This document was too large to scan as a single document; therefore, it has been divided into smaller sections.

Section 2 of 4

Document Information			
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5.0 ANALYSIS RESULTS

This section describes the impact assessment results of the various strategies and options regarding the environment and human health (Section 5.1 to 5.3). An uncertainty and sensitivity analysis is presented in Section 5.4. It also analyzes the ability of the strategies and options to comply with applicable Federal and State regulations (Section 5.5) and the performance of the strategies and options relative to stakeholder and Tribal Nation values (Section 5.6). Table 5.0.1 highlights the section numbers that provide detailed analysis results. Each of the areas of analysis were selected based on regulatory requirements and/or stakeholder and Tribal Nation values.

Table 5.0.1. RPE Report, Section Breakdown

Area of Analysis	Section of the RPE Report				
	Technical Approach	Results of Analysis	Conclusions	Performance Measures	Data Needs
Strategies	3.2	4.0	6.1.1	6.2.1	6.3.1
Source terms	3.3 and Appendix A (Source term results, conclusions, and data needs are identified within each of the areas of analysis as appropriate.)				
Short-term human health risks	3.4	5.1	6.1.2	6.2.2	6.3.2
Contaminant transport	3.5	5.2	6.1.3	6.2.3	6.3.3
Long-term human health risks	3.6	5.3	6.1.4	6.2.4	6.3.4
Uncertainty and sensitivity	3.7	5.4	6.1.5	6.2.5	6.3.5
Regulatory compliance	3.8	5.5	6.1.6	6.2.6	6.3.6
Stakeholder and Tribal Nation values	3.9	5.6	6.1.7	6.2.7	6.3.7

5.1 SHORT-TERM HUMAN HEALTH RISKS

The purpose of this analysis is to estimate the potential remediation (i.e., short-term) health impacts resulting from both accident and normal (i.e., nonaccident, or routine) conditions during implementation of each strategy or option and the probability of the accidents. Accidents are unplanned events or a sequence of events that result in undesirable consequences. The analysis evaluates potential accidents associated with construction, transportation, and operation activities involved in each AX Tank Farm retrieval and tank farm closure strategy and a No Action strategy. The hazards associated with these activities include potential occupational and transportation hazards resulting in physical trauma, radiological exposure resulting in LCFs, and toxicological exposure resulting in toxic or corrosive health effects. Initiating events that could result in hazardous health effects include natural phenomena, human error, and component failure. Routine conditions include anticipated exposure to radiation fields and radiological and chemical releases to the atmosphere during normal construction and operation conditions. The methodology used for the analysis is discussed in Section 3.4.

Use of Significant Figures to Present Analysis Results

The impact analysis results in Section 5.0 are rounded to two significant figures and in some cases three significant figures to facilitate the comparison between the different options and strategies. However, using two or three significant figures in presenting the analysis results does not reflect an implied level of precision. This is especially true for long-term impacts on groundwater and human health risk. Given the uncertainty in the data and the inherent uncertainty in calculating impacts over long periods of time, the level of precision in the calculated long-term impacts may warrant using only one significant figure.

5.1.1 Baseline Retrieval/Restricted Land Use (Strategy 1)

The Baseline Retrieval/Restricted Land Use (Strategy 1) would include retrieval and closure activities as discussed in Section 4.3.1.

Normal emissions from Baseline Retrieval/Restricted Land Use (Strategy 1) activities would result in potential chemical and radiological health impacts. Activities that would result in chemical and radiological emissions are retrieving waste, grouting tanks, and grouting ancillary equipment. Chemical and radiological emissions from constructing an enhanced RCRA Subtitle C barrier would be negligible, if any, and were not analyzed. Potential accidents during these activities also could result in health impacts. For all activities that could result in accidents with potential chemical and radiological health impacts, loss of filtration accidents were identified in the Preliminary Hazards Analysis (Jacobs 1998d) as having the highest risk with the exception of grouting ancillary equipment. An accidental exposure to high radiation fields would result in the highest risk to the involved worker.

Before constructing the enhanced RCRA Subtitle C barrier, the tanks and ancillary equipment would be filled with grout. The grouted tanks and ancillary equipment would produce no appreciable emissions, and there would be a very low probability of an accident that could result in radiological or chemical health effects during the construction of the enhanced RCRA

Subtitle C barrier. All of the activities, including constructing the enhanced RCRA Subtitle C barrier, pose occupational health risks from construction, remediation, and transportation accidents.

Strategy 1 activities and their associated health risks are presented the following sections and in Tables 5.1.1 through 5.1.6. The sections identify enabling assumptions and data used for each area of risk addressed.

Table 5.1.1. Chemical Health Impacts from Baseline Retrieval/ Restricted Land Use (Strategy 1) – Normal Operations

Activity	Involved Worker MEI		Noninvolved Worker MEI		General Public MEI	
	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)
Retrieval	2.3E-01	1.8E-06	1.0E-02	7.9E-07	5.3E-05	2.4E-10
Grout tank	1.2E-06	9.0E-11	5.3E-07	3.9E-11	2.9E-10	2.2E-14
Grout ancillary	<1.2E-06	<9.0E-11	<5.3E-07	<3.9E-11	<2.9E-10	<2.2E-14
Enhanced RCRA Subtitle C barrier	No exposure	No exposure	No exposure	No exposure	No exposure	No exposure

Table 5.1.2. Radiological LCF Risk from Baseline Retrieval/ Restricted Land Use (Strategy 1) – Normal Operations

Activity	Involved Worker (LCF)		Noninvolved Worker (LCF)		General Public (LCF)	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	6.0E-04	6.6E-01	2.6E-08	1.1E-06	1.5E-09	3.1E-05
Grout tank	6.0E-04	1.1E-04	8.8E-11	3.8E-09	4.2E-14	1.1E-09
Grout ancillary	1.0E-01	4.9E-01	<8.8E-11	<3.8E-09	<4.2E-14	<1.1E-09
Enhanced RCRA Subtitle C barrier	No exposure	No exposure	No exposure	No exposure	No exposure	No exposure
Total	Not additive	1.2E+00	2.6E-08	1.1E-06	1.5E-09	3.1E-05

Table 5.1.3. Chemical Risk from Baseline Retrieval/Restricted Land Use (Strategy 1) – Accident

Activity	Involved Worker	Noninvolved Worker	General Public
Retrieval	Lethal radiological dose[1]	7.3E+01 (ERPG-3)	1.1E-01 (ERPG-1)
Grout tank	2.0E-05 (ERPG-1)	1.9E-07 (ERPG-1)	1.0E-12 (ERPG-1)
Grout ancillary	<2.0E-05 (ERPG-1)	<1.9E-07 (ERPG-1)	<1.0E-12 (ERPG-1)
Enhanced RCRA Subtitle C barrier	No chemical accidents	No chemical accidents	No chemical accidents

Notes:
[1] An involved worker would receive a lethal radiological dose from the same accident.

Table 5.1.4. Radiological Point-Estimate LCF Risk from Baseline Retrieval/Restricted Land Use (Strategy 1)

Activity	Involved Worker		Noninvolved Worker		General Public	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	1.3E-05	1.3E-04	2.1E-07	9.2E-06	5.8E-10	8.6E-07
Grout tank	1.2E-10	1.2E-09	5.7E-14	1.4E-12	6.6E-17	3.0E-13
Grout ancillary equipment	8.1E-05	5.7E-04	<5.7E-14	<1.4E-12	<6.6E-17	<3.0E-13
Enhanced RCRA Subtitle C barrier	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents
Total	Not additive	Not additive	Not additive	Not additive	Not additive	Not additive

Table 5.1.5. Occupational Injury/Illness and Fatalities from Baseline Retrieval/Restricted Land Use (Strategy 1)

Activity	Total Recordable Cases	Lost Workday Cases	Fatalities
Retrieval	3.4E+01	1.5E+01	2.5E-02
Grout tank	1.1E+00	4.8E-01	8.1E-04
Grout ancillary equipment	5.5E+00	2.4E+00	4.1E-03
Enhanced RCRA Subtitle C barrier	5.6E-01	2.4E-01	4.1E-04
Total	4.1E+01	1.8E+01	3.0E-02

Table 5.1.6. Transportation Injuries and Fatalities from Baseline Retrieval/Restricted Land Use (Strategy 1)

Activity	Injuries	Fatalities
Retrieval	2.1E-02	1.4E-03
Grout tank	2.9E-01	1.9E-02
Grout ancillary equipment	1.4E-02	8.2E-04
Enhanced RCRA Subtitle C barrier	8.2E-02	4.4E-03
Total	4.1E-01	2.6E-02

Chemical Health Impacts from Normal Operations

Waste retrieval – Chemical emissions resulting from normal retrieval operations from a single tank were assumed to be the same as the emissions from a single tank evaluated in the TWRS EIS (DOE 1996b) for retrieval operations. The chemical health impacts therefore were assumed to be the same as those calculated in the TWRS EIS based on a single tank.

Grout tanks – Chemical emissions while grouting the tanks were based on emissions provided in the Engineering Data for Grout Filling AX Tanks (Jacobs 1998b). Atmospheric dispersion coefficients generated by the GXQ computer code were used to calculate the chemical concentrations at the noninvolved worker MEI and general public MEI locations.
A hand-calculation was used to calculate the chemical concentrations for the involved worker MEI.

Grout ancillary equipment – Chemical emissions data for grouting ancillary equipment was not available at the time of this evaluation. Emissions were assumed to be small in comparison to the emissions from grout filling the tanks, therefore the health impacts were assumed to be negligible.

Radiological Health Impacts From Normal Operations

Waste retrieval – Radiological emissions during normal retrieval operations were assumed to be the same as those evaluated in the TWRS EIS (DOE 1996b) for retrieval operations. The LCF risk calculated in the TWRS EIS was based on waste retrieval from 149 tanks. The LCF risk from retrieving the waste from four tanks in the AX Tank Farm was scaled from those 149 tanks. The involved worker population dose was based on projected worker exposure rates in radiation zones and the number of worker hours in the zones. Worker exposure rates were assumed to be the same as those provided in the Engineering Data for Grout Filling AX Tanks adapted from WHC (1996a). The radiation worker hours for performing various zone work activities were developed from data taken from the AX Tank Farm Retrieval Alternatives Cost Estimates (NHC 1998) for the 99 percent retrieval case. The involved worker MEI was assumed to receive a dose of 1,500 mrem/yr in less than 1 yr of retrieval operation activities.

