G). Results for the disposal of melters and ILAW would be expected to be similar to those calculated for these facilities in Alternative Group D_3 (see Table G.45 in Volume II, Appendix G).

Alternative Group E_2

The potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 near PUREX and the disposal of melters and ILAW at ERDF. Results for LLW and MLLW disposed of after 2007 would be expected to be similar to results for the same wastes in Alternative Group D_1 (see Section 5.3.6.1.2 and Table G.43 in Volume II, Appendix G). Results for the melters and ILAW would be expected to be similar to those calculated for Alternative Group D_3 (see Section 5.3.6.3.2 and Table G.45 in Volume II, Appendix G) and Alternative Group E_1 (see the preceding paragraph).

Alternative Group E_3

The potential impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 at ERDF and the disposal of melters and ILAW near PUREX. Results for LLW and MLLW disposed of after 2007 would be expected to be similar to results for the same wastes in Alternative Group D_3 (see Section 5.3.6.3.2 and Table G.45 in Volume II, Appendix G). Results for the melters and ILAW would be expected to be similar to those calculated for Alternative Group D_1 (see Section 5.3.6.3.1 and Table G.43 in Volume II, Appendix G).

5.3.6.5.3 Summary of Results for Disposal Alternatives

Results of the detailed analyses of the subalternatives in Alternative Group D and the qualitative analysis of for the other Alternative Groups (A, B, C, and E) at LLWMA boundaries lead to the following general conclusions:

- The range of potential groundwater quality impacts at disposal facility boundaries for the alternative groups is largely reflective of differences in hydrogeologic conditions found beneath different postulated disposal facility locations. Differences in potential impacts also are, to a lesser extent, a function of assumed disposal facility configurations.

- Maximum concentrations of technetium-99 and iodine-129 conservatively estimated from a combined-use facility at the range of disposal facility locations yielded potential exceedances of benchmark MCLs using the sum-of-fractions rule for two of the subalternatives in Alternative Group D. However, associated drinking water doses were found to be below the DOE benchmark drinking water standard of 4 mrem/yr at the LLWMA boundary points of analysis for the subalternatives in Alternative Group D. Detailed analysis of the other alternative groups (A, B, C, and E) likely would lead to the same general human health impact (that is, estimated potential drinking water doses would be below the DOE benchmark drinking water standard of 4 mrem/yr at the LLWMA or disposal area boundary points of analysis).

- From the standpoint of estimated impacts at LLWMA boundaries, the most favorable alternative for LLW and MLLW disposed of after 2007 appears to be Alternative Group D_1 where all LLW and MLLW, including melters and ILAW, are assumed to be disposed of near the PUREX Plant. This site would have the lowest estimated impacts because of the high permeability and moderate saturated thickness of the Hanford formation sediments found at the water table beneath this location.

- For the same assumed LLW and MLLW inventories, higher impacts would be expected at the LLWMA boundaries for alternative groups that consider disposal of wastes within the 218-W-5 and 218-E-12B LLBGs and at the ERDF location. These impacts would be expected to be higher because of the hydrogeologic conditions found at the water table at these locations (that is, slightly lower hydraulic conductivities and thinner saturated thicknesses of the Hanford formation at the water table at the 218-E-12B LLBG and the lower permeability of the Ringold Formation found at the water table at the 218-W-5 LLBG and ERDF locations).

5.3.7 Potential Groundwater Quality Impacts from Hazardous Chemicals in Pre-1988 Wastes

In response to comments received during the public comment periods on the drafts of the HSW EIS, efforts were made to develop an estimate of quantities of potentially hazardous chemicals in previously buried LLW so that potential impacts of such chemicals on groundwater quality could be evaluated. The estimation of these inventories, which used a waste stream analysis estimation method, is summarized in the Technical Information Document (FH 2004).

The most substantial quantities of hazardous chemicals (in terms of inventory quantities) identified from this effort are summarized in Table 5.16. These specific, selected hazardous chemical inventories provided the basis for the following analysis of potential groundwater quality impacts from hazardous chemical inventories in wastes disposed of before 1988.

Table 5.16. Estimated Inventories of Selected Hazardous Chemicals Potentially Disposed of in HSW LLBGs Between 1962 and 1987

Constituent	Inventory (kg)
Chromium	100
Fluoride	5,000[(a)]
Nitrate	5,000[(b)]
Lead	>600,000
Mercury	1,000
1,1,1-trichloroethane	900
Xylene	3,000
Toluene	3,000
Methylene chloride	800
Oil	3,000
Diesel fuel	20,000
Hydraulic fluid	40,000
PCBs	8,000

(a) Fluoride mass equivalent for 10,000 kg of sodium fluoride.
(b) Nitrate mass equivalent to 6,000 kg of sodium nitrate.

5.3.7.1 Contaminant Group and Screening Analysis

As was done in the impact analysis for radiological constituents, the potential for each of the hazardous chemical constituents to impact groundwater was evaluated. Screening of these constituents evaluated their relative mobility in the subsurface system within a 10,000-year period of analysis. In addition, because of the presence of several organic chemicals in the table, the screening also considered the potential for chemical degradation within the period of analysis.

As in the radiological constituent analysis, the constituents were grouped based on their mobility in the vadose zone and underlying unconfined aquifer using estimated or assumed K_d for each constituent as a measure of mobility. A summary of all hazardous constituents using the same mobility groupings (based on K_d values) described in Section G.1.3.1 is provided in Table G.49 (both in Volume II, Appendix G).

The mobility of constituents in Table G.49 in Volume II, Appendix G were further evaluated using estimates of constituent transport times through the thick vadose zone to the unconfined aquifer during the 10,000-year period of analysis described in Section G.1.3.1. Based on a natural infiltration rate of 0.5 cm/yr through the underlying vadose zone (see the screening analysis method described in Volume II, Appendix G, Section G.1.3.1) and the estimated levels of sorption and associated retardation for each of the classes above, travel times of all constituents were estimated. Results of this analysis show that without a substantial driving force, arrival times of constituents within Mobility Classes 3, 4, and 5 through the thick vadose zone to the unconfined aquifer beneath the LLBGs were calculated to be well beyond the 10,000-year period of analysis. Thus all constituents in these classes were eliminated from further consideration. The constituents eliminated from further consideration include diesel fuel, hydraulic fluid, oil, lead, mercury, and PCBs.

Because the constituent list evaluated includes a few volatile organic chemicals, the effect of potential biotic and abiotic degradation and volatization also were examined in the constituent screening process. Table G.50 (see Volume II, Appendix G), which provides generic estimates of the biotic and abiotic degradation for selected chemicals, suggests that degradation, particularly biotic degradation, may be an important factor in reducing inventories of the organic constituents in question. Table G.51 (see Volume II, Appendix G), which provides some laboratory estimates of volatilization rates, suggests that this process also would be important. Consideration of relatively high degradation and volatilization rates for the compounds in question provided the basis for eliminating the volatile organic chemicals within Mobility Class 1 including: 1,1,1-trichloroethane, xylene, toluene, and methylene chloride. No contaminants were identified in Mobility Class 2.

While these organic compounds would be expected to be reduced in source areas by the processes of degradation and volatilization, the impact from breakdown products generated from degradation of the constituents in question potentially exists. While these impacts were not evaluated in detail, the general types of by-product compounds that could be formed were examined qualitatively to identify other potential constituents of concern.

Breakdown products from the above constituents may be produced from combinations of three subsurface processes. Two of these processes include biotic degradation by microorganisms under aerobic or anaerobic conditions. In the absence of viable microbial populations, abiotic degradation, which usually occurs as a result of chemical hydrolysis of the constituent, may also occur. Breakdown of these constituents have generally established degradation pathways resulting in the formation of a number of intermediate breakdown products. Intermediate breakdown products that are regulated would be of most interest from an impact perspective.

A review of established degradation pathways for the four constituents (Jordan and Payne 1980; Truex et al. 2001; Vogel et al. 1987) identified two regulated byproducts of greatest potential concern: 1,1-dichloroethene and vinyl chloride, which would be associated with degradation of 1,1,1-trichloroethane. Methylene chloride produces chloromethane as a breakdown product (EPA 2000a), but chloromethane is not regulated compound. Toluene and xylene produce breakdown products that are common constituents found in lignin (woody materials) and that break down in natural biological cycles. Such breakdown products are not regulated (EPA 2000a).

The final list of constituents considered for further analysis include the remaining inorganic chemicals in Mobility Class 1—chromium, fluoride, and nitrate.

5.3.7.2 Methods and Other Key Assumptions

The following hypothetical groundwater quality impacts associated with hazardous chemicals contained in waste disposed of before 1988 were based on the same source-term release and vadose transport calculations for the main comparative analysis described in Volume II, Appendix G, Sections G.1.3 and G.1.4, for this waste category. Little is known about the actual quantities and distribution of hazardous chemicals, hence the analysis based on the estimated inventory of the selected constituents should be considered an approximation of the potential impacts from these hazardous chemicals in disposed of wastes. For purposes of these calculations, the entire hazardous chemical inventory was conservatively assumed to be uniformly disposed of in wastes contained within the 218-W-4B LLBG in the 200 West Area. The wastes currently disposed of in this LLBG are wastes disposed of prior to 1970.

This analysis made use of the unit-release calculations for pre-1970 wastes in the local-scale groundwater model developed for the 200 West Area described in Volume II, Appendix G, Section G.5.1. The underlying assumptions and analysis characteristics associated specifically with the analysis for pre-1970 LLW described in Section G.5.1 provided the basis for the results described here.

5.3.7.3 Summary of Results

Based on the estimated inventories of the listed constituents assumed to be disposed of before 1988, summarized in Table 5.16 (Volume II, Appendix G), the analysis showed that potential groundwater quality impacts from such hazardous chemicals would not be expected to be substantial. A screening analysis that considered a combination of contamination mobility (due to sorption) and the potential contaminant degradation (due to biotic degradation and volatilization) reduced the initial number of inorganic and organic constituents with the most significant inventories to a list of three chemicals—chromium, fluoride, and nitrate.

For conditions where all of the estimated hazardous chemical inventories for these constituents are hypothetically emplaced in the 218-W-4B LLBG in the 200 West Area, estimated concentration levels at about 100 meters downgradient of the associated low-level waste management area (for example, LLWMA 3) were found to be below benchmark MCLs for all three chemicals (see Table 5.17).

Table 5.17. Estimated Peak Concentrations in Groundwater from Selected Hazardous Chemicals in Waste Hypothetically Disposed of in HSW LLBGs Before 1988

Constituent	Benchmark MCL (mg/L)	Inventory (Kg)	Maximum Concentration[(a)] (mg/L)	Approximate Peak Arrival Time (yrs)
Chromium	0.10	100	0.02	140
Fluoride	4.0	5000[(b)]	1.0	140
Nitrate	10.0[(c)]	5000[(d)]	0.25[(e)]	140

(a) Results are based on hypothetical disposal of these wastes in LLBG 218-W-4B in the 200 West Area, and concentration levels reflect levels estimated at about 100 m downgradient of the LLWMA 4 boundary.
(b) Fluoride mass equivalent in 10,000 kg of sodium fluoride.
(c) Benchmark maximum contaminant level for nitrate is expressed as nitrogen.
(d) Nitrate mass equivalent for 6,000 kg of sodium nitrate.
(e) Concentration expressed as nitrogen.

Actually, waste disposed of before 1988 can be found within multiple burial grounds in the 200 East Area within the 218-E-10 and 218-E-12B LLBGs and in the 200 West Area primarily within the 218-W-4B, 218-W-4C, 218-W-3A, and 218-W-3AE LLBGs. Use of alternative assumptions that would distribute the estimated inventory to multiple LLBGs would result in further reductions in estimated concentration levels at aggregate LLWMA boundaries.

Final closure or remedial investigations of these facilities under RCRA and/or CERCLA guidelines could involve further evaluation of historical waste records, more detailed waste characterization, and a more comprehensive analysis of the potential impacts of the chemical components of these inventories, including potential degradation products.

Results from this qualitative assessment suggest that potential groundwater impacts from the estimated hazardous chemicals inventories hypothetically contained in HSW disposed of before 1988 would not be substantial. This analysis also shows that a substantially larger hazardous chemical inventory would need to be specified for the constituents considered before impacts would approach current benchmark standards.

5.4 Geologic Resources

Impacts on geologic resources would result principally from extraction of basalt, sand, gravel, and silt/loam from the Area C borrow pit for use in capping the disposal facilities upon closure. Geologic resources would also be used for construction of trenches and facilities as well as routine maintenance and operations. The amounts of these geologic resources committed in the alternative groups are quantified in Section 5.10. A comparison among the alternative groups of quantities that would be needed with and without needed ILAW resources is summarized in Table 5.18. (As a result of refined calculations of resource needs based on the Technical Information Document [FH 2004], the need for gravel and sand, silt/loam, and basalt for the action alternative groups increased by factors of approximately 1.8, 2.6, and 1.2, respectively, over those reported in the revised draft HSW EIS [DOE 2003].) Impacts on scenic aspects of topography are described in Section 5.12. No other impacts on geologic resources were identified.[(a)]

Table 5.18. Comparison of Commitments of Geologic Resources, Millions of m^3

Waste Volume	Gravel & Sand	Silt/Loam	Basalt	Total
Alternative Group A (without ILAW)				
Hanford Only	0.776	1.90	0.518	3.19
Lower Bound	0.782	1.91	0.521	3.22
Upper Bound	0.828	2.03	0.552	3.41
Alternative Group B (without ILAW)				
Hanford Only	0.881	2.16	0.587	3.62
Lower Bound	0.895	2.19	0.597	3.68
Upper Bound	1.01	2.47	0.673	4.15
Alternative Group C (without ILAW)				
Hanford Only	0.776	1.90	0.518	3.19
Lower Bound	0.782	1.91	0.521	3.22
Upper Bound	0.828	2.03	0.552	3.41
Alternative Group D (without ILAW)				
Hanford Only	0.777–0.821	1.90–2.01	0.518–0.548	3.20–3.38
Lower Bound	0.780–0.824	1.91–2.02	0.520–0.549	3.21–3.39
Upper Bound	0.807–0.850	1.97–2.08	0.538–0.567	3.32–3.50
Alternative Group E (without ILAW)				
Hanford Only	0.772	1.89	0.515	3.18
Lower Bound	0.775	1.90	0.516	3.19
Upper Bound	0.801	1.96	0.534	3.29
No Action Alternative (without ILAW)				
Hanford Only	0.013	0.031	0.008	0.052
Lower Bound	0.013	0.031	0.008	0.052
ILAW				
Vault	2.603[(b,c)]	NA	NA	NA
Multiple trench	0.770[(b,d)]	NA	NA	NA
Single trench	0.550[(b,e)]	NA	NA	NA

(a) Conversion factors: 1 m^3 = about 1.3 yd^3
(b) Total fill (sand, gravel, silt, and rip rap).
(c) Applicable to the No Action Alternative.
(d) Applicable to Alternative Groups A and B.
(e) Applicable to Alternative Groups C, D, and E.
NA = not applicable.

(a) The use of accelerated process lines would not be expected to require any geologic resources, except for, perhaps, minor amounts of gravel when placed temporarily outside of the CWC.

5.5 Ecological Resources

Potential impacts on ecological resources as a result of implementing Alternative Groups A, B, C, D_1, D_2, D_3, E_1, E_2, and E_3, and the No Action Alternative are discussed in the following sections. Additional information is provided in Appendix I (see Volume II of this EIS).

Near-term impacts on terrestrial habitats and species relate primarily to surface disturbance associated with use of the existing LLBGs, a proposed Hanford solid waste (HSW) disposal facility near the PUREX Plant, borrow sites in Area C from which capping materials would be obtained, and construction sites for new facilities. The potential for impacts during future waste management operations was determined by field surveys in those areas to identify the presence of sensitive species or habitats that might be affected. Potential long-term impacts on aquatic and riparian organisms would be associated with eventual migration of radionuclides and other hazardous chemicals through the vadose zone to groundwater and on to the Columbia River. (Potential impacts to groundwater are presented in Section 5.3.) Results of the field surveys conducted for this HSW EIS, and the methods used to assess long-term impacts are described further in Volume II, Appendix I.

Areas associated with activities described in the HSW EIS have typically been extensively disturbed, or they consist of relatively low quality habitat. These areas were previously designated for waste management operations and conservation/mining in decisions resulting from the Hanford Comprehensive Land-Use Plan EIS (DOE 1999) in order to protect higher quality resources elsewhere on the Hanford Site. DOE manages potential operational impacts on biological resources in accordance with the Hanford Site Biological Resources Management Plan (BRMaP) (DOE-RL 2001a) and the Hanford Site Biological Resources Mitigation Strategy (BRMiS) (DOE-RL 2003c). These plans were developed following extensive public input and in consultation with regulatory agencies. In general, pre-construction surveys of these areas would be conducted, and any mitigation measures needed to protect resources noted during those surveys would be identified and agreed upon by DOE before construction begins. Potential mitigation measures are discussed further in Section 5.18 and in Volume II, Appendix I.

The 24 Command Fire, a range fire that burned over parts of the Hanford Site in late June–early July 2000, removed large amounts of vegetation in areas of interest, particularly in the western half of the 200 West Area and westward and southward from that area (DOE-RL 2000c). The 24 Command Fire did not reach the 200 West LLBGs or the 200 East Area. The lack of vegetation has resulted in considerable movement of soil by wind since the fire. In the absence of similar fires in the future, ecological resources might begin to restore themselves naturally prior to initiation of some project activities. In the near term, nuisance species such as Russian thistle (*Salsola kali*) and cheatgrass (*Bromus tectorum*) likely are to be particularly abundant.

Impacts on ecological resources are sufficiently similar among the alternative groups in that they would not be expected to be an important discriminator in the selection process. Conclusions regarding potential impacts to terrestrial biota were based on spring/summer field surveys conducted from 1998 to 2003. Conclusions regarding potential impacts to Columbia River aquatic and riparian biota were based on an ecological risk assessment of future contaminant releases.

5.5.1 Alternative Group A

5.5.1.1 LLBGs

Currently, the 200 East Area LLBGs contain about 106 ha (262 ac) of land, most of which has been surface disturbed. Approximately 64 ha (158 ac) of this area already have been used for waste disposal. In Alternative Group A, the disposal area would be expanded from about 64 ha to about 66 ha (163 ac) for the Hanford Only and Lower Bound waste volumes and to about 70 ha (173 ac) for the Upper Bound waste volume.

Cheatgrass and Sandberg's bluegrass (*Poa sandbergii*) dominate approximately two-thirds of the 200 East Area LLBGs. The planted perennial, crested wheatgrass (*Agropyron cristatum*), dominates the other one-third. The 200 East Area LLBGs receive regular herbicide applications and thus have limited habitat value for native species. Consequently, continued use of these LLBGs, or new disturbance of the extant plant communities within them via expansion of the disposal area, would not result in the loss of any State of Washington-designated priority habitat.

Several plant species of concern have been noted within the 200 East Area LLBGs. The most notable of these is Piper's daisy (*Erigeron piperianus*), listed by Washington State as a Sensitive species (a taxon that is vulnerable or declining and could become endangered or threatened in Washington without active management or removal of threats). This species was noted on the 218-E-10 and 218-E-12B LLBGs during spring 1999 but not in spring 2000, 2001, or 2002. Piper's daisy populations on these LLBGs have been reduced or eliminated, likely as a result of regular herbicide applications. If herbicide spraying were to cease, these populations could regenerate from buried seed and be disturbed by waste management activities. However, continuing maintenance of the burial grounds is necessary to prevent the growth of deep-rooted species that could transfer contaminants to the surface before final closure. DOE's biological control program is discussed further in Volume II, Appendix I, and in Section 5.11.2.2.4.

The other plant species of concern observed within the 218-E-10 and 218-E-12B LLBGs is crouching milkvetch (*Astragalus succumbens*), a Washington State Watch List species (plant taxon that is of concern but is considered to be more abundant and/or less threatened in Washington than previously assumed). This species was observed in spring 2000, 2001, and 2002 within Trench 94 in the 218-E-12B LLBG and on the northeast side of the 218-E-10 LLBG. Because crouching milkvetch is relatively common on the Central Plateau, disturbance of those individuals on the 218-E-12B and 218-E-10 LLBGs likely would not adversely affect the overall local population.

The 200 West Area LLBGs contain about 319 ha (788 ac), most of which has been surface disturbed. About 67 ha (166 ac) already have been used for burial of solid waste. In Alternative Group A, the disposal area would be expanded from about 67 ha to about 70 ha (173 ac) for the Hanford Only waste volume, to 71 ha (175 ac) for the Lower Bound waste volume, and to 76 ha (188 ac) for the Upper Bound waste volume.

Virtually all the 200 West Area LLBGs are sparsely colonized by cheatgrass, Russian thistle, and crested wheatgrass. These LLBGs also receive regular herbicide applications and thus have limited habitat value for native species. Consequently, continued use of these LLBGs, or new disturbance of the extant plant communities within them via expansion of the disposal area, would not result in the loss of any Washington State-designated priority habitat.

The undeveloped southeastern portion of the 218-W-4C LLBG in the 200 West Area is dominated by mature shrub-steppe, designated a Washington State priority habitat. However, because the 5 ha (12 ac) that currently are being used would not be expanded, no impacts to shrub-steppe are expected.

One plant species of concern has been observed within some of the 200 West LLBGs—stalked-pod milkvetch (*Astragalus sclerocarpus*), a Washington State Watch List species. Stalked-pod milkvetch was observed in spring 1998, 1999, 2000, 2001, and 2002 at the extreme western edge of the 218-W-5 LLBG and within the undeveloped portion of the 218-W-4C LLBG. Because Stalked-pod milkvetch is relatively common on the Central Plateau (Sackschewsky and Downs 2001), disturbance of those individuals on the 218-W-5 and 218-W-4C LLBGs likely would not adversely affect the overall local population.

Wildlife that could be affected by disturbance of the 200 East and 200 West LLBGs includes the mule deer (*Odocoileus hemionus*), Great Basin pocket mouse (*Perognathus parvus*), side-blotched lizard (*Uta stansburiana*), and several migratory bird species. Ground-nesting birds that have been observed and that may nest within the 200 East and 200 West LLBGs include the horned lark (*Eremophila alpestris*), killdeer (*Charadrius vociferous*), long-billed curlew (*Numenius americanus*), and Western meadowlark (*Sturnella neglecta*). If excavation activities were to occur during the nesting season, generally March through July, they could destroy eggs or young birds and temporarily displace nesting individuals into other areas of the Hanford Site. As noted previously in this section and in Volume II, Appendix I, DOE would typically take measures to avoid or mitigate these potential consequences (such as limiting major excavation during the nesting season) before proceeding with construction.

5.5.1.2 HSW Disposal Facility Near the PUREX Plant in the 200 East Area

Currently, the proposed HSW disposal facility near the PUREX Plant contains about 41 ha (101 ac), of which none has been cleared or used for burial of solid waste. The overstory in this area is dominated by sagebrush; the understory is dominated by cheatgrass and Sandberg's bluegrass. Development of the new HSW disposal facility for ILAW near the PUREX Plant would result in the loss of 32 ha (79 ac) (all waste volumes) of shrub-steppe. No plant species of concern were observed on the disposal area near the PUREX Plant during the summer field survey of 2002.

Wildlife that could be affected by disturbance of the new HSW disposal facility near the PUREX Plant includes the black-tailed jackrabbit (*Lepus californicus*), mule deer, coyote (*Canis latrans*), and Northern pocket gopher (*Thomomys talpoides*), as well as several migratory bird species. Shrub- and ground-nesting birds that have been observed and that likely nest within the disposal area near the PUREX Plant include the sage sparrow (*Amphispiza belli*) and Western meadowlark, respectively. If excavation activities were to occur during the nesting season, generally March through July, they could destroy eggs or young birds and temporarily displace nesting individuals into other areas of the Hanford Site. As noted previously in this section and in Volume II, Appendix I, DOE would typically take measures to avoid or mitigate these potential consequences (such as limiting major excavation during the nesting season) before proceeding with construction.

The black-tailed jackrabbit and sage sparrow are considered Washington State Candidate species (species that the Washington Department of Fish and Wildlife will review for possible listing as state-endangered, -threatened, or -sensitive). The distribution of the black-tailed jackrabbit and sage sparrow within Washington is limited mostly to the Columbia Basin. Both species have a strong affinity for sagebrush habitat. The area of sagebrush habitat to be disturbed by waste management activities is small relative to the overall area of such habitat on the Hanford Site and in the Columbia Basin. Consequently, removal of sagebrush within the proposed HSW disposal facility near the PUREX Plant would have, at most, a small impact on populations of these species within the Columbia Basin.

5.5.1.3 Facilities

The CWC and WRAP lie in an industrialized area of about 90 ha (222 ac). No new impacts are expected to result from continued operation of these facilities or installation and operation of APLs to facilitate expedited processing of TRU waste.

The T Plant Complex, which covers about 8 ha (20 ac), also lies within an industrial area and provides habitat only for those birds that use the exterior of these buildings. Because modifications of the T Plant Complex would be carried out within the T Plant, no new impacts are expected.

The 200 Area Effluent Treatment Facility (ETF) and Liquid Effluent Retention Facility (LERF) lie in an industrialized area of about 65 ha (161 ac). No new impacts are expected to result from continued operation of these facilities.

5.5.1.4 Borrow Pit

Basalt, gravel, and silt/loam for use in capping the HSW disposal facilities would be obtained from borrow pits in Area C, an area of about 926 ha (2288 ac). This area also was burned in the 24 Command Fire; however, some of the pre-fire shrub and understory vegetation survived, so the underlying soil surface has not been as severely affected by wind erosion. The associated stockpile area east of SR 240 and the area designated for the conveyance roads to the 200 Areas were burned severely in the 24 Command Fire, removing all the vegetation.

Excavation of borrow materials would require about 69 ha (170 ac), 70 ha (173 ac), and 73 ha (180 ac) for the Hanford Only, Lower Bound, and Upper Bound waste volumes, respectively. Impacts to habitats and species would depend largely on the locations of borrow pits within Area C. The locations of these areas of disturbance have not yet been determined.

Three habitats of concern within Area C may be affected by the excavation of borrow materials, depending on the location of the borrow pits. These three habitats are designated element occurrences of plant community types by the State of Washington Natural Heritage Program (NHP). An element occurrence of a plant community type is one that meets the minimum standards set by NHP for ecological condition, size, and the surrounding landscape. Element occurrences are generally considered to be of substantial conservation value from a state and/or regional perspective. The largest of these is a cheatgrass/needle-and-thread grass/Indian ricegrass community, an element occurrence of the bitterbrush/ Indian ricegrass sand dune complex community type, consisting of 97 ha (241 ac). The other two communities are much smaller. The needle-and-thread grass/cheatgrass community, an element occurrence of the sagebrush/needle-and-thread grass community type, consists of 5 ha (12 ac). The Sandberg's bluegrass/cheatgrass community, an element occurrence of the big sagebrush/bluebunch wheatgrass community type, consists of 1.5 ha (4 ac). These and other habitats that could be disturbed or eliminated by excavation of borrow materials within Area C are discussed in detail in Volume II, Appendix I. As noted previously in this section and in Volume II, Appendix I, DOE typically would establish measures to avoid or mitigate these potential consequences before proceeding with construction.

The only plant species of concern observed in Area C during the summer 2002 field survey were purple mat (*Nama densum* var. *parviflorum*), crouching milkvetch, and stalked-pod milkvetch. Purple mat is a Washington State Review 1 species (plant taxon of potential concern that is in need of additional field work before a status can be assigned). Purple mat occurs occasionally throughout central Hanford, and crouching milkvetch and stalked-pod milkvetch are relatively common on the Central Plateau. Consequently, disturbance of the individual plants located in Area C likely would not adversely affect the overall local populations of these species.

Wildlife that could be impacted by disturbance of Area C includes the badger (*Taxidea taxus*), coyote, elk (*Cervus elaphus*), mule deer, northern pocket gopher, and several migratory birds. No wildlife species of concern were observed in Area C. However, a herd of several hundred elk currently uses the Fitzner/Eberhardt Arid Lands Ecology (ALE) Reserve and surrounding private lands. Elk have been observed using Area C for foraging and loafing. Calving generally occurs at the upper elevations of Rattlesnake Mountain. Blasting and use of heavy equipment to remove borrow materials from Area C, particularly if conducted during the winter months, might disturb elk and displace some animals into adjacent areas. However, because Area C is only a small portion of their overall range and is not known to be particularly important for either overwintering or calving, the effect on the population likely is to be minimal.

The stockpile and conveyance road area currently supports Russian thistle, cheatgrass, and dune scurfpea (*Psoralea lanceolata*). The only plant species of concern observed in this area during the summer 2002 field survey was stalked-pod milkvetch. Because Stalked-pod milkvetch is relatively common on the Central Plateau (Sackschewsky and Downs 2001), disturbance of the individual plants in the stockpile and conveyance road area likely would not adversely affect the overall local population of this species.

The black-tailed jackrabbit is the only wildlife species of concern observed within the stockpile and conveyance road area. Other wildlife species observed include the coyote. Some local jackrabbit mortalities may result from increased vehicular traffic. However, because this area is relatively small and because sagebrush recovery in the area would be expected to be minimal before the start of new construction, the impact of its disturbance on the black-tailed jackrabbit population within the Columbia Basin likely would be minimal.

Ground-nesting birds that have been observed and that may nest in Area C and within the stockpile and conveyance road area include the horned lark and Western meadowlark. If excavation activities were to occur during the nesting season, generally March through July, they could destroy eggs or young birds and temporarily displace nesting individuals into other areas of the Hanford Site. As noted previously in this section and in Volume II, Appendix I, DOE would typically take measures to avoid or mitigate these potential consequences (such as limiting major excavation during the nesting season) before proceeding with construction.

5.5.2 Alternative Group B

5.5.2.1 LLBGs

The impacts on ecological resources in the 200 East and 200 West LLBGs in Alternative Group B would be essentially the same as for Alternative Group A, although the scale of disturbance would be somewhat larger. The area occupied by LLW and MLLW in Alternative Group B would increase by about 15 to 30 percent, depending on waste volume, over that specified in Alternative Group A. Because this expanded area still would be within the boundaries of the existing 200 East and 200 West LLBGs, which have limited habitat value for native species due to regular herbicide applications, any additional impacts on ecological resources are expected to be minimal.

5.5.2.2 Facilities

Impacts from the operation of the CWC, WRAP, APLs, ETF, T Plant Complex, and LERF would be essentially the same as those described for Alternative Group A.

The new waste processing facility would be located just west of WRAP. Constructing this facility would disturb about 4 ha (10 ac) of habitat. This area was burned severely in the 24 Command Fire and continues to be severely eroded by wind. The dominant plant species in the area is bur ragweed (*Ambrosia acanthacarpa*), a native annual. The only wildlife observed in this area was the coyote. No plant or wildlife species of concern occur in the area, except crouching milkvetch. Because crouching milkvetch is relatively common on the Central Plateau, disturbance of individual plants in this area likely would not adversely affect the overall local population of this species.

The CWC expansion area is located north of 16th Street and west of Dayton Avenue to the north-south line of the CWC. This area was burned in the 24 Command Fire and continues to be severely eroded by wind. Disposal of ILAW would disturb about 26 ha (64 ac) of habitat in this area. The dominant plant species in the CWC expansion area is Russian thistle. Stalked-pod milkvetch and purple mat were the only plant species of concern observed in the CWC expansion area. Because purple mat occurs occasionally throughout central Hanford and Stalked-pod milkvetch is relatively common on the

Central Plateau (Sackschewsky and Downs 2001), disturbance of the individual plants of these two species located in the CWC expansion area likely would not adversely affect the overall local populations.

The only wildlife species observed in the CWC expansion area was the coyote. Ground-nesting birds that were observed and may nest within the CWC expansion area include the horned lark and Western meadowlark. If excavation activities were to occur during the nesting season, generally March through July, they could destroy eggs or young birds and temporarily displace nesting individuals into other areas of the Hanford Site. As noted previously in this section and in Volume II, Appendix I, DOE would typically take measures to avoid or mitigate these potential consequences (such as limiting major excavation during the nesting season) before proceeding with construction. No wildlife species of concern were observed in the CWC expansion area.

Although there are no plans at present to use the 218-W-5 Expansion Area, it could be used in the future. The dominant plant species in the 218-W-5 Expansion Area are Sandberg's bluegrass, cheatgrass, Indian ricegrass, and Russian thistle. The only plant species of concern observed in the 218-W-5 Expansion Area were crouching milkvetch, stalked-pod milkvetch, and purple mat. Because purple mat occurs occasionally throughout central Hanford, and crouching milkvetch and stalked-pod milkvetch are relatively common on the Central Plateau, disturbance of the individual plants of these three species located in the 218-W-5 Expansion Area likely would not adversely affect the overall local populations.

Wildlife that could be impacted by disturbance of the 218-W-5 Expansion Area include the badger, coyote, Great Basin pocket mouse, and mule deer. Ground-nesting birds that were observed and may nest within the 218-W-5 Expansion Area include the horned lark and Western meadowlark. If excavation activities were to occur during the nesting season, generally March through July, they could destroy eggs or young birds and temporarily displace nesting individuals into other areas of the Hanford Site. As noted previously in this section and in Volume II, Appendix I, DOE would typically take measures to avoid or mitigate these potential consequences (such as limiting major excavation during the nesting season) before proceeding with construction. No wildlife species of concern were observed in the 218-W-5 Expansion Area.

5.5.2.3 Borrow Pit

Impacts associated with use of Area C in Alternative Group B would be slightly greater compared with those in Alternative Group A because the scale of disturbance would be somewhat larger. The area to be excavated in Alternative Group B would be about 10 to 20 percent greater, depending on waste volume, over that specified in Alternative Group A. The area of the associated stockpile and conveyance road would remain the same in Alternative Group B as in Alternative Group A.

5.5.3 Alternative Group C

5.5.3.1 LLBGs

The impacts on ecological resources in Alternative Group C would be the same as those for Alternative Group A because the areas occupied by LLW and MLLW in Alternative Group C would be the same as those in Alternative Group A.

5.5.3.2 HSW Disposal Facility near the PUREX Plant in the 200 East Area

The impacts on ecological resources in Alternative Group C would be substantially smaller compared with those in Alternative Group A; the scale of disturbance would be reduced by about 55 percent for all waste volumes because of the reduced area required for ILAW disposal.

5.5.3.3 Facilities

Impacts from the operation of the CWC, WRAP, APLs, ETF, LERF, and the T Plant Complex would be essentially the same as those described for Alternative Group A.

5.5.3.4 Borrow Pit

Impacts associated with use of Area C in Alternative Group C would be slightly smaller compared with those in Alternative Group A because the scale of disturbance would be somewhat smaller. The area to be excavated in Alternative Group C would be about 10 percent less for all waste volumes than that specified in Alternative Group A. The area of the associated stockpile and conveyance road would remain the same in Alternative Group C as in Alternative Group A.

5.5.4 Alternative Group D_1

5.5.4.1 LLBGs

Because the 200 East and 200 West LLBGs have limited habitat value for native species due to regular herbicide applications, the impacts on ecological resources in Alternative Group D_1 would be essentially the same as for Alternative Group A, although the scale of disturbance would be somewhat smaller. The LLW and MLLW for all waste volumes in Alternative Group D_1 would use only the areas that already have been used for disposal of solid waste (64 ha [158 ac] in the 200 East LLBGs and 67 ha [166 ac] in the 200 West LLBGs), representing about 5 to 15 percent less area disturbed, depending on waste volume, than Alternative Group A.

5.5.4.2 HSW Disposal Facility near the PUREX Plant in the 200 East Area

The impacts on ecological resources in Alternative Group D_1 would be smaller than those in Alternative Group A. The scale of disturbance in Alternative Group D_1 would be smaller than that of Alternative Group A by about 25 percent for the Upper Bound waste volume but by about 40 percent for the Hanford Only and Lower Bound waste volumes because of the reduced area required for ILAW disposal.

5.5.4.3 Facilities

Impacts from the operation of the CWC, WRAP, APLs, ETF, LERF, and the T Plant Complex would be essentially the same as those described for Alternative Group A.

5.5.4.4 Borrow Pit

Impacts associated with use of Area C in Alternative Group D_1 would be slightly smaller than those in Alternative Group A because the scale of disturbance would be somewhat smaller. The area to be excavated in Alternative Group D_1 would be about 10 percent less for all waste volumes than that specified in Alternative Group A. The area of the associated stockpile and conveyance road would remain the same in Alternative Group D_1 as in Alternative Group A.

5.5.5 Alternative Group D_2

5.5.5.1 LLBGs

Because the 200 West LLBGs have limited habitat value for native species due to regular herbicide applications, the impacts on ecological resources in Alternative Group D_2 would be essentially the same as those in Alternative Group A, although the scale of disturbance would be somewhat smaller. The LLW and MLLW for all waste volumes in Alternative Group D_2 would use only the areas that already have been used for disposal of solid waste (67 ha [166 ac]), representing about 5 to 10 percent less area of disturbance, depending on waste volume, than Alternative Group A.

The impacts on ecological resources in the 200 East LLBGs in Alternative Group D_2 would be essentially the same as those for Alternative Group A, although the scale of disturbance would be somewhat larger due to ILAW disposal. The area occupied by LLW, MLLW, and ILAW in Alternative Group D_2 would be about 25 percent less for all waste volumes over that specified for LLW and MLLW in Alternative Group A. Because this expanded area still would be within the boundaries of the existing 200 East LLBGs, which have limited habitat value for native species due to regular herbicide applications, any additional impacts on ecological resources are expected to be minimal.

5.5.5.2 Facilities

Impacts from the operation of the CWC, WRAP, APLs, ETF, LERF, and the T Plant Complex would be essentially the same as those described for Alternative Group A.

5.5.5.3 Borrow Pit

Impacts associated with use of Area C in Alternative Group D_2 would be slightly less than those in Alternative Group A because the scale of disturbance would be somewhat smaller. The area to be excavated in Alternative Group D_2 would be about 10 percent less for all waste volumes than that specified in Alternative Group A. The area of the associated stockpile and conveyance road would remain the same in Alternative Group D_2 as in Alternative Group A.

5.5.6 Alternative Group D_3

5.5.6.1 LLBGs

Because the 200 East and 200 West LLBGs have limited habitat value for native species due to regular herbicide applications, the impacts on ecological resources in Alternative Group D_3 would be essentially the same as those for Alternative Group A, although the scale of disturbance would be somewhat smaller. The LLW and MLLW for all waste volumes in Alternative Group D_3 would use only the areas that already have been used for disposal of solid waste (64 ha [158 ac] in the 200 East LLBGs and 67 ha [166 ac] in the 200 West LLBGs), representing about 5 to 15 percent less area disturbed, depending on waste volume, than Alternative Group A.

5.5.6.2 ERDF

About 19 to 20 ha (47 to 49 ac) (Hanford Only and Lower Bound waste volumes) to 25 ha (62 ac) (Upper Bound waste volume) at ERDF would be cleared for disposal of ILAW, which most likely would be located just east of the existing ERDF disposal cells. Therefore, the area within 1 km (0.62 mi) of the existing ERDF disposal cells was surveyed in spring 2003. This site and some of the surrounding area, including the area surveyed, was burned in the 24 Command Fire. Currently, vegetation in the surveyed area consists primarily of cheatgrass. The only observed plant species of concern was stalked-pod milkvetch. Stalked-pod milkvetch is relatively common on the Central Plateau (Sackschewsky and Downs 2001). Therefore, disturbance of those individuals in the surveyed area likely would not adversely affect the local population.