Grout tanks – Radiological emissions from grouting the tanks were based on emissions provided in the Engineering Data for Grout Filling AX Tanks (Jacobs 1998b). The emissions data and atmospheric dispersion coefficients generated by the GXQ computer code were used in the GENII computer code to calculate the radiological doses for the noninvolved worker and general public receptors. The involved worker population dose was based on projected worker exposure rates in radiation zones and the number of worker hours in the zones. The worker exposure rates also are provided in the Engineering Data for Grout Filling AX Tanks adapted from WHC (1996a). The involved worker MEI was assumed to receive a dose of 1,500 mrem/yr for less than 1 yr of tank stabilization activities

Grout ancillary equipment – Radiological emissions data for grouting ancillary equipment were not available. Emissions were assumed to be less than the emissions from grouting the tanks, therefore the LCF risk to the noninvolved worker and general public receptors was assumed to be less. Exposure rates to the involved workers, and a population dose, were provided in the AX Tank Farm Ancillary Equipment Study (COGEMA 1998). The involved worker MEI would receive a dose of 125 rem in less than 1 yr. A sensitivity case was performed (Appendix F) to evaluate the potential reduction in worker exposure by not grouting pipe 6 in. in diameter or smaller. The study concludes that involved worker exposure would be reduced by one order of magnitude.

Total activities – The population LCF risk from the various activities were summed to show a total LCF risk for each receptor population.

Chemical Risk from Accidents

Waste retrieval – The chemical health impacts resulting from a potential retrieval accident were assumed to be the same as the health impacts calculated for a retrieval accident in the TWRS EIS. The waste retrieval accident evaluated in the TWRS EIS was a loss of the HEPA filters on the tank ventilation system. It was postulated that a ventilation heater failure could occur due to an electrical fault resulting in humid air plugging the HEPA filter followed by filter blowout.

Grout tanks – The chemicals that would be released to the environment from unfiltered ventilation emissions while filling the tank with grout were calculated from data provided in the Engineering Data for Grout Filling AX Tanks (Jacobs 1998b). Atmospheric dispersion coefficients generated by the GXQ computer code were used to calculate the chemical concentrations at the noninvolved worker MEI and general public MEI locations. A hand calculation was used to calculate the chemical concentrations for the involved worker MEI.

Grout ancillary equipment – Chemical emissions data for grouting ancillary equipment were not available at the time of this evaluation. Unfiltered emissions from a potential HEPA filter failure accident were assumed to be small in comparison to the unfiltered emissions from grout filling the tanks, therefore the health impacts were assumed to be negligible.

Radiological Risk from Accidents

Waste retrieval – The LCF risk resulting from a potential retrieval accident was assumed to be the same as the LCF risk calculated for a retrieval accident in the TWRS EIS. The waste retrieval accident evaluated in the TWRS EIS was a loss of HEPA filters. It was postulated that a ventilation heater failure could occur due to an electrical fault resulting in humid air plugging the HEPA filter followed by filter blowout. The annual frequency of this event was calculated to be 8.8E-06 in the TWRS EIS (DOE 1996b). The probability of 2.2E-04 calculated in the TWRS EIS was based on 25 yr of operation. The time required to retrieve 99 percent of the waste from the AX Tank Farm was estimated from the AX Tank Farm Retrieval Alternative Cost Estimates (NHC 1998) to be 1.42 yr, which would result in a probability of 1.3E-05. The lower point-estimate LCF risk for the AX Tank Farms as compared to the point-estimate LCF risk calculated in the TWRS EIS is accounted for by the lower probability.

Grout tanks – The radiological constituents that would be released to the environment from unfiltered ventilation emissions while filling the tank with grout were calculated from emissions data provided in the Engineering Data for Grout Filling AX Tanks (Jacobs 1998b).
The emissions were increased by a factor of 2,000 to account for the loss of one stage of HEPA filters with a 99.95 percent efficiency. Atmospheric dispersion coefficients generated by the GXQ computer code were used to calculate the radiological concentration from an 8-hr release at the noninvolved worker and general public receptor locations. A hand calculation was used to calculate the radiological concentrations for the involved worker receptor. Dose conversion factors from the GENII library were used to calculate the dose resulting from the radiological exposure. The probability of the accident was estimated to be 2.0E-06 (Jacobs 1998b) and was used to calculate the point-estimate LCF risk.

Grout ancillary equipment – Radiological emission data for grouting ancillary equipment was not available at the time of this evaluation. Unfiltered emissions from a potential HEPA filter failure

accident were assumed to be small in comparison to the unfiltered emissions from grout filling the tanks, therefore the point-estimate LCF risk to the noninvolved workers and general public was assumed to be negligible. The potential exists whereby the involved worker could inadvertently be exposed to high ionizing radiation fields while uncovering ancillary equipment or while manually installing a tapping sleeve to a pipe for grouting. The exposure rate off the end of an open pipe could reach levels as high as 101 rem/hr EDE (COGEMA 1998). A health physics technician is to accompany the workers in the zone and survey the area before and while performing the work. These actions would protect the workers from inadvertent exposures. However, it is possible through human error or failure of the monitoring equipment for the worker to be exposed to the high ionizing radiation field. The point-estimate LCF risk per worker in Table 5.1.4 is based on an assumed probability of 1.0E-03 for human error or equipment failure. The exposure duration was assumed to be 1 hr. The involved worker population would depend on the number of workers involved in the accident. The number of workers was assumed to be 7.

Occupational Accidents

Waste retrieval – Labor hour requirements for installing retrieval equipment and retrieval operations were calculated based on data provided in the AX Tank Farm Retrieval Alternative Cost Estimates (NHC 1998).

Grout tanks – Labor hour requirements for installing tank grout fill equipment and grout fill operations were calculated from data provided in the Engineering Data for Grout Filling AX Tanks (WHC 1996a).

Grout ancillary equipment – Labor hour requirements for installing ancillary grout fill equipment and ancillary grout fill operations were calculated from data provided in Jacobs (1998b), which was based on data provided in the AX Tank Farm Ancillary Equipment Study (COGEMA 1998).

Enhanced RCRA Subtitle C barrier – Labor hour requirements for constructing the enhanced RCRA Subtitle C barrier over the AX Tank Farm were calculated from data provided in the Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas (DOE 1996a).

Transportation Accidents

Waste retrieval – Transportation requirements for installing retrieval equipment and retrieval operations were calculated based on data provided in the AX Tank Farm Retrieval Alternative Cost Estimates (NHC 1998).

Grout tanks – Transportation requirements for installing tank grout fill equipment and grout fill operations were calculated from data provided in the Engineering Data for Grout Filling AX Tanks (WHC 1996a).

Grout ancillary equipment – Transportation requirements for installing ancillary grout fill equipment and ancillary grout fill operations were calculated from data provided in Jacobs (1998b), which was based on data provided in the AX Tank Farm Ancillary Equipment Study (COGEMA 1998).

Enhanced RCRA Subtitle C barrier – Transportation requirements for constructing the enhanced RCRA Subtitle C barrier over the AX Tank Farm were calculated from data provided in the Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas (DOE 1996a).

5.1.1.1 Nominal Retrieval Losses (Option 1a)

A description of the retrieval and closure features of the Nominal Retrieval Losses (Option 1a) is provided in Section 4.3.2. The major difference between Strategy 1 and Option 1a is that Option 1a includes a 30 m^3 (8,000 gal.) retrieval leakage loss from each tank, while Strategy 1 assumes no retrieval leak would occur. While this retrieval leakage loss would have long-term human health risk implications it would not affect the short-term human health risk for this option because no action would be taken to remediate the contaminated soils.

Because Option 1a retrieval, grouting tanks, grouting ancillary equipment, and enhanced RCRA Subtitle C barrier construction activities would be the same as those evaluated for Strategy 1, the short-term human health risks would be the same as those presented in Tables 5.1.1 through 5.1.6. The data sources and assumptions for this option would be the same as those provided for Strategy 1 in Section 5.1.1.

5.1.1.2 Large Retrieval Losses (Option 1b)

A description of the retrieval and closure features of the Large Retrieval Losses (Option 1b) is provided in Section 4.3.3. The major difference between Strategy 1 and Option 1b is that Option 1b assumes a 151 m^3 (40,000 gal.) retrieval leakage loss from each tank while Strategy 1 assumes no retrieval leak would occur. While this retrieval leakage loss would have long-term human health risk implications, it would not affect the short-term human health risk for this option because no action would be taken to remediate the contaminated soil.

Because Option 1b retrieval, grouting tanks, grouting ancillary equipment, and enhanced RCRA Subtitle C barrier construction activities would be the same as those evaluated for Strategy 1, the short-term human health risks would be the same as those presented in Tables 5.1.1 through 5.1.6. The data sources and assumptions would be the same as those discussed for Strategy 1 (Section 5.1.1).

5.1.1.3 Optimal Residual Volume (Option 1c)

A description of the retrieval and closure features of the Optimal Residual Volume (Option 1c) is provided in Section 4.3.4. The major difference between Strategy 1 and Option 1c is that Option 1c would result in a residual waste volume of 1 m^3 (36 ft^3) following tank waste retrieval compared to 10 m^3 (360 ft^3) tank waste residual for Strategy 1, and a 30 m^3 (8,000 gal.) retrieval leakage loss is assumed to occur compared to no retrieval leaks for Strategy 1.

Chemical Health Impacts from Normal Operations

Waste retrieval – There would be a greater volume of waste retrieved (99.9 percent compared to 99 percent); however, the chemical concentration of the waste would remain the same. The chemical health impacts therefore were assumed to be the same as those for Strategy 1 (Section 5.1.1).

Grout tanks – Chemical emissions while grouting the tanks were based on emissions provided in the Engineering Data for Grout Filling AX Tanks (Jacobs 1998b). There would be less waste in the tank compared to Strategy 1 (1 m^3 [36 ft^3] compared to 10 m^3 [360 ft^3]); however, the concentration of the waste would be the same, and there would be no appreciable difference between the emissions concentrations.

Grout ancillary equipment – Chemical emission for grouting ancillary equipment would be the same as Strategy 1 (Section 5.1.1).

Radiological Health Impacts From Normal Operations

Waste retrieval – Radiological emissions during normal retrieval operations would be 1 percent greater than the radiological emissions from Strategy 1 retrieval operations to account for 99.9 percent retrieval success compared to 99 percent. The LCF risk to the noninvolved worker and general public receptors therefore would be increased by 1 percent. Worker exposure rates were assumed to be the same as those provided in the Engineering Data for Grout Filling AX Tanks (Jacobs 1998b). The radiation worker hours for performing various zone work activities was based on data taken from the AX Tank Farm Retrieval Alternatives Cost Estimates (NHC 1998) for a 99.9 percent retrieval success. The involved worker MEI was assumed to receive a dose of 1,500 mrem/yr for less than 1 yr.

Grout tanks – Radiological emissions while grouting the tanks were based on emissions provided in the Engineering Data for Grout Filling AX Tanks (Jacobs 1998b). There would be less waste in the tanks compared to Strategy 1 (1 m^3 [36 ft^3] compared to 10 m^3 [360 ft^3]); however, the concentration of the waste would be the same, and there would be no appreciable difference between the emission rates (concentration and volume).

Grout ancillary equipment – Radiological emission and worker exposure for grouting ancillary equipment would be the same as Strategy 1 (Section 5.1.1).

Total activities – The population LCF risk from the various activities were summed to show a total LCF risk for each receptor population.

Chemical Risk from Accidents

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1c would be the same as Strategy 1 (Section 5.1.1). The chemical risk from accidents for each activity in Option 1c therefore would be the same as Strategy 1.

Radiological Risk from Accidents

Waste retrieval – The retrieval accident evaluated for Option 1c would be the same as the Strategy 1 retrieval accident discussed in Section 5.1.1 except for the probability of the accidents. The time required to retrieve 99.9 percent of the waste from the AX Tank Farm for Option 1c was estimated from the AX Tank Farm Retrieval Alternative Cost Estimates (NHC 1998) to be 2.04 yr, which would result in a probability of 8.1E-05. The higher point-estimate LCF risk for Option 1c as compared to the point-estimate LCF risk calculated for Strategy 1 is accounted for by the higher probability.

The parameters associated with the grouting tanks and grouting ancillary equipment for Option 1c would be the same as Strategy 1 (Section 5.1.1). The point-estimate LCF risk for these activities in Option 1c therefore would be the same as Strategy 1.

The short-term human health risk resulting from radiological accidents from the various activities to support Option 1c are presented in Table 5.1.7.

Table 5.1.7. Radiological Point-Estimate LCF Risk from Optimal Residual Volume (Option 1c) – Accident

Activity	Involved Worker		Noninvolved Worker		General Public	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	1.8E-05	1.8E-04	3.1E-07	1.3E-05	8.3E-10	1.2E-06
Grout tank	1.2E-10	1.2E-09	5.7E-14	1.4E-12	6.6E-17	3.0E-13
Grout ancillary equipment	8.1E-05	5.7E-04	<5.7E-14	<1.4E-12	<6.6E-17	<3.0E-13
Enhanced RCRA Subtitle C barrier	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents
Total	Not additive	Not additive	Not additive	Not additive	Not additive	Not additive

Occupational Accidents

Waste retrieval – Labor hour requirements for installing retrieval equipment and retrieval operations were calculated based on data provided in the AX Tank Farm Retrieval Alternative Cost Estimates (NHC 1998).

Labor hour requirements for grouting tanks, grouting ancillary equipment and constructing a enhanced RCRA Subtitle C barrier for Option 1c would be the same as Strategy 1 (Section 5.1.1).

The short-term human health risks resulting from occupational accidents from various activities to support Option 1c are presented in Table 5.1.8.

Table 5.1.8. Occupational Injury/Illness and Fatalities from Optimal Residual Volume (Option 1c)

Activity	Total Recordable Cases	Lost Workday Cases	Fatalities
Retrieval	3.7E+01	1.6E+01	2.7E-02
Grout tank	1.1E+00	4.8E-01	8.1E-04
Grout ancillary equipment	5.5E+00	2.4E+00	4.1E-03
Enhanced RCRA Subtitle C barrier	5.6E-01	2.4E-01	4.1E-04
Total	4.4E+01	1.9E+01	3.2E-02

Transportation Accidents

The transportation requirements for retrieval, grouting tanks, grouting ancillary equipment, and constructing an enhanced RCRA Subtitle C barrier for Option 1c would be the same as Strategy 1 (Section 5.1.1).

5.1.1.4 Suboptimal Residual Volume (Option 1d)

A description of the retrieval and closure features of the Suboptimal Residual Volume (Option 1d) is provided in Section 4.3.5. The major difference between Strategy 1 and Option 1d is that a larger residual waste volume 100 m^3 (3,600 ft^3) would remain following waste retrieval compared to 10 m^3 (360 ft^3) for Strategy 1 and a 30 m^3 (8,000 gal.) retrieval leak is assumed to occur compared to no retrieval leaks for Strategy 1.

Chemical Health Impacts from Normal Operations

Waste retrieval – There would be a less volume of waste retrieved (90 percent compared to 99 percent); however, the chemical concentration of the waste would remain the same. The chemical health impacts therefore were assumed to be the same as those for Strategy 1 (Section 5.1.1).

Grout tanks – Chemical emissions while grouting the tanks were based on emissions provided in the Engineering Data for Grout Filling AX Tanks (Jacobs 1998b). There would be more waste in the tanks compared to Strategy 1 (100 m^3 [3,600 ft^3] compared to 10 m^3 [360 ft^3]); however, the concentration of the waste would be the same, and there would be no appreciable difference between the emission concentrations.

Grout ancillary equipment – Chemical emissions for grouting ancillary equipment would be the same as Strategy 1 (Section 5.1.1).

Radiological Health Impacts From Normal Operations

Waste retrieval – Radiological emissions during normal retrieval operations were assumed to be 10 percent less than the radiological emissions from Strategy 1 retrieval operations to account for 90 percent retrieval success compared to 99 percent. The LCF risk therefore would decrease by 10 percent. There were no data that would indicate what the worker exposure might be, therefore worker exposure rates were assumed to be the same as those provided in the Engineering Data for Grout Filling AX Tanks (Jacobs 1998b). The radiation worker hours for performing various zone work activities was based on data taken from the AX Tank Farm Retrieval Alternatives Cost Estimates (NHC 1998) for a 90 percent retrieval success. The involved worker MEI was assumed to receive a dose of 1,500 mrem/yr for less than 1 yr.

Grout tanks – Radiological emissions while grouting the tanks were based on emissions provided in the Engineering Data for Grout Filling AX Tanks (Jacobs 1998b). There would be more waste in the tanks compared to Strategy 1 (100 m^3 [3,600 ft^3] compared to 10 m^3 [360 ft^3]); however, the concentration of the waste would be the same, and there would be no appreciable difference between the emission rates (concentration and volume).

Grout ancillary equipment – Radiological emissions and worker exposure for grouting ancillary equipment would be the same as Strategy 1 (Section 5.1.1).

Total activities – The population LCF risk from the various activities were summed to show a total LCF risk for each receptor population in Table 5.1.9.

Table 5.1.9. Radiological LCF Risk from Suboptimal Residual Volume (Option 1d) – Normal Operations

Activity	Involved Worker (LCF)		Noninvolved Worker (LCF)		General Public (LCF)	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	6.0E-04	5.3E-01	2.3E-07	9.9E-07	1.4E-09	2.8E-05
Grout tank	6.0E-04	1.1E-04	8.8E-11	3.8E-09	4.2E-14	1.1E-09
Grout ancillary equipment	1.0E-01	4.9E-01	<8.8E-11	<3.8E-09	<4.2E-14	<1.1E-09
Enhanced RCRA Subtitle C barrier	No exposure	No exposure	No exposure	No exposure	No exposure	No exposure
Total	Not additive	1.0E+00	2.3E-08	1.0E-08	1.4E-09	2.8E-05

Chemical Risk from Accidents

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1d would be the same as Strategy 1 (Section 5.1.1). The chemical risk from accidents for each activity in Option 1d therefore would be the same as Strategy 1.

Radiological Risk from Accidents

Waste retrieval – The retrieval accident evaluated for Option 1d would be the same as the Strategy 1 retrieval accident discussed in Section 5.1.1, except for the probability of the accident. The time required to retrieve 90 percent of the waste from the AX Tank Farm was estimated from the AX Tank Farm Retrieval Alternative Cost Estimates (NHC 1998) to be 0.55 yr, which would result in a probability of 4.8E-06. The lower point-estimate LCF risk for Option 1d as compared to the point-estimate LCF risk calculated for Strategy 1 is accounted for by the lower probability.

The parameters associated with grouting tanks and grouting ancillary equipment for Option 1d would be the same as Strategy 1 (Section 5.1.1). The point-estimate LCF risk for these activities in Option 1d therefore would be the same as Strategy 1.

The short-term human health risk resulting from radiological accidents from various activities to support Option 1d are presented in Table 5.1.10.

Table 5.1.10. Radiological Point-Estimate LCF Risk from Suboptimal Residual Volume (Option 1d) – Accident

Activity	Involved Worker		Noninvolved Worker		General Public	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	4.8E-06	4.8E-05	8.3E-08	3.6E-06	2.2E-10	3.3E-07
Grout tank	1.2E-10	1.2E-09	5.7E-14	1.4E-12	6.6E-17	3.0E-13
Grout ancillary equipment	8.1E-05	5.7E-04	<5.7E-14	<1.4E-12	<6.6E-17	<3.0E-13
Enhanced RCRA Subtitle C barrier	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents
Total	Not additive	Not additive	Not additive	Not additive	Not additive	Not additive

Occupational Accidents

Waste retrieval – Labor hour requirements for installing retrieval equipment and retrieval operations were calculated based on data provided in the AX Tank Farm Retrieval Alternative Cost Estimates (NHC 1998).

Labor hour requirements for grouting tanks, grouting ancillary equipment, and constructing an enhanced RCRA Subtitle C barrier for Option 1d would be the same as Strategy 1 (Section 5.1.1).

The short-term human health risks resulting from occupational accidents from various activities to support Option 1d are presented in Table 5.1.11.

Table 5.1.11. Occupational Injury/Illness and Fatality from Suboptimal Residual Volume (Option 1d)

Activity	Total Recordable Cases	Lost Workday Cases	Fatalities
Retrieval	2.3E+01	9.9E+00	1.7E-02
Grout tank	1.1E+00	4.8E-01	8.1E-04
Grout ancillary equipment	5.5E+00	2.4E+00	4.1E-03
Enhanced RCRA Subtitle C barrier	5.6E-01	2.4E-01	4.1E-04
Total	3.0E+01	1.3E+01	2.2E-02

Transportation Accidents

Waste retrieval – Transportation requirements for installing retrieval equipment and retrieval operations were calculated based on data provided in the AX Tank Farm Retrieval Alternative Cost Estimates (NHC 1998). Option 1d would involve 90 percent of the transportation requirements identified for Strategy 1.

The transportation requirements for grouting tanks, grouting ancillary equipment, and constructing an enhanced RCRA Subtitle C barrier for Option 1d would the same as Strategy 1 (Section 5.1.1).

The short-term human health risks resulting from transportation accidents from various activities to support Option 1d are presented in Table 5.1.12.

Table 5.1.12. Transportation Injuries and Fatalities from Suboptimal Residual Volume (Option 1d)

Activity	Injuries	Fatalities
Retrieval	1.9E-02	1.2E-03
Grout tank	2.9E-01	1.9E-02
Grout ancillary equipment	1.4E-02	8.2E-04
Enhanced RCRA Subtitle C barrier	8.2E-02	4.4E-03
Total	4.1E-01	2.5E-02

5.1.1.5 Temporary Operations Barrier (Option 1e)

A discussion of the retrieval and closure features of the Temporary Operations Barrier (Option 1e) is provided in Section 4.3.6. The major difference between Strategy 1 and Option 1e is that a temporary asphalt barrier will be constructed over the AX Tank Farm prior to retrieval operations compared to no temporary asphalt barrier for Strategy 1, and a 30 m^3 (8,000 gal.) retrieval leakage loss is assumed to occur compared to no retrieval leaks for Strategy 1.

Chemical Health Impacts from Normal Operations

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1e would be the same as Strategy 1 (Section 5.1.1). The chemical risk from normal operations for each of these activities in Option 1e therefore would be the same as Strategy 1.