Wildlife observed within 1 km of the current ERDF eastern boundary includes the coyote, northern pocket gopher, side-blotched lizard, and several migratory bird species—the horned lark, Western meadowlark, and loggerhead shrike (*Lanius ludovicianus*). The latter species is a Washington State Candidate species and a Federal Species of Concern (species whose conservation standing is of concern to the U.S. Fish and Wildlife Service but for which status information still is needed).

The horned lark and Western meadowlark are ground-nesting species. The same temporal restrictions as set forth above apply for conducting ground-disturbing activities outside the nesting season to protect the nests, eggs, and young of these species in this area. The loggerhead shrike generally nests in shrubs and trees. There are no trees in the surveyed area and shrubs are very scarce. Therefore, it is unlikely that the shrikes observed during the spring 2003 survey were nesting in the surveyed area.

5.5.6.3 Facilities

Impacts from the operation of the CWC, WRAP, APLs, ETF, LERF, and the T Plant Complex would be essentially the same as those described for Alternative Group A.

5.5.6.4 Borrow Pit

Impacts associated with use of Area C in Alternative Group D_3 would be slightly less than those in Alternative Group A because the scale of disturbance would be somewhat smaller. The area to be excavated in Alternative Group D_3 would be about 10 percent less for all waste volumes than that specified in Alternative Group A. The area of the associated stockpile and conveyance road would remain the same in Alternative Group D_3 as in Alternative Group A.

5.5.7 Alternative Group E_1

5.5.7.1 LLBGs

Because the 200 West LLBGs have limited habitat value for native species due to regular herbicide applications, the impacts on ecological resources in Alternative Group E_1 would be essentially the same as in Alternative Group A, although the scale of disturbance would be somewhat smaller. The LLW and MLLW for all waste volumes in Alternative Group E_1 would use only the areas that already have been used for disposal of solid waste (67 ha [166 ac]), representing about 5 to 10 percent less area disturbed, depending on waste volume, than Alternative Group A.

Because the 200 East LLBGs have limited habitat value for native species due to regular herbicide applications, the impacts on ecological resources in Alternative Group E_1 would be essentially the same as in Alternative Group A, although the scale of disturbance would be somewhat larger. The area occupied by LLW and MLLW for all waste volumes in Alternative Group E_1 would be about 5 percent greater than that specified in Alternative Group A.

5.5.7.2 ERDF

Impacts on ecological resources in Alternative Group E_1 would be smaller than those in Alternative Group D_3. The scale of disturbance in Alternative Group E_1 would be less than that in Alternative Group D_3 by about 30 percent for the Hanford Only and Lower Bound waste volumes but by about 45 percent for the Upper Bound waste volume because of the smaller area required for ILAW disposal.

5.5.7.3 Facilities

Impacts from the operation of the CWC, WRAP, APLs, ETF, LERF, and the T Plant Complex would be essentially the same as those described for Alternative Group A.

5.5.7.4 Borrow Pit

Impacts associated with use of Area C in Alternative Group E_1 would be less than those in Alternative Group A because the scale of disturbance would be somewhat smaller. The area to be excavated in Alternative Group E_1 would be about 10 percent less for all waste volumes than that specified in Alternative Group A. The area of the associated stockpile and conveyance road would remain the same in Alternative Group E_1 as in Alternative Group A.

5.5.8 Alternative Group E_2

5.5.8.1 LLBGs

Because the 200 East and 200 West LLBGs have limited habitat value for native species due to regular herbicide applications, the impacts on ecological resources in Alternative Group E_2 would be essentially the same as those in Alternative Group A, although the scale of disturbance would be somewhat smaller. The LLW and MLLW for all waste volumes in Alternative Group E_2 would use only the areas that already have been used for disposal of solid waste (64 ha [158 ac] in the 200 East LLBGs and 67 ha [166 ac] in the 200 West LLBGs), representing about 5 to 15 percent less area of disturbance, depending on waste volume, than Alternative Group A.

5.5.8.2 ERDF

The impacts on ecological resources in Alternative Group E_2 would be smaller than those in Alternative Group D_3. The scale of disturbance in Alternative Group E_1 would be less than that in Alternative Group D_3 by about 30 percent for the Hanford Only and Lower Bound waste volumes but by about 45 percent for the Upper Bound waste volume because of the smaller area required for ILAW disposal.

5.5.8.3 HSW Disposal Facility near the PUREX Plant in the 200 East Area

The impacts on ecological resources in Alternative Group E_2 would be much smaller compared with those in Alternative Group A; the scale of disturbance would be about 65 percent less for the Upper Bound waste volume and about 85 percent less for the Hanford Only and Lower Bound waste volumes because of the smaller area required for ILAW disposal.

5.5.8.4 Facilities

Impacts from the operation of the CWC, WRAP, APLs, ETF, LERF, and the T Plant Complex would be essentially the same as those described for Alternative Group A.

5.5.8.5 Borrow Pit

Impacts associated with use of Area C in Alternative Group E_2 would be slightly smaller than those in Alternative Group A because the scale of disturbance would be somewhat smaller. The area to be excavated in Alternative Group E_2 would be about 10 percent less for all waste volumes than that specified in Alternative Group A. The area of the associated stockpile and conveyance road would remain the same in Alternative Group E_2 as in Alternative Group A.

5.5.9 Alternative Group E_3

5.5.9.1 LLBGs

Because the 200 East and 200 West LLBGs have limited habitat value for native species due to regular herbicide applications, the impacts on ecological resources in Alternative Group E_3 would be essentially the same as those in Alternative Group A, although the scale of disturbance would be somewhat smaller. The LLW and MLLW for all waste volumes in Alternative Group E_3 would use only the areas that already have been used for disposal of solid waste (64 ha [158 ac] in the 200 East LLBGs and 67 ha [166 ac] in the 200 West LLBGs), representing about 5 to 15 percent less area disturbed, depending on waste volume, than Alternative Group A.

5.5.9.2 ERDF

The impacts on ecological resources in Alternative Group E_3 would be much smaller compared with those in Alternative Group A because the scale of disturbance would be about 60 percent less for the Upper Bound waste volume and about 75 percent less for the Hanford Only and Lower Bound waste volumes.

5.5.9.3 HSW Disposal Facility near the PUREX Plant in the 200 East Area

The impacts on ecological resources in Alternative Group E_3 would be substantially smaller compared with those in Alternative Group A; the scale of disturbance would be about 55 percent less for all waste volumes because of the smaller area required for ILAW disposal.

5.5.9.4 Facilities

Impacts from the operation of the CWC, WRAP, APLs, ETF, LERF, and the T Plant Complex would be essentially the same as those described for Alternative Group A.

5.5.9.5 Borrow Pit

Impacts associated with use of Area C in Alternative Group E_3 would be slightly smaller than those in Alternative Group A because the scale of disturbance would be somewhat smaller. The area to be excavated in Alternative Group E_3 would be about 10 percent less for all waste volumes from that specified in Alternative Group A. The area of the associated stockpile and conveyance road would remain the same in Alternative Group E_3 as in Alternative Group A.

5.5.10 No Action Alternative

5.5.10.1 LLBGs

The impacts on ecological resources in the 200 West LLBGs in the No Action Alternative would be essentially the same as those in Alternative Group A, although the scale of disturbance would be somewhat larger. The area occupied by LLW and MLLW in the No Action Alternative would be about 13 percent greater for the Hanford Only and Lower Bound waste volumes over that specified in Alternative Group A. Because this expanded area still would be within the boundaries of the existing 200 West LLBGs, which have limited habitat value for native species due to regular herbicide applications, any additional impacts on ecological resources would be expected to be minimal.

Because the 200 East LLBGs have limited habitat value for native species due to regular herbicide applications, the impacts on ecological resources in the No Action Alternative would be essentially the same as those in Alternative Group A, although the scale of disturbance would be somewhat larger. The area occupied by LLW and MLLW for the Hanford Only and Lower Bound waste volumes in the No Action Alternative would be about 3 percent larger than that specified in Alternative Group A.

5.5.10.2 HSW Disposal Facility near the PUREX Plant in the 200 East Area

Impacts on ecological resources in the No Action Alternative would be much smaller compared with those in Alternative Group A. The scale of disturbance would be about 70 percent less for the Hanford Only and Lower Bound waste volumes because of the smaller area required for ILAW disposal.

5.5.10.3 Facilities

Impacts from the operation of the CWC, WRAP, APLs, T Plant Complex, ETF, and LERF would be essentially the same as those described for Alternative Group A.

The CWC expansion in the No Action Alternative is intended for the purpose of facilities construction, whereas the CWC expansion in Alternative Group B is intended for the purpose of ILAW disposal. These two CWC expansion areas occur at different but nearby locations. Both locations were burned in the 24 Command Fire, and the ecological resources at both sites are essentially the same.

Consequently, the impacts on ecological resources in the CWC expansion area for the Hanford Only waste volume for the No Action Alternative would be essentially the same as those in Alternative Group B, although the scale of disturbance would be about 10 percent smaller.

Likewise, the impacts on ecological resources in the CWC expansion area for the Lower Bound waste volume for the No Action Alternative would be essentially the same as those in Alternative Group B, although the scale of disturbance would be about 15 percent larger.

5.5.10.4 Borrow Pit

Impacts associated with use of Area C in the No Action Alternative would be very small compared with those in Alternative Group A because the scale of disturbance would be about 80 percent less for the Hanford Only and Lower Bound waste volumes. The area of the associated stockpile and conveyance road would remain the same in the No Action Alternative as in Alternative Group A.

5.5.11 Microbiotic Crusts

Disruption of microbiotic crusts (cryptogams) may result in decreased diversity of microbiota, soil nutrients, and organic matter (Belnap and Harper 1995; Belnap et al. 2001). The 24 Command Fire during summer 2000 intensely burned the soil surface in areas (outside the LLBGs) that would be disturbed by new construction as described in the HSW EIS (that is, Area C and the associated stockpile and conveyance road areas, the two CWC expansion areas identified for facilities construction and ILAW disposal, and the area identified for the new waste processing facility). This undoubtedly resulted in the destruction of soil microbiota, facilitating the severe wind erosion experienced in these areas (Becker and Sackschewsky 2001; Sackschewsky and Becker 2001). Recovery of microbiotic crusts following disturbance is generally a slow process. For example, in burned areas on the ALE Reserve, soil algae recovery took place during the winter months of the second year following the fire of 1984 (Johansen et al. 1993). The recovery time required by soil microbiota following construction is no exception.

Although microbiotic crusts may tolerate shallow burial, deep burial such as would result from construction described in the HSW EIS will kill crusts (Shields et al. 1957). Recolonization of Area C and the associated stockpile and conveyance road area, the two CWC expansion areas identified for facilities construction and ILAW disposal, and the area identified for the new waste processing facility undoubtedly would require several years following construction, the speed of which may depend largely on the availability of nearby sources of cryptogams (Belnap 1993). Consequently, a temporary loss of benefits derived from microbiotic crusts would ensue.

5.5.12 Threatened or Endangered Species

In November 1998, DOE initiated consultation with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) regarding the LLBGs. At that time, DOE requested a listing of federally protected species that might occur in these and other areas potentially disturbed by waste management activities. The FWS response, which identified species protected under the Endangered Species Act (ESA), contained no species known to occur in the LLBGs and other project areas covered under the 1998 consultation (see Volume II, Appendix I, Attachment B). In addition, these same areas have been surveyed annually under the DOE Ecological Compliance Assessment Project (DOE-RL 1995), and no federally protected species have been documented (see Volume II, Appendix I of the HSW EIS).

However, the footprint of potential surface disturbance since has expanded beyond that of 1998 (for example, addition of Area C). Consequently, DOE re-initiated consultation with the NMFS and FWS in March 2002 (see Volume II, Appendix I, Attachment B), again requesting a listing of federally protected species that could occur in all areas potentially disturbed by waste management activities. The NMFS responded by telephone on April 26, 2002, and provided a web site (http://www.nwr.noaa.gov/1habcon/habweb/listnwr.htm) containing currently listed threatened and endangered species in the Pacific Northwest (see Volume II, Appendix I, Attachment B). The FWS responded in April 2002 by letter containing currently listed threatened and endangered species that may be present near the proposed project site in Benton County (see Volume II, Appendix I, Attachment B). The NMFS- and FWS-listed threatened and endangered species known to occur on the Hanford Site are tabulated in Section 4.6.4.

In February 2003, DOE again requested from the FWS a listing of federally protected species that could occur in all areas potentially disturbed by waste management activities (Volume II, Appendix I, Attachment B). DOE revisited the NMFS web site noted above in March 2003. The FWS responded by letter in February 2003 (see Volume II, Appendix I, Attachment B). The result of revisiting the NMFS web site also is provided in Attachment B of Volume II, Appendix I.

The terrestrial habitats that potentially could be disturbed have been surveyed previously, and none of the federally listed threatened or endangered species tabulated in Section 4.6.4 were observed (see Volume II, Appendix I). The aquatic endangered species that potentially could be affected are the upper Columbia River spring-run evolutionarily significant unit (ESU) of Chinook salmon (*Oncorhynchus tshawytscha*) and the upper Columbia River ESU of steelhead (*Oncorhynchus mykiss*). Spring Chinook salmon do not spawn within the Hanford Reach; instead, the reach is used by in-migrating salmon as a passage corridor and by out-migrating juvenile salmon as a corridor and for interim feeding. Steelhead are present in the Hanford Reach all year, with most adults residing from 6 to 8 months. Juveniles usually spend 1 to 3 years in freshwater before migrating downstream to the ocean. It has long been believed that limited spawning occurs within the Hanford Reach (DOE-RL 2000b). This was verified in February 2003 when at least two redds were observed near the shoreline of the 300 Area (Lohn 2004, Sackschewsky et al. 2003 [see Volume II, Appendix O]). The risk of future adverse effects to these two species posed by contaminants migrating through the vadose zone and into groundwater, and ultimately entering the Columbia River, is expected to be negligible (see Volume II, Appendix I).

The threatened bull trout (*Salvelinus confluentus*) spends the majority of its life cycle in Columbia River tributaries, of which the Hanford Reach has none. The bull trout has been observed only a very few times in the Hanford Reach within the last 30 years. Consequently, the probability that this species could be exposed to contaminants reaching the Columbia River would be near zero. In addition, the risk of future adverse effects to the bull trout posed by contaminants migrating through the vadose zone and into the groundwater, and, ultimately, entering the Columbia River, would be negligible (see Volume II, Appendix I). Critical habitat for the bull trout is proposed for the mainstem Columbia River, including the Hanford Reach. No actions that would physically modify proposed critical habitat for this species would occur under any of the alternative groups of the HSW EIS. Further, because the species occurs so rarely in the Hanford Reach, contaminants reaching the Columbia River would not be expected to affect its use of proposed critical habitat.

5.5.13 Potential Impacts on Columbia River Aquatic and Riparian Biota in the Long Term

Leaching of radionuclides and other hazardous chemicals from the waste via infiltrating precipitation would eventually result in small quantities of long-lived mobile radionuclides reaching the Columbia River. The following is a general discussion of the risk of future adverse impacts to Columbia River aquatic and riparian biota posed by these contaminant releases within 10,000 years of 2046, and of risk as a discriminator among the alternative groups.

Risk of radiological impacts is not an important discriminator among the alternative groups within 0 to 2500 years following 2046 (see Volume II, Appendix I, Section I.3.4). However, in the time period 2,500 to 10,000 years following 2046, risks of radiological impacts are about one order of magnitude higher in the No Action Alternative and about half an order of magnitude higher in Alternative Group B than in the other alternative groups (see Volume II, Appendix I, Section I.3.4). These higher risks are the result of larger quantities of uranium reaching the river environment in the latter time period under the conditions inherent in these two alternative groups. Further, the risks of uranium chemical toxicological impacts to terrestrial and aquatic animal receptors are about two orders of magnitude higher for the No Action Alternative and about one order of magnitude higher for Alternative Group B than for the other alternative groups during the time period extending from 2,500 to 10,000 years after 2046 (see Volume II, Appendix I, Section I.3.5). These relative risks are described below in absolute terms.

Based on results presented in Volume II, Appendix I, Section I.3.5, the risk of radiological impacts to aquatic and terrestrial animals and plants from future contaminant releases would be very small. The risk of chronic uranium chemical toxicological impacts to terrestrial animal receptors also would be very small. The risk of chronic uranium chemical toxicological impacts to the carp (*Cyprinus carpio*), largescale/mountain sucker (*Catostomus macrocheilus*/*C. platyrhynchus*), and smallmouth bass (*Micropterus dolomieui*) would be negligible. The risk of uranium chemical toxicological impacts to all other aquatic animal species evaluated would be less than that of these three fish species, with the possible exception of the Woodhouse's toad (*Bufo woodhousii*) tadpole. The potential impact on this species is inconclusive because of the lack of species-specific uranium uptake and toxicity data and uncertainty regarding the applicability of available data (from fish studies) used to prepare risk calculations for this species in the HSW EIS (see Volume II, Appendix I, Section I.3.5). However, impacts to Woodhouse's toad populations are unlikely considering 1) the conservatism in the groundwater modeling that produced the uranium concentrations used in the risk assessment (see Volume II, Appendix G of this EIS) and 2) the assumption of simultaneous exposure to maximum uranium concentrations entering the river at different times from different disposal facilities. Uranium chemical toxicological impacts, if any, would not occur until approximately 10,000 years following 2046.

5.6 Socioeconomics

The primary socioeconomic region of interest is the Richland-Kennewick-Pasco metropolitan statistical area, comprising Benton and Franklin counties in Washington state (Tri-Cities region), where the vast majority of the socioeconomic impacts would be expected. Because the Tri-Cities region is the major retail and service center for the Hanford Site and its employees, over 90 percent of whom also live in Benton and Franklin counties, relatively little impact would be expected on the economies of the surrounding counties (Grant, Adams, Yakima, and Walla Walla counties in Washington or Umatilla County in Oregon) as a result of actions related to management of solid waste at Hanford.

The socioeconomic impacts are classified in terms of primary and secondary. Changes in Hanford employment and non-labor expenditures associated with the various alternative groups for dealing with LLW, MLLW, TRU waste, and ILAW are classified as primary impacts. Additional changes that result in the general regional economy and community as a result of these primary changes are classified as secondary effects. Examples of secondary impacts include changes in retail and service employment or changes in demand for housing. The total socioeconomic impact in the region is the sum of the primary and secondary impacts. Based on this analysis, the implementation of any of the HSW EIS alternative groups likely would have very small impacts on the local socioeconomic infrastructure, for instance housing, schools, medical support, and transportation.

Estimates of total employment impacts were calculated using a variant of the IMPLAN regional economic model (Minnesota IMPLAN Group, Inc. 1997) for the Tri-Cities region. These estimates were checked for consistency with the less-detailed estimates produced for the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (WM PEIS) (DOE 1997a) using the Regional Input-Output Modeling System (RIMS) of the U.S. Bureau of Economic Analysis. Allowing for differences in methods, the more-detailed estimates produced for the HSW EIS are in general agreement, but at the lower end of the range, with those produced by the earlier, less-detailed analysis in the WM PEIS. The HSW EIS estimate reports the changes in employment and earnings based on the most recently available historical data. The reports indicate that 93 percent of Hanford employees reside in the Tri-Cities region and that about 81 percent of all non-labor procurements made by Hanford management and operations contractors occur in the same region.

Impacts other than employment and income are largely based on changes in population, with respect to current capacities of the local roads, schools, waste and water treatment, and other elements of local infrastructure. Historical geographic patterns of settlement are assumed to persist.

For purposes of this analysis, a baseline forecast of budgets and employment at Hanford was constructed that reflect October 2001 budget plans and estimates at the U.S. Department of Energy (DOE), Richland Operations Office; DOE, Office of River Protection; and the Pacific Northwest National Laboratory for DOE and non-DOE work. The baseline was necessary to provide perspective on the size of changes in Hanford activity that may occur as a result of actions to manage Hanford solid waste. Table 5.19 shows the baseline scenario.

Because the time pattern of spending is different under each of the alternative groups, Figure 5.24 depicts the level of Hanford employment as a simple way of showing how the solid waste program scenarios compare both with each other and total Hanford activity over time. Because the Hanford Solid Waste Program is an ongoing function, even the No Action Alternative has changing levels of employment and spending associated with it. For purposes of the socioeconomic analysis, all impacts were calculated as changes from conditions in 2002. For example, Hanford Solid Waste Program employment rises from the 2002 level of roughly 435 to levels over 750, and then eventually declines below 200. The corresponding impacts on direct employment are roughly +350 workers and -200 workers, relative to current conditions. The analysis calculates the direct and indirect socioeconomic impacts of these changes in direct employment and associated programmatic spending at the Hanford Site. Figure 5.25 shows solid waste program employment in each case relative to the 2002 level. The time patterns of total spending are similar for Alternative Groups A through E, as shown in Figure 5.26. Alternative Groups C, D_1, D_2, D_3, E_1, E_2, and E_3 all have virtually identical levels of spending and employment in each year, and all are similar to Alternative Group A. To simplify Figures 5.24 through 5.26, Alternative Groups C through E are represented by Alternative Group C.

Non-labor costs play a relatively larger role in the No Action Alternative (Lower Bound waste volume), so that total costs in that case peak in about 2005 at $150 million and again in 2013 at about $132 million (with corresponding employment peaks), decline until 2023, reach a plateau between 2023 and 2032, and then finally decline for good. All costs are just slightly lower in the No Action Alternative when the Hanford Only waste volume is considered. In analyzing the socioeconomic impacts of the alternative groups, emphasis was placed on finding years between 2002 and 2046 showing the largest impacts, either positive or negative. Because the time pattern of spending is different under each of the alternative groups, the largest impacts (positive or negative) sometimes occur in different years.

Table 5.19. Hanford Budget and Direct Employment Associated with Baseline Conditions

Variable	2002–2009	2010-2020	2021–2032	2033–2046
Budget (in millions)[a,b]	$2,000–$2,300	$1,450–$2,250	$800–$1,450	$550–800
Hanford Jobs[b]	11,700–15,200	9,200–11,700	7,550–9,250	6,150–7,500

(a) Budget is in 2002 dollars.
(b) Maximum and minimum during the period. Jobs rounded to nearest 50; budget to nearest 50 million. These values provide bounds for impacts.

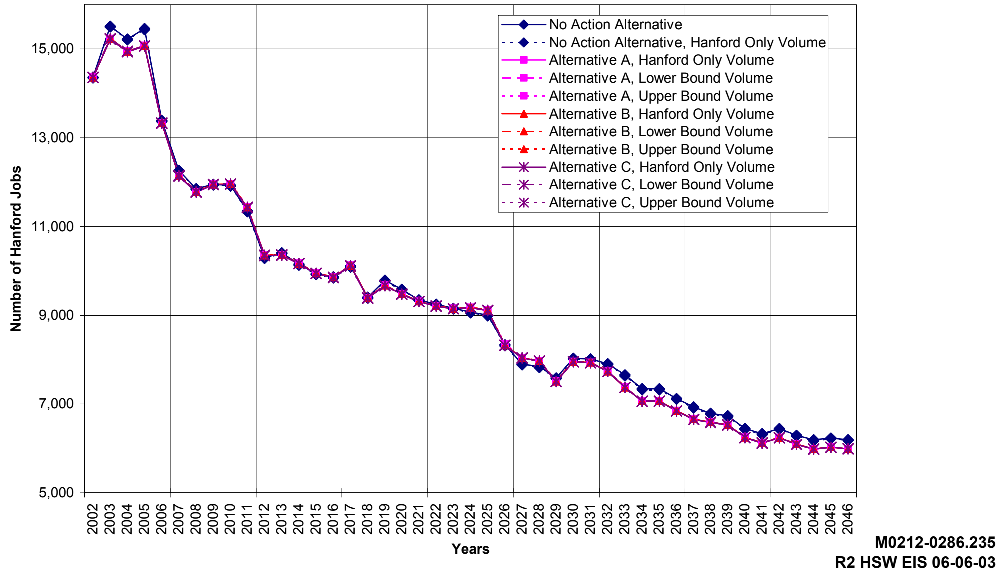


Figure 5.24. Impact of HSW EIS Alternative Groups on Total Hanford Employment

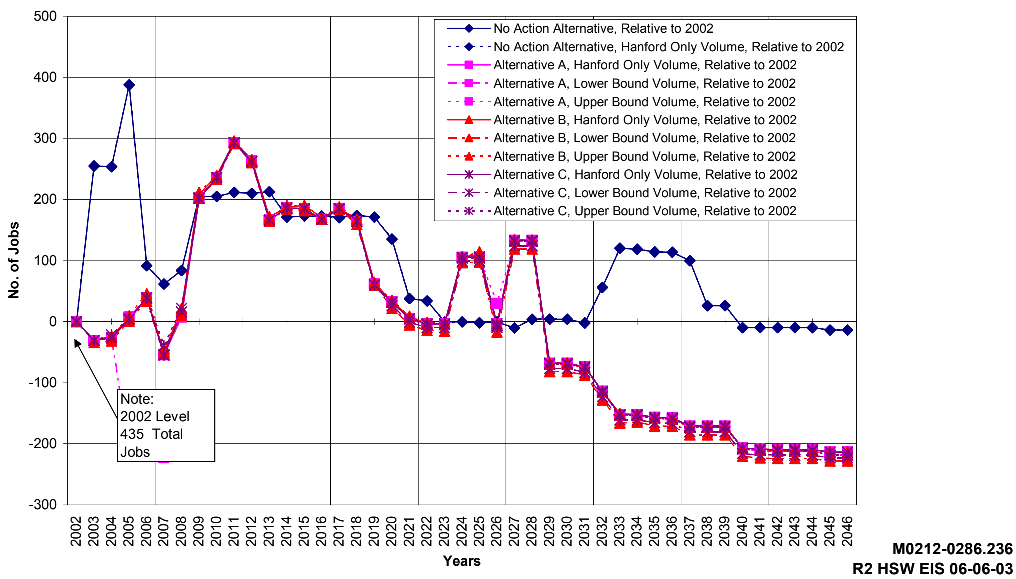


Figure 5.25. Impact of HSW EIS Alternative Groups on Solid Waste Program Employment

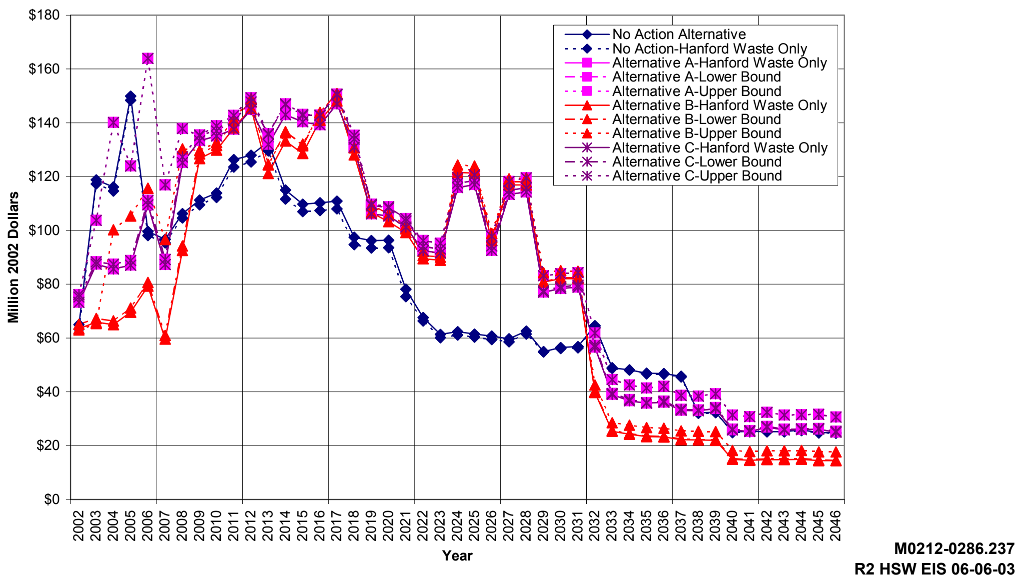


Figure 5.26. Impact of HSW EIS Alternative Groups on Solid Waste Program Total Costs

5.6.1 Alternative Group A

Table 5.20 shows the employment and population changes related to construction and operations of the additional required facilities relative to those expected under baseline conditions for certain key years.

For purposes of this analysis, the general level of employment and budget at the Hanford Site is assumed to follow the level discussed previously under the baseline conditions. Population impacts were calculated at 1.3 times total employment impacts, consistent with DOE (1996a). An unknown number of current Hanford workers could be reassigned to operations activities, reducing immigration to the region below the estimates shown in this section. Construction activity is assumed to require a normal proportion of new construction workers coming into the region.

Estimates of Hanford primary jobs and budget for LLW, MLLW, and TRU waste operations are provided in the Technical Information Document (FH 2004) for Alternative Group A. Primary jobs and budget for ILAW operations were calculated in support of the ILAW EIS, which now has been merged with this document. For construction activity, FH (2004) and the ILAW documentation report the construction year or years, total labor-years required, and schedule. This procedure resulted in an estimate of the number of jobs by year, consistent with the peak year and total labor-years required.

Table 5.20. Socioeconomic Impacts Associated with Alternative Group A, Relative to Baseline Conditions[(a)]

Alternative Group A	2011	2017	2032	2046
Hanford Solid Waste Program Total Budget (Million 2002$)				
Hanford Only Volume	$138	$147	$57	$25
Lower Bound Volume	$141	$150	$57	$25
Upper Bound Volume	$143	$151	$62	$31
Hanford Jobs[(b)]				
Solid Waste Program Total, Hanford Only Volume	750	650	350	250
Solid Waste Program Total, Lower Bound Volume	800	650	350	250
Solid Waste Program Total, Upper Bound Volume	750	650	350	250
Impact, Hanford Only Volume	*300*	*200*	*(100)*	*(200)*
Impact, Lower Bound Volume	*300*	*200*	*(100)*	*(200)*
Impact, Upper Bound Volume	*300*	*200*	*(100)*	*(200)*
Non-Labor Procurements (Million 2002$)[(b)]				
Solid Waste Program Total, Hanford Only Volume	$83	$100	$30	$6
Solid Waste Program Total, Lower Bound Volume	$85	$102	$31	$6
Solid Waste Program Total, Upper Bound Volume	$88	$103	$35	$11
Impact, Hanford Only Volume	*$45*	*$61*	*($8)*	*($33)*
Impact, Lower Bound Volume	*$46*	*$63*	*($9)*	*($34)*
Impact, Upper Bound Volume	*$47*	*$62*	*($6)*	*($29)*
Tri-Cities Region Jobs Impacts[(c)]				
Hanford Only Volume	*1,400*	*1,450*	*(350)*	*(1,000)*
Lower Bound Volume	*1,400*	*1,500*	*(400)*	*(1,050)*
Upper Bound Volume	*1,450*	*1,500*	*(350)*	*(1,000)*
Population Change Impacts[(c)]				
Hanford Only Volume	*1,800*	*1,900*	*(500)*	*(1,350)*
Lower Bound Volume	*1,800*	*1,950*	*(500)*	*(1,400)*
Upper Bound Volume	*1,850*	*1,900*	*(450)*	*(1,250)*

(a) Numbers in parentheses denote lower level of activity (negative impact) relative to baseline conditions. Area jobs and population rounded to nearest 50.
(b) Hanford Solid Waste Program totals and positive or negative impact or change (italicized text) relative to 2002. These impacts provide the basis for area-wide impacts.
(c) Maximum positive or negative impact only.

The solid waste program budget under Alternative Group A is projected to peak in 2017, with employment slightly higher in 2011. In 2011, solid waste program employment is expected to be about 750 to 800 for the Hanford Only, Lower Bound, and Upper Bound waste volumes, representing an increment of about 300 to 350 to the baseline. Additionally, there is an increment to non-labor procurements of $83 to $88 million relative to the baseline (see Table 5.20). The largest total impact on community employment (Hanford and non-Hanford workers) in the Tri-Cities region would be about +1,450 to +1,500 relative to the baseline in 2017. In Alternative Group A, the level of solid waste program employment and spending is above that in the No Action Alternative for the period 2007 through 2032. Employment falls below 2002 levels beginning about the year 2029, and spending does the same in 2032, reflecting an incremental reduction in the DOE mortgage (that is, ongoing annual costs of managing and safekeeping facilities and wastes from former activities) at the Hanford Site. As a result, a slight negative impact would occur on the economy after about 2032.

The population impact is expected to peak in 2017, with an increase in population of 1,900 to 1,950, representing an increase of about 1 percent over the 2000 Census population of 191,822 (Census 2000a, 2000b). Because most communities can usually handle an increase in population of up to 5 percent without disruption in services (Gilmore and Duff 1975), the effects on demand for community infrastructure and services would be small due to the impact of the solid waste program alone. The impact of the long-term reduction in population of 1,250 to 1,400 shown in Table 5.20 is about 0.7 percent of the 2000 baseline. The infrastructure impacts likely would be very small.

5.6.2 Alternative Group B

Estimates of Hanford primary jobs and budget for LLW, MLLW, and TRU waste operations and construction are provided in the Technical Information Document (FH 2004) for Alternative Group B. Primary jobs and budget for ILAW operations were calculated in support of the ILAW EIS, which now has been merged with this document.

Table 5.21 shows the employment and population changes related to construction and operations of the additional required facilities relative to those expected under baseline conditions for certain key years. The scenarios in Alternative Group B achieve their peak positive impact on economic activity in 2017, with the peak total Tri-Cities employment impact reaching about 1,650 above baseline conditions for the Hanford Only waste volume and 1,750 for the Upper Bound waste volume. The peak total of Tri-Cities employment increases represents a 2 percent increase over the 1999 baseline of 88,100 (DOE-RL 2000a), the last year for which complete data are available. After 2030, the largest negative impact on employment is the loss of 950 to 1,100 jobs relative to the baseline in the year 2046.

Corresponding population increases and decreases range from +2,150 to 2,250 in 2017 to -1,250 to -1,400 in 2046, representing an increase of about 1.2 percent relative to the 2000 Census population of 191,822 (Census 2000a, 2000b) and a decrease of 0.7 percent relative to the 2000 Census value. By themselves, these figures imply that the incremental impact on demand for community infrastructure and services likely would be very small.

Table 5.21. Socioeconomic Impacts Associated with Alternative Group B, Relative to Baseline Conditions[(a)]

Alternative Group B	2011	2017	2032	2046
Hanford Solid Waste Program Total Budget (Million 2002$)				
Hanford Only Volume	$138	$148	$40	$14
Lower Bound Volume	$141	$151	$40	$15
Upper Bound Volume	$141	$151	$40	$18
Hanford Jobs[(b)]				
Solid Waste Program Total, Hanford Only Volume	800	700	350	250
Solid Waste Program Total, Lower Bound Volume	800	700	350	250
Solid Waste Program Total, Upper Bound Volume	800	700	350	250
Impact, Hanford Only Volume	*300*	*200*	*(100)*	*(200)*
Impact, Lower Bound Volume	*300*	*200*	*(150)*	*(250)*
Impact, Upper Bound Volume	*300*	*200*	*(100)*	*(200)*
Non-Labor Procurements (Million 2002$)[(b)]				
Solid Waste Program Total, Hanford Only Volume	$83	$100	$13	$5
Solid Waste Program Total, Lower Bound Volume	$85	$102	$13	$5
Solid Waste Program Total, Upper Bound Volume	$86	$102	$15	$2
Impact, Hanford Only Volume	*$55*	*$72*	*($15)*	*($33)*
Impact, Lower Bound Volume	*$56*	*$73*	*($16)*	*($34)*
Impact, Upper Bound Volume	*$58*	*$75*	*($12)*	*($29)*
Tri-Cities Region Jobs Impacts[(c)]				
Hanford Only Volume	*1,550*	*1,650*	*(500)*	*(1,000)*
Lower Bound Volume	*1,600*	*1,700*	*(550)*	*(1,100)*
Upper Bound Volume	*1,650*	*1,700*	*(450)*	*(950)*
Population Change Impacts[(c)]				
Hanford Only Volume	*2,050*	*2,150*	*(650)*	*(1,350)*
Lower Bound Volume	*2,050*	*2,200*	*(700)*	*(1,400)*
Upper Bound Volume	*2,100*	*2,250*	*(600)*	*(1,250)*

(a) Numbers in parentheses denote lower level of activity (negative impact) relative to baseline conditions. Area jobs and population rounded to nearest 50.
(b) Hanford Solid Waste Program totals and positive or negative impact or change (italicized text) relative to 2002. These impacts provide the basis for area-wide impacts.
(c) Maximum positive or negative impact only.

5.6.3 Alternative Group C

Estimates of Hanford primary jobs and budget for LLW, MLLW, and TRU waste operations and construction are derived from the Technical Information Document (FH 2004) for Alternative Group C. Primary jobs and budget for ILAW operations were calculated in support of the ILAW EIS, which now has been merged with this document.

Table 5.22 shows the employment and population changes related to construction and operations of the additional required facilities relative to those expected under baseline conditions for certain key years. The scenarios in Alternative Group C achieve their peak positive impact on economic activity in 2017, where projected employment increases of 1,450 to 1,500 represent a 1.7 percent increase over the 1999 baseline of 88,100 (DOE-RL 2000a), the last year for which complete data are available. After 2030, the largest negative impact on employment is the loss of 950 to 1,050 jobs relative to the baseline in the year 2046.

Corresponding population increases and decreases range from +1,900 to +1,950 in 2017 to -1,250 to -1,400 in 2046, representing an increase of about 1 percent relative to the 2000 Census population of 191,822 (Census 2000a, 2000b) and a decrease of 0.7 percent relative to the 2000 Census value. By themselves, these figures imply that an incremental impact on demand for community infrastructure and services likely would be very small.

5.6.4 Alternative Group D

Estimates of Hanford primary jobs and budget for LLW, MLLW, and TRU waste operations and construction are derived from the Technical Information Document (FH 2004) for Alternative Group D. Primary jobs and budget for ILAW operations were calculated in support of the ILAW EIS, which now has been merged with this document. It is assumed there is no difference in cost and employment among Alternative Groups D_1, D_2, and D_3, as similar activities are conducted in different onsite locations that have similar characteristics.

Table 5.23 shows the employment and population changes related to construction and operations of the additional required facilities relative to those expected under baseline conditions for certain key years. The scenarios in Alternative Group D achieve their peak positive impact on economic activity in 2017, with the peak total Tri-Cities employment impact reaching about 1,450. The peak total of Tri-Cities employment increases represents a 1.6-percent increase over the 1999 baseline of 88,100 (DOE-RL 2000a), the last year for which complete data are available. After 2030, the largest negative impact on employment is the loss of 950 to 1,050 jobs relative to the baseline in the year 2046.

Corresponding population increases and decreases range from +1,900 in 2017 to -1,250 to -1,350 in 2046, representing a net increase of about 1 percent relative to the 2000 Census population of 191,822 (Census 2000a, 2000b) and a decrease of 0.7 percent relative to the 2000 Census value. By themselves, these figures imply that incremental impact on demand for community infrastructure and services likely would be very small.

Table 5.22. Socioeconomic Impacts Associated with Alternative Group C, Relative to Baseline Conditions[(a)]

Alternative Group C	2011	2017	2032	2046
Hanford Solid Waste Program Total Budget (Million 2002$)				
Hanford Only Volume	$138	$147	$57	$25
Lower Bound Volume	$141	$150	$57	$25
Upper Bound Volume	$143	$151	$62	$31
Hanford Jobs[(b)]				
Solid Waste Program Total, Hanford Only Volume	750	650	350	250
Solid Waste Program Total, Lower Bound Volume	800	650	350	250
Solid Waste Program Total, Upper Bound Volume	750	650	350	250
Impact, Hanford Only Volume	*300*	*200*	*(100)*	*(200)*
Impact, Lower Bound Volume	*300*	*200*	*(100)*	*(200)*
Impact, Upper Bound Volume	*300*	*200*	*(100)*	*(200)*
Non-Labor Procurements (Million 2002$)[(b)]				
Solid Waste Program Total, Hanford Only Volume	$83	$100	$30	$6
Solid Waste Program Total, Lower Bound Volume	$85	$102	$31	$6
Solid Waste Program Total, Upper Bound Volume	$88	$103	$35	$11
Impact, Hanford Only Volume	*$45*	*$61*	*($8)*	*($33)*
Impact, Lower Bound Volume	*$46*	*$63*	*($9)*	*($34)*
Impact, Upper Bound Volume	*$47*	*$62*	*($6)*	*($29)*
Tri-Cities Region Jobs Impacts[(c)]				
Hanford Only Volume	*1,400*	*1,450*	*(350)*	*(1,000)*
Lower Bound Volume	*1,400*	*1,500*	*(400)*	*(1,050)*
Upper Bound Volume	*1,400*	*1,450*	*(350)*	*(950)*
Population Change Impacts[(c)]				
Hanford Only Volume	*1,800*	*1,900*	*(500)*	*(1,350)*
Lower Bound Volume	*1,800*	*1,950*	*(550)*	*(1,400)*
Upper Bound Volume	*1,850*	*1,900*	*(450)*	*(1,250)*

(a) Numbers in parentheses denote lower level of activity (negative impact) relative to baseline conditions. Area jobs and population rounded to nearest 50.
(b) Hanford Solid Waste Program totals and positive or negative impact or change (italicized text) relative to 2002. These impacts provide the basis for area-wide impacts.
(c) Maximum positive or negative impact only.

Table 5.23. Socioeconomic Impacts Associated with Alternative Group D, Relative to Baseline Conditions[(a)]

Alternative Group D	2011	2017	2032	2046
Hanford Solid Waste Program Total Budget (Million 2002$)				
Hanford Only Volume	$138	$147	$56	$25
Lower Bound Volume	$140	$150	$59	$27
Upper Bound Volume	$143	$151	$64	$33
Hanford Jobs[(b)]				
Solid Waste Program Total, Hanford Only Volume	750	650	350	250
Solid Waste Program Total, Lower Bound Volume	800	650	350	250
Solid Waste Program Total, Upper Bound Volume	800	650	350	250
Impact, Hanford Only Volume	*300*	*200*	*(100)*	*(200)*
Impact, Lower Bound Volume	*300*	*200*	*(100)*	*(200)*
Impact, Upper Bound Volume	*300*	*200*	*(100)*	*(200)*
Non-Labor Procurements (Million 2002$)[(b)]				
Solid Waste Program Total, Hanford Only Volume	$83	$91	$30	$6
Solid Waste Program Total, Lower Bound Volume	$85	$102	$32	$8
Solid Waste Program Total, Upper Bound Volume	$89	$104	$37	$13
Impact, Hanford Only Volume	*$45*	*$61*	*($8)*	*($33)*
Impact, Lower Bound Volume	*$45*	*$62*	*($8)*	*($33)*
Impact, Upper Bound Volume	*$46*	*$61*	*($6)*	*($30)*
Tri-Cities Region Jobs Impacts[(c)]				
Hanford Only Volume	*1,400*	*1,450*	*(350)*	*(1,000)*
Lower Bound Volume	*1,400*	*1,450*	*(350)*	*(1,050)*
Upper Bound Volume	*1,400*	*1,450*	*(350)*	*(950)*
Population Change Impacts[(c)]				
Hanford Only Volume	*1,800*	*1,900*	*(500)*	*(1,350)*
Lower Bound Volume	*1,800*	*1,900*	*(500)*	*(1,350)*
Upper Bound Volume	*1,850*	*1,900*	*(450)*	*(1,250)*

(a) Numbers in parentheses denote lower level of activity (negative impact) relative to baseline conditions. Area jobs and population rounded to nearest 50.
(b) Hanford Solid Waste Program totals and positive or negative impact or change (italicized text) relative to 2002. These impacts provide the basis for area-wide impacts.
(c) Maximum positive or negative impact only.

5.6.5 Alternative Group E

Estimates of Hanford primary jobs and budget for LLW, MLLW, and TRU waste operations and construction are derived from the Technical Information Document (FH 2004) for Alternative Group E. Primary jobs and budget for ILAW operations were calculated in support of the ILAW EIS, which now has been merged with this document. Primary jobs and budget for Alternative Group E ILAW operations are assumed to be the same as in Alternative Group D. It is assumed there is no difference in cost and employment among Alternative Groups E_1, E_2, and E_3, as similar activities are conducted in different onsite locations that have similar characteristics.

Impacts on employment and population are the same as those for Alternative Group D (see Section 5.6.4)

5.6.6 No Action Alternative

Estimates of Hanford primary jobs and budget for LLW, MLLW, and TRU waste construction and operations are provided in the Technical Information Document (FH 2004) for the No Action Alternative, Lower Bound volume. Costs and budget for the No Action Alternative with the Hanford Only waste volume are nearly the same as for the Lower Bound volume and are derived by scaling for the slightly lower volume of wastes handled in the Hanford Only waste volume case. Primary jobs and budget for ILAW operations were calculated in support of the ILAW EIS, which now has been merged with this document.

Total employment at Hanford is currently expected to increase by as much as 3,000 jobs (from the 2001 level of 12,000, the last year of historical data) through 2005, as the Hanford Waste Treatment Plant is constructed and begins operations (see Figure 5.22). Overall, the activity associated with the No Action Alternative would add increases in annual budgets of as much as $150 million in 2005 (an increase of $82 million from the level in 2002) and up to 400 additional jobs onsite to this baseline. After 2040, employment in solid waste management operations would fall to about the baseline value, as shown in Figure 5.23, while the solid waste management budget would decline below the 2002 level by 2032 (see Figure 5.24). Overall, the Tri-Cities socioeconomic conditions would continue as they currently are, with employment increasing and fluctuating in the short run and generally declining over the long-term.

Table 5.24 shows the current solid waste program budget, employment, and estimated non-labor procurements that would continue under the No Action Alternative.

In 2002, the solid waste management program (including ILAW) required a total budget of about $68 million and employed slightly over 400 workers. As shown in Figure 5.23, in 2005 (the highest direct employment year), about 400 additional employees beyond 2002 levels would be needed to operate and support the solid waste program (over 800 total). This is also the year with the largest impact on total community employment (Hanford and non-Hanford workers), with about 1,800 workers needed beyond baseline levels (see Table 5.24). This impact relative to 2002 is noticeable but not large (about 2 percent of the 1999 base of 88,100 total non-farm jobs) (DOE-RL 2000a). Area population might increase above baseline by as many as 2,350 people, or about 1.3 percent of the 2000 Census population of 191,822 (Census 2000a, 2000b).

Table 5.24. Socioeconomic Impacts Associated with the No Action Alternative, Relative to Baseline Conditions[(a)]

No Action Alternatives	2005	2013	2032	2046
Hanford Solid Waste Program Total Budget (Million 2002$)				
Hanford Only Volume	$148	$130	$64	$25
Lower Bound Volume	$150	$133	$65	$25
Hanford Jobs[(b)]				
Solid Waste Program Total, Hanford Only Volume	850	700	500	450
Solid Waste Program Total, Lower Bound Volume	850	700	550	450
Impact, Hanford Only Volume	*400*	*200*	*50*	*(0)*
Impact, Lower Bound Volume	*400*	*200*	*50*	*(0)*
Non-Labor Procurements (Million 2002$)[(b)]				
Solid Waste Program Total, Hanford Only Volume	$86	$80	$26	0
Solid Waste Program Total, Lower Bound Volume	$86	$82	$25	0
Impact, Hanford Only Volume	*$54*	*$47*	*($10)*	*($38)*
Impact, Lower Bound Volume	*$54*	*$48*	*($10)*	*($39)*
Tri-Cities Region Jobs Impact[(c)]				
Impact, Hanford Only Volume	*1,800*	*1,350*	*50*	*(700)*
Impact, Lower Bound Volume	*1,800*	*1,400*	*50*	*(700)*
Population Change Impacts[(c)]				
Impact, Hanford Only Volume	*2,350*	*1,750*	*50*	*(900)*
Impact, Lower Bound Volume	*2,350*	*1,800*	*50*	*(950)*

(a) Numbers in parentheses denote lower level of activity (negative impact) relative to baseline conditions. Area jobs and population rounded to nearest 50.
(b) Hanford Solid Waste Program totals and positive or negative impact or change (italicized text) relative to 2002. These impacts provide the basis for area-wide impacts.
(c) Maximum positive or negative impact only.

5.7 Cultural Resources Impacts

This section describes the potential impact of implementing the alternative groups as previously stated in this HSW EIS on Hanford Site cultural resources, namely archaeological sites, archaeological features, artifacts, and historic buildings. In addition, several places in the vicinity of the 200 Areas have had, and continue to have, traditional roles in Native American creation beliefs and the cultural heritage of the Wanapum, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Yakama Nation. These places include, but are not limited to, the Columbia River, Gable Mountain, Gable Butte, and Rattlesnake Mountain.

Archaeological surveys of all undeveloped portions of the 200 East Area and a random sample of 50 percent of undeveloped portions of the 200 West Area indicate no findings of archaeological sites. However, some small sites exist within the boundaries of the 200 East and 200 West Areas (Chatters and Cadoret 1990).

A prominent archaeological resource located in the 200 Areas is an extensive linear feature known as the White Bluffs Road, a portion of which passes diagonally southwest to northeast through the 200 West Area. The road in its entirety was determined eligible for listing in the National Register of Historic Places (National Register). Segments of the White Bluffs Road that are located in the 200 West Area, however, have been determined to be non-contributing. Such non-contributing segments of the White Bluffs Road are those that do not add to the historic significance of the road, but retain evidence of its contiguous bearing.

Originally used as a Native American trail, the White Bluffs Road played a role in Euro-American immigration, development, agricultural, and Hanford Site operations. The White Bluffs Road survey of 2000 recorded an additional 54 historic isolated artifacts and 2 prehistoric isolated finds, as well as 6 cans. In addition, 58 buildings and structures in the 200 East and 200 West Areas have been determined eligible for the National Register as contributing properties within the Historic District recommended for individual documentation (Neitzel 2001). Mitigation has been completed for these buildings and structures.

Previous archaeological investigations and historical research indicate that Native Americans used sites throughout the Cold Creek Valley, primarily near water sources, for campgrounds, ceremonial uses, plant gathering, hunting, and possibly the grazing of cattle and horses from the prehistoric period to 1943. Ethno-historic research suggests that Native American use of Area C was limited to travel through the vicinity to destinations along the Columbia and Yakima rivers. There is a possibility that Native American use of the area prior to Euro-American contact, even extending as far back as 10,000 years, occurred. If so, the archaeological remains associated with that area and time period likely have been buried by sand dune activity and wind blown deposition.

Both Native Americans and Euro-Americans used trails and roads, such as the White Bluffs Road, to the west and north of Area C. Research also indicates a well-used trail connected the Benson Ranch (on the western boundary of Area C) to Rattlesnake Springs. Historic maps show the Ellensburg to Yakima River Road passed through Rattlesnake Springs and traversed the central and southern sections of Area C as early as 1881. A four-wheel drive dirt road in the northern section of Area C, parallel to Dry Creek, connected Cold Creek Valley with the city of Richland prior to the construction of State Route 240 through the Hanford Site. Historic occupations in the Cold Creek Valley seem to have been centered on sheep and cattle grazing and the raising of horses. Farmsteads have been identified west of Area C where irrigation water from Rattlesnake Springs allowed for the cultivation of alfalfa and grain.

For activities associated with this HSW EIS, cultural resources surveys have been conducted of Area C (borrow pit site); the T Plant Complex; the CWC and 218-W-5 LLBG expansion areas; the proposed ILAW disposal facility in the 200 East Area near the PUREX Plant; the melter trench in the 200 East and 200 West Areas; groundwater well installations in the 200 West Area; and lined modular facility locations in the 200 Area East, near the PUREX Plant, and at ERDF. Details are provided in Volume II, Appendix K, as are copies of consultation letters with the State of Washington Office of Archaeology and Historic Preservation.

Installation and operation of mobile accelerated process lines would be within the CWC buildings or near the TRU waste trenches and, based on surveys of those areas, there would appear to be no potential for impacts on cultural resources.

Because Area C is within the viewshed from Rattlesnake Mountain, the project might have an indirect effect on the characteristics that contribute to the cultural and religious significance of Rattlesnake Mountain to local tribes. Additional information on aesthetic and scenic impacts of these activities is presented in Section 5.12.

Section 5.18 provides information regarding the protection of cultural resources discovered during construction or operations.

5.7.1 Alternative Group A

The principal potential for impacts on cultural resources in Alternative Group A (Hanford Only, Lower Bound, and Upper Bound waste volumes) is associated with obtaining materials for the Modified RCRA Subtitle C Barrier to be placed over the disposal sites. This material, which includes basalt, sand, gravel, and silt/loam, would be obtained from a borrow pit in Area C, the location of which is shown in Volume II, Appendix D, Figure D.9. The borrow pit is within an area of about 926 ha (2287 ac), of which about 73 ha (180 ac) would be the maximum area excavated.

There is a reasonable likelihood that archaeological sites are located within Area C. However, any sites are likely to be buried, as the field reconnaissance failed to locate any on the surface. Little is known about the pre-contact use of the Cold Creek Valley; thus, any sites located there would provide an opportunity to gain new knowledge about prehistoric life. Further, if campsites or village sites were found, human remains and possibly cemeteries might also be located there.

Prior to construction activities associated with waste management operations, additional research as well as a 100-percent pedestrian archaeological survey would be needed to identify and address potential cultural impacts. Given the possibility for buried deposits, some methodology would likely be needed to observe the subsurface. Depending upon conditions or circumstances, ground-penetrating radar, shovel testing, or backhoe testing might be appropriate, as would monitoring for cultural resources during construction. Frequency of monitoring may range from continuous to intermittent to periodic.

Modifications to the T Plant Complex are not expected to impact significant cultural resources. Any effects to T Plant have been mitigated through Historic American Engineering Record documentation and through historical narratives and individual building documentation compiled in *History of Plutonium Production Facilities at the Hanford Site Historic District, 1943-1990* (DOE-RL 2002a).

Cultural resources surveys of the proposed locations of the ILAW disposal facility, melter trench, and groundwater well installations in the 200 East and West Areas were conducted. The surveys concluded that the proposed locations in Alternative Group A would have no effect on historic properties in the 200 East and West Areas.

5.7.2 Alternative Group B

In Alternative Group B, the potential for impacts on cultural resources at the Area C borrow pit would be slightly greater than those for Alternative Group A, based on the area being disturbed in order to obtain the materials required for the Modified RCRA Subtitle C Barrier for the LLBGs.

In this alternative group, a new waste processing facility would be located directly west of WRAP in the 200 West Area. Previous cultural resources surveys conducted in the CWC expansion area concluded that no known historic properties or archaeological resources are located within the footprint of the new facility.

As in Alternative Group A, cultural resources surveys of the proposed locations of the ILAW disposal facility (and multiple lined trenches in the 200 West Area), melter trench, and groundwater well installations were conducted. The surveys concluded that the proposed locations in Alternative Group B would have no effect on historic properties in the 200 East and West Areas.

5.7.3 Alternative Group C

In Alternative Group C, the potential for impacts on cultural resources at the Area C borrow pit would be slightly less than those for Alternative Groups A and B, based on the area being disturbed in order to obtain the materials required for the Modified RCRA Subtitle C Barrier for the LLBGs.

In this alternative group, LLW would be located in the 200 West Area, MLLW would be located in the 200 East Area, and ILAW and the melter trench would be located near the PUREX Plant. Previous cultural resources surveys conducted in the CWC expansion area concluded that no known historic properties or archaeological resources are located within these areas.

As in Alternative Groups A and B, cultural resources surveys of the proposed locations of the ILAW disposal facility (and multiple lined trenches in the 200 West Area), melter trench, and groundwater well installations were conducted. The surveys concluded that the proposed locations in Alternative Group C would have no effect on historic properties in the 200 East and West Areas.

5.7.4 Alternative Group D

This alternative group contains three subalternative groupings that depend on the location of disposal in a lined modular facility. D_1 would locate the disposal facility near the PUREX Plant, D_2 would locate the disposal facility in the 200 East LLBGs, and D_3 would locate the disposal facility at ERDF between the 200 East and 200 West areas.

In Alternative Group D, the potential for impacts on cultural resources at the Area C borrow pit would be slightly less than those for Alternative Groups A, B, and C, based on the area being disturbed in order to obtain the materials required for the Modified RCRA Subtitle C Barrier for the LLBGs.

As in Alternative Groups A, B, and C, cultural resources surveys of the proposed locations of the ILAW disposal facility (and multiple lined trenches in the 200 West Area), melter trench, and groundwater well installations were conducted. The surveys concluded that the proposed locations in this alternative group would have no effect on historic properties in the 200 East and West Areas, as well as at ERDF, as called out in Alternative Group D_3.

5.7.5 Alternative Group E

This alternative group contains three subalternative groupings that depend on the location of disposal in lined modular facilities. E_1 would locate the LLW and MLLW disposal facilities in the 200 East LLBGs and the melters and ILAW at ERDF, E_2 would locate the LLW and MLLW disposal facilities near the PUREX Plant and the melters and ILAW at ERDF, and E_3 would locate the LLW and MLLW disposal facilities at ERDF and the melters and ILAW near the PUREX Plant.

In Alternative Group E, the potential for impacts on cultural resources at the Area C borrow pit would be the same as those for Alternative Group D and slightly less than the potential for impacts for Alternative Groups A, B, and C, based on the area being disturbed in order to obtain the materials required for the Modified RCRA Subtitle C Barrier for the LLBGs.

As in Alternative Groups A, B, C, and D, cultural resources surveys of the proposed locations of the ILAW disposal facility (and multiple lined trenches in the 200 West Area), melter trench, and groundwater well installations were conducted. The surveys concluded that the proposed locations in this alternative would have no effect to historic properties in the 200 East and West Areas, as well as at ERDF, as called out for in Alternative Group $D_{3,}$ and the other subalternatives in this grouping.

5.7.6 No Action Alternative

The No Action Alternative consists essentially of the continuation of current solid waste management practices.

In the No Action Alternative, materials would only be needed for a Modified RCRA Subtitle C Barrier over the two existing MLLW trenches in the 200 West Area and the Hanford Barrier over ILAW near the PUREX Plant at closure. Thus the amount of material required from the borrow pit would be substantially smaller than that for action alternative groups. Regardless, the same approach would be necessary to protect presently undisclosed cultural resources in the Area C borrow pit.

In addition, the CWC would be expanded to store MLLW and TRU waste that could not be treated or disposed of elsewhere. About 36 ha (89 ac) directly south of the existing CWC buildings would be needed, as would about 30 ha (74 ac) in the 218-W-5 Expansion Area just to the west of the CWC. Staff of the Hanford Cultural Resources Laboratory conducted a records and literature search that revealed the CWC expansion area has been previously surveyed for cultural resources. The cultural resources surveys concluded that no known historic properties or archaeological resources are located within the CWC expansion area.

5.8 Traffic and Transportation

Presented in this section are the results of an evaluation of the impacts of onsite shipments of LLW, MLLW (including melters), TRU wastes (including mixed TRU wastes), and ILAW to treatment and disposal facilities; shipments of LLW, MLLW, and TRU wastes from offsite to Hanford; shipments of TRU wastes from Hanford to WIPP; and the shipment of construction and capping materials. The methods and data used in this analysis are described in detail in Volume II, Appendix H.

The types of potential transportation impacts evaluated and the approaches taken to quantify the transportation impacts are summarized in the following paragraphs.

Radiological impacts of routine (incident-free) transport. These potential impacts result from routine or incident-free transportation of radioactive materials where the shipments arrive at their destinations without release of the shipment's contents. The potential impacts would result from exposure of truck crews and populations on or near the highways to low levels of radiation emitted from shipping containers containing radioactive materials. The RADTRAN 5 computer code (Neuhauser et al. 2003) was used to estimate the potential impacts of incident-free transportation of waste materials. Route data were developed using the TRAGIS computer code (Johnson and Michelhaugh 2000), the current version of which is based on the 2000 Census. Because most of the shipments would occur in the next decade, the population estimates were not adjusted over time.

Radiological impacts of vehicular accidents. These potential impacts would result from accidental releases of radioactive material in transit. Accident impacts are determined by combining the probabilities and consequences of potential transportation accidents, ranging from minor to severe accidents, and then integrating them over the entire shipping campaign. The RADTRAN 5 computer code was used to quantify these impacts. An analysis of the impacts of severe but highly unlikely TRU waste accidents is also presented (see Volume II, Appendix H, Section H.3.2.3.2). Given the range of accidents and the resulting impacts analyzed in this EIS, these impacts were considered to also represent those that could occur from a terrorist attack (see Volume II, Appendix H, Section H.8).

Non-radiological impacts of routine (incident-free) transportation. Non-radiological impacts of routine transportation are the potential health effects that would result from routine emissions of hydrocarbon pollutants and dust from the truck tractors used to haul waste and capping and construction materials. These non-radiological impacts are estimated using a unit-factor approach (that is, latent cancer fatalities per kilometer) using data from Biwer and Butler (1999).

Non-radiological impacts of vehicular accidents. The metric used for these potential impacts is the number of fatalities that would result from physical trauma as a result of vehicular accidents involving the heavy trucks used to transport waste and construction and capping materials. A unit-factor approach based on accidents and fatalities per kilometer was used to estimate these non-radiological accident impacts. Unit-factor data were taken from Green et al. (1996) for onsite shipments and from Saricks and Tompkins (1999) for offsite shipments.

Hazardous chemical impacts of vehicular accidents. These potential impacts would result from accidental releases of hazardous chemical constituents contained in mixed waste (including TRU mixed waste). A maximum credible accident approach was used to estimate the impacts. Hazardous chemical release and atmospheric dispersion calculations were performed to determine the maximum downwind concentration from a postulated maximum credible accident to which an individual might be exposed. The downwind concentrations were compared to safe exposure levels for each chemical to determine the potential public and worker impacts. These potential impacts were considered to also represent those that could occur from a successful terrorist attack.

Figure 5.27 illustrates the number of shipment-miles for each waste volume and alternative group. In general, the Hanford Only waste volume for the No Action Alternative results in the fewest shipment-miles because the volume of TRU wastes shipped offsite is lowest for the No Action Alternative and there are no shipments to Hanford from offsite. The Upper Bound waste volume for the action alternative groups results in the highest shipment-miles because of the relatively large volumes of TRU wastes shipped from Hanford to WIPP and offsite LLW, MLLW, and TRU wastes shipped to Hanford.

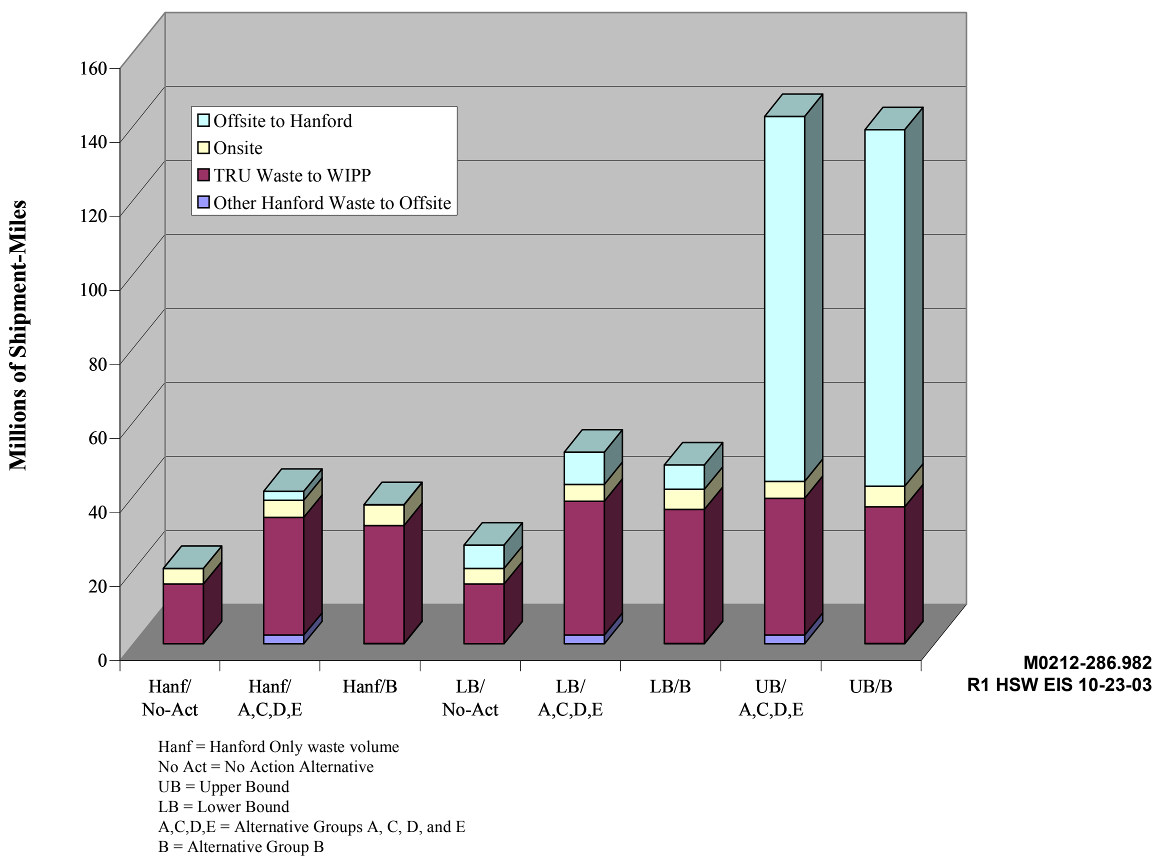


Figure 5.27. Shipment-Miles for Onsite and Offsite Waste Shipments

Table 5.25 presents the results, for the Hanford Only waste volume, of the analysis of potential transportation impacts of shipping LLW, MLLW, TRU wastes, and ILAW onsite, and shipping small volumes of LLW and MLLW to offsite treatment facilities and back. All of the impacts provided in Table 5.25 are in fatalities, except for the estimated number of traffic accidents. Fatalities are expressed in terms of latent cancer fatalities (LCFs) for radiological impacts and routine non-radiological emissions and in terms of trauma-induced fatalities for non-radiological accidents. (Many of the entries in the table are expressed as fractional fatalities, for example, 1E-01 or 0.1 fatalities. However, fatalities occur only as whole numbers and the totals have been obtained by rounding to the nearest whole number.)

Table 5.25. Summary of Potential Radiological and Non-Radiological Transportation Impacts - Hanford Only Waste Volumes, All Alternative Groups[(a)(b)]

Waste Type	Radiological Impacts, LCFs			Total Number of Accidents	Non-Radiological Impacts	
	Occupational	Non-Occupational	Radiological Accidents		Accident Fatalities	Emissions, LCFs
	Alternative Groups A, C, D, E					
LLW	6E-03	4E-02	3E-06	7.1E-01	3.1E-02	3E-02
MLLW	2E-02	1E-01	2E-06	1.8	4.7E-02	2E-01
TRU	3E-03	3E-02	7E-06	9.1E-02	3.9E-03	4E-03
ILAW	5 E-03	7E-02	2E-09	5.4E-02	2.3E-03	3E-03
Total	0 (3.8E-02)	0 (2E-01)	0 (1E-05)	3 (2.6)	0 (8.5E-02)	0 (2E-01)
	Alternative Group B					
LLW	6E-03	4E-02	3E-06	7.1E-01	3.1E-02	3E-02
MLLW	2E-03	1E-02	2E-07	2.8E-01	1.0E-02	2E-02
TRU	3E-03	3E-02	7E-06	9.1E-02	3.9E-03	4E-03
ILAW	5E-02	7E-01	2E-08	5.4E-01	2.3E-02	3E-02
Total	0 (6E-02)	1 (8E-01)	0 (1E-05)	2 (1.6)	0 (6.8E-02)	0 (8E-02)
	No Action Alternative					
LLW	6E-03	4E-02	3E-06	7.1E-01	3.0E-02	3E-02
MLLW	3E-03	2E-02	7E-08	3.4E-01	1.5E-02	1E-02
TRU	3E-03	4E-02	9E-06	1.1E-01	4.7E-03	5E-03
ILAW	Intrafacility Transfer					
Total	0 (1E-02)	0 (9E-02)	0 (1E-05)	1 (1.2)	0 (5.0E-02)	0 (5E-02)

Note: Totals are rounded to one significant figure. Due to rounding, the sums of the numbers in the table may not exactly match the totals.

(a) Table 5.25 presents the results, for the Hanford Only waste volume, of the analysis of the potential transportation impacts of shipping LLW, MLLW, TRU wastes, and ILAW onsite in addition to small volumes of Hanford LLW and MLLW offsite for treatment and back. This table does not include the potential transportation impacts of shipping TRU wastes from Hanford to WIPP for disposal. These potential impacts are presented in Table 5.26.

(b) Radiological impacts (incident-free and accident) are expressed in units of latent cancer fatalities (LCFs). Non-radiological accident impacts are expressed as the expected number of accidents and the resulting non-radiological fatalities. Non-radiological emission impacts are expressed as LCFs.

Table 5.25 indicates that the No Action Alternative results in the lowest total (that is, the sums across all waste types) potential onsite radiological impacts of all the alternative groups. This is primarily because, under the No Action Alternative, ILAW would be placed in concrete vaults adjacent to the Waste Treatment Plant (WTP) and, thus, is assumed not to involve transportation. The volume of TRU wastes shipped to WIPP is also lower for the No Action Alternative than for the action alternative groups. Of the action alternatives, Alternative Group B has the largest total potential radiological incident-free impacts. Potential radiological incident-free impacts are dominated by the large volume and high number of shipments of ILAW to a disposal facility located in the 200 West Area. The potential radiological incident-free impacts associated with ILAW transportation are lower for Alternative Groups A, C, D, and E than for Alternative Group B, because in Alternative Groups A, C, D, and E, the shipping distance is shorter since the ILAW disposal facility is assumed to be located in the 200 East Area (the WTP is also located in the 200 East Area). None of the alternative groups was predicted to result in a radiological fatality from onsite shipments of TRU wastes and ILAW, including the Hanford Only waste volumes of MLLW and LLW that would be shipped to offsite treatment facilities and back.

Total non-radiological impacts are also lowest under the No Action Alternative. However, for the action alternatives, the potential impacts are larger for Alternative Groups A, C, D, and E than they are for Alternative Group B. This is because the potential non-radiological impacts are dominated by the shipments of MLLW to the Oak Ridge Reservation (ORR) for treatment and back. There are fewer shipments to ORR and back in Alternative Group B than in Groups A, C, D, and E. None of the action alternative groups was predicted to result in a non-radiological fatality from onsite shipments of solid waste, including the Hanford Only waste volumes of LLW and MLLW that would be shipped to offsite treatment facilities and back.

The potential impacts of shipments of solid waste to Hanford and shipments of TRU wastes from Hanford to WIPP are summarized in Table 5.26. Actual highway routes to and from Hanford were used in the analysis. The table presents the impacts of shipping LLW, MLLW, and TRU wastes from offsite to Hanford, and shipments of TRU wastes from Hanford to WIPP. For the Hanford Only and Lower Bound waste volumes, updated information was obtained from the Solid Waste Integrated Forecast Technical (SWIFT) report (Barcot 2002) to reflect the best available TRU waste volume projections for onsite and offsite (see Volume II, Appendix C). A recent study by DOE (DOE 2002c) to accelerate disposal of TRU wastes considered the creation of a "western hub" to certify TRU wastes from small-quantity sites for shipment to WIPP. Hanford is one of the sites being considered as a potential western hub. If Hanford is designated as a western hub, additional TRU wastes may be shipped from small-quantity sites to Hanford for certification and temporary storage prior to shipment to WIPP for disposal. For purposes of the analysis in this HSW EIS, additional quantities of TRU wastes assumed to be shipped to Hanford as a potential hub site are included in the Upper Bound waste volume, as discussed in Volume II, Appendix C.

As shown in Table 5.26, shipments of the Hanford Only waste volume of TRU waste to WIPP under the No Action Alternative result in the lowest potential radiological impacts. The next highest potential radiological impacts were estimated for the Hanford Only waste volume of TRU waste shipments to WIPP for the action alternatives. There are only small differences between the potential radiological impacts for the Hanford Only (action alternatives) and the Lower Bound waste volumes. These differences in potential impacts are due to the small quantities of LLW, MLLW, and TRU wastes that would be shipped to Hanford and the small additional TRU waste volume that would be shipped from Hanford to WIPP under the Lower Bound waste volume case. The highest potential radiological impacts were estimated for the Upper Bound waste volume. The Upper Bound waste volume case results in higher potential impacts than the other alternative groups because of the LLW, MLLW, and the additional TRU wastes that would be shipped to Hanford and from Hanford to WIPP.

Table 5.26. Summary of Radiological and Non-Radiological Transportation Impacts for Offsite Shipments by Waste Type[(a)]

Waste Type	Radiological Impacts: Routine Transport, LCFs: Worker	Radiological Impacts: Routine Transport, LCFs: Public	Radiological Impacts: Accidents, LCFs: Public	Total Number of Accidents	Non-Radiological Impacts: Fatalities	Non-Radiological Impacts: Emissions LCFs
Hanford Only Waste Volume (TRU Waste—No Action Alternative)						
CH TRU to WIPP	0 (2E-01)	1 (1E+00)	0 (4E-03)	8 (8E+00)	0 (2.8E-01)	0 (2E-01)
Hanford Only Waste Volume (TRU Waste—Action Alternatives)						
CH TRU to WIPP	2E-01	2E+00	5E-03	1E+01	4E-01	2E-01
RH TRU to WIPP	1E-01	2E+00	3E-03	6E+00	2E-01	1E-01
Total	0 (3E-01)	4 (4.4)	0 (8E-03)	17 (17)	1 (5E-01)	0 (3E-01)
Lower Bound Waste Volume						
LLW to Hanford	3E-02	1E-01	3E-03	3E+00	1E-01	1E-01
MLLW to Hanford	2E-04	1E-03	5E-05	3E-02	8E-04	1E-03
CH-TRU Waste to Hanford	6E-05	6E-04	2E-06	4E-03	1E-04	2E-04
RH-TRU Waste to Hanford	1E-03	4E-02	3E-05	8E-02	3E-03	4E-03
TRU Wastes to WIPP	3E-01	4E+00	8E-03	2E+01	6E-01	3E-01
Total	0 (3E-01)	5 (4.5)	0 (1E-02)	20 (20)	1 (6E-01)	0 (4E-01)
Upper Bound Waste Volume						
LLW to Hanford	3E-01	1E+00	4E-03	3E+01	1E+00	1E+00
MLLW to Hanford	2E-01	6E-01	2E-04	2E+01	6E-01	5E-01
CH-TRU Waste to Hanford	4E-03	5E-02	1E-04	1E-01	8E-03	2E-02
RH-TRU Waste to Hanford	2E-03	7E-02	6E-05	1E-01	5E-03	1E-02
TRU Wastes to WIPP	3E-01	4E+00	8E-03	2E+01	6E-01	3E-01
Total	1 (7E-01)	6 (6.4)	0 (1E-02)	73 (73)	2 (2.3)	2 (1.9)

(a) Radiological impacts (incident-free and accident) are expressed in units of LCFs. Non-radiological accident impacts are expressed as the expected number of accidents and the resulting non-radiological fatalities. Non-radiological emissions impacts are expressed as LCFs.

Also shown in Table 5.26, the potential non-radiological accident fatality estimates are zero for the Hanford Only waste volume TRU waste under the No Action Alternative, one for the Hanford Only waste volume of TRU waste under the action alternatives and the Lower Bound waste volume, and two for the Upper Bound waste volume. Potential non-radiological emissions impacts were two LCFs for the Upper Bound waste volume and zero for the other two volumes. (For perspective it may be noted that over the next 40 years in the United States, several million traffic fatalities would result from other causes.) Figure 5.28 illustrates the transportation routes used in this analysis. The potential impacts presented in this HSW EIS are similar in magnitude to those presented in the WM PEIS (DOE 1997a) and WIPP SEIS-II (DOE 1997b). See additional details in Volume II, Appendix H, Section H.9.

Figure 5.28. Highway Routes used in the Analysis of Offsite Transportation Impacts

The analysis of maximally exposed individuals under routine transport conditions indicated that the largest individual exposures of non-truck crew members would be received by a service station attendant. The assumption that this same individual attends one-third of the shipments (assuming the service station is visited by all of the shipments and the attendant works one of three shifts per day) to and from Hanford resulted in a radiation exposure of about 0.84 rem (840 mrem) over an approximate 40-year period, resulting in a probability of a latent cancer fatality from this dose of about 0.0005 (that is, 5 chances in 10,000).

An evaluation (see Volume II, Appendix H, Section H.3.2.3.2) of the population and maximum individual exposures that could result from a severe transportation accident in a densely populated urban area was extracted from the WIPP SEIS-II (DOE 1997b). These estimates are pure consequence estimates; that is, the consequence estimates are not weighted by their probability of occurrence, which would be extremely small. These potential impacts were considered to also represent those that could occur from a terrorist attack (see Volume II, Appendix H, Section H.8). The analysis used bounding and average TRU waste inventories to develop a range of potential impacts. The bounding-case WIPP SEIS-II TRU waste inventories were used in the HSW EIS and are reflected in the impact estimates presented in Tables 5.25 and 5.26. The severe transportation accident analysis results demonstrated that, for the bounding TRU waste inventory case, up to 20 LCFs in the exposed population could be inferred. A maximum individual dose of about 125 rem was calculated, resulting in an inferred probability of a latent cancer fatality from this dose of about 0.08 (that is, 8 chances in 100). For the average inventory case, the respective impact estimates are about 4 inferred LCFs in the exposed population and an LCF probability of about 0.05 to the maximally exposed individual.

Table 5.27 provides estimates of the total shipment-miles and potential impacts for waste shipments within the Hanford Site, from offsite to Hanford, and from Hanford to offsite. The table illustrates that the impacts are approximately a function of the total distance traveled. Shipments from Hanford to offsite (which include a small number of LLW and MLLW shipments to offsite treatment facilities and back and shipments of TRU wastes from Hanford to WIPP) represent the largest impacts for all the waste transportation configurations shown in Table 5.27. The potential impacts of waste shipments from offsite to Hanford represent only a small fraction of the transportation impacts estimated for the Hanford Only and Lower Bound waste volumes. The potential impacts of offsite shipments to Hanford represent a substantial fraction of the total impacts of the Upper Bound waste volume case, but are still smaller than the impacts of shipments from Hanford to offsite facilities. The total potential latent cancer fatalities (sum of radiological incident-free impacts, radiological accident risks, and non-radiological emissions impacts) and non-radiological accident fatality estimates are illustrated in Figures 5.29 and 5.30, respectively.