Chemical health impacts from emissions resulting from nonaccident conditions while constructing a temporary barrier were taken from the health hazards evaluated in the TWRS EIS. The construction workers would be working over the tank farm and would receive the same exposure a tank farm operator would receive. The construction of a temporary barrier would not result in any changes to the chemical emissions, therefore there would be no change in the health risk to the noninvolved worker and general public receptors.

The short-term human health risks resulting from routine chemical emissions from various activities to support Option 1e are presented in Table 5.1.13.

Table 5.1.13. Chemical Health Impacts from Temporary Operations Barrier (Option le) – Normal Operations

Activity	Involved Worker MEI		Noninvolved Worker MEI		General Public MEI	
	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)
Temporary barrier	7.7E-02	6.8E-07	No additional exposure	No additional exposure	No additional exposure	No additional exposure
Retrieval	2.3E-01	1.8E-06	1.0E-02	7.9E-07	5.3E-05	2.4E-10
Grout tank	1.2E-06	9.0E-11	5.3E-07	3.9E-11	2.9E-10	2.2E-14
Grout ancillary equipment	<1.2E-06	<9.0E-11	<5.3E-07	<3.9E-11	<2.9E-10	<2.2E-14
Enhanced RCRA Subtitle C barrier	No exposure	No exposure	No exposure	No exposure	No exposure	No exposure

Radiological Health Impacts From Normal Operations

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1e would be the same as Strategy 1 (Section 5.1.1). The LCF risk for each of these activities in Option 1e therefore would be the same as Strategy 1 for normal operations.
For temporary barrier construction it was assumed that the workers would receive the same dose rate of 0.014 rem/yr as was used in the TWRS EIS for tank farm worker exposure. It was also assumed that it would require five persons two months to complete the job. The involved worker MEI was assumed to receive a dose of 1,500 mrem/yr for less than 1 yr.

Total activities – The population LCF risk from the various activities were summed to show a total LCF risk for each receptor population and are presented in Table 5.1.14.

Table 5.1.14. Radiological LCF Risk from Temporary Operations Barrier (Option 1e) – Normal Operations

Activity	Involved Worker (LCF)		Noninvolved Worker (LCF)		General Public (LCF)	
	MEI	Population	MEI	Population	MEI	Population
Temporary barrier	6.0E-04	4.6E-06	No additional dose	No additional dose	No additional dose	No additional dose
Retrieval	6.0E-04	6.6E-01	2.6E-08	1.1E-06	1.5E-09	3.1E-05
Grout tank	6.0E-04	1.1E-04	8.8E-11	3.8E-09	4.2E-14	1.1E-09
Grout ancillary equipment	1.0E-01	4.9E-01	<8.8E-11	<3.8E-09	<4.2E-14	<1.1E-09
Enhanced RCRA Subtitle C barrier	No exposure	No exposure	No exposure	No exposure	No exposure	No exposure
Total	Not additive	1.2E+00	2.6E-08	1.1E-06	1.5E-09	3.1E-05

Chemical Risk from Accidents

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1e would be the same as Strategy 1 (Section 5.1.1). The chemical risk from accidents for each of these activities in Option 1e therefore would be the same as Strategy 1. For temporary barrier construction the potential accident that was evaluated was a loss of filtration when a truck accidentally crashes into a ventilation stack. It was assumed that the chemical health impacts would be no worse than those estimated for a HEPA filter failure accident during the tank grouting operation. The short-term health risks are presented in Table 5.1.15.

Table 5.1.15. Chemical Risk from Temporary Operations Barrier (Option 1e) – Accident

Activity	Involved Worker	Noninvolved Worker	General Public
Temporary barrier	<2.0E-05 (ERPG-1)	<1.9E-07 (ERPG-1)	<1.0E-12 (ERPG-1)
Retrieval	Lethal radiological dose	7.3E+01 (ERPG-3)	1.1E-01 (ERPG-1)
Grout tank	2.0E-05 (ERPG-1)	1.9E-07 (ERPG-1)	1.0E-12 (ERPG-1)
Grout ancillary equipment	<2.0E-05 (ERPG-1)	<1.9E-07 (ERPG-1)	<1.0E-12 (ERPG-1)
Enhanced RCRA Subtitle C barrier	No chemical accidents	No chemical accidents	No chemical accidents

Radiological Risk from Accidents

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1e would be the same as Strategy 1 (Section 5.1.1). The point-estimate LCF risk from accidents for each of these activities in Option 1e therefore would be the same as Strategy 1. For temporary barrier construction, the potential accident that was evaluated was a loss of filtration when a truck accidentally crashes into a ventilation stack. It was assumed that the radiological health impacts would be no worse than those estimated for a HEPA filter failure accident during the tank grouting operation. The short-term human health risks are presented in Table 5.1.16

Table 5.1.16. Radiological Point-Estimate LCF Risk from Temporary Operations Barrier (Option 1e) – Accident

Activity	Involved Worker		Noninvolved Worker		General Public	
	MEI	Population	MEI	Population	MEI	Population
Temporary barrier	<1.2E-10	<1.2E-09	<5.7E-14	<1.4E-12	<6.6E-17	<3.0E-13
Retrieval	1.3E-05	1.3E-04	2.1E-07	9.2E-06	5.8E-10	8.6E-07
Grout tank	1.2E-10	1.2E-09	5.7E-14	1.4E-12	6.6E-17	3.0E-13
Grout ancillary equipment	8.4E-05	5.7E-04	<5.7E-14	<1.4E-12	<6.6E-17	<3.0E-13
Enhanced RCRA Subtitle C barrier	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents
Total	Not additive	Not additive	Not additive	Not additive	Not additive	Not additive

Occupational Accidents

The labor hour requirements for retrieval, grouting tanks, grouting ancillary equipment, and constructing an enhanced RCRA Subtitle C barrier for Option 1e would be the same as Strategy 1 (Section 5.1.1). For temporary barrier construction, labor hour requirements for constructing a temporary barrier over the AX Tank Farms were provided in Jacobs (1998b). The short-term human health risks are presented in Table 5.1.17.

Table 5.1.17. Occupational Injury/Illness and Fatality from Temporary Operations Barrier (Option 1e)

Activity	Total Recordable Cases	Lost Workday Cases	Fatalities
Temporary barrier	1.0E-01	4.4E-02	7.5E-05
Retrieval	3.4E+01	1.5E+01	2.5E-02
Grout tank	1.1E+00	4.8E-01	8.1E-04
Grout ancillary equipment	5.5E+00	2.4E+00	4.1E-03
Enhanced RCRA Subtitle C barrier	5.6E-01	2.4E-01	4.1E-04
Total	4.1E+01	1.8E+01	3.0E-02

Transportation Accidents

The transportation requirements for retrieval, grouting tanks, grouting ancillary equipment, and constructing an enhanced RCRA Subtitle C barrier for Option 1e would be the same as Strategy 1 (Section 5.1.1). Transportation requirements for constructing a temporary asphalt barrier over the AX Tank Farm were provided in Jacobs (1998b). The transport distances were multiplied by the applicable unit-risk factors to estimate the number of injuries and fatalities. The short-term health risks are presented in Table 5.1.18.

Table 5.1.18. Transportation Injuries and Fatalities from Temporary Operations Barrier (Option le)

Activity	Injuries	Fatalities
Temporary barrier	5.4E-02	3.5E-03
Retrieval	2.1E-02	1.4E-03
Grout tank	2.9E-01	1.9E-02
Grout ancillary equipment	1.4E-02	8.2E-04
Enhanced RCRA Subtitle C barrier	8.2E-02	4.4E-03
Total	4.6E-01	2.9E-02

5.1.1.6 Postretrieval Hanford Barrier (Option 1f)

A description of the retrieval and closure features of the Postretrieval Hanford Barrier (Option 1f) is provided in Section 4.3.7. The major difference between Strategy 1 and Option 1f is that a 30 m^3 (8,000 gal.) retrieval leakage loss is assumed to occur compared to no retrieval leaks for Strategy 1, and a Hanford Barrier would be constructed instead of the enhanced RCRA Subtitle C barrier for Strategy 1.

Chemical Health Impacts from Normal Operations

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1f would be the same as Strategy 1 (Section 5.1.1). The chemical risk from normal operations for each of these activities in Option 1f therefore would be the same as Strategy 1.

Radiological Health Impacts from Normal Operations

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1f would be the same as Strategy 1 (Section 5.1.1). The LCF risk from normal operations for each of these activities in Option 1f therefore would be the same as Strategy 1.

Total activities – The population LCF risk from the various activities were summed to show a total LCF risk for each receptor population.

Chemical Risk from Accidents

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1f would be the same as Strategy 1 (Section 5.1.1). The chemical risk from accidents for each of these activities in Option 1f therefore would be the same as Strategy 1.

Radiological Risk from Accidents

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1f would be the same as Strategy 1 (Section 5.1.1). The point-estimate LCF risk from accidents for each of these activities in Option 1f therefore would be the same as Strategy 1.

Occupational Accidents

The labor hour requirements for retrieval, grouting tanks, and grouting ancillary equipment would be the same as Strategy 1 (Section 5.1.1). Labor hour requirements for constructing the Hanford Barrier over the AX Tank Farm were calculated from data provided in DOE (1996a).

The construction of a Hanford Barrier would require four times more labor hours than an enhanced RCRA Subtitle C barrier. The short-term human health risks are presented in Table 5.1.19.

Table 5.1.19. Occupational Injury/Illness and Fatalities from Postretrieval Hanford Barrier (Option 1f)

Activity	Total Recordable Cases	Lost Workday Cases	Fatalities
Retrieval	3.4E+01	1.5E+01	2.5E-02
Grout tank	1.1E+00	4.8E-01	8.1E-04
Grout ancillary equipment	5.5E+00	2.4E+00	4.1E-03
Hanford Barrier	2.3E+00	9.9E-01	1.7E-03
Total	4.3E+01	1.9E+01	3.2E-02

Transportation Accidents

Transportation requirements for retrieval, grouting tanks, and grouting ancillary equipment for Option 1f would be the same as Strategy 1 (Section 5.1.1). Transportation requirements for constructing the Hanford Barrier over the AX Tank Farm were calculated from data provided in DOE (1996a). The short-term human health risks are presented in Table 5.1.20.

Table 5.1.20. Transportation Injuries and Fatalities from Postretrieval Hanford Barrier (Option 1f)

Activity	Injuries	Fatalities
Retrieval	2.1E-02	1.4E-03
Grout tank	2.9E-01	1.9E-02
Grout ancillary equipment	1.4E-02	8.2E-04
Hanford Barrier	1.2E-01	5.3E-03
Total	4.5E-01	2.7E-02

5.1.1.7 Nominal Losses/Soil Grouting (Option 1g)

A description of the retrieval and closure features of the Nominal Losses/Soil Grouting (Option 1g) is provided in Section 4.3.8. The major difference between Strategy and Option 1g is a 30 m^3 (8,000 gal.) retrieval leakage loss is assumed to occur compared to no retrieval leak for Strategy 1, and the vadose zone contamination from past leaks, spills, and a portion of the 30 m^3 (8,000 gal.) retrieval leakage loss not recovered in the leachate collection system would be grouted in place to the extent possible compared to no vadose zone grouting for Strategy 1. Also a horizontal grout blanket would be installed beneath the tank farm prior to initiating retrieval.

The short-term human health risks associated with the various activities to support Option 1g are presented in Tables 5.1.21 through 5.1.26.

Table 5.1.21. Chemical Health Impacts from Nominal Losses/Soil Grouting (Option 1g) – Normal Operations

Activity	Involved Worker MEI		Noninvolved Worker MEI		General Public MEI	
	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)
Retrieval	2.3E-01	1.8E-06	1.0E-02	7.9E-07	5.3E-05	2.4E-10
Grout tank	1.2E-06	9.0E-11	5.3E-07	3.9E-11	2.9E-10	2.2E-14
Grout ancillary equipment	<1.2E-06	<9.0E-11	<5.3E-07	<3.9E-11	<2.9E-10	<2.2E-14
Grout soil	<1.2E-06	<9.0E-11	<5.3E-07	<3.9E-11	<2.9E-10	<2.2E-14
Enhanced RCRA Subtitle C barrier	No exposure	No exposure	No exposure	No exposure	No exposure	No exposure

Table 5.1.22. Radiological LCF Risk from Nominal Losses/Soil Grouting (Option 1g) – Normal Operations

Activity	Involved Worker (LCF)		Noninvolved Worker (LCF)		General Public (LCF)	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	6.0E-04	6.6E-01	2.6E-08	1.1E-06	1.5E-09	3.1E-05
Grout tank	6.0E-04	1.1E-04	8.8E-11	3.8E-09	4.2E-14	1.1E-09
Grout ancillary equipment	1.0E-01	4.9E-01	<8.8E-11	<3.8E-09	<4.2E-14	<1.1E-09
Grout Soil	1.2E-03	<1.1E-04	<8.8E-11	<3.8E-09	<4.2E-14	<1.1E-09
Enhanced RCRA Subtitle C barrier	No exposure	No exposure	No exposure	No exposure	No exposure	No exposure
Total	Not additive	1.2E+00	2.6E-08	1.1E-06	1.5E-09	3.1E-05

Table 5.1.23. Chemical Risk from Nominal Losses/Soil Grouting (Option 1g) – Accident

Activity	Involved Worker	Noninvolved Worker	General Public
Retrieval	Lethal radiological. dose	7.3E+01 (ERPG-3)	1.1E-01 (ERPG-1)
Grout tank	2.0E-05 (ERPG-1)	1.9E-07 (ERPG-1)	1.0E-12 (ERPG-1)
Grout ancillary equipment	<2.0E-05 (ERPG-1)	<1.9E-07 (ERPG-1)	<1.0E-12 (ERPG-1)
Grout soil	<2.0E-05 (ERPG-1)	<1.9E-07 (ERPG-1)	<1.0E-12 (ERPG-1)
Enhanced RCRA Subtitle C barrier	No chemical accidents	No chemical accidents	No chemical accidents

Table 5.1.24. Radiological Point-Estimate LCF Risk from Nominal Losses/Soil Grouting (Option 1g) – Accident

Activity	Involved Worker		Noninvolved Worker		General Public	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	1.3E-05	1.3E-04	2.1E-07	9.2E-06	5.8E-10	8.6E-07
Grout tank	1.2E-10	1.2E-09	5.7E-14	1.4E-12	6.6E-17	3.0E-13
Grout ancillary equipment	8.1E-05	5.7E-04	<5.7E-14	<1.4E-12	<6.6E-17	<3.0E-13

Table 5.1.24. Radiological Point-Estimate LCF Risk from Nominal Losses/Soil Grouting (Option 1g) – Accident (cont'd)

Activity	Involved Worker		Noninvolved Worker		General Public	
	MEI	Population	MEI	Population	MEI	Population
Grout Soil	<1.2E-10	<1.2E-09	<5.7E-14	<1.4E-12	<6.6E-17	<3.0E-13
Enhanced RCRA Subtitle C barrier	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents
Total	Not additive	Not additive	Not additive	Not additive	Not additive	Not additive

Table 5.1.25. Occupational Injury/Illness and Fatalities from Nominal Losses/Soil Grouting (Option 1g)

Activity	Total Recordable Cases	Lost Workday Cases	Fatalities
Retrieval	3.4E+01	1.5E+01	2.5E-02
Grout tank	1.1E+00	4.8E-01	8.1E-04
Grout ancillary equipment	5.5E+00	2.4E+00	4.1E-03
Grout soil	4.8E+00	2.1E+00	3.5E-03
Enhanced RCRA Subtitle C barrier	5.6E-01	2.4E-01	4.1E-04
Total	4.6E+01	2.0E+01	3.4E-02

Table 5.1.26. Transportation Injuries and Fatalities from Nominal Losses/Soil Grouting (Option 1g)

Activity	Injuries	Fatalities
Retrieval	2.1E-02	1.4E-03
Grout tank	2.9E-01	1.9E-02
Grout ancillary equipment	1.4E-02	8.2E-04
Grout soil	1.6E-01	1:0E-02
Enhanced RCRA Subtitle C barrier	8.2E-02	4.4E-03
Total	5.7E-01	3.6E-02

Chemical Health Impacts from Normal Operations

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1g would be the same as Strategy 1 (Section 5.1.1). The chemical risk from normal operations for each of these activities in Option 1g therefore would be the same as Strategy 1. There were no chemical emissions data for grouting the soil in place. It was assumed that the chemical emissions from in situ grouting would be small and would not increase the chemical emissions beyond those estimated for Strategy 1.

Radiological Health Impacts From Normal Operations

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1g would be the same as Strategy 1 (Section 5.1.1). The LCF risk from normal operations for each of these activities in Option 1g therefore would be the same as Strategy 1.

There were no emissions data for grouting the soil in place. It was assumed that the emissions from in situ grouting would be small and would not increase the chemical emissions beyond those estimated for Strategy 1. The involved worker MEI was assumed to receive a dose of 1,500 mrem/yr for less than 2 yr.

Total activities – The population LCF risk from the various activities were summed to show a total LCF risk for each receptor population.

Chemical Risk from Accidents

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1g would be the same as Strategy 1 (Section 5.1.1). The chemical risk from accidents for each of these activities in Option 1g therefore would be the same as Strategy 1. There were no emissions data for grouting the soil in place. It was assumed that the emissions would be less than those estimated for grouting the tanks, therefore the chemical health impacts from accidents would be less.

Radiological Risk from Accidents

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1g would be the same as Strategy 1 (Section 5.1.1). The point-estimate LCF risk from accidents for each of these activities in Option 1g therefore would be the same as Strategy 1. There were no emissions data for grouting the soil in place. It was assumed that the emissions would be less than those estimated for grouting the tanks, therefore the radiological LCF risk from accidents would be less.

Occupational Accidents

Labor hour requirements for retrieval, grouting tanks, grouting ancillary equipment, and constructing an enhanced RCRA Subtitle C barrier would be the same as Strategy 1 (Section 5.1.1). Labor hour requirements for grouting soil in situ were based on data provided in the Hanford Tanks Initiative Study Refinements (Norman 1999).

Transportation Accidents

Transportation requirements for retrieval, grouting tanks, grouting ancillary equipment and constructing an enhanced RCRA Subtitle C barrier would be the same as Strategy 1 (Section 5.1.1). Transportation requirements for grouting soil in situ were based on data provided in the Hanford Tanks Initiative Study Refinements (Norman 1999).

5.1.1.8 Large Losses/Soil Grouting (Option 1h)

A description of the retrieval and closure features of the Large Losses/Soil Grouting (Option 1h) is provided in Section 4.3.9. The major difference between Strategy 1 and Option 1h is a 151 m^3 (40,000 gal.) retrieval leakage loss is assumed to occur compared to no retrieval leaks for Strategy 1 and vadose zone contamination from past leaks, spills, and a 151 m^3 (40,000 gal.) retrieval leakage loss not recovered in the leachate collection system would be grouted in place to the extent possible compared to no vadose zone grouting for Strategy 1.

The short-term human health risks associated with the various activities to support Option 1h are presented in Tables 5.1.27 through 5.1.32.

Table 5.1.27. Chemical Health Impacts from Large Losses/Soil Grouting (Option 1h) – Normal Operations

Activity	Involved Worker MEI		Noninvolved Worker MEI		General Public MEI	
	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)
Retrieval	2.3E-01	1.8E-06	1.0E-02	7.9E-07	5.3E-05	2.4E-10
Grout tank	1.2E-06	9.0E-11	5.3E-07	3.9E-11	2.9E-10	2.2E-14
Grout ancillary equipment	<1.2E-06	<9.0E-11	<5.3E-07	<3.9E-11	<2.9E-10	<2.2E-14
Grout soil	<1.2E-06	<9.0E-11	<5.3E-07	<3.9E-11	<2.9E-10	<2.2E-14
Enhanced RCRA Subtitle C barrier	No exposure	No exposure	No exposure	No exposure	No exposure	No exposure

Table 5.1.28. Radiological LCF Risk from Large Losses/Soil Grouting (Option 1h) – Normal Operations

Activity	Involved Worker (LCF)		Noninvolved Worker (LCF)		General Public (LCF)	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	6.0E-04	6.6E-01	2.6E-08	1.1E-06	1.5E-09	3.1E-05
Grout tank	6.0E-04	1.1E-04	8.8E-11	3.8E-09	4.2E-14	1.1E-09
Grout ancillary equipment	1.0E-01	4.9E-01	<8.8E-11	<3.8E-09	<4.2E-14	<1.1E-09
Grout Soil	1.2E-03	<1.1E-04	<8.8E-11	<3.8E-09	<4.2E-14	<1.1E-09
Enhanced RCRA Subtitle C barrier	No exposure	No exposure	No exposure	No exposure	No exposure	No exposure
Total	Not additive	1.2E+00	2.6E-08	1.1E-06	1.5E-09	3.1E-05

Table 5.1.29. Chemical Risk from Large Losses/Soil Grouting (Option 1h) – Accident

Activity	Involved Worker	Noninvolved Worker	General Public
Retrieval	Lethal radiological dose	7.3E+01 (ERPG-3)	1.1E-01 (ERPG-1)
Grout tank	2.0E-05 (ERPG-1)	1.9E-07 (ERPG-1)	1.0E-12 (ERPG-1)
Grout ancillary equipment	<2.0E-05 (ERPG-1)	<1.9E-07 (ERPG-1)	<1.0E-12 (ERPG-1)
Grout soil	<2.0E-05 (ERPG-1)	<1.9E-07 (ERPG-1)	<1.0E-12 (ERPG-1)
Enhanced RCRA Subtitle C barrier	No chemical accidents	No chemical accidents	No chemical accidents

Table 5.1.30. Radiological Point-Estimate LCF Risk from Large Losses/Soil Grouting (Option 1h) – Accident