The total projected radiation and emissions impacts in Table 5.27 range from about two to ten over the approximately 40 years of waste operations. For perspective, according to the U.S. Centers for Disease Control, National Center for Health Statistics, a total of 10,802 residents of the state of Washington and 7,057 residents of the state of Oregon died of cancer in 2001 (CDC 2003). The cancer mortality rates were 193 and 196 per 100,000 residents, respectively. A total of 36,245 residents of Washington and Oregon were estimated by TRAGIS to live within 800 meters of the highway route between Hanford and Ontario, Oregon. Based on a cancer mortality rate of 200 fatalities per year per 100,000 people, about 70 cancer fatalities per year, or about 2,800 cancer fatalities over a 40-year period,

Table 5.27. Summary of the Potential Transportation Impacts by Shipment Origin

	Hanford Only Waste Volume			Lower Bound Waste Volume			Upper Bound Waste Volume		
	No Action Alternative	Alternative Groups A,C,D, E	Alternative Groups B	No Action Alternative	Alternative Groups A,C,D,E	Alternative Groups B	No Action Alternative	Alternative Groups A,C,D,E	Alternative Groups B
Millions of Shipment-Miles									
Onsite	4.1	4.6	5.5	4.1	4.6	5.5	NA	4.6	5.5
Offsite Shipments to Hanford	<0.1	2.4	0.1	6.4	8.7	6.5	NA	98.5	96.3
Offsite Shipments from Hanford	16.2	34.2	32.0	16.2	38.5	36.3	NA	39.3	37.1
Total	20.4	41.1	37.6	26.7	51.8	48.3	NA	142.4	138.9
Latent Cancer Fatalities[(a)]									
Onsite	0.15	0.23	0.9	0.15	0.23	0.90	NA	0.23	0.90
Offsite Shipments to Hanford	<0.001	0.12	0.0064	0.3	0.41	0.30	NA	4.0	3.9
Offsite Shipments from Hanford	1.8	5.1	5.0	1.8	5.1	5.0	NA	5.3	5.2
Total	2 (1.9)	5 (5.4)	6 (5.9)	2 (2.2)	6 (5.8)	6 (6.2)	NA	10 (9.5)	10 (10)
Non-Radiological Accident Fatalities from Traffic Accidents									
Onsite	0.05	0.055	0.067	0.05	0.055	0.067	NA	0.055	0.067
Offsite Shipments to Hanford	<0.0001	0.015	0.0008	0.11	0.13	0.12	NA	1.8	1.7
Offsite Shipments from Hanford	0.28	0.56	0.54	0.28	0.56	0.55	NA	0.58	0.56
Total	0 (0.33)	1 (0.63)	1 (0.61)	0 (0.44)	1 (0.75)	1 (0.73)	NA	2 (2.4)	2 (2.4)

Note: Total LCFs and non-radiological accident fatalities are rounded to one significant figure. Due to rounding, the sums of the numbers in the table may not exactly match the totals.

(a) These values are the sums of the potential LCFs from incident-free radiological exposures, probability-weighted radiological accident risks, and incident-free non-radiological emissions.

NA = not applicable.

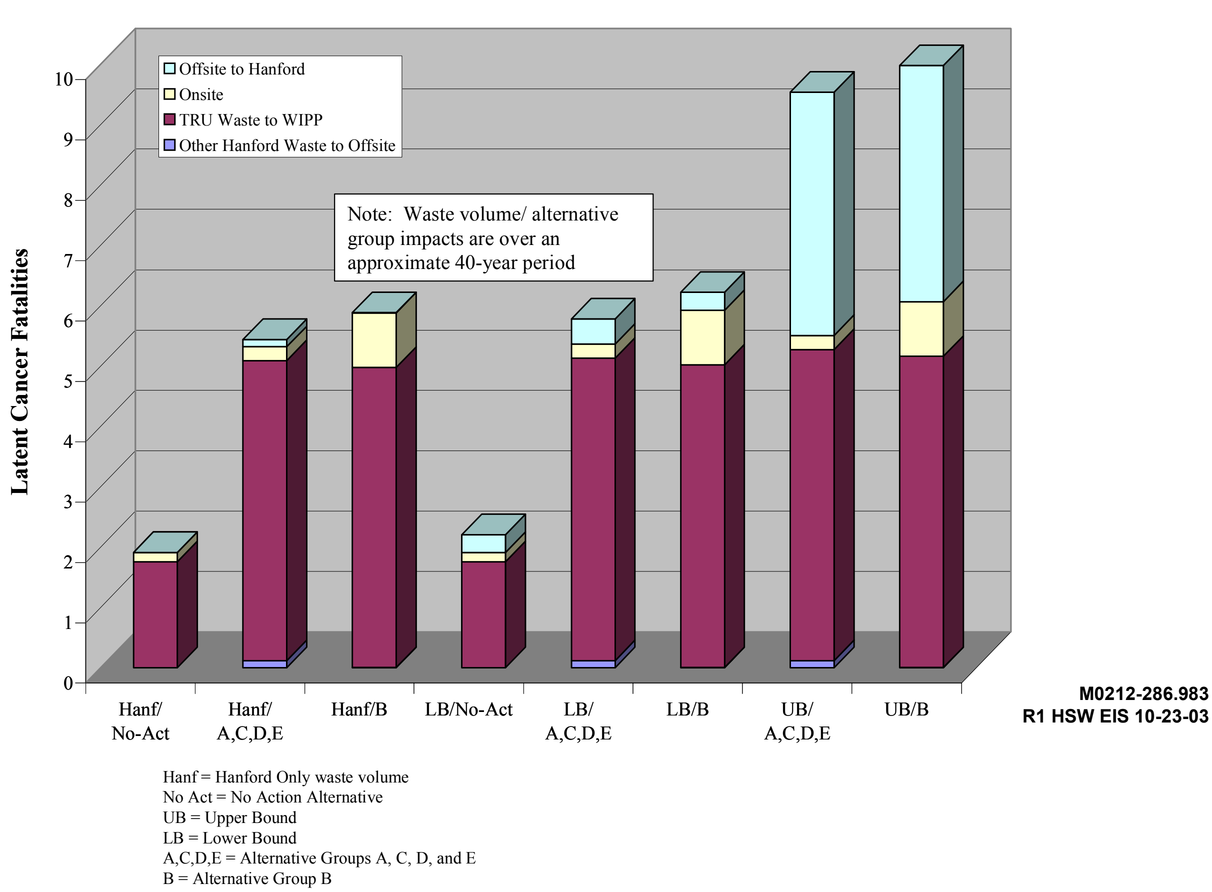


Figure 5.29. Potential Transportation Impacts of Onsite and Offsite Waste Shipments—LCFs from Radiological Incident-Free Transport, Radiological Accidents, and Non-Radiological Emissions[(a)]

would be estimated in the population along the route from Hanford to Ontario, Oregon, due to causes unrelated to shipments of waste to and from Hanford. The projected LCFs from the shipments of waste to and from Hanford would not be discernible.

For additional perspective, according to the U.S. Department of Transportation, National Highway Traffic Safety Administration, there were a total of 649 traffic fatalities in the state of Washington and 488 traffic fatalities in the state of Oregon for a total of 1,137 fatalities in the two states combined for 2001 (DOT 2002). This represents about 3 traffic fatalities per day in the 2 states. This can be compared to the total projected impacts of about 2 traffic fatalities over about 40 years for the Upper Bound waste volume shipments. Therefore, the total number of projected traffic fatalities from 40 years of transporting

(a) Although fatalities should be expressed as whole numbers, fractional fatalities are presented to facilitate illustration. Elsewhere fractional fatalities of 0.5 and greater are rounded up to the next whole number.

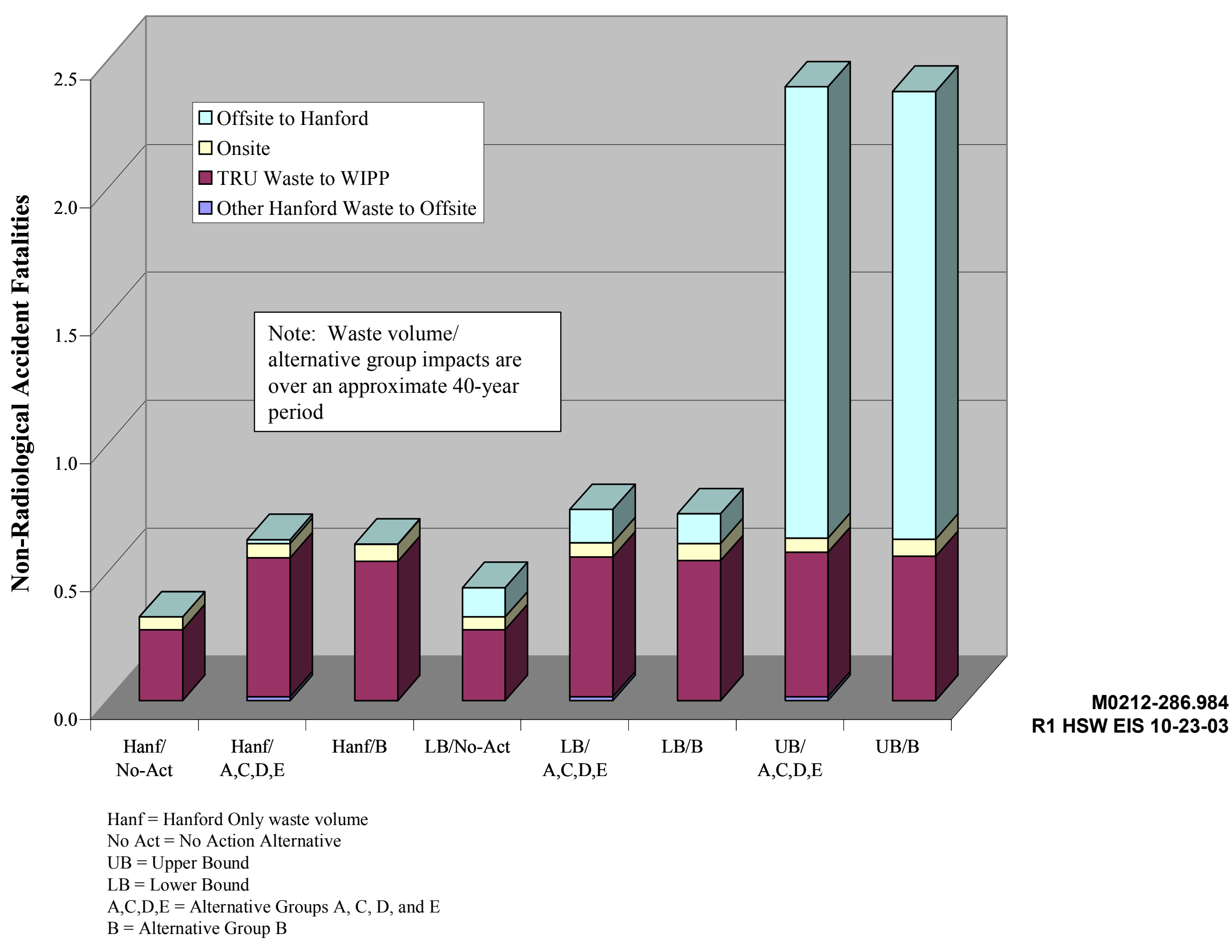


Figure 5.30. Shipment Mileages and Potential Transportation Impacts of Onsite and Offsite Waste Shipments—Non-Radiological Accident Fatalities(a)

solid waste to, from, and within Hanford is approximately the same as the traffic fatalities that occur, on average, every day in the states of Washington and Oregon. The incremental traffic fatalities from the waste shipments would not be discernible.

The HSW EIS, in addition to presenting a revised nationwide transportation analysis based on actual routes and 2000 Census information, also presents, in response to comments, the potential impacts for the states of Washington and Oregon. Three actual routes through Washington and Oregon were analyzed in this EIS for LLW, MLLW, and TRU wastes (see Figure 5.31). These include a route that enters Oregon from the east on Interstate-84 (I-84) near Ontario, Oregon, and one that enters Oregon from the south on I-5 near Ashland, Oregon. For the Lower Bound waste volume, the Ontario route would be used for about 9,500 shipments, and the Ashland route would be used for about 180 shipments. For the Upper

(a) Although fatalities should be expressed as whole numbers, fractional fatalities are presented to facilitate illustration. Elsewhere fractional fatalities of 0.5 and greater are rounded up to the next whole number.

Figure 5.31. Shipping Routes in Washington and Oregon

Bound waste volume, the Ontario route would be used for about 34,000 shipments, and the Ashland route would be used for about 1,100 shipments. These estimates include LLW, MLLW, and TRU waste shipments from offsite to Hanford and TRU waste shipments from Hanford to WIPP. For the Hanford Only waste volume, there would be approximately 8,200 shipments of TRU wastes to WIPP for the action alternatives and approximately 4,200 shipments for the No Action Alternative. All of these shipments would use the Ontario, Oregon, route. A third route is included for one MLLW shipment from Puget Sound Naval Shipyard to Hanford via I-90 and I-82. A northern route that enters Washington near Spokane on I-90 was not used in this analysis. Based on actual practice, shipments from midwestern and eastern generators were assumed to travel across country on more southerly routes (that is, I-80 and I-84) to avoid severe winter weather and minimize shipping distances and times.

The waste shipments to Hanford will predominately travel on interstate highways. Only in extremely rare instances would interstate highway or bridge construction lead to a detour through municipal streets. The waste shipments will be conducted using heavy-combination trucks but are not "overweight" vehicles that require special permits. The weights of the trucks that haul the waste to Hanford will be below legal-weight limits, similar to the vast majority of tractor-trailer vehicles that carry cargo on the interstates every day, In addition to the precautions taken by DOE during loading, trucks are subject to weighing and inspecting by state agencies as required.

If a waste shipment encounters a highway or bridge repair situation, it would stay on the interstate wherever possible and would typically not be detoured through cities along the route. If construction/ repair of a bridge is taking place, traffic would be detoured to the opposite side of the freeway from where construction/repair is taking place - the open half of the freeway would temporarily become a two-way road. If an entire bridge were to be closed, the most common procedure would be to have traffic exit the freeway at the interchange immediately before the bridge and enter the freeway on the other side of the bridge at the same interchange or at the next entrance. In such cases, having a small number of shipments travel a short distance on routes other than the interstate freeways would not substantially change the transportation risks or conclusions presented in the HSW EIS.

The results of this analysis are presented in Table 5.28. Further details, including shipments and potential impacts by waste type, are presented in Volume II, Appendix H. Note that one radiological fatality was calculated for the Lower Bound waste volume, primarily due to shipments from Hanford to WIPP. The potential impacts are dominated by TRU waste shipments from Hanford to WIPP. Due to the higher volume of LLW and MLLW shipments in the Upper Bound waste volume than the Lower Bound waste volume, the impact estimates are higher; that is, one radiological fatality and one non-radiological fatality from traffic accidents are predicted. There are approximately equal contributions to these potential impact estimates from LLW and MLLW shipments to Hanford and TRU waste shipments from Hanford to WIPP. The full analysis of the potential impacts of transporting LLW, MLLW, and TRU wastes from offsite to Hanford are contained in Volume II, Appendix H of this EIS. The routes used in these analyses and the data used to calculate the impacts include some areas with relatively high traffic hazards, such as Cabbage Hill on I-84 in Oregon. Refer to Section 2.2.4 for further information on emergency preparedness for transportation accidents involving radioactive materials.

The impacts of transporting construction and capping materials to solid waste management facilities on the Hanford Site are summarized in Table 5.29. The materials that were included in the calculations included concrete, asphalt, gravel/sand, silt/loam, basalt, bentonite, and steel. Although some accidents were predicted to occur, there were no predicted fatalities associated with transport of construction and backfill materials. The impacts of all alternative groups were found to be dominated by transport of gravel/sand, silt/loam, and basalt to use as capping materials. The impacts for the No Action Alternative were found to be dominated by the transport of steel and concrete.

The results of the hazardous chemical impact analysis are presented in Table 5.30. The results indicate that downwind concentrations of the hazardous chemicals would not exceed the Temporary Emergency Exposure Limit-2 (TEEL-2) guidelines following a severe transportation accident involving a shipment of maximum-inventory 208-L drums. Additional analyses were performed to determine the impacts of assuming that all of the released materials become volatilized under the thermal effects of a transportation-related fire. This was done by changing the release aerosol and respirable fractions of all of the chemicals to 1.0. This resulted in three chemicals exceeding their TEEL-2 concentrations—elemental lead, elemental mercury, and beryllium. The downwind concentrations of these three chemicals were then compared to their Immediately Dangerous to Life and Health (IDLH) values for additional perspective (see Volume II, Appendix H). The TEEL-2 and IDLH exposure guideline concentrations are defined as follows:

TEEL-2: The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

IDLH: The maximum concentration from which, in the event of respirator failure, a person could escape within 30 minutes without a respirator and without experiencing any escape-impairing (for example, severe eye irritation) or irreversible health effects.

The downwind concentrations of all chemicals are well below their respective IDLH values. Based on these observations, the conclusion was that releases of hazardous chemicals from possible transportation accidents involving waste materials would be unlikely to result in a fatality. These consequence estimates for a severe transportation accident were also considered to represent the potential impacts of a successful terrorist attack which, based on this analysis, would not be expected to result in catastrophic or wide ranging impacts due to release of chemically hazardous waste constituents.

Table 5.28. Impacts in Oregon and Washington by State from Shipments of Solid Wastes to and from Hanford[(a)]

Waste Volume/ Alternative Group	Radiological Impacts, LCFs			Total Number of Accidents	Non-Radiological Impacts	
	Routine Transport		Accidents		Number of Fatalities	Emissions LCFs
	Worker	Public	Public			
Oregon State						
Hanford Only – Action Alternatives[(b)]	0 (0.026)	0 (0.34)	0 (4.2E-4)	1 (1.2)	0 (0.11)	0 (0.023)
Lower Bound – All Alternatives	0 (0.029)	0 (0.37)	0 (7.7E-4)	1 (1.4)	0 (0.14)	0 (0.037)
Upper Bound – Action Alternatives	0 (0.074)	1 (0.59)	0 (4.7E-3)	5 (5.1)	0 (0.48)	0 (0.16)
Hanford Only – No Action Alternative[(b)]	0 (0.013)	0 (0.11)	0 (2.2E-4)	1 (0.60)	0 (0.057)	0 (0.012)
Washington State						
Hanford Only – Action Alternatives[(b)]	0 (8.0E-3)	0 (0.11)	0 (1.3E-4)	0 (0.38)	0 (8.2E-3)	0 (0.036)
Lower Bound – All Alternatives	0 (8.9E-3)	0 (0.11)	0 (2.1E-4)	0 (0.46)	0 (9.7E-3)	0 (0.042)
Upper Bound – Action Alternatives	0 (0.022)	0 (0.17)	0 (1.2E-3)	2 (1.6)	0 (0.034)	0 (0.15)
Hanford Only – No Action Alternative[(b)]	0 (4.2E-3)	0 (0.036)	0 (7.0E-5)	0 (0.20)	0 (4.2E-3)	0 (0.018)

(a) Radiological impacts (incident-free and accident) are expressed in units of LCFs. Non-radiological accident impacts are expressed as the expected number of accidents and the resulting physical trauma fatalities. Non-radiological emissions impacts are expressed as LCFs.
(b) TRU wastes to WIPP.

Table 5.29. Impacts of Transporting Construction and Capping Materials

Alternative Group	Waste Volume	Total Distance Traveled, millions of miles	Number of Accidents	Number of Fatalities
A	Hanford Only	8.4	2 (1.5)	0 (6E-02)
	Lower Bound	8.5	2 (1.5)	0 (6E-02)
	Upper Bound	9.4	2 (1.6)	0 (7E-02)
B	Hanford Only	11	2 (1.9)	0 (8E-02)
	Lower Bound	11	2 (2.0)	0 (8E-02)
	Upper Bound	15	3 (2.6)	0 (1.-01)
C	Hanford Only	7.9	1 (1.4)	0 (6E-02)
	Lower Bound	8.0	1 (1.4)	0 (6E-02)
	Upper Bound	8.9	2 (1.6)	0 (7E-02)
D	Hanford Only	7.9	1 (1.4)	0 (6E-02)
	Lower Bound	8.0	1 (1.4)	0 (6E-02)
	Upper Bound	8.9	2 (1.6)	0 (7E-02)
E	Hanford Only	7.9	1 (1.4)	0 (6E-02)
	Lower Bound	8.0	1 (1.4)	0 (6E-02)
	Upper Bound	8.8	2 (1.5)	0 (7E-02)
No Action	Hanford Only	20	4 (3.5)	0 (2E-01)
	Lower Bound	20	4 (3.5)	0 (2E-01)

Note: The materials that were included in the impact analysis were concrete, asphalt, gravel/sand, silt/loam, basalt, bentonite, and steel. Gravel/sand, silt/loam, and basalt were assumed to be transported from Area C on the Hanford Site. Various offsite locations were considered to be the sources for the other materials.

Table 5.30. Hazardous Chemical Concentrations (mg/m^3) 100 m (109 yd) Downwind from Severe Transportation Accidents[(a)]

Chemical	CH MLLW	RH MLLW	MLLW Ready for Disposal	RH TRU Boxes	CH TRU with PCBs	RH TRU in Trenches	Elemental Lead	Elemental Mercury	TEEL-2
Acetone	6.9E-03	6.7E-03	6.9E-03	2.6E-05	0	0	0	0	20,000
Beryllium	8.9E-04	8.9E-04	8.9E-04	8.4E-05	8.4E-05	8.4E-05	0	0	0.025
Bromodichloro-methane	3.9E-05	0	3.9E-05	0	0	0	0	0	30
Carbon tetrachloride	1.4E-02	0	1.4E-02	4.5E-03	0	0	0	0	639
Diesel fuel	2.7E-05	0	2.7E-05	0	0	0	0	0	500
Formic acid	3.2E-02	0	3.2E-02	0	0	0	0	0	15
Lead	0	0	0	0	0	0	1.6E-01	0	0.25
Methyl ethyl ketone (MEK or 2 Butanone)	5.4E-03	0	5.4E-03	0	0	0	0	0	750
Mercury	8.3E-06	0	8.3E-06	8.1E-07	0	0	0	2.3E-02	2.05
Nitrate	7.8E-03	0	0	0	0	0	0	0	50
Nitric acid	2.3E-01	2.3E-01	2.3E-01	0	0	0	0	0	15
Polychlorinated biphenyls (PCBs)	9.7E-05	0	9.7E-05	0	3.0E-04	0	0	0	1
p-Chloroaniline	1.9E-02	0	1.9E-02	0	0	0	0	0	50
Sodium hydroxide	3.2E-01	3.2E-01	3.2E-01	1.7E-02	1.7E-02	1.7E-02	0	0	5
Toluene	1.2E-02	3.6E-01	1.2E-02	0	0	0	0	0	1,125
1,1,1-Trichloroethane	2.5E-02	0	2.5E-02	2.6E-05	0	0	0	0	3,850
Xylene	2.1E-03	3.4E-02	2.1E-03	1.4E-04	1.6E-01	1.6E-01	0	0	750

(a) The results presented in this table were calculated assuming a 0.5% respirable release fraction for solid materials and 100% release for volatiles. Assuming a 100% release for all chemicals causes three chemicals, including beryllium, lead, and mercury, to exceed TEEL-2 concentrations. See Volume II, Appendix H, Section H.7 for additional details.

5.9 Noise

Noise is defined technically as sound that is unwanted and perceived as a nuisance by humans. Within the context of this HSW EIS, the public represents human habitations located adjacent to the boundary of the Hanford Site and communities bordering roads that may support material and waste shipments to and from the site. An understanding of noise impacts is facilitated by associating noise levels with common activities or sources (see Figure 5.32).

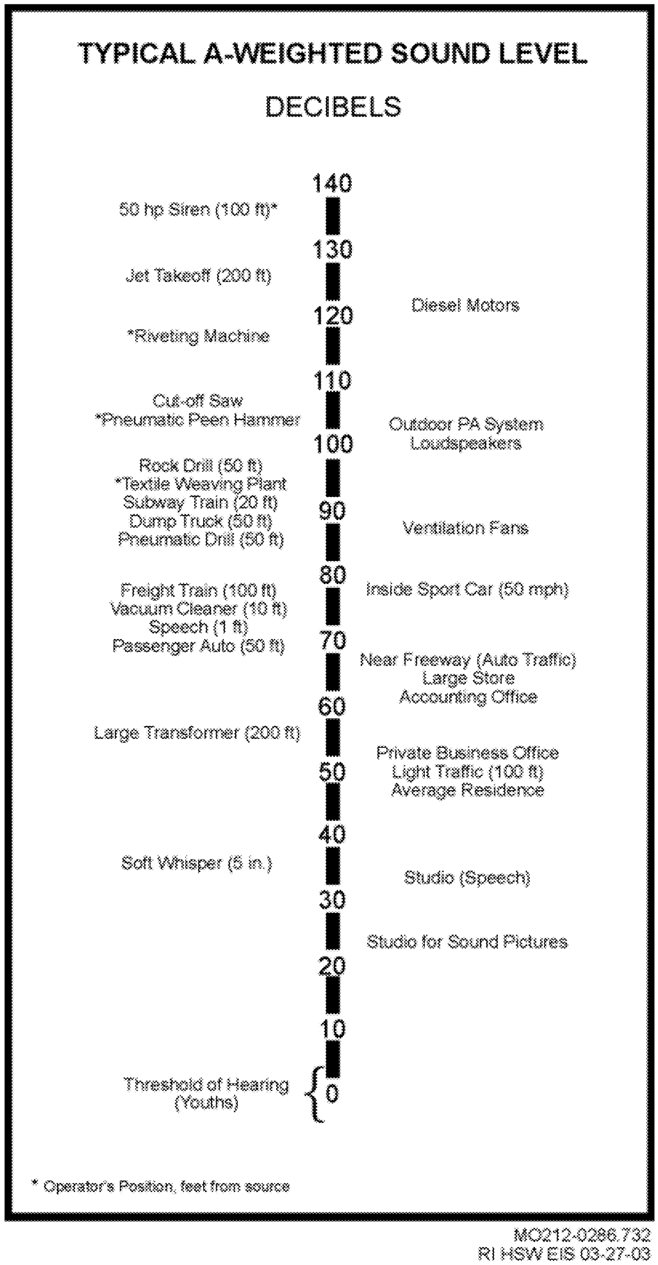


Figure 5.32. Association of Noise Levels with Common Sources or Activities

Potential impacts of noise on the public from implementing the alternative groups are addressed in the following sections. The analytical methods used to arrive at the conclusions drawn in this section are presented in Volume II, Appendix J.

In the course of implementing any of the alternative groups, various waste management construction and operations activities would generate noise. The total work force associated with the alternative groups likely would not exceed 850, which would result in a minimal addition to traffic noise.

For protection of the public, Washington Administrative Code (WAC) 173-60 has established a limit for daytime residential noise levels of 70 decibels (dBA) and a nighttime limit of 50 dBA at industrial site boundaries. No actual human habitations would be located within 10 km (6.2 mi) of the boundary of the Industrial-Exclusive zone surrounding the 200 Areas or the Area C borrow pit south of SR 240, thus ensuring that WAC limits would not be exceeded.

The point of closest potential exposure to noise for the transient public near the 200 Areas is about 2 km (1.2 mi) distant on SR 240. However, only emergency turnouts exist on SR 240 in that vicinity, and any exposure to noise would be of short duration and below applicable standards.

Noise is defined in terms of human perception, but sound also can be disturbing to wildlife. Because wildlife can relocate freely to areas of less sound intrusion, no substantial adverse sound-based impacts from waste management activities are anticipated.

Although not considered noise in the above sense, a potential might exist for impacts from ground vibrations on research conducted at the Laser Interferometer Gravitational Wave Observatory (LIGO). The major source of such ground vibrations would be associated with excavation for capping materials in Area C where the closest distance to one of the LIGO detection arms is approximately 14 km (8.7 mi). The impacts, if any, would be similar for any of the alternative groups; however, these impacts have not been quantified.

5.9.1 Alternative Group A

The principal activities associated with Alternative Group A (for the Hanford Only, Lower Bound, or Upper Bound waste volumes) would be modification of the T Plant Complex; construction of deeper and wider trenches; loading, backfilling, and closure of the LLBGs; operation of the WRAP, T Plant, and CWC; operation of pulse driers for MLLW leachate; onsite transport of construction materials and waste; transport of MLLW offsite for treatment; disposal of ILAW in a new disposal facility near the PUREX Plant; and transport of construction materials to the site. Noise emissions from construction equipment range from 75 to 89 dBA (see Table 5.31). Because of the distance from the sources of noise from these activities, noise levels would be less than applicable state standards at the nearest residence. The maximum calculated noise level at the nearest residence is 33 dBA, and this would be indistinguishable from background noise. Infrequent blasting of rock from the Area C borrow pit would not exceed applicable state standards at the nearest residence.

Table 5.31. Typical Noise Levels Associated with Construction Equipment[a] and Blasting[b]

Equipment	Representative Noise Level (dBA) at 15 m (50 ft)
Backhoe	80
Grader	85
Loader	85
Roller	75
Bulldozer	85
Truck	88
Scraper	89
Blasting	94[c]

(a) FTA (1995).
(b) Jones and Stokes (2002).
(c) Noise level at 1200 m (4000 ft) is about 59 dBA.

Material for capping LLBGs at closure would be acquired from the Area C borrow pit and would result in higher, but localized, noise levels from use of heavy equipment. In the absence of prolonged presence of the public in the vicinity, these noise levels likely would not result in a noticeable impact. Because there are no residential areas in the vicinity, state standards for noise would not be exceeded.

Incremental noise in communities through which waste is transported daily would be negligible when compared with background highway noise. Similarly, transport of construction material to the site and onsite would not result in substantial increases in traffic noise.

5.9.2 Alternative Group B

The principal activities associated with Alternative Group B (for either the Lower Bound or Upper Bound waste volumes) would be construction and operation of a new waste processing facility; construction of the current design, rather than deeper and wider trenches (as in Alternative Group A); loading, backfilling, and closure of the LLBGs; operation of the WRAP, T Plant Complex, and CWC; operation of pulse driers for MLLW leachate beginning in 2026; onsite transport of construction materials and waste; transport of MLLW offsite for treatment; disposal of ILAW in multiple, lined trenches in the 200 West Area; and transport of construction materials to the site. As in the case of Alternative Group A, noise levels resulting from these activities would be less than applicable state standards at the nearest residence.

The volume of capping materials required in Alternative Group B would be the largest among the alternatives. Although the activities would extend over a longer period of time, they would result in noise impacts similar to those described for Alternative Group A.

5.9.3 Alternative Group C

Alternative Group C is very similar to Alternative Group A in terms of industrial activities and associated noise propagation. Noise levels associated with the implementation of this alternative group would be less than applicable state standards at the nearest residence. Moreover, noise levels would not differ substantially in magnitude or duration from those associated with Alternative Group A.

5.9.4 Alternative Groups D and E

Except for excavation of capping materials, activities associated with Alternative Groups D and E are very similar to those of Alternative Group A, with only minor differences in scope and location of waste disposal. Noise levels associated with the implementation of these alternative groups would be less than applicable state standards at the nearest residence. They also would not differ substantially in magnitude or duration from those associated with Alternative Group A.

The volume of capping materials is less than for Alternative Group A. Hence, noise impacts indicated for Alternative Groups D and E would occur over a shorter period of time.

5.9.5 No Action Alternative

The principal activities associated with the No Action Alternative would be the construction of 66 additional CWC buildings for storage of waste that cannot be certified for disposal; construction of additional LLW trenches of current design, loading, and backfilling; capping of two existing MLLW trenches; operation of the WRAP, T Plant Complex, and CWC; operation of pulse driers for MLLW leachate beginning in 2026; onsite transport of construction materials and waste; transport of MLLW offsite for treatment; disposal of ILAW as glass cullet in vaults near the PUREX Plant; and transport of construction materials to the site. Again, noise levels resulting from these activities would be less than applicable state standards at the nearest residence.

Less than 25 percent of the volume of capping materials would be required to cap the MLLW trenches and the ILAW. The noise levels associated with extraction of these materials from the borrow pit would be similar to those for Alternative Group A, but the activities would occur over a much shorter time.

5.10 Resource Commitments

Various energy and material resources would be committed in the implementation of any of the alternative groups. Estimates of major resources committed are summarized by alternative group in Table 5.32. (As a result of refined calculations of resource needs based on the Technical Information Document [FH 2004], the need for gravel and sand, silt/loam, and basalt for the action alternative groups increased by factors of approximately 1.8, 2.6, and 1.2, respectively, over those reported in the revised draft HSW EIS [DOE 2003].) In this section, Alternative Groups D_1, D_2, and D_3 are referred to collectively as Alternative Group D (and similarly for Alternative Groups E_1, E_2, and E_3). The resource commitments for Alternative Groups D and E are considered collectively because the activities under each essentially are the same—only the locations of the activities change. The location changes do not significantly alter the resource commitments.

The ILAW resources are broken out separately at the bottom of Table 5.32 because the resource requirements to handle this one waste category can be much greater than those of the other categories. Resource estimates for management of melters are included with other Hanford solid waste streams. The ILAW vault resource commitments would be added to the No Action Alternative values, the ILAW multiple trench commitments would be added to values for Alternative Groups A and B, and the ILAW single trench commitments would be added to values for Alternative Groups C, D, and E. Resource commitments of the alternative groups with the appropriate ILAW actions included are presented in Table 5.32.

Resource requirements for a number of materials are larger for Alternative Group B than for Alternative Groups A, C, D, or E because of the less-efficient trench design. Some activities under the No Action Alternative require more resources than the action alternatives. Under the No Action Alternative, ILAW is disposed of in vaults, which increases the diesel, steel, concrete, and water needs. In addition, 66 CWC waste storage buildings would be constructed, which increases the steel and concrete needs compared with those for the other alternative groups. The use of accelerated process lines would be expected to require only minor amounts of resources, regardless of where placed.

When considering the resource commitments by inventory volume within an alternative group, the Hanford Only waste volume generally requires the least resources; the Upper Bound waste volume requires the most. In many cases, the Hanford Only and Lower Bound waste volume resource commitments are not substantially different.

The resource commitments presented in Table 5.33 for actions excluding ILAW would not be expected to impact available supplies or activities requiring these same resources. The peak electrical power required for construction of operations associated with the management of Hanford solid waste for any of the alternative groups would not be expected to impact Hanford's existing capacity. The commitment of resources for ILAW actions would not cause any impacts beyond those described in the *Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999) and the Hanford Waste Management Operations EIS (ERDA 1975).

Table 5.32. Resource Commitment Summary by Alternative Group and for ILAW[(a)]

Waste Volume	Total Electric (GWhr)	Diesel (m^3)	Gasoline (m^3)	Propane (t)	Asphalt[(b)] (1000 m^3)	Gravel/ Sand (1000 m^3)	Silt/Loam (1000 m^3)	Basalt (1000 m^3)	Bentonite Clay (t)	Steel (t)	Concrete (1000 m^3)	Total Water (1000 m^3)	Lead (t)	Land (ha)
Alternative Group A (without ILAW)														
Hanford Only	735	12,800	260	12,700	362	776	1,900	518	13,900	720	8.0	488	45	143
Lower Bound	735	12,800	260	12,700	364	782	1,910	521	13,900	870	9.6	488	45	144
Upper Bound	743	13,600	270	19,300	386	828	2,030	552	18,200	1,280	14	492	45	152
Alternative Group B (without ILAW)														
Hanford Only	5860	16,500	340	23,500	408	881	2,160	587	33,600	800	9.9	484	45	161
Lower Bound	5860	16,500	340	23,500	414	895	2,190	597	33,600	950	12	485	45	163
Upper Bound	587	20,500	430	38,300	468	1010	2,470	673	57,600	1,380	16	487	45	184
Alternative Group C (without ILAW)														
Hanford Only	735	12,800	260	12,700	362	776	1,900	518	13,900	720	8.0	488	45	143
Lower Bound	735	12,800	260	12,700	364	782	1,910	521	13,900	870	9.6	488	45	144
Upper Bound	743	13,600	270	19,300	386	828	2,030	552	18,200	1,280	14	492	45	152
Alternative Group D (without ILAW)														
Hanford Only	735	12,800	260	18,800	380	821	2,010	548	13,900	710	8.0	488	45	142
Lower Bound	735	12,800	260	20,300	382	824	2,020	549	13,900	870	9.9	488	45	142
Upper Bound	743	13,600	270	27,800	394	850	2,080	567	18,200	1,280	14	492	45	147
Alternative Group E (without ILAW)														
Hanford Only	735	12,800	260	18,800	360	772	1,890	515	13,900	710	8.0	488	45	142
Lower Bound	735	12,800	260	20,300	361	775	1,900	516	13,900	870	9.9	488	45	142
Upper Bound	743	13,600	270	27,800	373	801	1,960	534	18,200	1,280	14	492	45	147
No Action Alternative (without ILAW)														
Hanford Only	685	5,200	48	3,560	6	13	31	8	0	25,900	140	29.6	45	148
Lower Bound	685	5,300	50	3,560	6	13	31	8	0	26,000	142	29.6	45	149
ILAW														
Vault	NA	183,400	NA	0	20	2603[(c)]	NA	NA	NA	33,170	282	487	0	10
Multiple Trench	NA	120,100	NA	0	33	770[(c)]	NA	NA	NA	1,000	0.31	789	0	26
Single Trench	NA	53,100	NA	0	10	550[(c)]	NA	NA	NA	1,000	0	308	0	8

(a) Conversion factors: 1 m^3 (capacity) = 260 gal; 1 m^3 (volume) = 1.3 yd^3; and 1 t (metric tonne) = 1.1 tons.
(b) A fully prepared product including its components.
(c) Total fill (sand, gravel, silt, and rip rap).
NA = not applicable.

Table 5.33. Resource Commitment Summary by Alternative Group with ILAW Resources Included[(a)]

Waste Volume	Diesel (m^3)	Asphalt (1000 m^3)	Gravel/Sand, Silt/Loam, Basalt (1000 m^3)	Steel (t)	Concrete (1000 m^3)	Total Water (1000 m^3)
Alternative Group A						
Hanford Only	132,900	392	3,960	1,720	8.3	1,280
Lower Bound	132,900	394	3,990	1,870	9.9	1,280
Upper Bound	133,700	416	4,180	2,280	14	1,280
Alternative Group B						
Hanford Only	136,600	438	4,400	1,800	10	1,270
Lower Bound	136,700	444	4,450	1,950	12	1,270
Upper Bound	140,600	498	4,930	2,380	16	1,280
Alternative Group C						
Hanford Only	65,900	372	3,740	1,720	8.0	798
Lower Bound	65,900	374	3,770	1,870	9.6	798
Upper Bound	66,700	396	3,960	2,280	14	802
Alternative Group D						
Hanford Only	65,900	390	3,930	1,710	8.0	798
Lower Bound	65,900	392	3,940	1,870	9.9	798
Upper Bound	66,700	404	4,050	2,280	14	802
Alternative Group E						
Hanford Only	65,900	370	3,730	1,710	8.0	798
Lower Bound	65,900	371	3,740	1,870	9.9	798
Upper Bound	66,700	383	3,850	2,280	14	802
No Action Alternative						
Hanford Only	188,600	26	2,650	59,100	420	520
Lower Bound	188,700	26	2,650	59,200	422	520

(a) Conversion factors: 1 m^3 (capacity) = 260 gal; 1 m^3 (volume) = 1.3 yd^3; and 1 t (metric tonne) = 1.1 tons.

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.

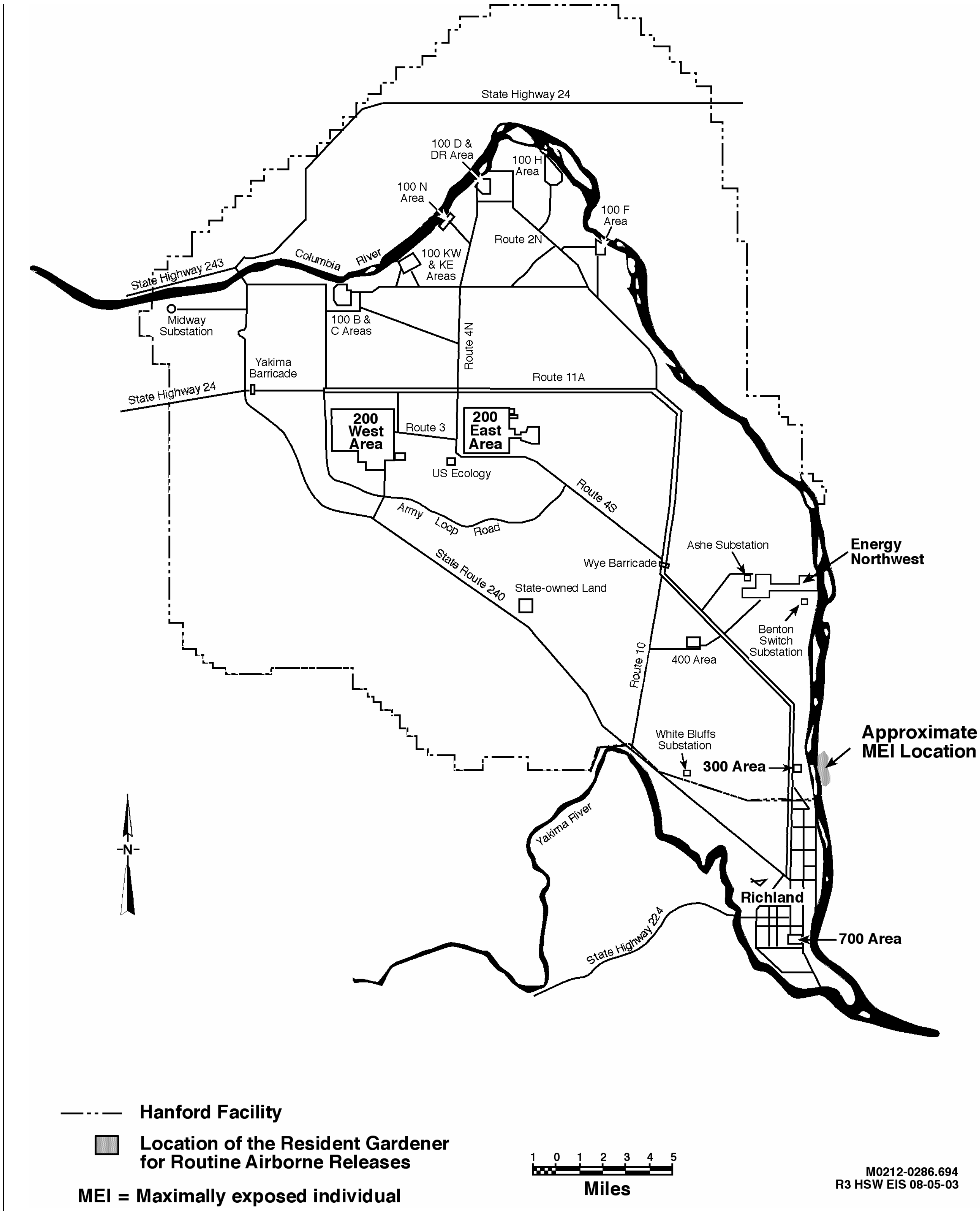


Figure 5.33. Location of the Resident Gardener for Routine Airborne Releases

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/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	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/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	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	Maximum Annual Dose 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	Maximum Annual Dose 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	Maximum Annual Dose 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	Maximum Annual Dose 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	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	(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.

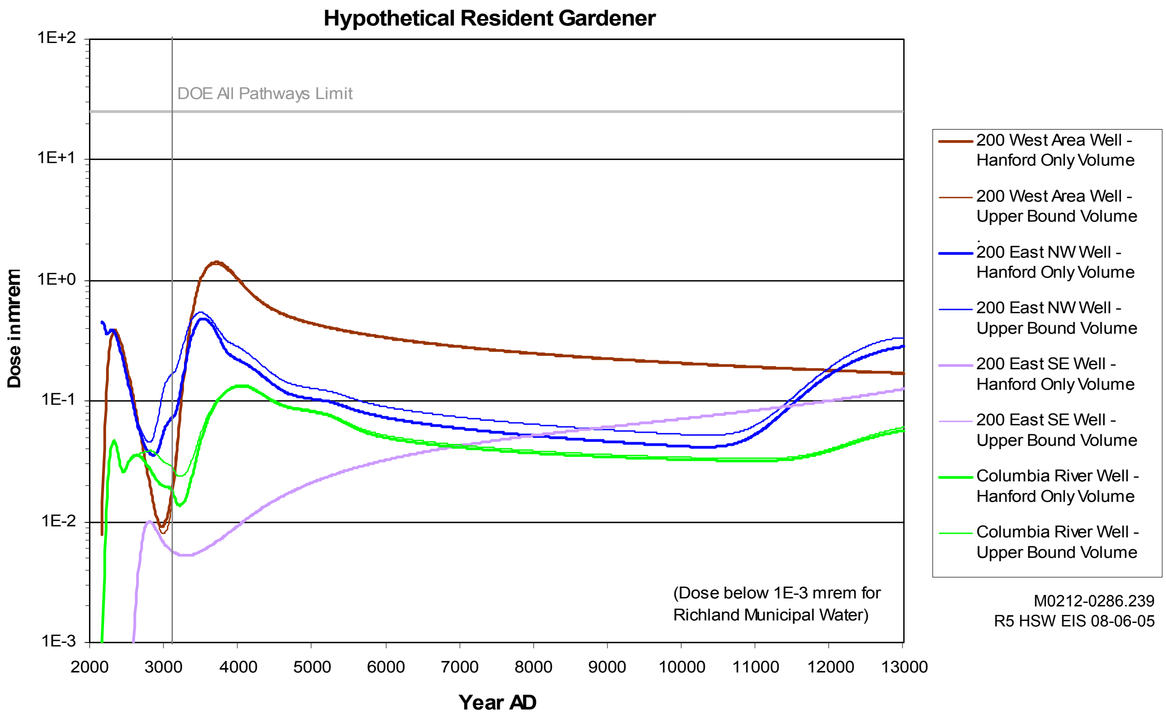
5.11.2.1.1 Alternative Group A

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.



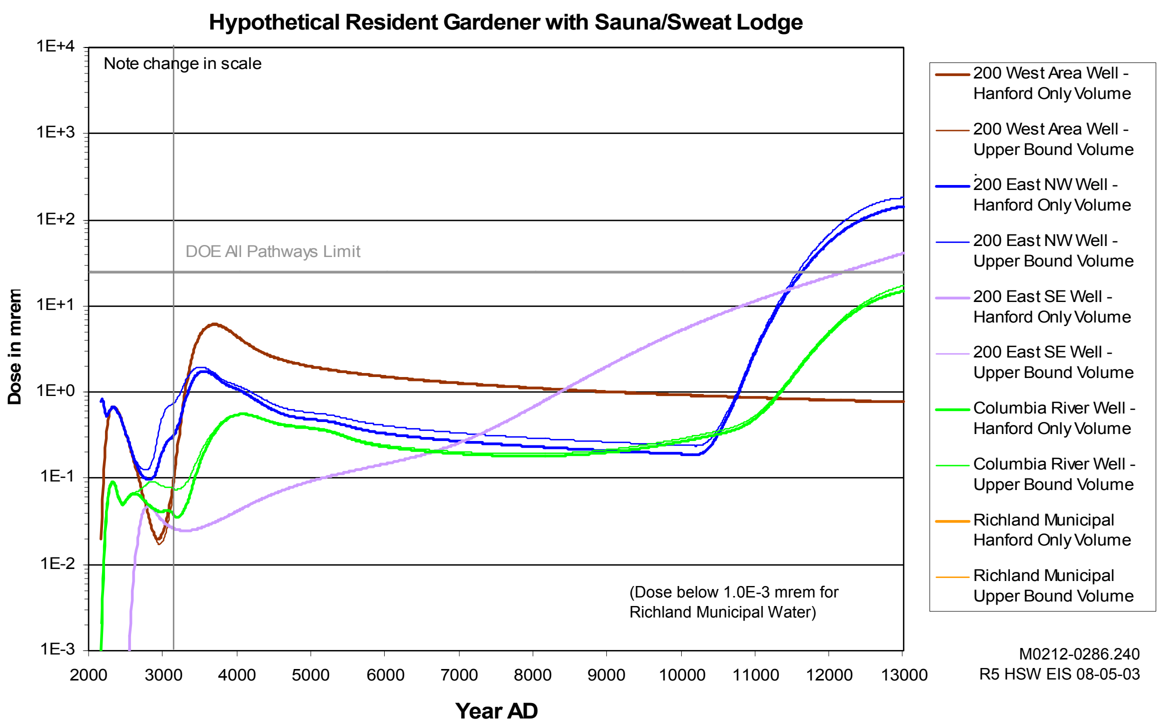


Figure 5.34. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group A, Hanford Only and Upper Bound Waste Volumes

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.

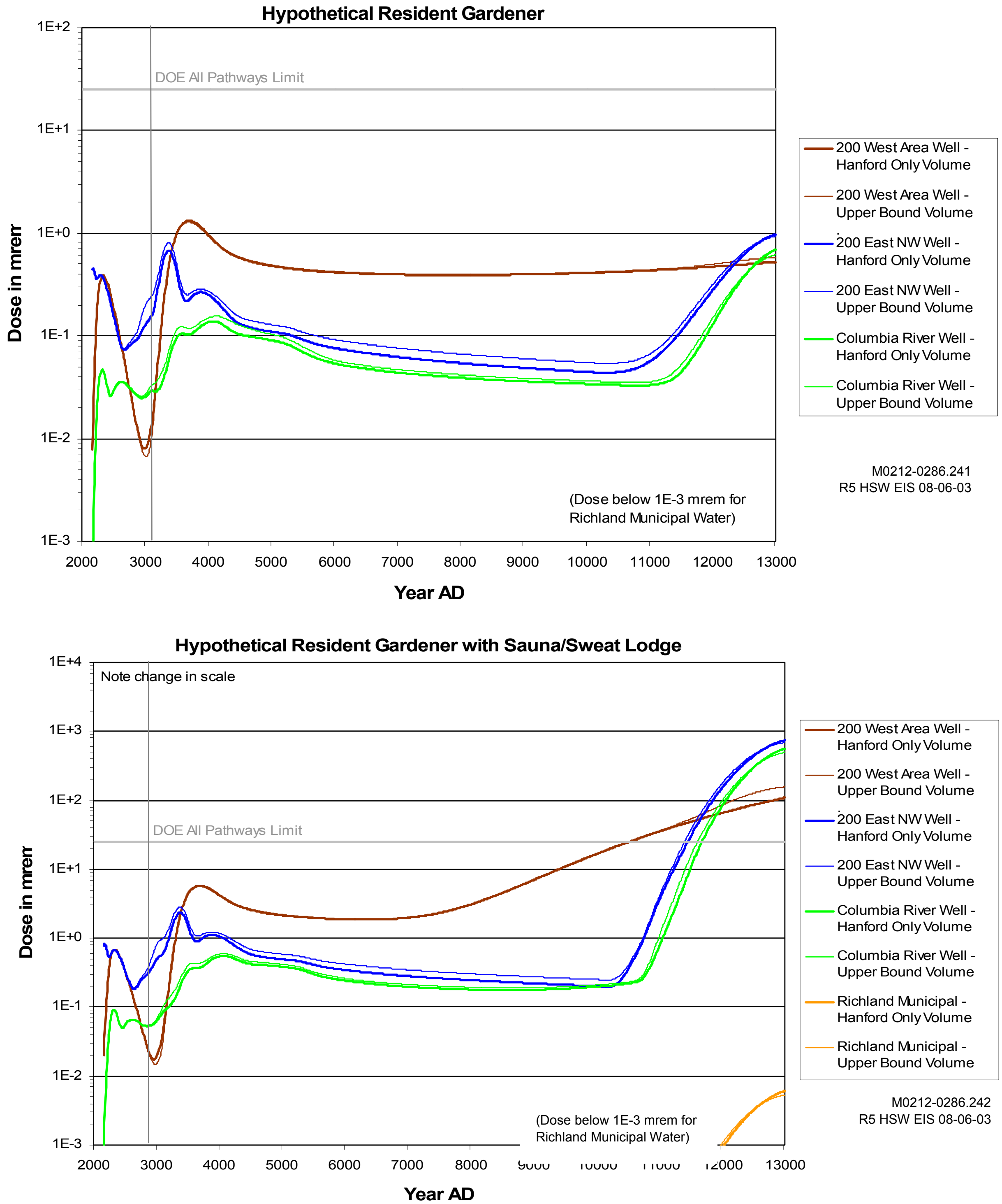


Figure 5.35. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group B, Hanford Only and Upper Bound Waste Volumes

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.

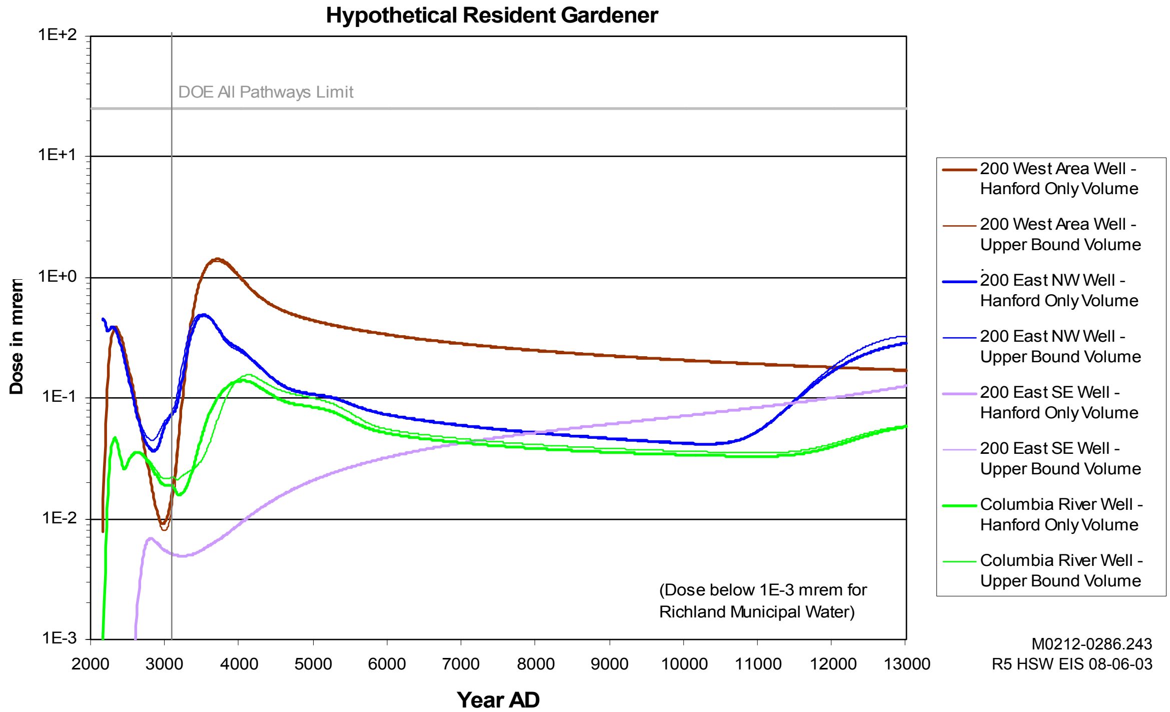
5.11.2.1.3 Alternative Group C

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.



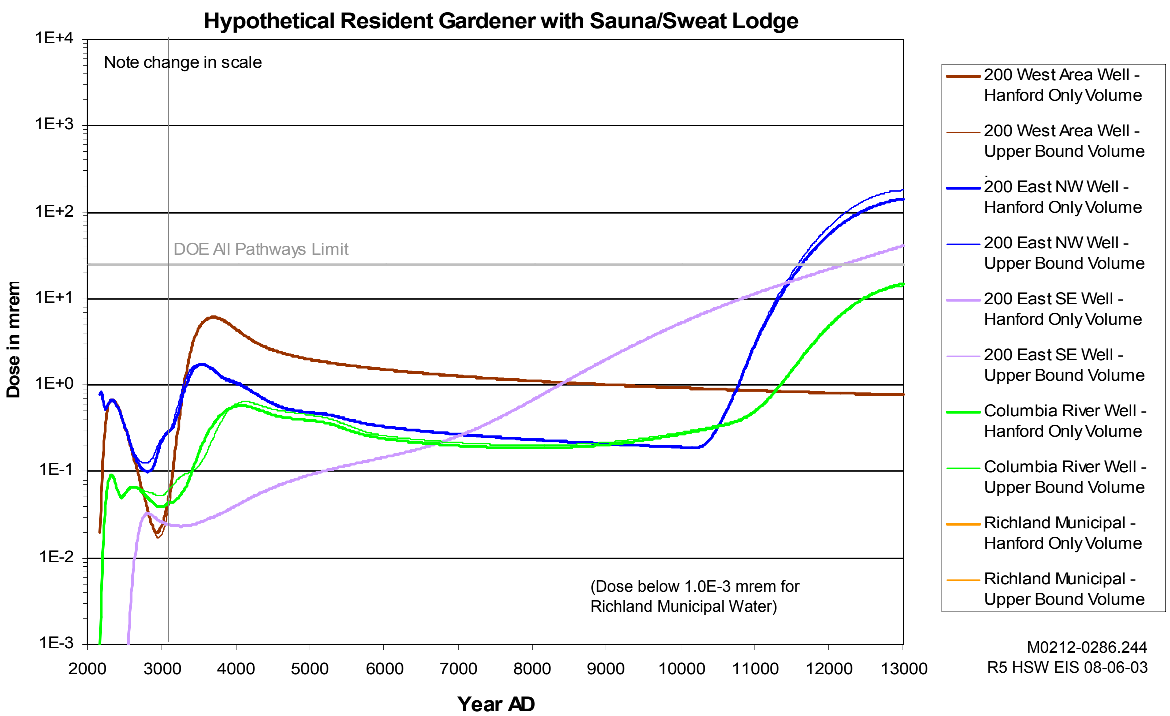


Figure 5.36. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group C, Hanford Only and Upper Bound Waste Volumes

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.

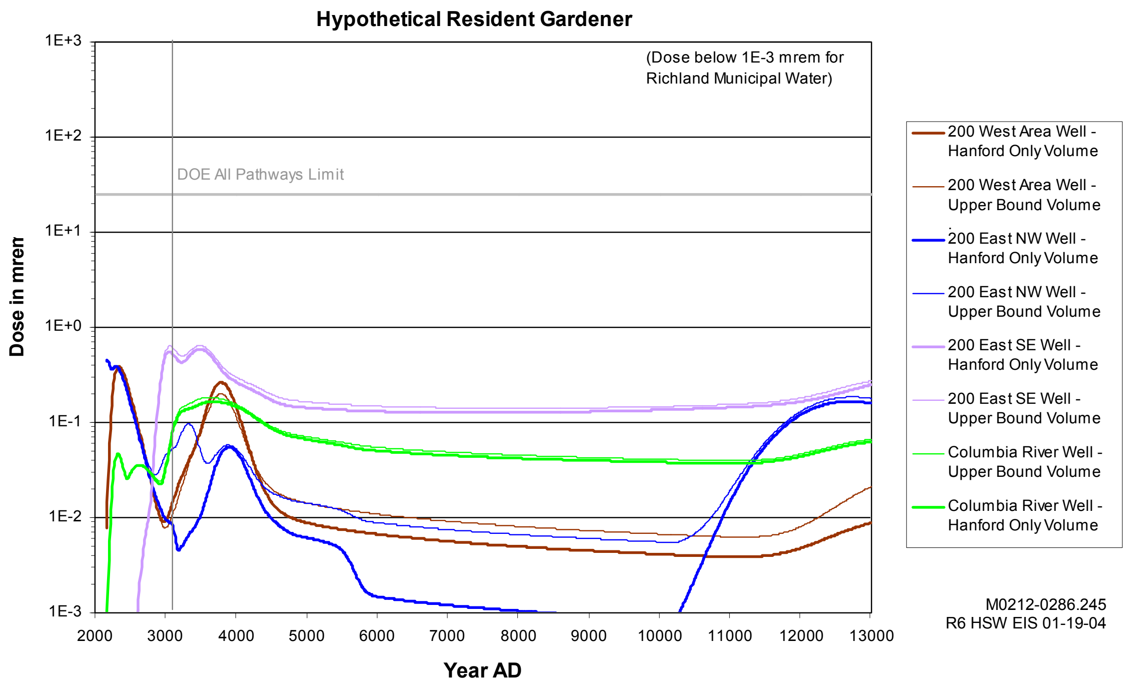
5.11.2.1.4.1 Alternative Group D_1

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.



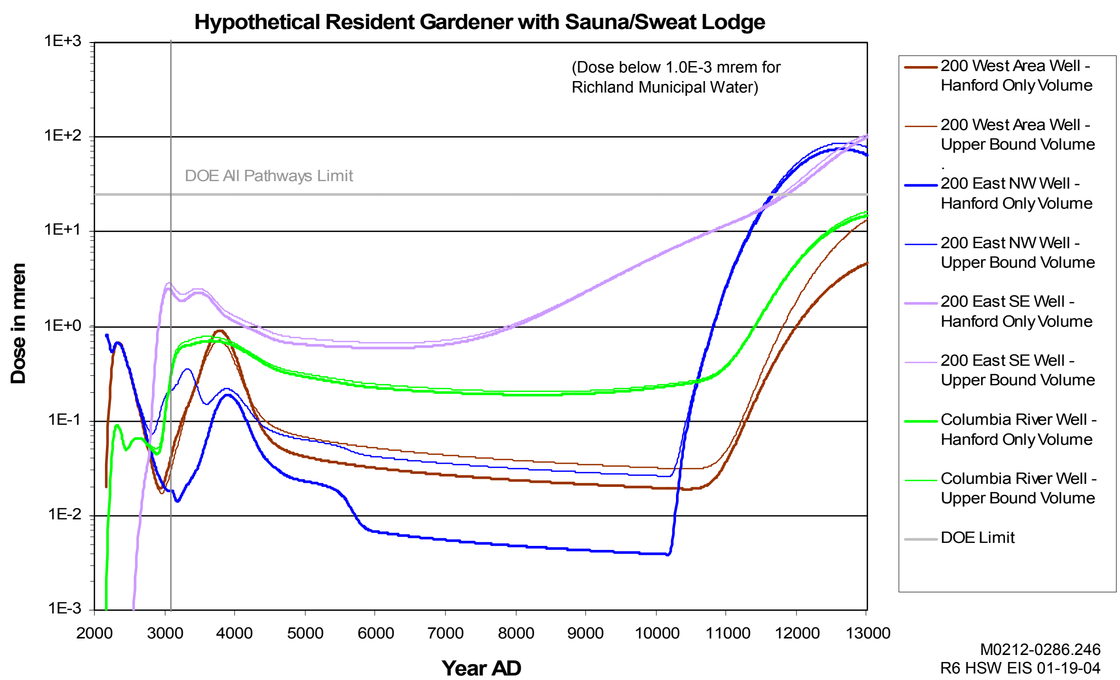


Figure 5.37. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group D_1, Hanford Only and Upper Bound Waste Volumes

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.

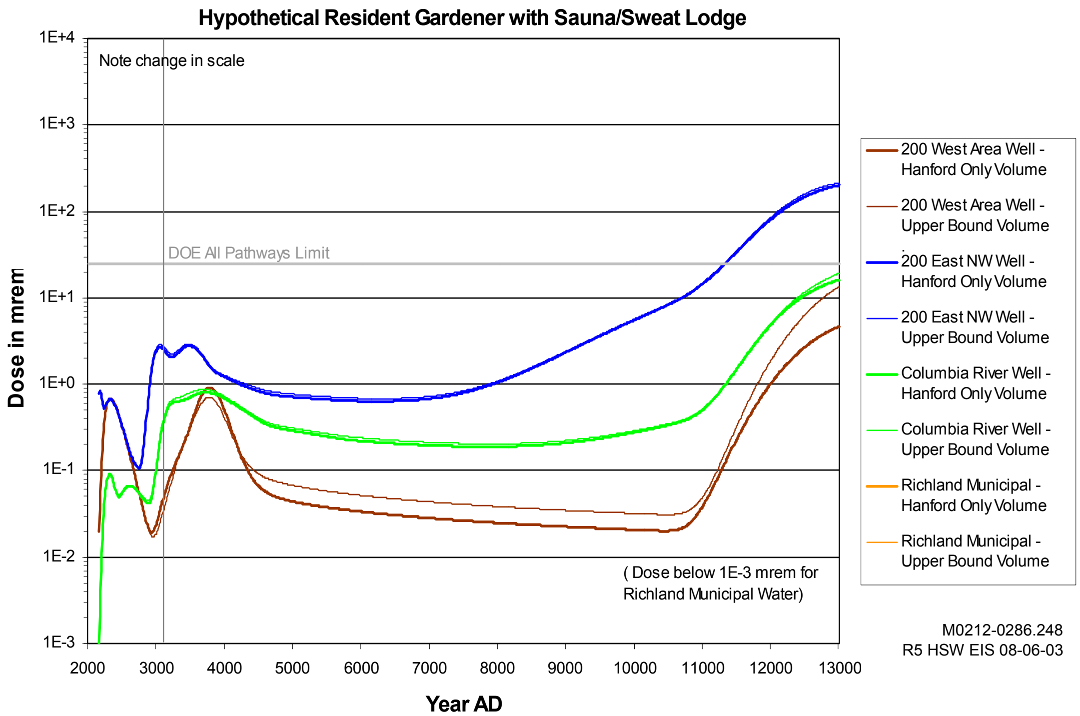
5.11.2.1.4.2 Alternative Group D_2

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.



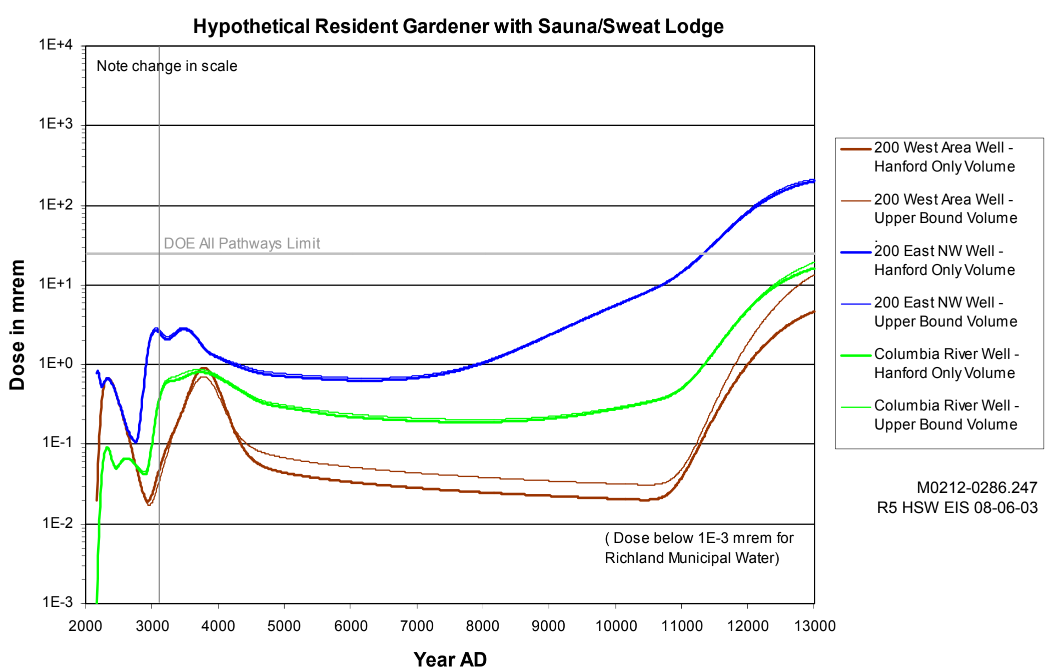


Figure 5.38. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group D_2, Hanford Only and Upper Bound Waste Volumes

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.

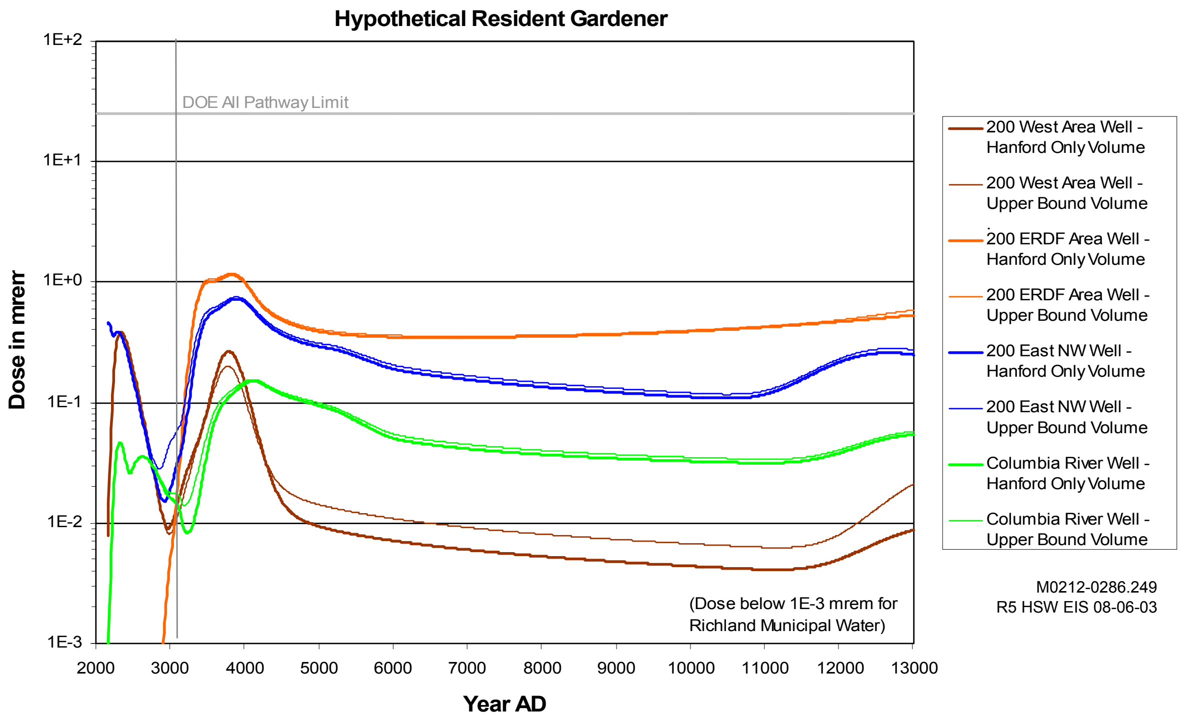
5.11.2.1.4.3 Alternative Group D_3

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.



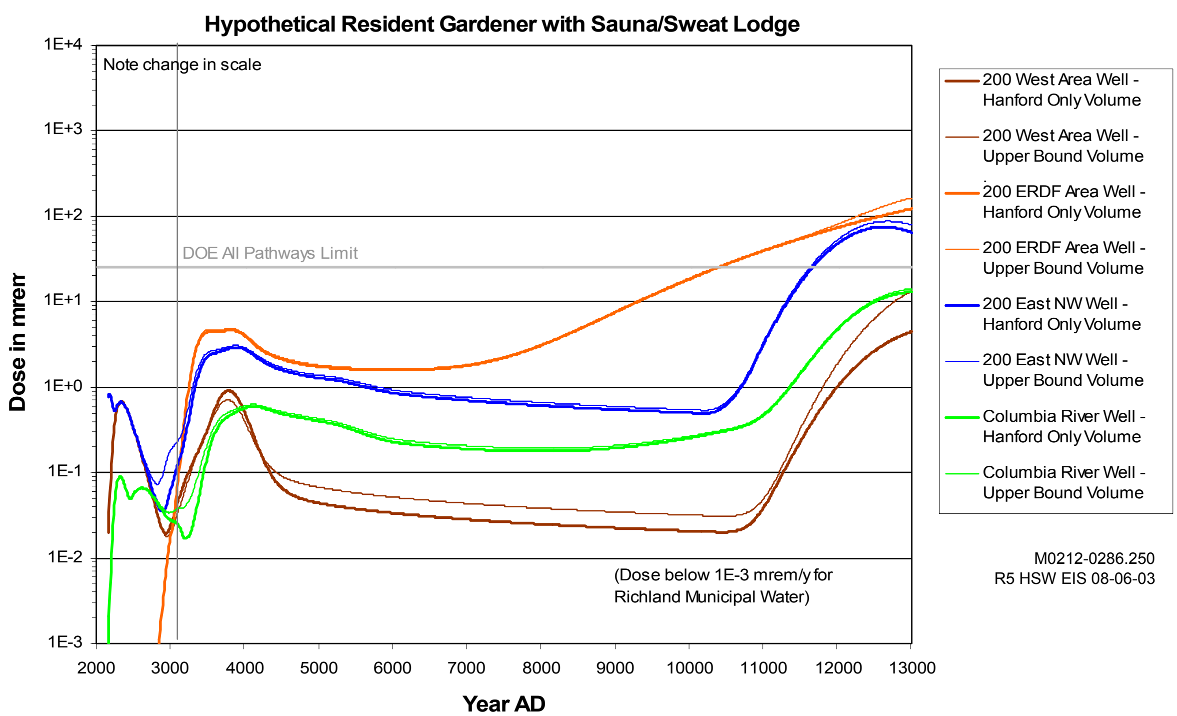


Figure 5.39. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group D_3, Hanford Only and Upper Bound Waste Volumes

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.

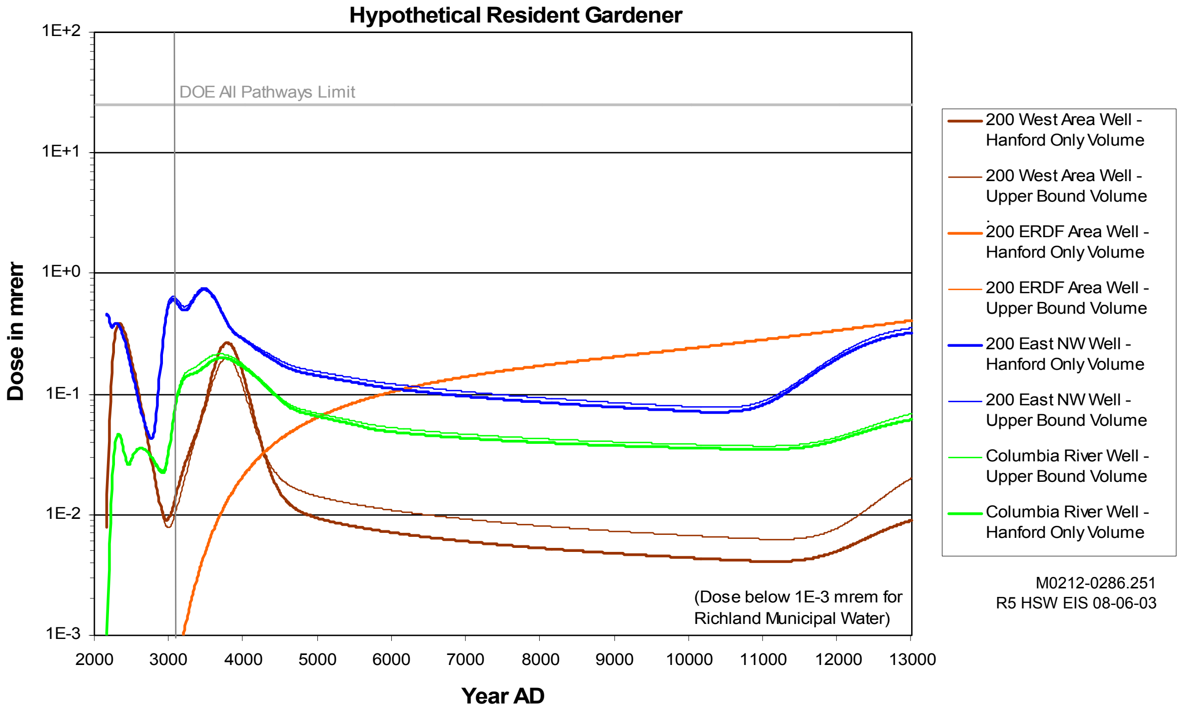
5.11.2.1.5.1 Alternative Group E_1

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.



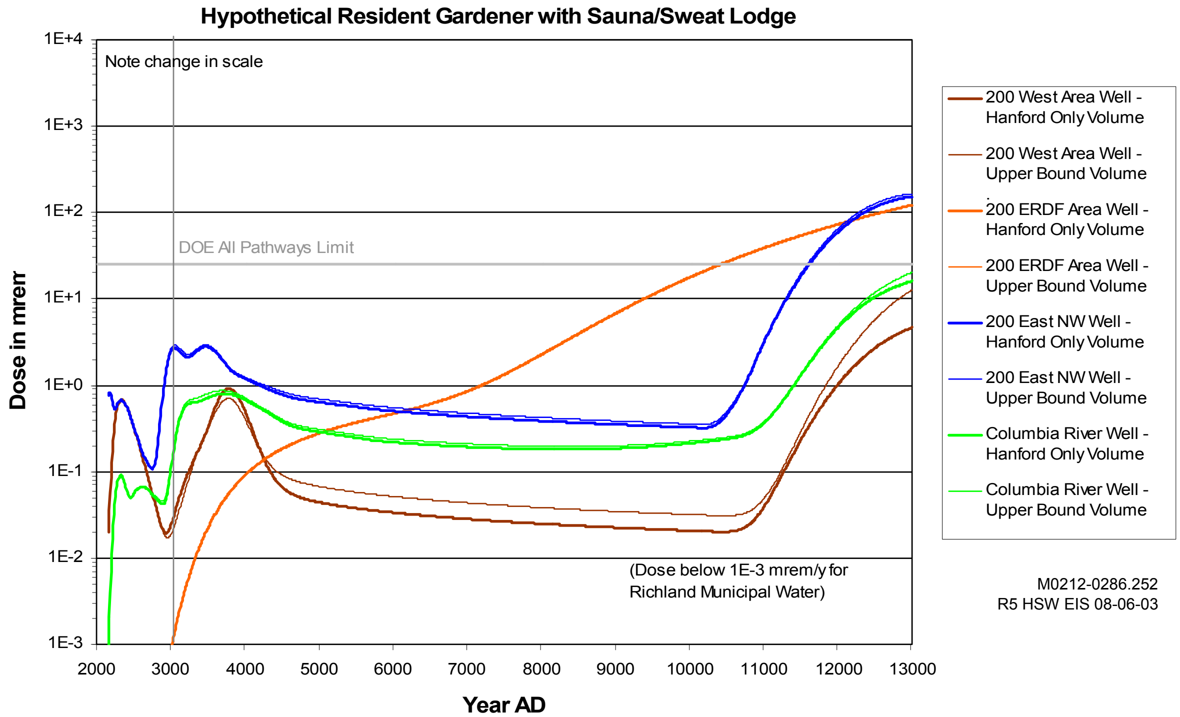


Figure 5.40. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group E_1, Hanford Only and Lower Bound Waste Volumes

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

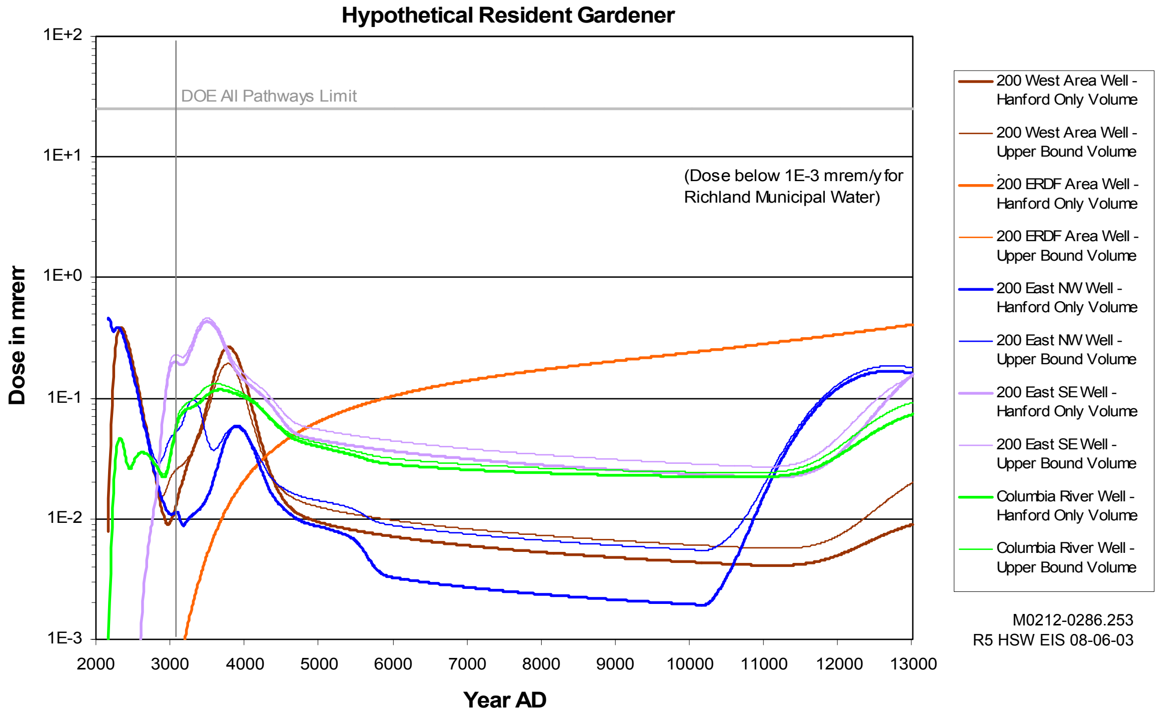
The potential consequences to the MEI are presented in Figure 5.41 for a hypothetical individual residing 1 km (0.6 mi) downgradient from the disposal facilities, a hypothetical individual residing near the Columbia River, and for users of municipal water from the Richland water supply system. Results 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.