Activity	Involved Worker		Noninvolved Worker		General Public	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	1.3E-05	1.3E-04	2.1E-07	9.2E-06	5.8E-10	8.6E-07
Grout tank	1.2E-10	1.2E-09	5.7E-14	1.4E-12	6.6E-17	3.0E-13
Grout ancillary equipment	8.1E-05	5.7E-04	<5.7E-14	<1.4E-12	<6.6E-17	<3.0E-13
Grout soil	<1.2E-10	<1.2E-09	<5.7E-14	<1.4E-12	<6.6E-17	<3.0E-13
Enhanced RCRA Subtitle C barrier	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents
Total	Not additive	Not additive	Not additive	Not additive	Not additive	Not additive

Table 5.1.31. Occupational Injury/Illness and Fatality from Large Losses/Soil Grouting (Option 1h)

Activity	Total Recordable Cases	Lost Workday Cases	Fatalities
Retrieval	3.4E+01	1.5E+01	2.5E-02
Grout tank	1.1E+00	4.8E-01	8.1E-04
Grout ancillary equipment	5.5E+00	2.4E+00	4.1E-03
Grout soil	2.6E+00	1.1E+00	1.9E-03
Enhanced RCRA Subtitle C barrier	5.6E-01	2.4E-01	4.1E-04
Total	4.4E+01	1.9E+01	3.2E-02

Table 5.1.32. Transportation Injuries and Fatalities from Large Losses/Soil Grouting (Option 1h)

Activity	Injuries	Fatalities
Retrieval	2.1E-02	1.4E-03
Grout tank	2.9E-01	1.9E-02
Grout ancillary equipment	1.4E-02	8.2E-04
Grout soil	4.6E-01	2.9E-02
Enhanced RCRA Subtitle C barrier	8.2E-02	4.4E-03
Total	8.7E-01	5.5E-02

Chemical Health Impacts from Normal Operations

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1h would be the same as Strategy 1 (Section 5.1.1). The chemical risk from normal operations for each of these activities in Option 1h therefore would be the same as Strategy 1. There were no chemical emissions data for grouting the soil in place. It was assumed that the chemical emissions would be small and would not increase the chemical emissions beyond those estimated for Strategy 1.

Radiological Health Impacts From Normal Operations

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1h would be the same as Strategy 1 (Section 5.1.1). The LCF risk from normal operations for each of these activities in Option 1h therefore would be the same as Strategy 1. There were no emissions data for grouting the soil in place. It was assumed that the emissions would be small and would not increase the radiological emissions beyond those estimated for Strategy 1. The involved worker MEI was assumed to receive a dose of 1,500 mrem/yr for less than 2 yr.

Total activities – The population LCF risk from the various activities were summed to show a total LCF risk for each receptor population.

Chemical Risk from Accidents

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1h would be the same as Strategy 1 (Section 5.1.1). The chemical risk from accidents for each of these activities in Option 1h therefore would be the same as Strategy 1. There were no emissions data for grouting the soil in place. It was assumed that the emissions would be less than those estimated for grouting the tanks, therefore the chemical health impacts from accidents would be less.

Radiological Risk from Accidents

The parameters associated with retrieval, grouting tanks, and grouting ancillary equipment for Option 1h would be the same as Strategy 1 (Section 5.1.1). The point-estimate LCF risk from accidents for each of these activities in Option 1h therefore would be the same as Strategy 1. There were no emissions data for grouting the soil in place. It was assumed that the emissions would be small and would not increase the emissions beyond those estimated for Strategy 1.

Occupational Accidents

Labor hour requirements for retrieval, grouting tanks, grouting ancillary equipment, and constructing an enhanced RCRA Subtitle C barrier would be the same as Strategy 1 (Section 5.1.1). Labor hour requirements for grouting soil in situ was based on data provided in the Hanford Tanks Initiative Study Refinements (Norman 1999).

Transportation Accidents

Transportation requirements for retrieval, grouting tanks, grouting ancillary equipment, and constructing an enhanced RCRA Subtitle C barrier would be the same as Strategy 1 (Section 5.1.1). Transportation requirements for grouting soil in situ were based on data provided in the Hanford Tanks Initiative Study Refinements (Norman 1999).

5.1.2 Baseline Retrieval/Unrestricted Land Use (Strategy 2)

The Baseline Retrieval/Unrestricted Land Use (Strategy 2) would include retrieval and closure activities as discussed in Section 4.4.1.

The short-term human health risks associated with the various activities to support Strategy 2 are presented in Tables 5.1.33 through 5.1.38. The following sections identify data sources and assumptions used in the calculation of short-term human health risks.

Table 5.1.33. Chemical Health Impacts from Baseline Retrieval/Unrestricted Land Use (Strategy 2) – Normal Operations

Activity	Involved Worker MEI		Noninvolved Worker MEI		General Public MEI	
	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)
Retrieval	2.3E-01	1.8E-06	1.0E-02	7.9E-07	5.3E-05	2.4E-10
Remove tank	No exposure	No exposure	9.0E-04	1.7E-11	5.0E-07	9.3E-15
Remove ancillary equipment	No exposure	No exposure	2.2E-08	2.9E-15	1.3E-11	1.7E-18
Preprocessing	No appreciable exposure	No appreciable exposure	No appreciable emissions	No appreciable emissions	No appreciable emissions	No appreciable emissions
Remove soil	No exposure	No exposure	No appreciable emissions	No appreciable emissions	No appreciable emissions	No appreciable emissions

Table 5.1.34. Radiological LCF Risk from Baseline Retrieval/Unrestricted Land Use (Strategy 2) – Normal Operations

Activity	Involved Worker (LCF)		Noninvolved Worker (LCF)		General Public (LCF)	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	6.0E-04	6.6E-01	2.6E-08	1.1E-06	1.5E-09	3.1E-05
Remove tank	1.8E-03	4.0E-03	6.4E-06	2.9E-04	5.5E-09	1.1E-04
Remove ancillary equipment	1.2E-03	4.7E-03	1.3E-07	5.6E-06	7.5E-11	2.1E-06
Preprocessing	6.0E-04	5.5E-03	2.0E-06	8.8E-05	1.9E-09	3.6E-05
Remove soil	1.8E-03	1.2E-03	3.9E-13	1.7E-17	4.3E-21	2.2E-17
Total	Not additive	6.8E-01	8.6E-06	3.8E-04	9.0E-09	1.8E-04

Table 5.1.35. Chemical Risk from Baseline Retrieval/Unrestricted Land Use (Strategy 2) – Accident

Activity	Involved Worker	Noninvolved Worker	General Public
Retrieval	Lethal radiological dose	7.3E+01 (ERPG-3)	1.1E-01 (ERPG-1)
Remove tank	Lethal radiological dose	1.3E-01 (ERPG-1)	7.0E-07 (ERPG-1)
Remove ancillary equipment	5.8E-06 (ERPG-1)	5.8E-08 (ERPG-1)	1.5E-11 (ERPG-1)
Preprocessing	No appreciable concentrations	No appreciable concentrations	No appreciable concentrations
Remove soil	<5.8E-06 (ERPG-1)	<5.8E-08 (ERPG-1)	<1.5E-11 (ERPG-1)

Table 5.1.36. Radiological Point-Estimate LCF Risk from Baseline Retrieval/ Unrestricted Land Use (Strategy 2) Accident

Activity	Involved Worker		Noninvolved Worker		General Public	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	1.3E-05	1.3E-04	2.1E-07	9.2E-06	5.8E-10	8.6E-07
Remove tank	1.0E-02	No scenario	1.6E-06	4.0E-05	9.3E-10	4.2E-06
Remove ancillary equipment	1.6E-03	No scenario	5.9E-07	1.4E-05	3.4E-10	1.5E-06
Preprocessing	No scenario	No scenario	1.4E-10	6.2E-09	1.3E-13	2.5E-09
Remove soil	1.1E-17	No scenario	5.3E-21	1.3E-19	4.9E-24	2.2E-20
Total	Not additive	Not additive	Not additive	Not additive	Not additive	Not additive

Table 5.1.37. Occupational Injury/Illness and Fatalities from Baseline Retrieval/Unrestricted Land Use (Strategy 2)

Activity	Total Recordable Cases	Lost Workday Cases	Fatalities
Retrieval	3.4E+01	1.5E+01	2.5E-02
Remove tank	2.0E+01	8.6E+00	1.5E-02
Remove ancillary equipment	6.1E+00	2.6E+00	4.4E-03
Preprocessing	2.6E+02	1.1E+02	1.9E-01
Remove soil	1.2E-01	5.4E-02	9.1E-05
Total	3.2E+02	1.4E+02	2.3E-01

Table 5.1.38. Transportation Injuries and Fatalities from Baseline Retrieval/Unrestricted Land Use (Strategy 2)

Activity	Injuries	Fatalities
Retrieval	2.1E-02	1.4E-03
Remove tank	2.2E-01	8.0E-03
Remove ancillary equipment	6.4E-03	2.2E-04
Preprocessing	5.0E-01	3.2E-02
Remove soil	8.4E-02	4.8E-03
Total	8.3E-01	4.6E-02

Chemical Health Impacts From Normal Operations

Waste retrieval – Chemical emissions resulting from normal retrieval operations for a single tank were assumed to be the same as the emissions from a single tank evaluated in the TWRS EIS (DOE 1996b) for retrieval operations. The chemical health impacts were therefore assumed to be the same as those calculated in the TWRS EIS based on a single tank.

Remove tanks – Chemical emissions while removing tanks were based on emissions provided in the AX Tank Farm Waste Inventory Study for the Hanford Tanks Initiative Project (NHC 1997). The emission rates were calculated from data provided in the AX Tank Farm Removal Study (SESC 1997). Atmospheric dispersion coefficients generated by the GXQ computer code were used to calculate the chemical concentrations at the noninvolved worker MEI and general public MEI locations. The involved workers would be on supplied air and would not receive a chemical exposure.

Remove ancillary equipment – Chemical emissions while removing ancillary equipment were based on emissions provided in the AX Tank Farm Ancillary Equipment Study (COGEMA 1998). Atmospheric dispersion coefficients generated by the GXQ computer code were used to calculate the chemical concentrations at the noninvolved worker MEI and general public MEI locations. The involved workers would be on supplied air and would not receive a chemical exposure.

Preprocessing – There would be no appreciable chemical emissions from the preprocessing operation; therefore, chemical emissions were not quantified.

Remove soil – There were no chemical emissions data for removing the contaminated soil under the tanks. It was assumed that there would be no appreciable chemical emissions.

Radiological Health Impacts From Normal Operations

Waste retrieval – Radiological emissions during normal waste retrieval operations were assumed to be the same as those evaluated in the TWRS EIS (DOE 1996b) for retrieval operations. The LCF risk calculated in the TWRS EIS was based on waste retrieval from 149 tanks. The LCF risk from retrieving the waste from four tanks in the AX Tank Farm was scaled from those 149 tanks. The involved worker population dose was based on projected worker exposure rates in radiation zones and the number of worker hours in the zones. There were no data that would indicate what the worker exposure might be, therefore worker exposure rates were assumed to be the same as those provided in the Engineering Data for Grout Filling AX Tanks adapted from Jacobs (1998b). The radiation worker hours for performing various zone work activities were developed from data taken from the AX Tank Farm Retrieval Alternatives Cost Estimates (NHC 1998) for the 99 percent retrieval case. The involved worker MEI was assumed to receive a dose of 1,500 mrem/yr for less than 1 yr.

Remove tanks – Radiological emissions during normal tank removal operations were based on emissions provided in the AX Tank Farm Tank Removal Study (SESC 1997), and the activity of the waste was provided in the AX Tank Farm Waste Inventory Study for the Hanford Tanks Initiative Project (NHC 1997). The emissions data and atmospheric dispersion coefficients generated by the GXQ computer code were used in the GENII computer code to calculate the

radiological doses for the noninvolved worker and general public receptors. The involved worker population dose was based on projected worker exposure rates in radiation zones and the number of worker hours in the zones. The worker exposure rates were also provided in the AX Tank Farm Tank Removal Study (SESC 1997). The involved worker MEI was assumed to receive a dose of 1,500 mrem/yr for less than 3 yr.

Remove ancillary equipment – Radiological emissions during normal ancillary equipment removal operations were based on emissions provided in the AX Tank Farm Ancillary Equipment Study (COGEMA 1998). The emissions data and atmospheric dispersion coefficients generated by GXQ computer code were used in the GENII computer code to calculate the radiological doses for the noninvolved worker and general public receptors. Exposure rates to the involved workers and a population dose were provided in the AX Tank Farm Ancillary Equipment Study (COGEMA 1998). The involved worker MEI was assumed to receive a dose of 1,500 mrem/yr for less than 2 yr.

Preprocessing – Radiological emissions during normal preprocessing operations were based on air emission data provided by COGEMA (1999). The emissions data and atmospheric dispersion coefficients generated by GXQ computer code were used in the GENII computer code to calculate the radiological doses for the noninvolved worker and general public receptors. Exposure rates to the involved worker population were based on the TWRS EIS processing exposure rate of 200 mrem/yr per person (DOE 1996). The involved worker MEI was assumed to receive a dose of 1,500 mrem/yr for less than 1 yr.

Remove soil – There were no radiological emissions data for removing contaminated soil beneath the tanks except for Cs-137 provided in AX Tank Farm Tank Removal Study. Radiological constituents in the past leak spreadsheet provided in Jacobs (1998b) were used to develop a ratio (past leak : emissions) for Cs-137. The same ratio was applied to the other radionuclides listed in the past leak spreadsheet. The emissions data and atmospheric dispersion coefficients generated by GXQ computer code were used in the GENII computer code to calculate the radiological doses for the noninvolved worker and general public receptors. Exposure rates to the involved workers and a population dose were provided in the Soil Remediation Engineering Study (Skelly 1999). The involved worker MEI was assumed to receive a dose of 1,500 mrem/yr for less than 3 yr.

Total activities – The population LCF risk from the various activities were summed to show a total LCF risk for each receptor population.

Chemical Risk from Accidents

Waste retrieval – The chemical health impacts resulting from a potential waste retrieval accident were assumed to be the same as the health impacts calculated for a retrieval accident in the TWRS EIS. The waste retrieval accident evaluated in the TWRS EIS was a loss of HEPA filters. It was postulated that a ventilation heater failure could occur due to an electrical fault resulting in humid air plugging the HEPA filter followed by filter blowout.

Remove tanks – The chemicals that would be released to the environment from unfiltered ventilation emissions while removing the tanks were calculated from data provided in the AX Tank Farm Tank Removal Study (SESC 1997). Atmospheric dispersion coefficients

generated by the GXQ computer code were used to calculate the chemical concentrations at the noninvolved worker MEI and general public MEI locations. The involved workers would be on supplied air and would not receive a chemical exposure. The evaluated scenario for the involved worker was a loss of supplied air accident. A hand calculation was used to calculate the chemical concentrations for the involved worker MEI for a 15-minute exposure. It was assumed it would take 15 minutes for the worker to evacuate the zone.

Remove ancillary equipment – The chemicals that would be released to the environment from unfiltered ventilation emissions while removing the ancillary equipment were calculated from data provided in the AX Tank Farm Ancillary Equipment Study (COGEMA 1998). Atmospheric dispersion coefficients generated by the GXQ computer code were used to calculate the chemical concentrations at the noninvolved worker MEI and general public MEI locations. The involved workers would be on supplied air and would not receive a chemical exposure. The evaluated scenario for the involved worker was a loss of supplied air accident. A hand calculation was used to calculate the chemical concentrations for the involved worker MEI for a 15-minute exposure. It was assumed it would take 15 minutes for the worker to evacuate the zone.

Preprocessing – There would be no appreciable chemical emissions from a preprocessing operation accident; therefore, chemical emissions were not quantified.

Remove soil – No chemical emissions data were developed for soil removed that could be used to calculate the chemical health impacts. The chemical emissions from an accident were assumed to be less than the chemical emissions calculated for the ancillary equipment removal accident.

Radiological Risk from Accidents

Waste retrieval – The LCF risk resulting from a potential waste retrieval accident was assumed to be the same as the LCF risk calculated for a retrieval accident in the TWRS EIS. The waste retrieval accident evaluated in the TWRS EIS was a loss of HEPA filters. It was postulated that a ventilation heater failure could occur due to an electrical fault resulting in humid air plugging the HEPA filter followed by filter blowout. The annual frequency of this event was calculated to be 8.8E-06. The probability of 2.2E-04 calculated in the TWRS EIS was based on 25 yr of operation. The time required to retrieve 99 percent of the waste from the AX Tank Farm was estimated from the AX Tank Farm Retrieval Alternative Cost Estimates (NHC 1998) to be 1.42 yr, which would result in a probability of 1.3E-05. The lower point-estimate LCF risk for the AX Tank Farms as compared to the point-estimate LCF risk calculated in the TWRS EIS is accounted for by the lower probability.

Remove tanks – The radiological constituents that would be released to the environment from unfiltered ventilation emissions while removing the tanks were calculated from emissions data provided in the AX Tank Farm Tank Removal Study (SESC 1997). The emissions were increased by a factor of 20,000 to account for the loss of an electrostatic precipitator and two stages of HEPA filters. Atmospheric dispersion coefficients generated by the GXQ computer code were used to calculate the radiological concentration from an 8-hr release at the noninvolved worker and general public receptor locations. The involved workers would be on supplied air and would not receive a chemical exposure. The scenario evaluated for the involved worker was a loss of supplied air accident. A hand calculation was used to calculate the

radiological concentrations for the involved worker MEI. Dose conversion factors from the GENII code library were used to calculate the dose resulting from the radiological exposure. The probability of the accident was estimated to be 6.2E-06 (Jacobs 1998b) and was used to calculate the point-estimate LCF risk to the noninvolved and general public receptors. The loss of supplied air was assumed to be an unlikely event (1.0E-02 to 1.0E-04). The conservative end of the range of 1.0E-02 was used to calculate the point-estimate LCF risk to the involved worker MEI.

Remove ancillary equipment – The radiological constituents that would be released to the environment from unfiltered ventilation emissions while removing ancillary equipment were calculated from emissions data provided in the AX Tank Farm Ancillary Equipment Study (COGEMA 1998). The emissions were increased by a factor of 20,000 to account for the loss of two stages of HEPA filters. Atmospheric dispersion coefficients generated by the GXQ computer code were used to calculate the radiological concentration from an 8-hr release at the noninvolved worker and general public receptor locations. The involved workers would be on supplied air and would not receive a radiological exposure. The scenario evaluated for the involved worker was a loss of supplied air accident. A hand calculation was used to calculate the radiological concentrations for the involved worker MEI. Dose conversion factors from the GENII code library were used to calculate the dose resulting from the radiological exposure. The probability of the accident was estimated to be 7.5E-06 (Jacobs 1998b) and was used to calculate the point-estimate LCF risk to the noninvolved and general public receptors. The loss of supplied air was assumed to be an unlikely event (1.0E-02 to 1.0E-04). The conservative end of the range of 1.0E-02 was used to calculate the point-estimate LCF risk to the involved worker MEI.

Preprocessing – The LCF risk resulting from an unfiltered ventilation emission while preprocessing the waste from the AX Tank Farm was calculated based on the routine emission rates. The LCF risk from an unfiltered release was scaled from the routine emission LCF risk by increasing the risk by a factor of 3,333 (Skelly 1999) to account for the loss of one stage of HEPA filters. The risk then was decreased by a factor of 4.8E-03 to account for an 8-hr unfiltered release. The probability of the accident was estimated to be 4.4E-06 (Jacobs 1998b) and was used to calculate the point-estimate LCF risk to the noninvolved worker and general public receptors.

Remove soil – There were no radiological emissions data for removing contaminated soil beneath the tanks except for Cs-137 provided in AX Tank Farm Tank Removal Study. Radiological constituents in the past leak spreadsheet provided in Jacobs (1998b) were used to develop a ratio (past leak/emissions) for Cs-137. The same ratio was applied to the other radionuclides listed in the past leak spreadsheet. It was assumed both stages of HEPA filters were lost, therefore no credit was taken for filtration. The emissions data and atmospheric dispersion coefficients generated by GXQ computer code were used in the GENII computer code to calculate the radiological doses for the noninvolved worker and general public receptors. The involved workers would be on supplied air and would not receive a radiological exposure. The scenario evaluated for the involved worker was a loss of supplied air accident. A hand calculation was used to calculate the radiological concentrations for the involved worker MEI. Dose conversion factors from the GENII code library were used to calculate the dose resulting from the radiological exposure. The probability of the accident was estimated to be 9.6E-06

(Jacobs 1998b) and was used to calculate the point-estimate LCF risk to the noninvolved and general public receptors. The loss of supplied air was assumed to be an unlikely event with a probability range of 1.0E-02 to 1.0E-04. The conservative end of the range of 1.0E-02 was used to calculate the point-estimate LCF risk to the involved worker MEI.

Occupational Accidents

Waste retrieval – Labor hour requirements for installing waste retrieval equipment and retrieval operations were calculated based on data provided in the AX Tank Farm Retrieval Alternative Cost Estimates (NHC 1998).

Remove tanks – Labor hour requirements for constructing an enclosure, removing soil from above the tank dome and along the sides of the tank, removing the tank, and back fill operations were calculated based on the AX Tank Farm Tank Removal Study (SESC 1997).

Remove ancillary equipment – Labor hour requirements for removing ancillary equipment were calculated based on data provided in the AX Tank Farm Ancillary Equipment Study (COGEMA 1998).

Preprocessing – Labor hour requirements for constructing a Preprocessing Facility were provided by COGEMA (1999 [Capital Cost Estimate, Rev. 2]). Labor hour requirements for operating the Preprocessing Facility were calculated based on the data provided by COGEMA (1999).

Remove soil – Labor hour requirements for removing contaminated soil beneath the tanks were calculated based on data provided in the soil remediation engineering study (Skelly 1999).