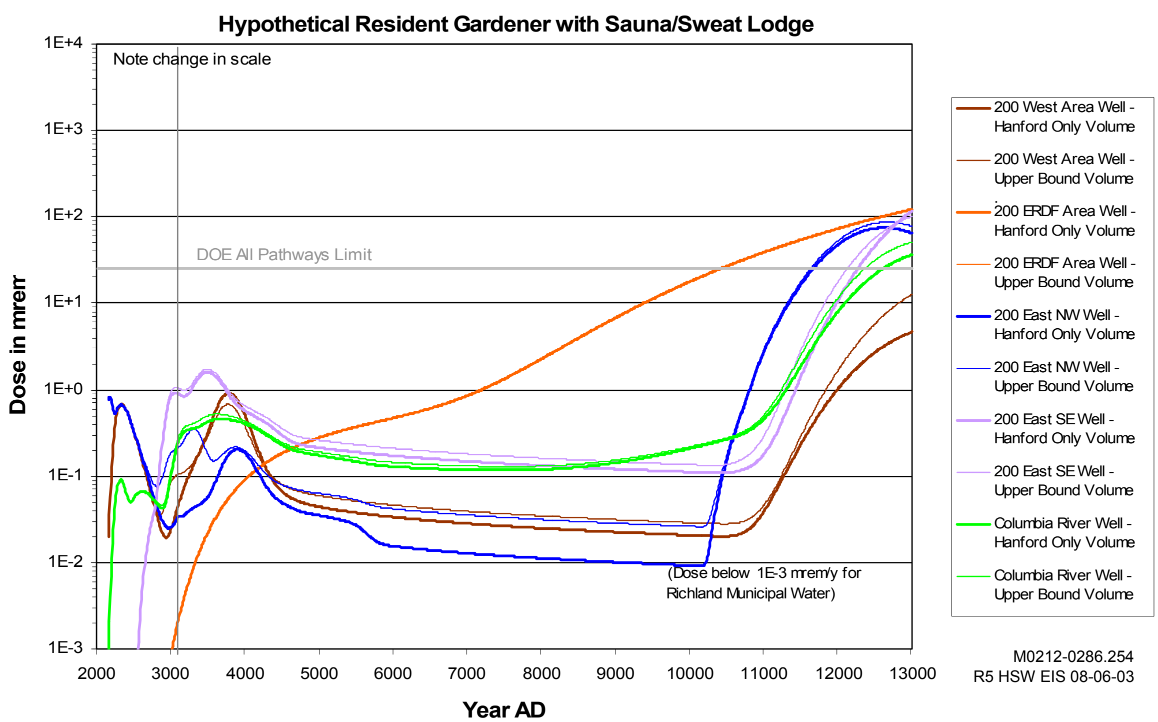


Figure 5.41. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group E_2, Hanford Only and Upper Bound Waste Volumes

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.

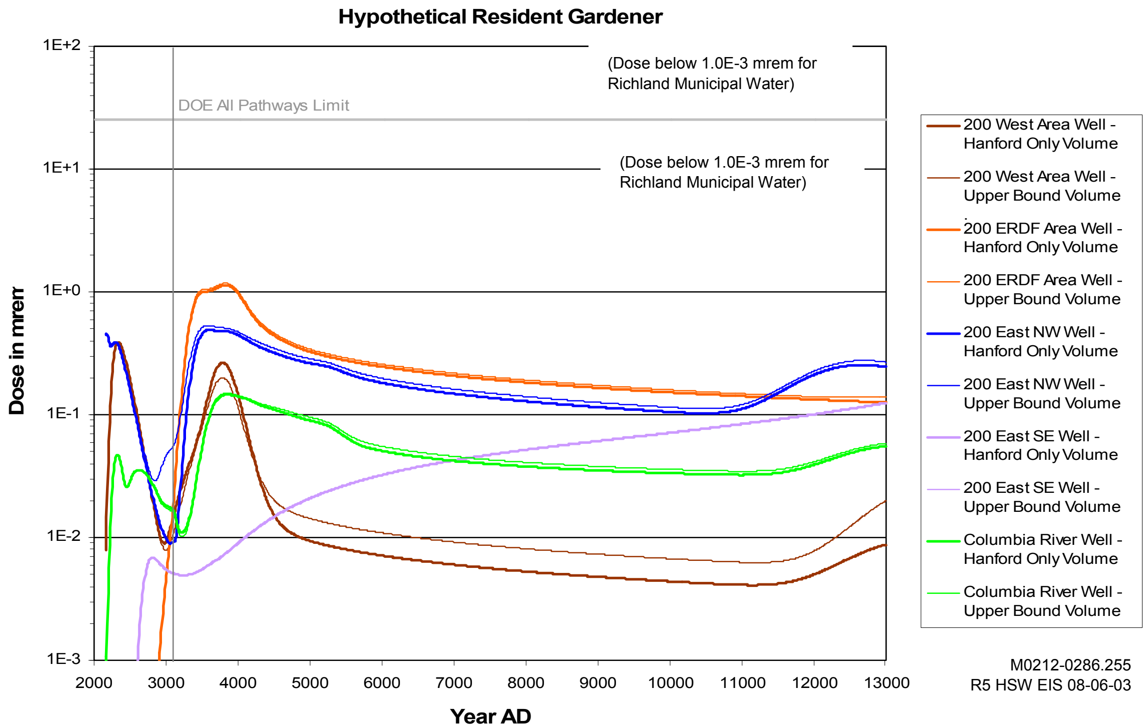
5.11.2.1.5.3 Alternative Group E_3

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.



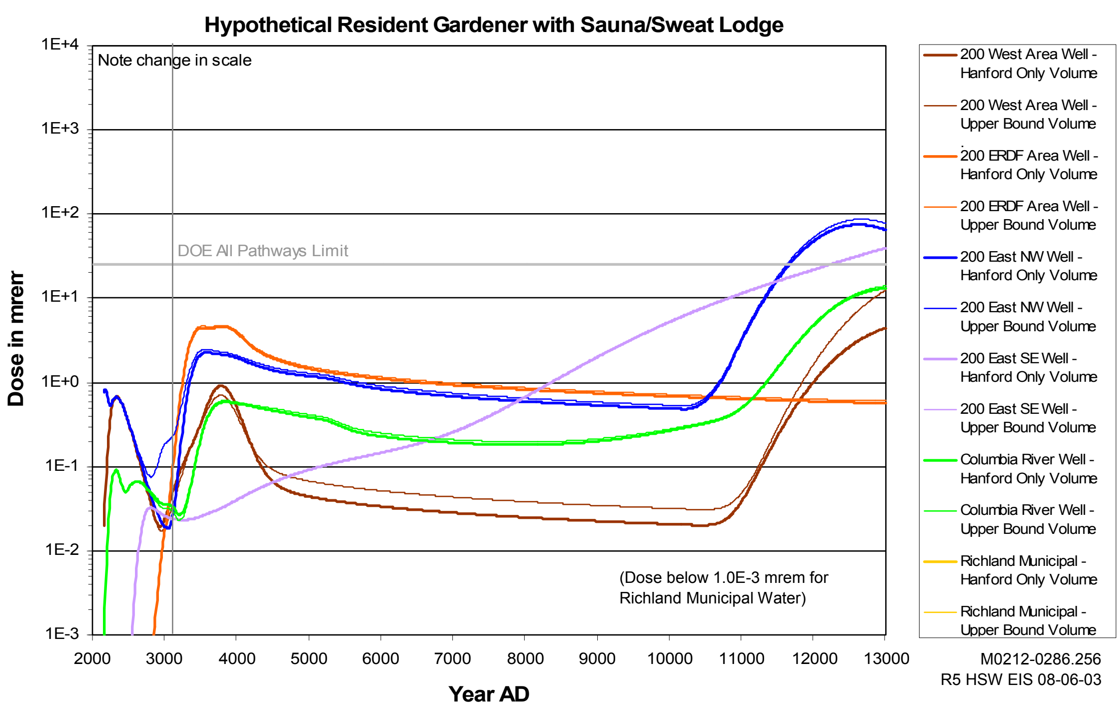


Figure 5.42. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – Alternative Group E_3, Hanford Only and Upper Bound Waste Volumes

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.

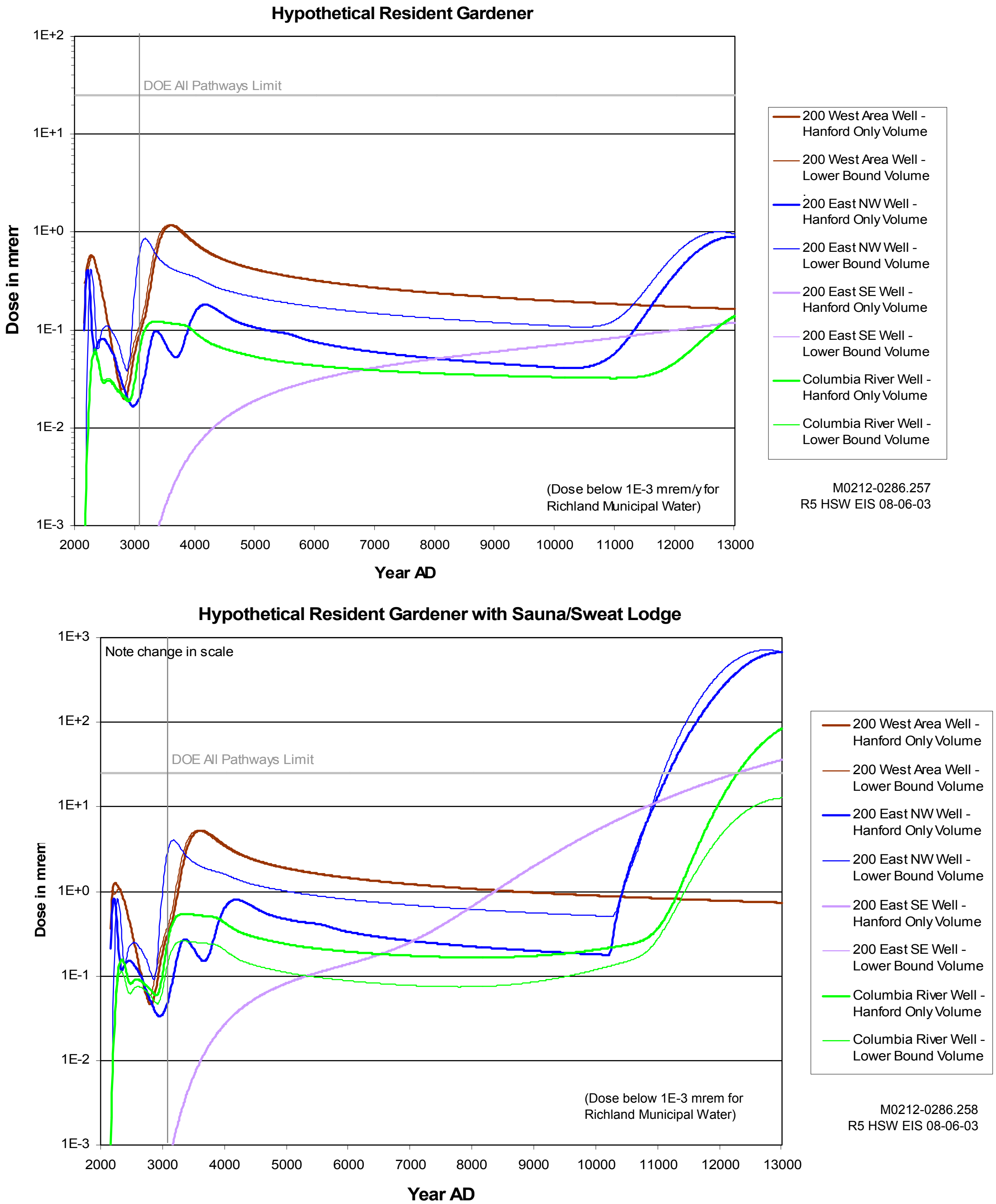


Figure 5.43. Annual Dose to a Maximally Exposed Individual at Various Times over 10,000 Years Using Water from Various Locations – No Action Alternative, Hanford Only and Upper Bound Waste Volumes

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.

5.12 Aesthetic and Scenic Resources

Potential impacts on aesthetics and scenic resources arising from implementing Alternative Groups A through E and the No Action Alternative are discussed in this section. The potential impacts would arise mainly from visual intrusions on the natural landscape from expansion of existing buildings; construction of new facilities undertaken in support of the waste transport, treatment, storage, and disposal in the 200 Areas; and activities associated with the borrow pit at Area C. Existing aesthetic and scenic resources of the Hanford Site are described more fully in Section 4.8.10.

Most facilities are not visible to the public because of the size of the facilities, the size of the Hanford Site, the location of the facilities within the Hanford Site, the terrain and restricted access to the site, and the distance between the viewer and the activity on the site.[a] The exception is the construction, operation, and eventual closures of the Area C borrow pits (see Figure 4.1 in Section 4).

The Area C borrow pit site is a large polygonal area located adjacent to and south of SR 240 and centered approximately at the intersection of Beloit Avenue and SR 240. This site is about 926 ha (2287 ac) in size and is located next to the Fitzner Eberhardt Arid Lands Ecology Reserve (ALE) but is not part of the Hanford Reach National Monument. The area was designated as conservation (mining) in the Record of Decision (ROD) (64 FR 61615) for the *Final Hanford Comprehensive Land-Use Plan EIS* (DOE 1999). The operation of the borrow pit would not be visible from vehicles using SR 240 from the southwest until they are approximately three-quarters of the way past the site. The reason for this restriction in the viewshed[b] is the elevated terrain adjacent to SR 240, separating Area C from the road. Travelers coming from the northwest on SR 240 would notice the site sooner and would be able to observe the activities in passing. The pits, themselves, would be located a minimum of 152 m (500 ft) from SR 240. During borrow pit site development, the bringing of utilities from the Hanford 200 West Area to the site would be noticeable by those traveling on SR 240. The Area C borrow pits would be within the northerly viewshed from Rattlesnake Mountain.

During the operation of the Area C borrow pits, a maximum of approximately 70 pits would be excavated, and 86 ha (213 ac) would be disturbed (Alternative Group B – Upper Bound waste volume). From the air and SR 240, the surface terrain will look pockmarked. During the 12 plus years of the site's operational life, stockpiles of sand, gravel, rock, and silt/loam would be located within 305 m (1000 ft) of SR 240. The individual borrow pits would be restored when their useful life ends. This restoration includes replacing excavated topsoil and re-seeding the area. After extraction of resources from the borrow pit area is complete, the site pit slopes would be re-graded and irregular terrain lines installed to blend the site with the surrounding terrain. No permanent adverse aesthetic or scenic impacts would be expected.

(a) Those accelerated process lines (APLs) located within CWC would not be seen and those outside would be dwarfed by the surrounding buildings. As a consequence it is concluded that the APLs would have no impact on aesthetic and scenic resources.
(b) Defined as the scenic resources that can be seen from a particular vantage point.

Fugitive dust associated with development and operation of the Area C borrow pits is a recognized, potential problem, and, as a result, a program would be undertaken to keep fugitive dust controlled during site development and operation, even during off hours. The use of soil adhesives, the application of water, and the discontinuance of excavation and truck loading activities, when winds are excessive, are some of the control measures that would be employed. As a consequence, fugitive dust from the borrow pit area would not be expected to develop into an adverse aesthetic or scenic impact.

Elk occupying the ALE site are sometimes seen from SR 240. Operation of the borrow pit might reduce the likelihood of sighting these animals near Area C because they might migrate farther away from where they might be seen from the highway as a result of these activities.

Travelers can see some site facilities in the 200 West Area on an 11-km (7-mi) segment of SR 240 south of the Yakima Barricade (near the junction of SR 240 and SR 24). At the closest approach, facilities associated with waste-management activities are about 3 km (2 mi) distant. Facilities throughout the 200 Areas are visible from elevated locations, such as Gable Mountain, Gable Butte, and Rattlesnake Mountain, and in the distance from atop the bluffs, east of the Columbia River. These locations generally are not points for public viewing because of their restricted access; however, they may be points of viewshed observation important to Native Americans.

5.12.1 Alternative Group A

The potential aesthetic impacts in Alternative Group A would be those associated with

- use of the modified T Plant Complex
- construction of additional disposal trenches of a deeper and wider design
- construction of caps for disposal facilities would raise the surface about 1.7 m (5.5 ft) for 169 ha to 179 ha (416 to 439 ac) for the Hanford Only to the Upper Bound waste volumes, respectively
- excavation of capping materials, temporarily disturbing 69 to 73 ha (170.4 to 180.6 ac) in the Area C borrow pit.

The T Plant Complex is a facility that has been in place for about 50 years and is not considered in terms of aesthetic impacts. Trench construction and the capped trenches for LLW, MLLW, and ILAW likely would not be noticeable from points of public viewing.

5.12.2 Alternative Group B

The potential aesthetic impacts in Alternative Group B would be those associated with

- construction of a new waste processing facility
- construction of additional disposal trenches of the current design

- capping of the LLW, MLLW, and ILAW trenches over an area ranging between 187 to 210 ha (462 to 519 ac) for the Hanford Only to the Upper Bound waste volumes, respectively

- excavation of capping materials, temporarily disturbing 77 to 86 ha (190 to 210 ac) in the Area C borrow pit area.

The T Plant Complex is a facility that has been in place for about 50 years and, as in Alternative Group A, is not considered in terms of aesthetic impacts. The new waste processing facility probably would be noticeable from SR 240 as one more multi-story building with a 30-m (100-ft) stack. Even if seen, it is questionable that it would be distinguishable from the other industrial buildings in the 200 West Area. Trench construction and the capped trenches for LLW, MLLW, and ILAW likely would not be noticeable from points of public viewing. The potential for aesthetic or scenic impacts related to excavation operations at the borrow pit would be essentially the same as those for Alternative Group A.

5.12.3 Alternative Group C

The potential aesthetic impacts in Alternative Group C would be those associated with

- use of the modified T Plant Complex

- capping of the disposal facilities over an area of 151 to 160 ha (373 to 395 ac) for the Hanford Only to the Upper Bound waste volumes, respectively

- excavation of capping materials, temporarily disturbing 62 to 66 ha (153 to 163 ac).

The T Plant Complex is a facility that has been in place for about 50 years and, as in Alternative Group A, is not considered in terms of aesthetic impacts. Trench construction and the capped LLBGs and LLW, MLLW and ILAW trenches would likely not be noticeable from points of public viewing. The potential for aesthetic or scenic impacts related to excavation operations at the borrow pit would be essentially the same as those for Alternative Groups A and B.

5.12.4 Alternative Group D

Alternative Group D contains three subalternative groupings that are dependent on the location of disposal. The potential for aesthetic impacts for all subalternatives is bounded in the numbers presented below. The potential aesthetic impacts in Alternative Group D would be those associated with

- use of the modified T Plant Complex

- capping of the disposal facilities for 150 to 155 ha (370 to 383 ac) for the Hanford Only to the Upper Bound waste volumes, respectively

- excavation of capping materials, temporarily disturbing 2 to 64 ha (153 to 158 ac).

The T Plant Complex has been in place for about 50 years and, as in Alternative Group A, is not considered in terms of aesthetic impacts. Trench construction and the capped trenches for LLW, MLLW, and ILAW likely would not be noticeable from points of public viewing. The potential for aesthetic or scenic impacts related to excavation operations at the borrow pit would be essentially the same as those for Alternative Groups A through C.

5.12.5 Alternative Group E

Alternative Group E contains three subalternative groupings that depend on the location of disposal. The potential for aesthetic impacts for all subalternatives are bounded in the numbers presented below. The potential aesthetic impacts in Alternative Group E would be those associated with

- use of the modified T Plant Complex
- construction of caps for disposal facilities for an area of 150 to 155 ha (371 to 383 ac) for the Hanford Only and Upper Bound waste volumes, respectively
- excavation of capping materials, temporarily disturbing 62 to 64 ha (153 to 158 ac).

The T Plant Complex is a facility that has been in place for about 50 years and, as in Alternative Groups A, C, and D, is not considered in terms of aesthetic impacts. Trench construction and the capped trenches for LLW, MLLW, and ILAW likely would not be noticeable from points of public viewing. The potential for aesthetic or scenic impacts related to excavation operations at the borrow pit would be essentially the same as those for Alternative Group A.

5.12.6 No Action Alternative

The potential aesthetic impacts in the No Action Alternative would be those associated with

- use of the T Plant Complex
- expansion of the CWC
- construction of caps for disposal facilities for an area of 158 to 159 ha (389 to 393 ac) for the Hanford Only and Upper Bound waste volumes, respectively
- extraction of capping materials from the Area C borrow pit temporarily disturbing 14 ac (35 ac) for that purpose.

Trench construction and the capped MLLW trenches likely would not be noticeable from points of public viewing. ILAW would be disposed of in vaults. Although the expansion of the CWC buildings might be noticeable from SR 240, they are co-located with other buildings in the developed 200 West Area and likely would not be considered an adverse aesthetic impact. Trench construction and capped MLLW trenches likely would not be noticeable from points of public view, particularly SR 240.

The potential for aesthetic and scenic impacts related to excavation operations at the borrow pit would be substantially smaller than those for the action alternative groups, as less than 20 percent of the volume of materials would be needed for MLLW trench capping.

5.13 Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (59 FR 7629), directs Federal agencies in the Executive Branch to consider environmental justice so that their programs will not have "…disproportionately high and adverse human health or environmental effects…" on minority and low-income populations. Executive Order 12898 further directed Federal agencies to consider effects to "populations with differential patterns of subsistence consumption of fish and wildlife." The Executive Branch agencies also were directed to develop plans for carrying out the order. The CEQ provided additional guidance later for integrating environmental justice into the National Environmental Policy Act process in a December 1997 document, *Environmental Justice Guidance Under the National Environmental Policy Act* (CEQ 1997b).

Environmental justice is concerned with assessing the disproportionate distribution of adverse impacts of an action among minority and low-income populations, in which the impacts are significantly greater than those experienced by the rest of the population. Adverse impacts are defined as negative changes to the existing conditions in the natural environment (for example, land, air, water, wildlife, vegetation) or in the human environment (for example, employment, health, land use). The distribution of minority and low-income groups in the Hanford environs is shown graphically in Section 4.8.

Based on the 2000 Census, the 80-km (50-mi) radius area surrounding the Hanford Site has a total population of 482,300 and a minority population of 178,500 (Census 2000). The ethnic composition of the minority population is primarily White Hispanic (24 percent), self-designated "other and multiple" races (63 percent), Native American (6 percent), and two or more races (9 percent). Asians and Pacific Islanders (4 percent) and African American (3 percent) make up the rest. The Hispanic population resides predominantly in Franklin, Yakima, Grant, and Adams counties. Native Americans within the 80-km (50-mi) area reside primarily on the Yakama Reservation and upstream of the Hanford Site near the town of Beverly, Washington.

The 2000 low-income population was approximately 80,700, or 17 percent of the total population residing in the 80-km (50-mi) radius of the Hanford Site. The majority of these households were located to the southwest and northwest of the site (Yakima and Grant counties) and in the cities of Pasco and Kennewick.

Native Americans of various tribal affiliations who live in the greater Columbia Basin rely in part on natural resources for subsistence. According to Harris and Harper (1997), the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, and the Yakama Nation depend on natural resources for dietary subsistence. For example, the treaty of 1855 with the Yakama Nation (Treaty with the Yakama 1855) secured to the Yakamas "…the right of taking fish at all usual and accustomed places, in common with the citizens of the Territory [now the state of Washington] and of erecting temporary buildings for curing them; together with the privilege of hunting, gathering roots and berries, and pasturing their horses and cattle upon open and unclaimed lands." The Wanapum historically lived along the Columbia River and continue to live upstream of the Hanford Site. They fish on the Columbia River and gather food resources near the Hanford Site. The Confederated Tribes of the Colville Reservation traditionally fished and gathered food resources in the Hanford area. They also are recognized as having cultural and religious ties to the Hanford Site.

The pathways through which the potential environmental impacts are associated, with respect to each of the alternative groups, and how they might disproportionately impact minority or low-income groups were reviewed for each of the associated sections of Section 5. The only aspect that exhibited the potential for disproportionate impacts dealt with implications of cultural resources on the Hanford Site with respect to Native Americans. Furthermore, these would be common to all of the alternative groups. Native American affiliations near the Hanford Site include such places as Gable Mountain, Rattlesnake Mountain, and Gable Butte with respect to their creation beliefs and cultural heritage. Thus disproportionate adverse impacts from implementing any of the alternative groups on minority or low-income populations would be limited to those that might be associated with restricted use of Native American traditional cultural places on the Hanford Site. Additional information on cultural resources were presented in Section 5.7. Other impacts related to aesthetic and scenic resources were addressed in Section 5.12.

5.14 Cumulative Impacts

This section presents a discussion of cumulative impacts on the human environment from past, current, and reasonably foreseeable future actions in the Hanford area in conjunction with the actions proposed in the HSW EIS. DOE endeavored to take into consideration all Hanford Site and nearby actions that might make an important contribution to cumulative impacts.

The Council on Environmental Quality Assessment of Cumulative Impacts

In 40 CFR 1508.7, the Council on Environmental Quality (CEQ) defines cumulative impact as:

"…the impact on the environment from the incremental impact of the action when added to other past, present, and reasonably future actions regardless of what agency (federal or non-federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time)."

In CEQ 1997a, the CEQ states:

"The continuing challenge of cumulative effects analysis is to focus on important cumulative issues…."

Past onsite actions that might lead to present-day or future cumulative impacts considered in this assessment include:

- operation of fuel fabrication facilities, reactors, and product separation facilities
- operation of research and development facilities
- management of liquid waste, including tank storage
- disposal of liquid radioactive waste in cribs, ponds, and ditches
- leaks and spills of liquid waste on the ground
- management of spent nuclear fuel
- storage of strontium, cesium capsules, and other radioactive materials
- retrievable storage of TRU waste
- disposal of solid radioactive wastes in trenches and caissons
- stabilization of the Plutonium Finishing Plant
- operation of the ETF, the LERF, the State-approved land disposal system, and the TEDF
- conduct of RCRA/CERCLA remediation projects including operation of the ERDF
- disposal of Navy reactor compartments
- operation of a commercial LLW disposal site by US Ecology, Inc.
- operation of the Columbia Generating Station by Energy Northwest.

Past offsite actions that were considered consists of those of a nearby commercial nuclear fuel fabrication plant and commercial waste treatment facilities.

Current onsite actions that were considered include:

- continued operation of research and development facilities
- preparations for treatment and disposal of tank waste
- continuation of RCRA/CERCLA remediation projects and operation of ERDF
- continued management of TRU waste (including retrieval), LLW, and MLLW
- continued management of spent nuclear fuel
- continued storage of strontium, cesium capsules, and other radioactive materials
- continued stabilization of the Plutonium Finishing Plant
- continued operation of the ETF, the LERF, the State-approved land disposal system, and the TEDF
- disposal of Navy reactor compartments
- operation of the commercial LLW disposal site by US Ecology, Inc.
- operation of the Columbia Generating Station by Energy Northwest.

Current offsite activities that were considered consist of those of the nearby commercial nuclear fuel fabrication plant and commercial waste treatment facilities.

In addition to the activities proposed in the HSW EIS, reasonably foreseeable future onsite activities that were considered include:

- continued operation of research and development facilities
- disposal of tank waste and closure of tank waste sites
- continued management of spent nuclear fuel
- continued storage of strontium, cesium capsules, and other radioactive materials
- continuation of RCRA/CERCLA remediation projects and operation of ERDF
- continued stabilization of the Plutonium Finishing Plant
- continued operation of the ETF, the LERF, the State-approved land disposal system, and the TEDF
- decommissioning and disposition of Hanford's surplus reactors and chemical processing facilities
- continued disposal of Navy reactor compartments
- continued operation of the commercial LLW disposal site by US Ecology, Inc.
- continued operation of the Columbia Generating Station by Energy Northwest.

Reasonably foreseeable future offsite activities that were considered consist of those of the nearby commercial nuclear fuel fabrication plant and commercial waste treatment facilities.

As evidenced by the data presented elsewhere in Section 5 and in the Hanford annual environmental reports, for most resource and potential impact areas, the cumulative impacts from implementation of the HSW EIS alternative groups for the Hanford Only, Lower Bound, and Upper Bound waste volumes, or for the No Action Alternative for the Hanford Only and Lower Bound waste volumes, when added to impacts of the other cited actions, would be small to negligible.

5.14.1 Land Use

Consistent with past NEPA actions, land within the 200 Areas has already been committed for Industrial-Exclusive use, including waste disposal (DOE 1999). Radionuclides are present in the soil from past discharges, disposal actions, or tank leaks. Because of their chemical characteristics and very long half-lives (for example, cesium-135 with a half-life of 2.3 million years), some radionuclides are held in the soil indefinitely.

Waste previously disposed of in the solid waste disposal facilities currently occupies 130.5 ha (322 ac) of the Hanford Site. As discussed in Section 5.1, additions to the commitment of land area for waste disposal would range from about 19.2 ha (47 ac) for the Hanford Only waste volume as disposed of in any of the configurations of Alternative Groups D or E to 79.6 ha (197 ac) for the Upper Bound waste volume estimate as disposed of in Alternative Group B (see Section 5.1). Waste management activities through 2046 (Upper Bound waste volume) would be expected to require up to a total of 427 ha (1050 ac) for waste storage, treatment, and disposal facilities and for capping materials. Of this total, 210 ha (519 ac) would be permanently committed for disposal of wastes in Alternative Group B (largest requirements). This amount would represent about 4.2 percent of the 5000 ha (12,350 ac) within the area previously designated for long-term waste management activities in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (HCP EIS) (DOE 1999).

5.14.2 Air Quality

As discussed in Section 5.2, air quality standards at the Hanford Site boundary would not be approached or exceeded as a result of implementing any of the actions described here or in combination with other reasonably foreseeable actions at the Hanford Site (see Section 5.2). This is due in large part to the current and projected:

- low density and intensity of pollutant emitting activities on the Hanford Site and in neighboring areas of south-central Washington

- relatively low population density in the region (minimizing the contribution of urban impacts on the region's air quality)

- substantial distances between the project activities and the Hanford Site boundary

- atmospheric dispersion conditions at Hanford that are generally favorable and meteorological conditions that could lead to a severe atmospheric stagnation event are of low-to-moderate frequency (and typically of short duration).

Quantification of cumulative non-radiological impacts for criteria pollutants was based on data presented in the Tank Waste Remediation System EIS and is shown in Table 5.150 (DOE and Ecology 1996). The maximum impacts from Hanford Solid Waste Program activities are presented in Table 5.151 for comparison.

Table 5.150. Cumulative Air Quality Impacts for Criteria Pollutants

Sources	Maximum Average Concentration (μg/m³)			
	Particulate (PM_{10})	Nitrogen Oxide (NO_2)	Sulfur Oxide (SO_2)	Carbon Monoxide (CO)
Hanford Site baseline	3	3	19	3
Hanford remedial action	43	40	5	26
Environmental Restoration Disposal Facility	33	Negligible	Negligible	Negligible
Tank Waste Remediation System alternative	98	2.2	27	2500
Standard[(a)]	150 (24 hour)	100 (Annual)	365 (24 hour)	10,000 (8 hour)
(a) 40 CFR 50.				

Table 5.151. Largest Criteria-Pollutant Impacts for HSW Operations Among the Alternative Groups and the No Action Alternative

Alternative Group	Hanford Only and Lower Bound Waste Volumes				Upper Bound Waste Volume			
	24-hr PM_{10}	1-hr SO_2	8-hr CO	Annual NO_2	24-hr PM_{10}	1-hr SO_2	8-hr CO	Annual NO_2
Alternative Group A, μg/m³	69	81	470	0.72	74	98	590	0.80
Alternative Group B, μg/m³	71	130	800	1.0	90	180	1110	1.1
Alternative Group C, μg/m³	60	79	460	0.77	61	80	470	0.77
Alternative Group D, μg/m³	61	84	500	0.79	62	84	500	0.85
Alternative Group E, μg/m³	60	93	530	0.89	62	95	530	0.89
No Action Alternative, μg/m³	57	86	460	0.85	Not applicable			
(a) Standards are: 24-hour PM10 = 150 μg/m³, 1-hour SO_2 = 1,000 μg/m³, 8-hour CO = 10,000 μg/m³. Annual NO_2 = 100 μg/m³								

It should be noted that the values presented in Tables 5.150 and 5.151 are maximums that would occur at different times and locations and may not be additive.

5.14.3 Ecological, Cultural, Aesthetic, and Scenic Resources

Cumulative impacts as they pertain to ecological, cultural, aesthetic, and scenic resources in general on the Hanford Site can be found in the HCP EIS, which is incorporated by reference (DOE 1999). There, it was concluded that the potential for cumulative impacts to biological resources could best be evaluated by determining the amount of *Hanford Site Biological Resources Management Plan* (BRMaP) Level III and Level IV resources that could be affected.

The HSW EIS does not consider any change in land use designated by the HCP EIS Record of Decision (64 FR 61615). The HCP EIS took a long-term look at the resources that would be required for the major reasonably foreseeable projects. Capping on the Central Plateau and complete conversion of the Industrial-Exclusive to industrial areas were two of the impacts assumed at that time. The HCP EIS contains the distribution of BRMaP Levels II, III, and IV resources for the DOE preferred alternative—prior to the 24 Command Fire. BRMaP mitigation would have been required for those areas that were designated Level III or Level IV. Assuming that the pre-fire condition represents the edaphic potential of the burned areas, the HCP EIS identified 44,183 ha (109,179 ac) in Conservation (Mining) and 5,064 ha (12,323 ac) in Industrial-Exclusive as BRMaP Level III resources, out of a site resource base of 148,080 ha (365,914 ac). These areas contain no BRMaP Level IV resources. In the HCP EIS, Conservation (Mining) was chosen for 30 percent of the site, while Preservation was chosen for 53 percent of the site.

Field surveys conducted during 2002 for each of the areas in which any of the HSW EIS alternative groups might be implemented identified the near PUREX disposal facility site (up to 24.5 ha [60 ac]) as mature shrub-steppe habitat that could qualify under BRMaP Level III and require mitigation. Isolated element occurrences in Area C might also qualify as Level III or Level IV but would need to be re-examined nearer the time of the planned disturbance (see Section 5.5).

The activities described in this EIS would take place in areas that are, and will be for the foreseeable future, dedicated to industrial type uses. However, the presence of the Hanford Reach Monument with its relatively low-density use and the portions of the Hanford Site designated for preservation/conservation would result in large areas remaining in a natural state.

Surveys of areas to be used in implementing each of the alternative groups did not disclose the presence of cultural resources (see Section 5.7). However, changes to the viewshed of the Hanford 200 Areas would occur as a result of activities evaluated in this EIS as well as other programs at Hanford. As facilities are closed and barriers are placed on waste disposal facilities, the visual appearance of waste disposal facilities would likely become more similar to the to pre-Hanford Site condition. Future uses of the Central Plateau are likely to include structures and activities consistent with its designation for Industrial-Exclusive use in the HCP EIS (DOE 1999). However, most areas of the viewshed on the Hanford Site are expected to remain in a near natural state due to designation of approximately 80,000 ha (200,000 ac) of the site as a national monument (65 FR 37253) and of many other major areas of the site for preservation/conservation (DOE 1999).

5.14.4 Geologic Resources

Geologic resources consisting of sand, gravel, silt/loam, and perhaps basalt would be required in the construction of Modified RCRA Subtitle C Barriers for any of the alternative groups and for the Hanford barrier to cover immobilized low-activity waste (ILAW) as disposed of in the No Action Alternative. The expected quantities of these resources were presented in Section 5.10. The resources would be obtained from Area C identified in the HCP EIS (DOE 1999) as Conservation (Mining). In areal extent, the requirements would at most (Alternative Group B) amount to about 10 percent of Area C designated for borrow-pit materials.

This HSW EIS does not consider any change in land use designated by the HCP EIS ROD (64 FR 61615). The HCP EIS took a long-term look at the resources that would be required for the major reasonably foreseeable projects. Capping on the Central Plateau and complete conversion of the Industrial-Exclusive to industrial areas were two of the impacts assumed at that time. Appendix D of the HCP EIS discussed using 36.1 million cubic meters (47.3 million cubic yards) of fine textured soils and developing a basalt source that could yield 15.3 million cubic meters (20 million cubic yards) of basalt riprap. A maximum of 90 ha (222 ac) of area C would be used for geologic resource development, out of the 44,183 ha (109,179 ac) reserved by the HCP EIS for Conservation (Mining). In the HCP EIS, Conservation (Mining) was chosen for 30 percent of the site, while Preservation was chosen for 53 percent of the site.

5.14.5 Socioeconomics

If a number of the projects being considered for Hanford were undertaken simultaneously, the activity levels and the workers needed to support the activities could temporarily strain community infrastructure. The impact of any of the HSW EIS alternative groups or the No Action Alternative would be small (300 to 400 workers out of 15,000 workers at the Hanford Site, see Section 5.6). The current projected baseline for Hanford shows declining employment beginning in about 2005. If this baseline is maintained and other considerations remain equal, most existing components of community infrastructure would be adequate to accommodate population growth of about 2,000 residents associated with any of the HSW EIS alternative groups in the long run. However, a projected 7,000 new residents are expected move into the area to support construction of the Hanford tank waste treatment plant. These new arrivals and any early arrival of the up to about 2,000 new residents related to the Hanford solid waste program in the Tri-Cities area could challenge the capacities of the local real estate markets, the transportation network, and the primary and secondary education facilities.

In addition, other projects are expected to be underway at Hanford in the near term, such as operations at the Hazardous Materials Management and Emergency Response (HAMMER) facility; cleanup of several older reactors and other buildings; and actions to remediate the K Basins, the vadose zone, and the groundwater on the site. These additional projects could increase Hanford employment by a few hundred workers during the period 2003 to 2010 and, therefore, might also affect the socioeconomic context against which the effects of any LLW, MLLW, and TRU waste-related activity under the proposed action would need to be judged (see Section 5.6).

While the increases in workers (300 to 400) mentioned above would be in addition to the existing Hanford workforce of about 15,000, that work force is anticipated to temporarily increase (from activities other than those associated with Hanford solid waste), then generally decline after about 2005, and finally continue to decline throughout the period of analysis (see Section 5.6, Figure 5.22). Overall employment may even decline at a faster rate than presently forecasted depending on the success of accelerated site cleanup. However, the impact of implementing any of the Hanford solid waste alternative groups would be a small addition to cumulative socioeconomic impacts.

5.14.6 Public Health

Although large amounts of various chemicals have been used during Hanford operations over the years, the breadth and depth of documented, quantitative information regarding these chemicals is very limited when compared with the amount of information available about radioactive materials. However, as shown in Section 5.11, hazards from releases of chemicals to the atmosphere have been calculated to be very small for all the alternative groups and would not be expected to add measurably to cumulative impacts regardless of their magnitude.

As was shown in Section, 4.5.3.2, Figure 4.19, a number of chemicals, principally from past liquid discharges to the ground, are found in the groundwater at Hanford. Again, there is only fragmentary data on the source quantities and transport to groundwater of these chemicals. In one case, however, it was estimated that the inventory of nitrate in groundwater beneath the 200 Areas exceeded 90,000 tonnes (100,000 tons) (ERDA 1975). The inventory of nitrate in Hanford solid waste is on the order of 6.2 tonnes (6.8 tons), which is small relative to other sources of this chemical at Hanford. In addition to the minimal impacts reported for chemicals in Section 5.3, this suggests that the impacts of other chemicals in Hanford solid waste would not contribute substantially to the cumulative impacts of existing chemicals in groundwater.

Cumulative impacts for the atmospheric, surface water, and groundwater pathways, which could lead to potential radiological impacts on the public, are presented in the following subsections (also see Section 5.11).

5.14.6.1 Atmospheric Pathway

A summary of cumulative radiological impacts on public health due to radiological air emissions from past, current, and reasonably foreseeable future activities at Hanford is provided in Table 5.152. Examples of past activities include operation of the fuel fabrication plants, reactors, the PUREX Plant and other fuel processing facilities; the Plutonium Finishing Plant; and research facilities. Current activities include site cleanup, waste disposal, and tank waste stabilization; reasonably foreseeable future activities include continuation of site cleanup, waste disposal, immobilization of both high-level and low-activity waste, and related activities.

The cumulative population dose since the startup of Hanford operations was estimated to be 100,000 person-rem (DOE 1995). The number of inferred latent cancer fatalities (LCFs) since Hanford startup from such a population dose would amount to about 60, essentially all of which would be attributed to a dose received in the 1945 to 1952 time period.

For perspective, since startup of the Hanford Site, the population of interest (assuming an average population within 80 km [50 mi] of 380,000 and an individual dose of 0.3 rem/yr [NCRP 1987]) would have received about 6 million person-rem from naturally occurring radiation sources (that is, natural background), from which about 4000 LCFs could be inferred.

Table 5.152. Cumulative Population Health Effects in the Hanford Environs from Atmospheric Pathways due to Hanford Site Activities[(a)]

Source of Impacts	Dose Person-rem	Latent Cancer Fatalities[(b)]
Past Hanford operations (DOE 1995)	100,000	60
Ongoing and Proposed Operations		
Hanford operations (1997–2046) (Poston et al. 2001)[(c)]	15	0
Columbia generating station (30 yr) (DOE 1996b)	21	0
HSW EIS—atmospheric releases		
Alternative Groups A, C, D, & E–range[(d)]	0.15–0.24	0
Alternative Group B–range[(d)]	0.19–0.29	0
No Action Alternative–range[(e)]	0.10–0.12	0
Reasonably Foreseeable Operations		
Plutonium Finishing Plant stabilization (DOE 1996b)	140[(f)]	0
K Basin fuel treatment and storage (DOE 1996a)	120[(f)]	0
TWRS phased implementation alternative (DOE and Ecology 1996)	400[(f)]	0
Cumulative total	100,696.3[(g)]	60
Perspective		
Cumulative natural background dose–100 yr, 1946–2046	12,000,000	7,000

(a) Assumes constant population of about 380,000.
(b) Assumes six inferred LCFs per 10,000 person-rem. Values less than 0.5 were rounded to zero.
(c) Assumed to continue at the 2000 population dose rate.
(d) Range based on Hanford Only and Upper Bound waste volumes.
(e) Range based on Hanford Only and Lower Bound waste volumes.
(f) Value based on previous NEPA analyses.
(g) For the solid waste program, this number includes only the value of 0.3 person-rem from Alternative Groups A, B, C, D, or E, Upper Bound waste volume activities.

If the entire Hanford sitewide contribution to population dose from all exposure pathways were to remain at calendar-year 2000 levels (Poston et al. 2001) through the period ending in 2046, the estimated collective population dose would be about 36 person-rem. No LCFs would be expected from such a population dose.

This estimated level was based on a 0.3-person-rem/yr population dose from DOE facilities at Hanford and a 0.7-person-rem/yr population dose from Energy Northwest's Columbia Generating Station for 30 years of operation (DOE 1996b). The largest contribution from solid waste management alternative groups to the total population dose of 36 person-rem would be about 0.3 person-rem (see Section 5.11).

Vitrification of the Hanford tank wastes could contribute up to about 400 person-rem to the cumulative, collective population dose (DOE and Ecology 1996). The cumulative, collective population dose from Plutonium Finishing Plant activities could be up to 140 person-rem (DOE 1996b). Similarly, remediation of K Basins could be up to 120 person-rem (DOE 1996a). No other activities are foreseen that would add substantially to these doses, and the total dose from these activities through the period ending in 2046 would not be expected to result in any LCFs.

Again for perspective, the doses to the local population from naturally occurring radioactive sources would result in about an additional 6 million person-rem for the 50-year period ending in 2046, from which about 4000 LCFs also would be inferred. Thus, over about 100 years from the start of the Hanford operations to the year 2046, about 7000 LCFs might have resulted from naturally occurring sources. To this number of LCFs resulting from natural sources would be the inference that Hanford operations might have added about 60 LCFs as a result of airborne releases of radioactive material mainly during the 1945 to 1952 time period.

5.14.6.2 Surface Water Pathway

Past impacts associated with the water pathway were principally associated with contamination of Columbia River water that was used as once-through coolant for the eight Hanford production reactors. Various elements present in the incoming water were made radioactive during their passage through one or more of these reactors.[a] In addition, some of the corrosion products that formed in the plants' piping were made radioactive and entered the water. Fuel element failures (slug ruptures) also exposed the fuel to cooling water and added contaminants to the water. On an average annual basis, the principal radionuclides contributing to a potential dose were phosphorous-32, chromium-51, zinc-65, arsenic-76, and neptunium-239. Contamination also occurred as a result of adding water-conditioning agents, with hexavalent chromium as the principal contaminant.

(a) A ninth reactor, N Reactor, did not use once-through cooling. Past discharges to nearby trenches is a source for seepage of some contaminants into the river.

(b) Before 1971, higher doses would have been experienced by those individuals making recreational use of the Columbia River, consuming food crops grown with irrigation water derived from the river, consuming fish and waterfowl inhabiting the river, and consuming seafood harvested from along the Washington and Oregon coast. Due to the number of pathways and uncertainties in numbers of individuals involved, this aspect has not been quantified on a collective basis for the 1944 to present time period. Estimates of maximum and average representative individual doses may be found in Farris et al. (1994). Doses from 1971 to present were estimated from the maximally exposed individual (MEI) doses taken from annual reports and, consequently, are substantially higher than would be expected for individuals with typical dietary habits (for example, the annual per capita dose for 1999 was reported as 0.0007 mrem, and the MEI dose was reported as 0.008 mrem, thus the MEI dose overestimates the per capita dose by a factor of about 10.)

An estimate of the collective population dose to the nearest downstream users of the Columbia River (Richland, Pasco, and Kennewick, Washington) from 1944 to present would amount to about 3000 person-rem, most of which occurred before 1971 at which time the last reactor that used once-through cooling was shut down. This estimate was based on the dose to people who drank water supplied by municipal water plants and estimates of the populations for Richland (after startup of its water treatment plant in late 1963), Pasco, and Kennewick, and included a nominal amount of time for people who engaged in boating and swimming in the Columbia River.[b] From 1971 to present, the collective population dose was estimated to be less than 400 person-rem. From a collective dose of 3000 person-rem, 2 LCFs could be inferred. The collective population drinking water dose for 2001 from the surface water pathway was determined to be 0.0024 person-rem (Poston et al. 2001). If that annual dose were to continue over 10,000 years, the total from all future Hanford activities might amount to 27 person-rem. The addition of radionuclides from the disposal of Hanford solid waste over that period was less than or equal to 0.3 person-rem in the Tri-Cities. Neither the current projection of drinking water dose nor that projected from disposal of Hanford solid waste would add substantially to the past cumulative population dose derived from the Columbia River of 3400 person-rem.

The presence of contaminants in surface water as a result of inflow of groundwater and a discussion of the cumulative impacts of contaminants in the groundwater, itself, are included in the next subsection.

5.14.6.3 Groundwater Pathway

Cumulative groundwater impacts are examined in the context of existing sources of contamination in the soil, vadose zone, and groundwater. The following contaminants have been consistently detectable in soil on the Hanford Site: strontium-90, cesium-137, uranium-238, plutonium isotopes (238, 239, 240), and americium-241. Contaminants in the vadose zone include cobalt-60, strontium-90, technetium-99, cesium-137, europium isotopes (152, 154), uranium isotopes (234, 235, 238), and plutonium isotopes (239, 240). Contaminants in the vadose zone also include non-radioactive materials including metals, volatile organics, semivolatile organics, and inorganics (Poston et al. 2002). Current contamination of the groundwater and vadose zone is due primarily to past liquid waste disposal practices involving hazardous chemicals and radionuclides. The existing level of contamination in the groundwater would exceed Federal Drinking Water Standards if it were a source of drinking water as defined in the standards (Poston et al. 2002). Hazardous chemical contaminants that would exceed this benchmark include nitrate, carbon tetrachloride, trichloroethene, and chromium, and radiological contaminants that exceed the standards include tritium, iodine-129, strontium-90, technetium-99, and uranium. Concentrations of these radionuclides and hazardous chemicals currently in groundwater are shown in Section 4.5.3.1, Figures 4.18 and 4.19, respectively.

Action alternatives analyzed in this EIS would not cause the dose from drinking groundwater at 1 km from the disposal facilities to exceed the DOE 4-mrem-per-year benchmark public drinking water limit (see Section 5.11.2.1). Analysis of the preferred alternative also indicated the dose from drinking groundwater at the disposal facility boundary would not exceed the DOE limit (see Section 5.11.2.1.4). By the time the waste constituents from the action alternatives are predicted to reach groundwater (hundreds of years) the waste constituents would not superimpose on existing plumes and would not exceed the benchmark dose, because the existing groundwater contaminant plumes will have migrated out of the unconfined aquifer by then.

Radionuclides leached from wastes disposed of in HSW disposal facilities could eventually be transported through the vadose zone to groundwater. For this analysis, it was assumed that an individual drilled a well through the vadose zone to the groundwater and used the groundwater as a source of drinking water. As an indication of cumulative Hanford groundwater impacts, the annual dose to an individual drinking 2 liters of that water per day and taking into account all wastes intentionally or unintentionally disposed of on the Hanford Site since the beginning of operations and waste forecast to be disposed of through 2046[(a)] was calculated for technetium-99, iodine-129, and uranium isotopes using the System Assessment Capability (SAC) (Kincaid et al. 2000) software and data. Technetium-99, iodine-129, and uranium were selected for analysis because they are expected to be the dominant contributors to risk in the future. Carbon-14 was omitted from this cumulative assessment based on prior analyses (Kincaid et al. 1998) that showed it to be less mobile and not substantially influencing cumulative results. The distribution coefficients assigned to carbon-14 in solid waste for that analysis were substantially greater than those assigned to uranium and iodine-129, and, consequently, carbon-14 would not be expected to release from solid waste deposits into groundwater during this 10,000-year assessment.

The more limited data available for chemical inventories in solid waste disposals would not support a SAC analysis on the same scale as the initial assessment conducted for radionuclides. However, based on available information, chemicals in solid waste do not appear to be as important in terms of human health impacts as the key radionuclides—technetium-99, iodine-129, and uranium. Carbon tetrachloride and chromium in Hanford solid waste are not expected to add substantially to impacts of those substances from other Hanford sources, that is, liquid discharge sites and unplanned releases. For further discussion of the potential impacts from hazardous chemical constituents in Hanford solid waste, see Volume I, Sections 5.3.2 and 5.3.5.

(a) ILAW from treating tank waste was not included in the original SAC or initial assessment. Initially the SAC was tasked to address a 1000-year period; however, technetium-99 and iodine-129 would not release from the ILAW form to the water table within that time period. An approximation of the drinking water doses combining SAC and ILAW results for technetium-99, iodine-129, and uranium is shown as a function of time in Figures 5.38 through 5.43. Melters and naval reactor compartments also were not included as sources of radioactive releases in the original SAC assessment. They, like ILAW, were assumed to not release any activity during the initial 1000-year post-closure period. Both of these waste types are encased in substantial steel containment and contain substantially lower inventories of technetium-99 and uranium than ILAW; therefore, they would not contribute to groundwater contamination and were not simulated.

A SAC analysis of hypothetical future impacts was conducted based on conservative assumptions (that is, absence of active institutional controls and cessation of barrier maintenance). The SAC analysis of the initial assessment for 10,000 years completed for the HSW EIS was comprised of two simulations: a stochastic analysis[(a)] and a deterministic analysis.[(b)]

Liquid Discharge of Carbon Tetrachloride

Groundwater modeling has been performed in support of the Hanford Carbon Tetrachloride Innovative Treatment Remediation Demonstration (ITRD) Program (Truex et al. 2001). Simulations, as part of this study, of the liquid discharge sites receiving carbon tetrachloride were based on an assumption that approximately 65 percent, 30 percent, 10 percent, and 1 percent of the source could reach the groundwater. Approximately 1 to 2 percent of the original carbon tetrachloride inventory is estimated to now exist in the plume based on averaged groundwater measurements (Ebasco Services, Inc. 1993). Other model parameters varied in Truex et al. (2001) included porosity, soil/water equilibrium partition coefficient (K_d), and abiotic degradation rate (K_a). The analysis revealed that a breakpoint for cleanup requirements lies between 1 and 10 percent of the initial discharge inventory reaching groundwater. If 1 percent of the inventory reaches groundwater, no cleanup is likely to be required, whereas if 10 percent of the inventory eventually reaches groundwater, some cleanup may be necessary. Therefore, an estimate of the initial inventory that may ultimately reach groundwater is important in determining the need for site cleanup. The study also showed that better definition of K_d, K_a, and porosity would aid in refining estimates of the compliance boundary concentrations. Truex et al. (2001) concluded, "…if 1% of the discharged CT [carbon tetrachloride] is all that ever reaches groundwater, then it is likely the highest concentration of CT to arrive at the compliance boundary will not exceed the compliance concentration."

LLBG Disposal of Carbon Tetrachloride

The presence of carbon tetrachloride in the aquifer underlying the 200 West Area is a direct result of the disposal of liquid waste streams containing carbon tetrachloride. The mean value inventory of carbon tetrachloride shows approximately 813,000 kg being released to liquid discharge sites in the 200 West Area. For comparison, all of the carbon tetrachloride in HSW is reported to be in "stored" solid waste; none is reported in "buried" solid waste, and the total inventory reported to be stored through 1997 was approximately 5000 kg. Storage is taking place in the radioactive mixed waste storage facilities (primarily CWC) and in retrievably stored TRU waste trenches in the 218-W-3A, 218-W-4B, and 218-W-4C LLBGs. While there is no record of past disposals, some carbon tetrachloride might have been disposed of in HSW; however, it is likely that the amount, its rate of release, and its potential impact on groundwater would not be substantial compared with that of past releases to liquid discharge facilities.

(a) Stochastic Analysis: Set of calculations performed using values randomly selected from a range of reasonable values for one or more parameters; in contrast, see deterministic analysis. In the HSW EIS, the median result from a set of stochastic calculations was reported.

(b) Deterministic Analysis: A single calculation using only a single value for each of the model parameters. A deterministic system is governed by definite rules of system behavior leading to cause and effect relationships and predictability. Deterministic calculations do not account for uncertainty in the physical relationships or parameter values.

The stochastic analysis included 25 realizations. Each realization represents a possible combination of the uncertain parameters. Using a cumulative performance measure, such as cumulative dose at a point of interest, a single realization can be identified as the median response for the stochastic problem. The single deterministic calculation was performed using the median value for each input parameter. Results of the 25 stochastic simulations, with the median result case highlighted, are provided in Volume II, Appendix L. The result of the deterministic calculation using median inputs is reported in this section as well as in Volume II, Appendix L for comparison to the stochastic cases. For additional information on the SAC calculation process, see Volume II, Appendix L to this EIS and the initial assessment report (Bryce et al. 2002). The SAC is the next generation methodology intended to update and improve the 1998 Composite Analysis completed by Kincaid et al. (1998). Using the dose predicted in the ILAW performance assessment (Mann et al. 2001) the influence of ILAW disposal has been added to that predicted in the initial assessment median-inputs case simulated with SAC. Thus, the cumulative impact shown below for selected points is achieved by superimposing the published ILAW impact on the simulated initial assessment results. The inventories simulated using the SAC tool for this EIS are shown in Table L.1 in Volume II, Appendix L and represent the combination of solid waste, liquid discharge and unplanned release, tank waste, and commercial low-level waste inventories addressed in the cumulative assessment.

1-km Line of Analysis

A line of analysis approximately 1 km from an operational area or waste disposal site was used in the 1998 composite analysis (Kincaid et al. 1998), the initial assessment completed with the SAC (Bryce et al. 2002), and in the simulations supporting this HSW EIS. The travel distance between the source and the uptake location is consistent with the groundwater model grid (that is, 375 m) and the longitudinal dispersivity (that is, 95 m) used in the sitewide groundwater model. In general, the rule of thumb for selecting an appropriate longitudinal dispersivity is to use approximately 10 percent of the mean travel distance of interest. A 1-km travel distance implies a 100-m longitudinal dispersivity. To control model stability and artificial dispersivity, the model grid Peclet number (that is, grid spacing/longitudinal dispersivity = 375 m/95 m) is typically selected to be no greater than 4 for finite element models. The existing model for the cumulative impacts was not configured to produce results at a 100-m travel distance. To achieve results at a 100-m line of analysis for the cumulative impacts would require development of a local-scale model based on an approximate grid size of 40 m and longitudinal dispersivity of 10 m.

Concentration profiles over time for technetium-99, iodine-129, and uranium from all Hanford sources at a line of analysis approximately 1 km (0.6 mi) southeast of the 200 East Area are shown in Figure 5.44. Maximum concentrations for each of the radionuclides occur in the near term.

Concentrations of technetium-99, iodine-129, and uranium are 1600, 0.90, and 1.1 pCi/L, respectively. The technetium-99 and iodine-129 concentrations are above or near the benchmark drinking water standards of 900 pCi/L and 1 pCi/L, respectively. The uranium concentration, approximately 3.3 μg/L, is below its benchmark drinking water standard of 30 μg/L. The cumulative impact for technetium-99, iodine-129, and uranium from all Hanford sources is provided in Figure 5.45. This is the annual dose

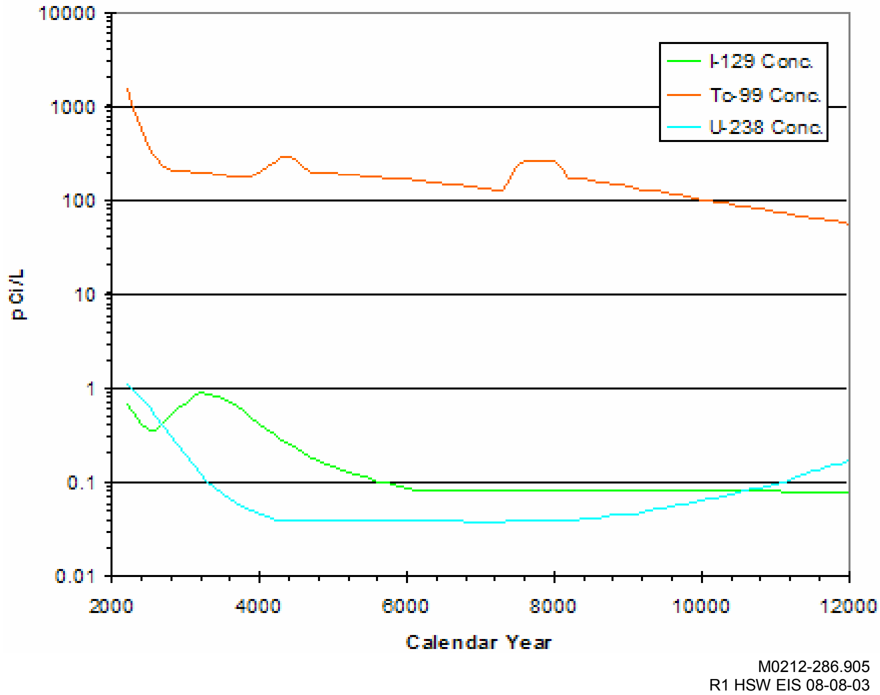


Figure 5.44. Concentrations of Technetium-99, Iodine-129, and Uranium in Groundwater Southeast of the 200 East Area from All Hanford Sources

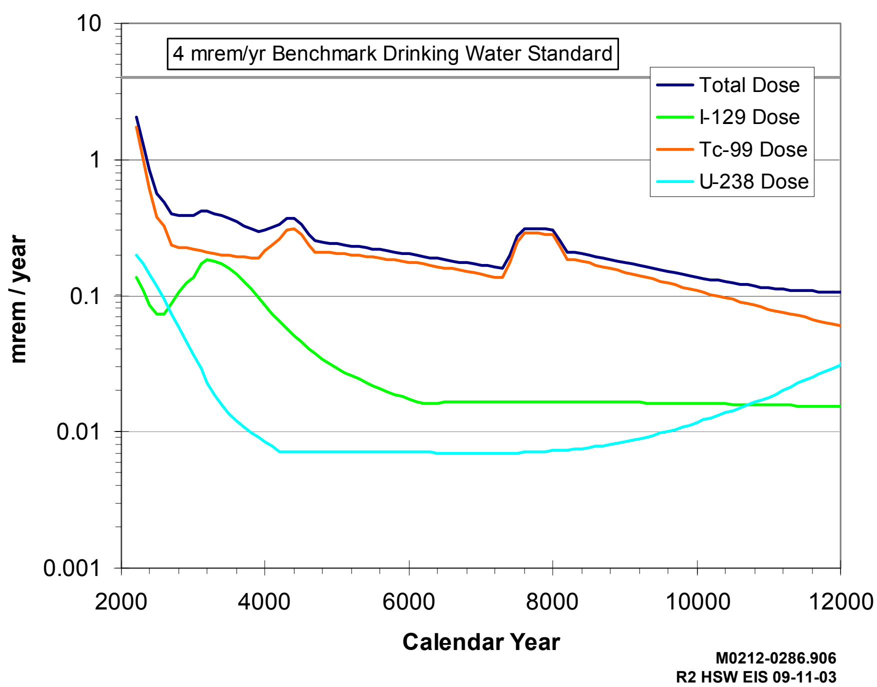


Figure 5.45. Hypothetical Drinking Water Dose from Technetium-99, Iodine-129, and Uranium in Groundwater Southeast of the 200 East Area from All Hanford Sources

resulting from a 2-L/d drinking water scenario for each of the radionuclides. The values of maximum dose for technetium-99, iodine-129, and uranium corresponding to the maximum concentrations are 1.7, 0.18, and 0.20 mrem/yr.

The annual dose exhibits a peak of approximately 2 mrem/yr. This peak appears to be related to releases from past liquid discharge sites in the 200 East Area. Additional, but lower, peaks of approximately 0.4 mrem/yr appear in approximately years 4400 and 7600. Releases of technetium-99 from HSW disposal facilities in the 200 West Area are responsible for the peak in approximately year 4400. Tank waste residuals releasing technetium-99 in the 200 East Area from a 1-percent residual volume and a salt cake waste are responsible for the last peak. The underlying long-term dose declines to 0.1 mrem/yr by 10,000 years post closure. This dose is related to long-term releases from HSW and other miscellaneous waste, which, when combined, account for approximately 0.07 mrem/yr, and from ILAW, which accounts for approximately 0.04 mrem/yr.

Based on uncertainty in the groundwater conceptual model and resulting direction of groundwater flow, the ILAW contribution to the cumulative result may be approximately four times larger when groundwater flows to the northeast rather than the southeast. The resulting cumulative 2-L/d drinking water dose from ILAW for technetium-99, iodine-129, and uranium would be approximately 0.2 mrem/yr at 10,000 years post closure for this northeast groundwater flow case. Somewhat higher contributions than shown here from HSW and other sources (that is, 0.07 mrem/yr) may also occur because of uncertainty in the groundwater conceptual model used in the SAC; however, groundwater model uncertainty as it relates to the HSW contributions is addressed in Section 5.3 and Volume II, Appendix G. It should be noted that the ILAW release and associated dose impacts play a role in the last several thousand years only and do not substantially influence the peaks that occur earlier.

The cumulative dose from all Hanford sources and that portion attributed to solid waste at the line of analysis southeast of the 200 East Area are shown in Figure 5.46. Differences in the two curves (that is, the slope of the curves) are attributed to somewhat different distribution coefficient (K_d) values used in the simulation of HSW EIS groundwater impact analysis and in this cumulative assessment. The more rapid release and migration of uranium in the evaluation of solid waste disposal alternatives enables uranium to influence the long-term solid waste contribution between 8,000 and 12,000 A.D. This uranium influence is not seen in the initial assessment simulated with SAC because of the use of somewhat higher distribution coefficients to represent median or central tendency behavior. More details can be found later in this section.

Figure 5.47 shows the concentrations of technetium-99, iodine-129, and uranium from all Hanford sources from Columbia River water at the City of Richland pumping station. This location is downriver from all groundwater plumes of Hanford origin, and reveals the substantial dilution and dispersion that occurs because of the relatively large discharge of the Columbia River as compared with that of the unconfined aquifer underlying Hanford. Although groundwater simulations continued through the year 12,050 A.D. (10,000 years post closure; see Figure 5.47), the river simulations were terminated at the year 9900 A.D. due to the software design constraints of the river model. Thus, river model forecasts are not available for the final 2000 years of the 10,000-year post-closure period. However, as is apparent from

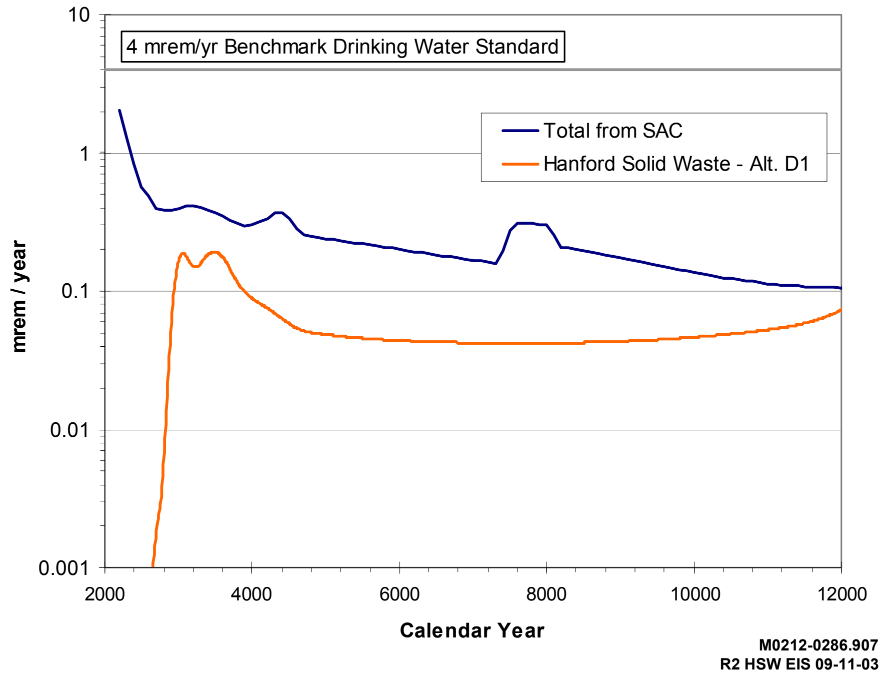


Figure 5.46. Hypothetical Total Drinking Water Dose from Groundwater for All Hanford Sources and the Hanford Solid Waste Contribution at the Line of Analysis Southeast of the 200 East Area

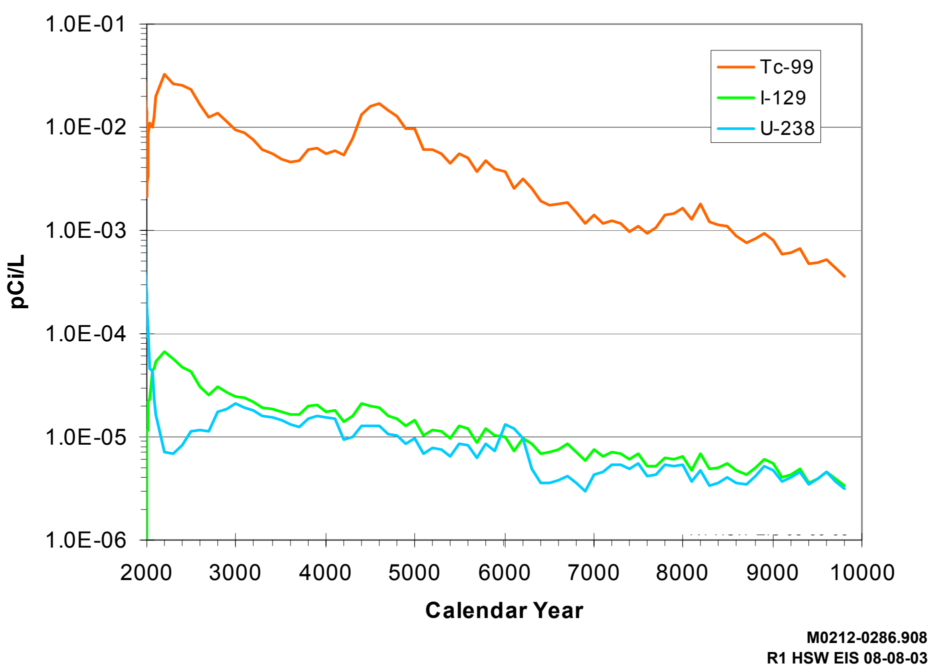


Figure 5.47. Concentrations of Technetium-99, Iodine-129, and Uranium in the Columbia River at the City of Richland Pumping Station from All Hanford Sources

the simulation results achieved, trends seen in the groundwater system near the Central Plateau appear somewhat later and at much reduced concentrations in the Columbia River at the City of Richland location.

A corresponding plot of the drinking water dose for technetium-99, iodine-129, and uranium is provided in Figure 5.48. While having a much more variable appearance caused by river discharge variability, the peaks seen in technetium-99 plots at the 200 East Area location are also present in Figure 5.48. Dose from Hanford-origin uranium and iodine-129 also exhibits a temporal variability caused by variability in Columbia River discharge. However, the peaks are subdued and delayed because these elements are sorbed and migrate more slowly than groundwater and non-sorbed elements, such as technetium. Concentration and annual dose values are approximately five orders of magnitude lower at the city of Richland compared with those predicted at the 200 East Area.

Figure 5.48 reveals the drinking water dose to a human from technetium-99, iodine-129, and uranium using water concentrations calculated near the City of Richland pumping station in the Columbia River never gets above 1.0×10^{-4}, or 0.0001, mrem/yr in the median inputs analysis. This location is downriver from all groundwater plumes of Hanford origin. The peak median dose from technetium-99 for the year 2000 through 9900 A.D. was approximately 3.5×10^{-5}, or 0.000035, mrem/yr. For the same period, the peak median dose from iodine-129 was approximately 1.5×10^{-5}, or 0.000015, mrem/yr. For uranium, the peak median dose was approximately 5×10^{-5}, or 0.00005, mrem/yr. These peaks occur at different times based on the sorption of each radionuclide. These results of dose analyses are presented as annual radiation dose.[(a)]

Figure 5.49 shows the cumulative dose from all Hanford sources and that portion attributed to solid waste at the City of Richland pumping station. By the end of this analysis, 8000 years after site closure, the contribution from solid waste will be increasing slightly while the cumulative dose from all sources will be decreasing, and the overall dose from the three radionuclides is estimated to be less than 1×10^{-5} mrem/yr for the median-inputs case. An examination of the contribution of solid waste compared with the total annual dose reveals that initially less than one percent of the total is from solid waste; by calendar year 3500 the solid waste contribution will be approximately 6 percent of the total dose, and by calendar year 10,000 the solid waste contribution will be approximately 20 percent of the total dose. However, the contribution from solid waste is never above 1.0×10^{-6}, or 0.000001, mrem/yr at the City of Richland pumping station.

The stochastic capability of SAC was employed to evaluate the relative role in overall release of different waste types including solid waste, past liquid discharges, tank wastes, and facilities including canyon buildings. The variability in the stochastic results is due to variability in the inventory, release,

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(a) 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 2002). 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.

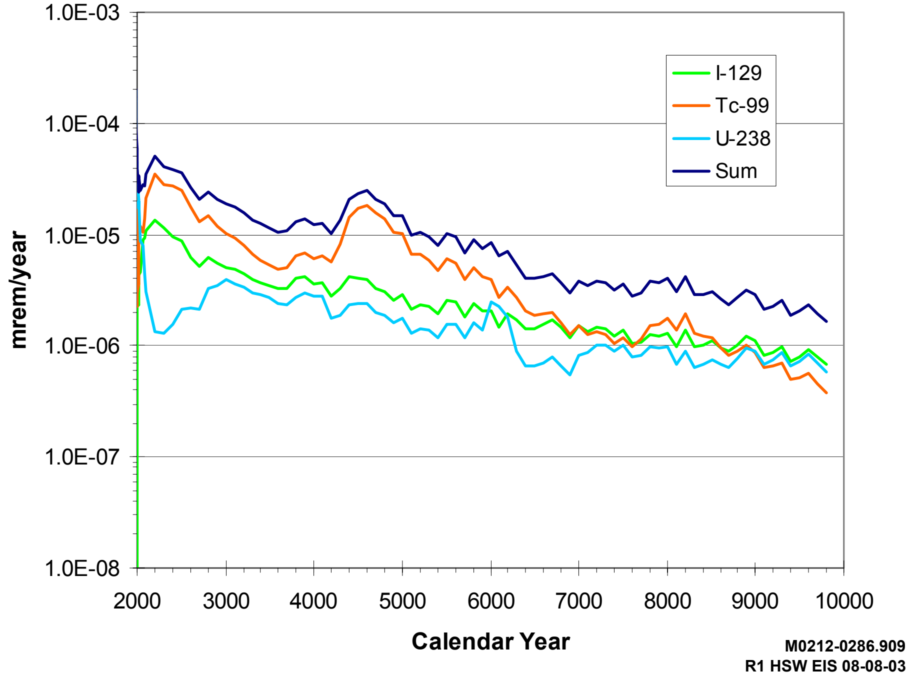

Figure 5.48. Drinking Water Dose from Technetium-99, Iodine-129, and Uranium in the Columbia River at the City of Richland Pumping Station from All Hanford Sources

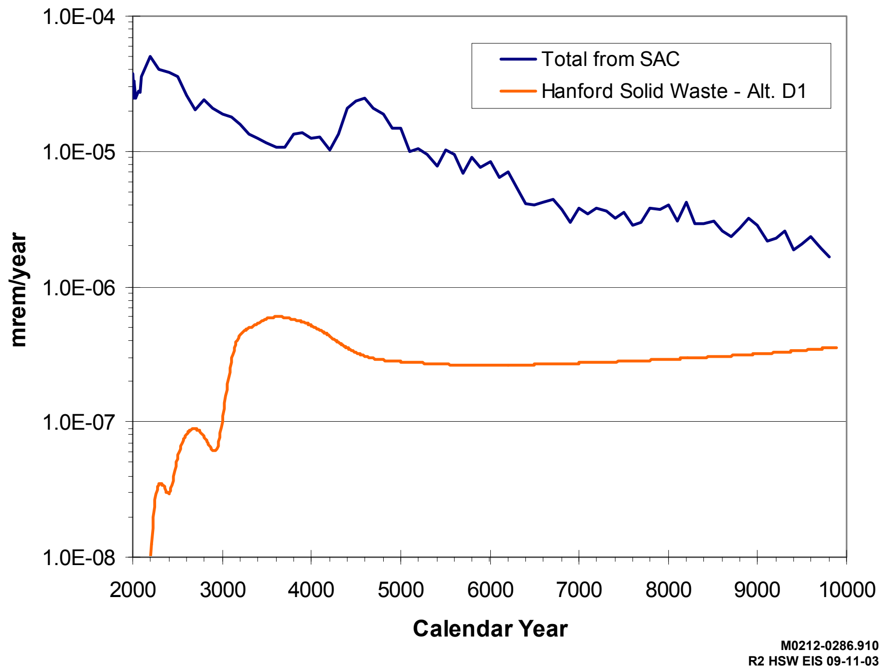

Figure 5.49. Hypothetical Total Drinking Water Dose from All Hanford Sources and the Hanford Solid Waste Contribution in the Columbia River at the City of Richland Pumping Station

and transport of technetium-99, iodine-129, and uranium. The human dose calculations use fixed inputs. These results include all waste releases (for example, releases from cribs, ponds, solid waste, past tank leaks, future tank losses, tank residuals, unplanned releases) that were considered in the initial assessment performed by Bryce et al. (2002). For reasons discussed previously, ILAW was analyzed separately and the results were added to the SAC analysis. The melters and naval reactor compartments would not contribute to the totals within 10,000 years (see the first footnote in Section 5.14.6.3 regarding ILAW, melters, and navy wastes).

In the SAC simulation, cumulative releases to groundwater from HSW, excluding ILAW disposed of in the Central Plateau, ranged from approximately 300 to 450 Ci for technetium-99 over the 10,000-year analysis period. This compares with releases to groundwater ranging from approximately 1500 to 2300 Ci of technetium-99 for all Hanford wastes except ILAW. Thus, the contribution to technetium-99 releases to groundwater from HSW, excluding ILAW, would amount to at most 20 percent of the cumulative release from all Hanford sources. The ILAW cumulative release of technetium-99 for the base case (Mann et al. 2001) used in this analysis was approximately 86 Ci by the end of the 10,000-year, post-closure period. Thus, the contribution from HSW, including ILAW, for technetium-99 would amount to, at most, 25 percent of the cumulative release. The majority of technetium-99 releases from wastes other than ILAW were predicted to occur from liquid discharge sites (cribs, ponds, trenches) used in the past and from unplanned releases on the plateau and from off-plateau waste sites.

For uranium, releases from HSW, excluding ILAW, to groundwater are much lower in the SAC simulation. No realizations showed any release of uranium to groundwater from these wastes in the 200 East Area, and only 5 of 25 realizations show any release of uranium to groundwater from these wastes in the 200 West Area. Thus, in an average (or median) sense, deposits of HSW, excluding ILAW, would release no uranium to groundwater over the 10,000-year period of analysis. This compares with a median release of approximately 84 Ci and a range of releases to groundwater from the 25 realizations of between approximately 10 and 300 Ci of uranium for all Hanford wastes except ILAW. Of the five stochastic realizations exhibiting non-zero uranium release from HSW, excluding ILAW, in the 200 West Area, the cumulative release ranged from 0 to approximately 90 Ci. Hence, the contribution of HSW, excluding ILAW, to overall uranium release to groundwater lies between 0 and 90 Ci, but the majority of the realizations showed no release. As a consequence, the contribution of HSW, excluding ILAW, to uranium releases to groundwater would amount to between 0 and 30 percent of the cumulative release from all Hanford sources except ILAW, and likely would be zero. The majority of uranium releases from wastes other than ILAW was predicted to occur from liquid discharge sites (for example, cribs, ponds, and trenches) used in the past and from unplanned releases on the plateau and from off-plateau waste sites. The ILAW cumulative release of uranium for the base case (Mann et al. 2001) was less than 1 Ci by the end of the 10,000-year post-closure period. Accordingly, the contribution from HSW including ILAW would amount to about 1 percent of the cumulative median release of uranium from all Hanford sources after 10,000 years.

Cumulative releases to groundwater from HSW disposed of in the Central Plateau, excluding ILAW, ranged from 0 to approximately 2.2 Ci for iodine-129 over the period of analysis. This compares with releases to groundwater ranging from approximately 0.1 to 8.8 Ci of iodine-129 for all Hanford wastes except ILAW. The contribution to iodine-129 releases to groundwater from HSW, excluding ILAW, would amount to, at most, 25 percent of the cumulative release from all Hanford sources. With the exception of commercial low-level radioactive waste, iodine-129 releases from solid waste disposal facilities were predicted to be on par with those from tank sites and only half of those from liquid discharge and unplanned release sites. The ILAW cumulative release of iodine-129 for the base case (Mann et al. 2001) was approximately 0.07 Ci by the end of the 10,000-year post-closure period. This is a nominal amount given the existing iodine-129 plume in groundwater and the forecast releases of other waste forms.

The SAC cumulative and HSW EIS alternative-specific (see Volume II, Appendix G) simulations of uranium migration and fate that appear in this EIS differ in the relative roles of technetium-99 and uranium at times nearing the end of the 10,000-year, post-closure period analyzed because distribution coefficients for uranium in the two analyses differ. The SAC produces results where technetium-99 is the dominant radionuclide throughout the post-closure analysis period. However, the HSW EIS alternative-specific approach, which is applied to generate comparative analyses of the 33 alternative groups, predicts that uranium becomes dominant towards the end of the post-closure analysis. The distribution coefficients of the linear sorption isotherm model were assigned a value of 0.6 mL/g in the HSW EIS alternative-specific approach and a value of 3 mL/g for release models and 0.8 mL/g for transport models in the median-value SAC simulation. The value used in the HSW EIS alternative-specific approach is a more conservative, lower value that causes more rapid migration at higher contaminant levels. The values used in the SAC are median values somewhat higher than the conservative value, and they result in slower migration and lower contaminant concentrations. As a result, the SAC assessment predicts that the median response will be dominated by technetium-99 with uranium making a contribution in the latter portion of the 10,000-year, post-closure period. The HSW EIS alternative-specific simulation of alternative groups shows uranium dominating in the last few thousand years because its mobility is greater in that model. The range of K_d applied for uranium in the stochastic SAC model includes the nominal value used in the HSW EIS alternative-specific simulation, and some realizations of the stochastic model exhibit the greater uranium mobility and contribution to dose seen in the HSW EIS alternative-specific results. However, for the purpose of reporting cumulative impacts using the SAC assessment, the median stochastic result is provided.

Leaching of radionuclides from wastes disposed of in HSW disposal facilities and their transport through the vadose zone, to groundwater, and then to the Columbia River also would lead in the long term to small additional collective doses to downstream populations. The collective dose from HSW for all action alternatives was calculated to range from about 0.2 person-rem for the total population of the cities of Richland, Kennewick, and Pasco, Washington, to about 0.6 person-rem for a hypothetical population of a city the size of Portland, Oregon, that might draw water from the Columbia River in the vicinity of Portland. No LCFs would be inferred from such population doses (see Section 5.11.2.1).

To provide some perspective on the preceding material on groundwater impacts that might be associated with disposal of HSW, impacts as a result of using water from various sources for the three principal groundwater related scenarios—drinking-water dose, dose to the resident gardener, and dose to the resident gardener with a sauna/sweat lodge—are presented in Table 5.153.

Table 5.153. Radiological Impacts (principally from uranium) in Various Sources of Water on, Near, or Downstream of the Hanford Site

Source of Water	Dose Scenario: Drinking Water (2 L/day) mrem/yr	Dose Scenario: Resident Gardener mrem/yr	Dose Scenario: Resident Gardener with Sauna/Sweat Lodge[(a)] mrem/yr
Sources of Water not Impacted by Hanford Groundwater			
Portland, OR municipal (Bull Run) water[(b)]	0.006	0.007	6
Columbia River upstream of the Hanford Site at Priest Rapids[(c)]	0.092	0.11	96
Yakima River at Benton City[(d)]	0.19	0.23	200
Yakima Barricade well[(e)]	0.45	0.54	470
Well - Mathews Corner, Franklin Co.[(f)]	1.3	1.6	1,400
Benton City municipal water system[(g)]	2.6	3.1	2,700
Hanford Groundwater and Sources of Water Downgradient from Hanford Groundwater			
Highest doses attributable to HSW - hypothetical wells in the 200 Areas - action alternatives[(h)]	0.42	1.4	200
Highest doses attributable to HSW - hypothetical wells near the Columbia River - action alternatives[(h)]	0.064	0.22	7.4
Highest doses attributable to HSW - hypothetical wells in the 200 Areas - No Action Alternative[(h)]	0.98	3.3	480
Highest doses attributable to HSW - hypothetical wells near the Columbia River - No Action Alternative[(h)]	0.039	0.12	14
Columbia River downstream of the Hanford Site at the Richland pump house[(c)]	0.10[(i)]	0.12	110[(j)]
Columbia River - Franklin County across from the Richland pump house[(k)]	0.15	0.18	160

(a) Water containing natural uranium (with 1:1 ratio of U-234 to U-238) at the MCL of 30 µg/L would yield about 4,000 mrem/yr in the sauna/sweat lodge scenario. Where the ratio is larger than 1, as is often the case for groundwater, the dose would be higher than 4,000 mrem/yr.
(b) July–December 1977 composite sample (Cothern and Lappenbusch 1983). In 1985 Portland began to use the Columbia South Shore well field to supplement their water supply. It was used exclusively for a few days in 1996 because of turbidity in Bull Run water (see discussion at http://www.water.ci.portland.or.us/groundwater.htm). Because of the high rainfall and recharge in the region of the well field, it is believed unlikely that contamination of Hanford origin could have any impact on the quality of Portland municipal water.
(c) 6-year average measurement (Poston et al. 2002).
(d) Single measurement sample collected March 2003.
(e) 7-year average measurement. Hanford Environmental Information System Database. Fluor Hanford, Inc.
(f) 5-year average measurement. Hanford Environmental Information System Database. Fluor Hanford, Inc.
(g) Average of 10 measurements 1959 (Junkins et al. 1960), single measurement 2003.
(h) Values given are exclusive of background which may be approximated by the Yakima Barricade values.
(i) To which HSW was determined to add up to about 6.0 x 10^{-7}, or 0.0000006, mrem/yr from Tc-99 and I-129 in about the year 4000 A.D.
(j) To which HSW was determined to add less than 0.001 mrem/yr from uranium in the year 12,000 A.D.
(k) Poston et al. (2002).

Of interest are the relatively large doses to the gardener with sauna/sweat-lodge even when the drinking water dose is less than the DOE 4-mrem/yr benchmark drinking water standard. This is attributed to the inhalation of uranium in the hot, moist air of the sauna/sweat lodge. Also of interest is the dose in this scenario for naturally occurring uranium is about twice that for doses associated with HSW for like masses of material. This difference is attributed to the reduction in the ratio of uranium-234 to uranium-238 in Hanford solid waste compared with that occurring naturally.

5.14.6.4 Transportation

Transportation impacts associated with transporting radioactive wastes and materials including that to and from the Hanford Site have been addressed in other NEPA documents. Table 5.154, based on DOE (2002a) and this EIS, provides cumulative impact information from those analyses and analyses performed for the HSW EIS.

Table 5.154. Cumulative Transportation Impacts

Category	Workers LCFs[a]	General Population, LCFs[a,b]	Traffic Fatalities
Representative Past and Reasonably Foreseeable Actions (Excluding HSW) Involving Transport of Radioactive Materials			
Historical DOE shipments	0 (0.20)	0 (0.14)	Not Listed
Sodium-bonded Spent Nuclear Fuel	0 (<0.001)	0 (<0.001)	0 (<0.001)
Surplus plutonium disposition	0 (0.036)	0 (0.040)	0 (0.053)
Waste Management PEIS	10	12	36
Waste Isolation Pilot Plant	0 (0.47)	4 (3.5)	5
Cruiser and submarine reactor plant disposal	0 (0.003)	0 (0.003)	0 (0.0095)
Spent nuclear fuel and high-level waste – Oregon & Washington	0 (<0.055)	0 (<0.021)	0 (0.049)
General transport of radio-pharmaceuticals, commercial LLW, etc.	198	174	22
Transport of Hanford Solid Wastes			
Alternative Groups A, C, D, and E – onsite, nearby treatment, and treatment at ORR	0 (0.038)	0 (0.43)	0 (0.084)
Alternative Group B – onsite and nearby treatment	0 (0.064)	1 (0.86)	0 (0.068)
No Action Alternative – onsite	0 (0.012)	0 (0.14)	0 (0.050)
Incoming and offsite shipments (Upper Bound waste volume)[c]	1 (0.74)	8 (8.2)	2 (2.3)
Incoming and offsite shipments, WA and OR impacts only – included in the above (Upper Bound waste volume)	0 (0.096)	1 (1.1)	1 (0.52)
TRU Waste Shipments from Hanford to WIPP			
Alternative Groups A – E (Upper Bound waste volume)	0 (0.30)	5 (4.8)	1 (0.56)
No Action Alternative	0 (0.15)	2 (1.6)	0 (0.28)

(a) Assumes 6 LCFs per 10,000 person-rem.
(b) For the HSW EIS, the numbers consist of inferred fatalities from radiation exposure and vehicular emissions.
(c) In the final HSW EIS, all offsite transport is addressed, including the entire transportation route for offsite waste sent to Hanford.

In addition, this EIS presents a discussion of transportation of wastes that are within the scope of this HSW EIS to and from the Hanford Site (see Section 5.8).

The information in Table 5.154 indicates that the cumulative transportation impacts associated with any of the HSW EIS alternative groups are small relative to transport of radioactive material in general. For perspective, it may be noted that several million traffic fatalities from all causes would be expected nationwide during the period 1943 to 2047 (DOE 2002a).

5.14.7 Worker Health and Safety

The cumulative Hanford worker dose since the startup of activities at Hanford is about 90,000 person-rem (DOE 1995), to which would be added approximately 1000 person-rem from spent fuel management (DOE 1996a); 8200 person-rem from tank waste remediation (DOE and Ecology 1996); 730 person-rem for Plutonium Finishing Plant stabilization (DOE 1996b); and 765 to 873 person-rem through the year 2046 from the management of Hanford solid waste, ILAW, and WTP melters (Hanford Only waste volume for Alternative Group A to either the Hanford Only or Lower Bound volume for the No Action Alternative, [see Section 5.11]). Thus, for about 100 years of Hanford operations, approximately 40 LCFs would be inferred among workers, none of which would be attributable to Hanford solid waste program activities. Because of DOE restrictions on worker dose and rigorous application of the ALARA principle, the cumulative collective worker dose associated with all future Hanford Site restoration activities would not be expected to add substantially to the collective worker dose to date.

5.15 Irreversible and Irretrievable Commitments of Resources

Irreversible and irretrievable commitments of resources (42 USC 4321) that likely would result from implementing any of the alternative groups or the No Action Alternative are addressed in this section. An irreversibly committed or irretrievable resource is one that is irreplaceably consumed and is non-renewable, is in limited supply, or cannot be replenished.

Implementation of any of the alternative groups would result in the irretrievable use of fossil fuels in construction activities, transport of materials and waste, and treatment processes. Bentonite clay, which is a limited resource, also would be committed. Although steel is not in limited supply, the steel used in drums and rebar essentially would be irretrievable. Land areas used for disposal facilities also would be irretrievably committed.

DOE anticipates that current contamination would preclude the beneficial use of groundwater underneath portions of the Hanford Site for the foreseeable future. It is assumed that the tritium and iodine-129 groundwater plumes would exceed the drinking water standards for the next several hundred years.

Within a few hundred years after disposal of wastes evaluated in the HSW EIS, some mobile radionuclides from the wastes would reach the vadose zone surrounding disposal areas and groundwater beneath the Hanford Site. Results of computer simulations (as presented in Sections 5.3 and 5.11) predict that levels of these contaminants in groundwater would be below DOE benchmark drinking water standards at 1 kilometer and below the DOE all-pathway limit for the hypothetical onsite resident gardener without a sauna or sweat lodge.

However, due to uncertainties in inventory estimates and mobility parameters, DOE considers groundwater underneath portions of the Hanford Site that is proximate to, or downgradient from, waste sites at Hanford to be irretrievably committed. At a minimum, depending on the location and time of interest, concentrations of radionuclides in groundwater might be such that it would be necessary to place some restrictions on groundwater usage (for example, restrictions on use of groundwater for saunas or sweat lodges late in the 10,000-year period of analysis; see Section 5.11 and Volume II, Appendix F).

The quantities of non-renewable resources that would be irreversibly or irretrievably committed are listed in Table 5.155.

In addition, geologic resources that form the above-grade cover for the waste disposal sites, as shown in Table 5.18 in Section 5.4, would, within the intent of the disposal site closure, be considered irreversibly committed.

Table 5.155. Irreversible and Irretrievable Commitments of Selected Resources by Alternative Group with ILAW

Resource (Units)[a]	Diesel[b] (m^3)	Gasoline (m^3)	Propane (t)	Bentonite Clay (t)	Steel[c] (t)	Land (ha)
Alternative Group A						
Hanford Only	132,900	260	12,700	13,900	1,720	169
Lower Bound	132,900	260	12,700	13,900	1,870	170
Upper Bound	133,700	270	19,300	18,200	2,280	178
Alternative Group B						
Hanford Only	136,600	340	23,500	33,600	1,800	187
Lower Bound	136,700	340	23,500	33,600	1,950	189
Upper Bound	140,600	430	38,300	57,600	2,380	210
Alternative Group C						
Hanford Only	65,900	260	12,700	13,900	1,720	151
Lower Bound	65,900	260	12,700	13,900	1,870	152
Upper Bound	66,700	270	19,300	18,200	2,280	160
Alternative Group D						
Hanford Only	65,900	260	18,800	13,900	1,710	150
Lower Bound	65,900	260	20,300	13,900	1,870	150
Upper Bound	66,700	270	27,800	18,200	2,280	155
Alternative Group E						
Hanford Only	65,900	260	18,800	12,800	1,710	150
Lower Bound	65,900	260	20,300	13,900	1,870	150
Upper Bound	66,700	270	27,800	18,200	2,280	155
No Action Alternative						
Hanford Only	188,600	48	3,560	0	59,100	273[d]
Lower Bound	188,700	50	3,560	0	59,200	275[d]

(a) Conversion factors: 1 m^3 (capacity) = 260 gal; 1 m^3 (volume) = 1.3 yd^3; and 1 t (metric tonne) = 1.1 tons.
(b) Includes 120,100 m^3 for ILAW in Alternative Groups A and B; 53,100 m^3 for ILAW in Alternative Groups C, D, and E; and 183,400 m^3 for ILAW in the No Action Alternative.
(c) Includes 1000 t for ILAW in Alternative Groups A through E and 33,200 t for ILAW in the No Action Alternative.
(d) Includes land committed to storage of waste at CWC.

5.16 Relationship Between Short-Term Uses of the Environment and the Maintenance or Enhancement of Long-Term Productivity

For purposes of the HSW EIS, short-term use is defined to encompass the period through the year 2046; long-term productivity is defined to encompass the period following 2046.

The principal objective of Alternative Groups A through E (whether for the Hanford Only, Lower Bound, or Upper Bound waste volume)—namely, permanent disposal of LLW, MLLW, and ILAW at Hanford—does not involve the short-term use of the environment in the usual sense.[a] In addition, TRU waste is being shipped from Hanford to WIPP. Implementation of any of these alternative groups is intended to result in permanent disposal by below-grade land burial, followed by backfilling to grade, and capping with above-grade Modified RCRA Subtitle C Barriers. For all practical purposes, the LLBGs and the vadose zone beneath and surrounding them have been and will continue to be dedicated to the isolation of radioactive and hazardous wastes from the environment. If selected, the disposal sites near the PUREX Plant, near the CWC, and at ERDF, including the vadose zone beneath and surrounding them, would be similarly committed. Thus these portions of the Hanford Site constitute perhaps the highest use in terms of long-term productivity.

In time, contaminants from past and proposed waste disposal on the Hanford Site would reach the groundwater and the Columbia River. Depending on the location and time of interest, concentrations of radionuclides in groundwater might be such that it would be necessary to place some restrictions on groundwater usage. When the contaminants reach the Columbia River, they will be in such small concentrations that they would pose no adverse impact on the long-term productivity of the Columbia River.

In time and with the absence of human activities, flora and fauna common to the Central Plateau in the past likely would re-occupy the surface areas above the disposed of waste, and the surface would probably be indistinguishable from nearby undisturbed areas. However, prudence would dictate invoking land-use covenants to prohibit future land disturbance by humans and to reduce the likelihood of inadvertent intrusion into a waste site or dispersal of contaminants for as long as institutional controls can be maintained.

In the No Action Alternative, similar restrictions would apply; however, no conclusion is made regarding short-term uses versus long-term productivity because about 59,000 m^3 (76,700 yd^3) of waste would be stored until the year 2046, with no defined disposition path thereafter.

(a) An example of "usual sense" in this context would be a mining operation in which the acid mine drainage contaminates a nearby stream. In that case, the short-term mining operation likely would have adverse effects on the long-term productivity of the streams and river into which contamination flows.

5.17 Unavoidable Adverse Impacts

This section summarizes the potential unavoidable adverse impacts associated with implementing the HSW EIS alternative groups. Identified are those unavoidable adverse impacts that would remain after incorporating all mitigation measures that were included in the development of the EIS alternative groups. Potentially adverse impacts for each of the alternative groups are described in other portions of Section 5. In Section 5.18, additional practicable mitigation measures are identified that might further reduce the impacts described in this section.

In particular, unavoidable adverse impacts that would occur if Alternative Groups A, B, C, D, E, or the No Action Alternative were to be implemented are identified in the following sections.

5.17.1 Alternative Group A

Unavoidable adverse impacts associated with implementing Alternative Group A would include:

- commitment of about 168.5 ha (410 ac) of land for disposal of the Hanford Only waste volume to about 177.9 ha (440 ac) for the Upper Bound waste volume of LLW, MLLW, ILAW, and melters

- small additions of pollutants to the atmosphere as a result of operating heavy equipment during modification of the T Plant Complex and construction of additional burial trenches, operation of facilities, trench backfilling, obtaining materials for constructing Modified RCRA Subtitle C Barriers for disposal facilities and capping the sites, and from transportation of materials and wastes

- small increments in dose to workers and the public

- potential for a total of 23 to 75 transport accidents (Lower Bound to Upper Bound waste volumes for LLW, MLLW, TRU Waste, ILAW, and WTP melters) and 1 to 3 fatalities from those accidents

- potential for 5 to 9 inferred LCFs as a result of routine transport of waste to and from the Hanford Site

- potential for 17 transport accidents and 1 non-radiological fatality from transporting TRU waste to WIPP (none of these fatalities would be expected to occur in the states of Oregon or Washington)

- potential for one transport accident in Oregon and none in Washington involving receipt of waste from offsite generators and subsequent transport of the TRU waste to WIPP in the Lower Bound waste volume case and five transport accidents in Oregon and two in Washington in the Upper Bound waste volume case. One fatality might occur in Oregon in the Upper Bound waste volume case.

- eventual migration of mobile radionuclides such as technetium-99, iodine-129, and uranium isotopes to the groundwater and ultimately to the Columbia River, leading to very small additional radiation doses to downstream populations.

5.17.2 Alternative Group B

Unavoidable adverse impacts associated with implementing Alternative Group B essentially would be the same as those for Alternative Group A, except for the following differences:

- commitment of about 186.6 ha (460 ac) of land for disposal of the Hanford Only waste volume to 210.1 ha (519 ac) for the Upper Bound waste volume of LLW, MLLW, and ILAW

- small additions of pollutants to the atmosphere as a result of operating heavy equipment during construction of a new waste processing facility for treatment of some wastes

- potential for 1 less transport accident (total for either the Lower Bound or Upper Bound waste volumes for LLW, MLLW, TRU Waste, ILAW and WTP melters), with the potential for 1 to 2 fatalities from those accidents.

5.17.3 Alternative Group C

Unavoidable adverse impacts associated with implementing Alternative Group C essentially would be the same as those for Alternative Group A, except for the following difference:

- commitment of about 150.5 ha (370 ac) of land for disposal of the Hanford Only waste volume to 159.9 ha (390 ac) for the Upper Bound waste volume of LLW, MLLW, and ILAW.

5.17.4 Alternative Groups D and E (All Subalternatives)

Unavoidable adverse impacts associated with implementing Alternative Groups D and E essentially would be the same as those for Alternative Group A, except for the following difference:

- commitment of about 149.9 ha (370 ac) of land for disposal of the Hanford Only waste volume to 155 ha (383 ac) for the Upper Bound waste volume of LLW, MLLW, ILAW, and melters.

5.17.5 No Action Alternative

Unavoidable adverse impacts associated with implementing the No Action Alternative would include:

- storage of certain MLLW and TRU wastes and melters requiring additional land disturbance of about 66 ha (163 ac)

- commitment of about 148 ha (365 ac) of land for below-grade disposal of LLW, MLLW, and ILAW for the Hanford Only waste volume to about 149 ha (368 ac) for the Lower Bound waste volume

- small additions of pollutants to the atmosphere from operating heavy equipment during construction and operation of burial trenches, construction of additional CWC storage buildings, operation of facilities, and from transportation of materials and wastes

- small increments in dose to the public and potential for one radiological LCF to the workers
- eventual migration of mobile radionuclides such as technetium-99, iodine-129, and uranium isotopes to the groundwater and ultimately to the Columbia River, leading to very small additional radiation doses to downstream populations
- potential for a total of 10 to 13 transport accidents (Hanford Only to Lower Bound waste volumes for LLW, MLLW, TRU Waste, ILAW and WTP melters) and no fatalities from those accidents
- potential for 2 inferred LCFs as a result of routine transport of waste to and from the Hanford Site
- potential for 8 transport accidents and zero fatalities from transport of TRU waste to WIPP
- potential for up to 1 transport accident in Oregon and none in Washington from the transport of TRU waste to WIPP. No fatalities are expected in either case.

5.18 Potential Mitigation Measures

Mitigation Measures

Mitigation measures as discussed in the following sections are those actions not already included in the alternative groups that could further reduce or avoid adverse impacts potentially resulting from waste management operations at Hanford.
As defined by regulation (40 CFR 1508.20), mitigation includes

- avoiding the impact altogether by not taking a certain action or parts of an action
- minimizing impacts by limiting the degree or magnitude of the action and its implementation
- rectifying the impact by repairing, rehabilitating, or restoring the affected environment
- reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action
- compensating for the impact by replacing or providing substitute resources or environments.

This section describes mitigation measures that could avoid or reduce environmental impacts caused by Hanford solid waste management operations. Several mitigation measures have been built into the alternative groups addressed in the HSW EIS, including installation of barriers, installation of liners and leachate collection systems, treatment of MLLW to meet applicable LDRs, use of mobile units (APLs) to accelerate certification and shipment of TRU waste to WIPP, and in-trench grouting and use of HICs for Cat 3 LLW and MLLW. Additional measures would be reviewed and revised as appropriate, depending on the relevant actions to be taken at a facility, the level of impact, and other pertinent factors. Following the publication of the Record of Decision (ROD), a mitigation action plan would be prepared, if warranted, to address actions specific to the alternative group selected for implementation. That plan would be implemented as necessary to mitigate significant adverse impacts of solid waste management activities. Possible mitigation measures are generally the same for all alternative groups and are summarized in the following sections.

5.18.1 Pollution Prevention/Waste Minimization

DOE is implementing Executive Order 13148, *Greening the Government Through Leadership in Environmental Management* (65 FR 24595), and associated DOE orders or guidelines by reducing toxic chemical use; improving emergency planning, response, and accident notification; and encouraging the development and use of clean technologies. Program components include waste minimization, recycling, source reduction, and buying practices that prefer products made from recycled materials. The Pollution Prevention Program at the Hanford Site is formalized in a Hanford Site Waste Minimization and Pollution Prevention Awareness Program Plan (DOE-RL 2001b). The plan includes an overview of pollution prevention and waste minimization at Hanford, how the program is implemented at Hanford, and specific objectives and goals to be obtained.

The solid waste management activities have been and would continue to be conducted in accordance with this plan. Implementation of the pollution prevention and waste minimization plans would minimize the generation of secondary wastes.

5.18.2 Cultural Resources

In the HCP EIS (DOE 1999), the Central Plateau was designated for Industrial-Exclusive use and Area C was designated for Conservation (mining). The activities described in this HSW EIS would be consistent with those designations. To avoid loss of cultural resources during construction of solid waste management facilities on the Hanford Site, cultural resources surveys have been and would continue to be made of the areas of interest. If any cultural resources were discovered during construction, construction would be halted. The appropriate authorities would be notified so the find could be evaluated to determine its appropriate management or its effect on continuation of activities.

Because Area C is within the viewshed from Rattlesnake Mountain, operation of the borrow pit there might have an indirect effect on the characteristics that contribute to the cultural and religious significance of Rattlesnake Mountain to local tribes. However, at the end of borrow pit operations, the area would be restored to natural contours and revegetated (see Volume II, Appendix D). Additional information on aesthetic and scenic impacts of these activities is presented in Section 5.12.

Given the possibility for buried cultural resources, some methodology would likely be needed to observe the subsurface. Ground-penetrating radar, shovel testing, or backhoe testing might be appropriate, as would monitoring for cultural resources during construction. Depending on conditions of the area, the frequency of monitoring may range from continuous to intermittent to periodic.

5.18.3 Ecological Resources

In the HCP EIS (DOE 1999) the Central Plateau was designated for Industrial-Exclusive use and Area C was designated for Conservation (mining). Most ecological resources in the Industrial-Exclusive zone of the Central Plateau were destroyed or displaced during the 24 Command Fire or by previous disturbances of the area. However, the fire did not affect the 200 East Area. Consequently, the mature sagebrush (*Artemisia tridentata*) habitat in the candidate disposal site near the PUREX Plant, if selected, would be subject to mitigation under current DOE guidelines, as prescribed in the *Hanford Site Biological Resources Management Plan* (DOE-RL 2001a) and the *Hanford Site Biological Resources Mitigation Strategy* (DOE-RL 2003c). In addition, some other habitats and species found in the burned area would be subject to mitigation under existing biological conditions and current mitigation guidelines. These are the element occurrences (see Volume II, Appendix I) and purple mat (*Nama densum* var. *parviflorum*) found in Area C.

Volume II, Appendix I sets forth what the mitigation requirements for the above habitats/species would be if these were to be disturbed in their current condition under current mitigation guidelines. For example, disturbance of ground-nesting birds and their young could be avoided by limiting major construction during the nesting season, or loss of sensitive habitat could be mitigated by restoration of lower quality habitat or by preservation of similar high quality habitat in another location. This is done primarily for the purpose of comparison of impacts among the alternative groups. Current biological conditions and mitigation guidelines are appropriate for determining mitigation requirements for impacts that would occur in the near term. However, they are not suitable for judging mitigation requirements that would occur some years hence because habitats and species assemblages may change in time (for example, fire-damaged habitats may recover), as might mitigation guidelines at Hanford. Consequently, the actual mitigation requirements for later activities will depend on the results of field surveys conducted just prior to initiating operations and the mitigation guidelines in effect at Hanford at that time.

5.18.4 Water Quality

No activities associated with the proposed action or alternative groups would result in direct discharges to surface water such as the Columbia River. Therefore, any impacts on water quality would result from waste disposal and the potential for contamination of groundwater and, ultimately, the river. Many of the activities associated with waste disposal incorporate mitigating measures as part of normal operations. For example, disposal practices include the use of a rain curtain, or placing interim soil covers over trenches and contouring the soil to minimize water infiltration through the waste. Disposal facilities are also maintained to minimize intrusion of plants and animals into the waste. Higher-activity wastes are disposed of in high-integrity containers or are grouted in place to reduce the release rates of contaminants to the surrounding soil. Use of liners and leachate collection systems in disposal facilities would afford the opportunity to take corrective actions if necessary during the time when the facility was actively monitored; however, such measures would not prevent groundwater contamination over the long term. Use of reactive barriers beneath disposal facilities has also been proposed to delay migration of contaminants. In addition, treating MLLW may delay and slow release of some contaminants. Capping the disposal facility provides a greater opportunity to minimize water infiltration and contaminant transport. Recent studies indicate there may be some benefit from early capping in reducing long-term contaminant concentrations in groundwater (Bryce et al. 2002).

DOE's approach is to protect groundwater through the Performance Assessment process. Disposal facility performance assessments are routinely reviewed to ensure that facilities meet requirements established in DOE Orders 435.1 and 5400.5 (DOE 2001b, 1993). Changes in the disposal facility waste acceptance criteria would be made if the review indicates that groundwater contamination could exceed applicable requirements. As a result, some waste could require further treatment (for example, macro-encapsulation) prior to disposal, or additional confinement such as disposal in high-integrity containers or by grouting the waste in place. The waste could also be disposed of at another facility where it would meet the waste acceptance criteria, or it could be stored until another method was found to treat or dispose of the waste. In no case would DOE knowingly dispose of waste in violation of applicable legal requirements.

5.18.5 Health and Safety – Routine Operations

It is not expected that the public would experience any adverse consequences from routine waste management activities. Current and anticipated design, construction, and operation of waste management facilities would incorporate the best available technology to control discharge of potentially hazardous materials to the environment.

Under routine operations, exposure of workers to radioactive or other potentially hazardous materials would be maintained within permissible limits and, further, would be reduced under the as low as reasonably achievable (ALARA) principle. This principle involves formal analysis by the workers, supervisors, and radiation and or chemical protection personnel of the work in a hazardous environment to reduce exposure of workers to the lowest practicable level.

There is some potential for contamination reaching the affected environment from waste in LLBGs via uptake through deep roots by nuisance weeds such as Russian thistle (tumbleweeds). Before capping of LLBGs, herbicides could be used to control such weeds. After the LLBGs are capped, they could be planted with vegetative species (such as wheatgrass [*Agropyron* sp.]) that could, in effect, choke out the nuisance weeds and assist in evapotranspiration.

5.18.6 Health and Safety – Accidents

Although the safety record for operations at Hanford and other DOE facilities is good, DOE-RL and all Hanford Site contractors have established emergency response plans to prepare for and mitigate the consequences of potential emergencies on the site (DOE-RL 1999). These plans were prepared in accordance with DOE orders and other federal, state, and local regulations. The plans describe action that will be taken to evaluate the severity of a potential emergency and the steps necessary to notify and coordinate the activities of other agencies having emergency response functions in the surrounding communities. The plans also specify the level at which the hazard to workers and the public is of sufficient concern that protective action should be taken. The site holds regularly scheduled exercises to help ensure that individuals with responsibilities in emergency planning are properly trained in the procedures that have been implemented to mitigate the consequences of potential accidents and other events. As necessary, Hanford Site emergency response plans would be updated to include consideration of new solid waste management facilities and activities.

5.18.7 Traffic and Transportation

Transport of LLBG capping materials from the borrow pit in Area C across SR 240 to the 200 Areas was determined to have the potential for traffic congestion and accident hazards. As a consequence, an underground conveyor system could be used to move the materials to a staging area east of SR 240 and to minimize crossings of trucks and other equipment. Further, additional safety measures would be expected to take the form of dust control; restrictions on crossings to off-shift-change hours; signs and warning lights along SR 240 to the north, south, and well in advance of the crossing; and a traffic control light at the crossing itself.

Many measures to mitigate transportation impacts are incorporated into regulatory requirements for shipping hazardous materials. Shipment of hazardous materials is regulated by the U.S. Department of Transportation (DOT), and many states have established additional requirements. The DOT regulations for shipping hazardous materials can be found in the Hazardous Material Regulations (49 CFR 171-180), the Federal Motor Carrier Safety Regulations (49 CFR 390-397), and "Packaging and Transportation of Radioactive Material" (10 CFR 71). Other regulations and requirements for the shipment of radioactive materials can be found in DOE's Radioactive Material Transportation Practices (DOE 2002b). These regulations address many specific subjects including shipper and carrier responsibilities, planning information, routing and route selection, notifications, shipping papers, driver qualifications and training, vehicles and required equipment, equipment inspections, labeling (information on containers), placarding (information on the shipping vehicle), emergency planning, emergency notification, emergency response, and security.

DOE operates a Radiological Assistance Program with eight Regional Coordinating Offices staffed with experts available for immediate assistance in offsite radiological monitoring and assessment. Radiological Assistance Program teams assist state, local, and tribal officials in identifying the material and monitoring to determine if there is a release, as well as providing general support. Like private-sector shippers, DOE must provide emergency response information required on shipping papers, including a 24-hour emergency telephone number. Shippers have overall responsibility for providing adequate technical assistance for emergency response, should the carrier fail to do so.

Security requirements and shipping containers used for transporting radioactive and hazardous materials are commensurate with the hazard associated with those materials. Low-hazard shipments, such as most LLW and MLLW shipments, would not represent attractive targets for sabotage or terrorism because they have relatively low potential for producing human casualties. Relatively high-hazard shipments, such as TRU waste, also are not highly attractive targets because the accident-resistant packaging used to transport the higher-hazard materials provides a measure of protection against potential terrorist actions.

In summary, offsite shipments of LLW, MLLW, and TRU waste can be conducted safely. This is ensured by a number of means that emphasize preventing releases of radioactive and hazardous material in transit, including appropriate packaging, route selection, communications, vehicle safety, and driver training. In addition, in the unlikely event that an accidental release occurs, DOE would provide the necessary support to local first responders to effectively mitigate, clean up, monitor potential releases and provide any necessary medical treatment.

5.18.8 Area and Resource Management and Mitigation Plans

DOE or its contractors have prepared, or are preparing, a number of area and resource management and mitigation plans. These plans have been completed, are in draft form, or are being revised. These plans include the following:

- *Hanford Cultural Resources Management Plan* (DOE-RL 2003a)
- *Hanford Site Biological Resources Management Plan* (DOE-RL 2001a)
- Hanford Bald Eagle Management Plan
- Noxious Weed Management Plan
- Chinook Salmon – Upper Columbia River Spring Run Hanford Management Plan
- Steelhead – Middle Columbia River Run Hanford Management Plan
- Steelhead Upper Columbia River Run Hanford Management Plan
- Aesthetic and Visual Resources Management Plan
- Facility and Infrastructure Assessment and Strategy
- Mineral Resources Management Plan (that is, soils, sand, gravel, and basalt)

- Hanford Site Watershed Management Plan
- *Hanford's Groundwater Management Plan: Accelerated Cleanup and Protection* (DOE-RL 2003d)
- *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions* (DOE-RL 2002b)
- *Hanford Site Biological Resources Mitigation Strategy* (DOE-RL 2003c).

All of the plans listed above would be expected to be available as DOE guidance by the time the activities described in this HSW EIS would be underway and for which special management or mitigation might be appropriate.

Potential Mitigation Measures

- Continue implementing DOE's pollution prevention/waste minimization program.
- Perform cultural surveys prior to construction.
- Implement guidelines (such as the replacement of shrub-steppe community disturbed by construction or capping activities) consistent with the *Hanford Site Biological Resources Management Plan* and the *Hanford Site Biological Resources Mitigation Strategy*.
- Continue implementing As-Low-As-Reasonably-Achievable principles during operations and construction.
- Continue training and practices to prepare for possible emergencies and accidents.
- Perform large movements of construction and capping materials during low traffic times.
- Prepare and implement resource management plans and mitigation plans associated with the *Hanford Comprehensive Land Use Plan.*
- Construct new facilities and trenches in areas that have already been disturbed. This would minimize the chances for encountering items of cultural significance or disturbing items of cultural significance that have not been disturbed. It would also minimize the impacts to animals, plants, and ecosystems.
- Construct new trenches in uncontaminated areas within the Low Level Burial Grounds to minimize potential health impacts to workers.
- Construct final closure barriers that would allow the growth or re-growth of shrub-steppe habitat.
- Plan construction activities to avoid nesting seasons.
- Reuse soils removed during construction of disposal trenches for construction of final closure caps to the extent possible.
- Install and use rain curtains in operating trenches. This would prevent some of the rainwater and snow melt from coming into contact with waste already in place. This, in turn, would reduce the amount of waste that could leach into the rainwater, reduce the amount of contaminated rainwater (leachate) that would have to be treated, and reduce the amount of leachate that could possibly reach the vadose zone or groundwater.
- Use soil fixants to minimize dust generated during construction activities, waste disposal, and final closure activities.
- Treat and dispose of mixed-low level waste in storage as quickly as possible to minimize accidents and exposure to workers from aboveground storage.
- Certify and ship transuranic waste in storage as quickly as possible to minimize accidents and exposure to workers from aboveground storage.
- Keep areas around facilities and trenches clear of combustible material to limit impacts from wildfires.
- Keep trenches clear of deep-rooted plants and burrowing animals to minimize the potential for spreading contamination.
- Provide additional waste treatment prior to disposal.

5.18.9 Long-Term Stewardship and Post Closure

Cleanup plans and decisions strive to achieve an appropriate balance between contaminant reduction, use of engineered barriers to isolate residual contaminants and retard their migration, and reliance on institutional controls. Decisions are influenced by several factors:

- risks to members of the public, workers, and the environment
- legal and regulatory requirements
- technical and institutional capabilities and limitations
- current state of scientific knowledge
- values and preferences of interested and affected parties
- costs and related budgetary considerations
- impacts on, and activities at, other sites.

Reliance on institutional controls after contaminants have been reduced and engineered barriers have been put in place is referred to as long-term stewardship. Specific long-term stewardship activities depend on the specific hazards that remain and how those hazards are being controlled. Long-term stewardship activities are intended to continue isolating hazards from people and the environment.

DOE does not rely solely on long-term stewardship to protect people and the environment. As indicated in the DOE-sponsored report *Long-Term Institutional Management of U.S. Department of Energy Legacy Waste Sites* (National Research Council 2000), "contaminant reduction is preferred to contaminant isolation and the imposition of stewardship measures." Contaminant reduction is a large part of the ongoing cleanup efforts at Hanford. The long-term stewardship plan for the Hanford Site was approved in August 2003 (DOE-RL 2003b).

Typical Long-Term Stewardship Activities

- monitoring to verify the integrity of barriers placed over disposal sites
- maintaining barriers to ensure their continued integrity
- monitoring groundwater and the vadose zone to determine whether systems to contain hazards are working
- monitoring for surface contamination
- monitoring animals, plants, and ecosystems
- performing groundwater pump-and-treatment operations
- installing and maintaining fences and other barriers
- posting warning signs
- establishing easements and deed restrictions
- establishing zoning and land-use restrictions
- maintaining records on cleanup activities, remaining hazards, and locations of the hazards
- maintaining necessary infrastructure (for example, utilities, roads, communication systems).

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