Transportation Accidents

Retrieval – Transportation requirements for installing retrieval equipment and retrieval operations were calculated from data based on data provided in the AX Tank Farm Retrieval Alternative Cost Estimates (NHC 1998).

Removing tanks – Transportation requirements for constructing an enclosure, removing soil from above the tank dome and along the sides of the tank, removing the tank, and back fill operations were calculated based on the AX Tank Farm Tank Removal Study (SESC 1997).

Remove ancillary equipment – Transportation requirements for removing ancillary equipment were calculated from data based on data provided in the AX Tank Farm Ancillary Equipment Study (COGEMA 1998).

Preprocessing – Transportation requirements for constructing a Preprocessing Facility and transporting Category 1 and 3 waste to ERDF and the LLBG, respectively, were calculated based on the data provided in COGEMA (1999).

Remove soil – Transportation requirements for removing soil were calculated based on data provided in the Soil Remediation Engineering Study (Skelly 1999).

5.1.2.1 Nominal Losses/Excavation (Option 2a)

A description of the retrieval and closure features of the Nominal Losses/Excavation (Option 2a) is provided in Section 4.4.2. The major difference between Strategy 2 and Option 2a is a 30 m^3 (8,000 gal.) retrieval leakage loss is assumed to occur compared to no retrieval leaks for Strategy 2.

Chemical Health Impacts from Normal Operations

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2a would be the same as Strategy 2 (Section 5.1.2). The chemical risk from normal operations for each of these activities in Option 2a therefore would be the same as Strategy 2.

There were no chemical emissions data for removing the contaminated soil under the tanks. It was assumed that there would be no appreciable chemical emissions.

Radiological Health Impacts from Normal Operations

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2a would be the same as Strategy 2 (Section 5.1.2). The LCF risk from normal operations for each of these activities in Option 2a therefore would be the same as Strategy 2.

Radiological emissions during normal soil removal operations were provided in Norman (1999). The emissions data and atmospheric dispersion coefficients generated by GXQ computer code were used in the GENII computer code to calculate the radiological doses for the noninvolved worker and general public receptors. Exposure rates to the involved workers and a population dose were provided in the Hanford Tank Initiative Study Refinements (Norman 1999). The involved worker MEI was assumed to receive a dose of 23 rem in less than 1 yr.

Total activities – The population LCF risk from the various activities were summed to show a total LCF risk for each receptor population as presented in Table 5.1.39.

Table 5.1.39. Radiological LCF Risk from Nominal Losses/Excavation (Option 2a) – Normal Operations

Activity	Involved Worker (LCF)		Noninvolved Worker (LCF)		General Public (LCF)	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	6.0E-04	6.6E-01	2.6E-08	1.1E-06	1.5E-09	3.1E-05
Remove tank	1.8E-03	4.0E-03	6.4E-06	2.9E-04	5.5E-09	1.1E-04
Remove ancillary equipment	1.2E-03	4.7E-03	1.3E-07	5.6E-06	7.5E-11	2.1E-06
Preprocessing	6.0E-04	5.5E-03	2.0E-06	8.8E-05	1.9E-09	3.6E-05
Remove soil	1.1E-01	4.2E-01	9.2E-13	4.0E-11	9.0E-15	2.4E-10
Total	Not additive	1.1E+00	8.6E-06	3.8E-04	9.0E-09	1.8E-04

Chemical Risk from Accidents

The parameters associated with retrieval, tank removal, and ancillary equipment removal for Option 2a would be the same as Strategy 2 (Section 5.1.2). The chemical risk from accidents for each of these activities in Option 2a therefore would be the same as Strategy 2.

There were no chemical emissions data developed for soil excavation for use in calculating the chemical health impacts. The chemical emissions from an accident were assumed to be less than the chemical emissions calculated for the ancillary equipment removal accident.

Radiological Risk from Accidents

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2a would be the same as Strategy 2 (Section 5.1.2). The point-estimate LCF risk from accidents for each of these activities in Option 2a therefore would be the same as Strategy 2.

The radiological constituents that would be released to the environment from unfiltered ventilation emissions while removing the contaminated soil beneath the tanks was calculated from emissions data provided in Norman (1999). Atmospheric dispersion coefficients generated by the GXQ computer code were used to calculate the radiological concentration from an 8-hr release at the noninvolved worker and general public receptor locations. The scenario evaluated for the involved worker was a loss of supplied air accident. The accident was postulated to occur when maintenance personnel enter the zone on supplied air to perform maintenance work.

A hand calculation was used to calculate the radiological concentrations for the involved worker MEI. Dose conversion factors from the GENII code library were used to calculate the dose resulting from the radiological exposure. The probability of the accident was estimated to be 1.3E-06 (Jacobs 1998b) and was used to calculate the point-estimate LCF risk to the noninvolved and general public receptors. The loss of supplied air was assumed to be an unlikely event, with a probability range of 1.0E-02 to 1.0E-04. The conservative end of the range, 1.0E-02, was used to calculate the point-estimate LCF risk to the involved worker MEI.

The short-term human health risks resulting from radiological accidents from the various activities to support Option 2a are presented in Table 5.1.40.

Table 5.1.40. Radiological Point-Estimate LCF Risk from Nominal Losses/Excavation (Option 2a) – Accident

Activity	Involved Worker		Noninvolved Worker		General Public	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	1.3E-05	1.3E-04	2.1E-07	9.2E-06	5.8E-10	8.6E-07
Remove tank	1.0E-02	No scenario	1.6E-06	4.0E-05	9.3E-10	4.2E-06
Remove ancillary equipment	1.6E-03	No scenario	5.9E-07	1.4E-05	3.4E-10	1.5E-06
Preprocessing	No scenario	No scenario	1.4E-10	6.2E-09	1.3E-13	2.5E-09
Remove soil	1.1E-02	No scenario	1.3E-05	3.0E-04	7.1E-09	3.2E-05
Total	Not additive	Not additive	Not additive	Not additive	Not additive	Not additive

Occupational Accidents

Labor hour requirements for retrieval, tank removal, ancillary equipment removal, and preprocessing would be the same as Strategy 2 (Section 5.1.2). Labor hour requirements for removing contaminated soil beneath the tanks were calculated based on data provided in the HTI Study Refinements (Norman 1999). The short-term human health risks are presented in Table 5.1.41.

Table 5.1.41. Occupational Injury/Illness and Fatalities from Nominal Losses/Excavation (Option 2a)

Activity	Total Recordable Cases	Lost Workday Cases	Fatalities
Retrieval	3.4E+01	1.5E+01	2.5E-02
Remove tank	2.0E+01	8.6E+00	1.5E-02
Remove ancillary equipment	6.1E+00	2.6E+00	4.4E-03
Preprocessing	2.6E+02	1.1E+02	1.9E-01
Remove soil	2.0E+01	8.6E+00	1.5E-02
Total	3.4E+02	1.4E+02	2.5E-01

Transportation Accidents

Transportation requirements for retrieval, tank removal, ancillary equipment removal, and preprocessing would be the same as Strategy 2 (Section 5.1.2). Transportation requirements for removing soil were calculated based on data provided in the Hanford Tanks Initiative Study Refinements (Norman 1999). The short-term human health risks are presented in Table 5.1.42.

Table 5.1.42. Transportation Injuries and Fatalities from Nominal Losses/Excavation (Option 2a)

Activity	Injuries	Fatalities
Retrieval	2.1E-02	1.4E-03
Remove tank	2.2E-01	8.0E-03
Remove ancillary equipment	6.4E-03	2.2E-04
Preprocessing	5.0E-01	3.2E-02
Remove soil	1.1E-01	5.1E-03
Total	8.6E-01	4.7E-02

5.1.2.2 Past Leak/In Situ Soil Treatment Option 2b

A description of the retrieval and closure features of the In Situ Soil Treatment (Option 2b) is provided in Section 4.4.3. The major difference between Strategy 2 and Option 2b is that contaminated soil below the base of the tanks from past leaks that would be grouted in place following tank removal compared to being retrieved for Strategy 2.

The short-term human health risks associated with the various activities to support Option 2b are presented in Tables 5.1.43 through 5.1.48.

Table 5.1.43. Chemical Health Impacts from In Situ Soil Treatment (Option 2b) – Normal Operations

Activity	Involved Worker MEI		Noninvolved Worker MEI		General Public MEI	
	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)
Retrieval	2.3E-01	1.8E-06	1.0E-02	7.9E-07	5.3E-05	2.4E-10
Remove tank	No exposure	No exposure	9.0E-04	1.7E-11	5.0E-07	9.3E-15
Remove ancillary equipment	No exposure	No exposure	2.2E-08	2.9E-15	1.3E-11	1.7E-18

Table 5.1.43. Chemical Health Impacts from In Situ Soil Treatment (Option 2b) – Normal Operations (cont'd)

Activity	Involved Worker MEI		Noninvolved Worker MEI		General Public MEI	
	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)
Pretreatment	No appreciable exposure	No appreciable exposure	No appreciable emissions	No appreciable emissions	No appreciable emissions	No appreciable emissions
Grout Soil	<1.2E-06	<9.0E-11	<5.3E-07	<3.9E-11	<2.9E-10	<2.2E-14

Table 5.1.44. Radiological LCF Risk from In Situ Soil Treatment (Option 2b) – Normal Operations

Activity	Involved Worker (LCF)		Noninvolved Worker (LCF)		General Public (LCF)	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	6.0E-04	6.6E-01	2.6E-08	1.1E-06	1.5E-09	3.1E-05
Remove tank	1.8E-03	4.0E-03	6.4E-06	2.9E-04	5.5E-09	1.1E-04
Remove ancillary equipment	1.2E-03	4.7E-03	1.3E-07	5.6E-06	7.5E-11	2.1E-06
Preprocessing	6.0E-04	5.5E-03	2.0E-06	8.8E-05	1.9E-09	3.6E-05
Grout soil	1.2E-03	<1.1E-04	<8.8E-11	<3.8E-09	<4.2E-14	<1.1E-09
Total	Not additive	6.7E-01	8.6E-06	3.8E-04	9.0E-09	1.8E-04

Table 5.1.45. Chemical Risk from In Situ Soil Treatment (Option 2b) – Accident

Activity	Involved Worker	Noninvolved Worker	General Public
Retrieval	Lethal radiological dose	7.3E+01 (ERPG-3)	1.1E-01 (ERPG-1)
Remove tank	Lethal radiological dose	1.3E-01 (ERPG-1)	7.0E-07 (ERPG-1)
Remove ancillary equipment	5.8E-06 (ERPG-1)	5.8E-08 (ERPG-1)	1.5E-11 (ERPG-1)
Preprocessing	No appreciable concentrations	No appreciable concentrations	No appreciable concentrations
Grout soil	<2.0E-05 (ERPG-1)	<1.9E-07 (ERPG-1)	<1.0E-12 (ERPG-1)

Table 5.1.46. Radiological Point-Estimate LCF Risk from In Situ Soil Treatment (Option 2b) – Accident

Activity	Involved Worker		Noninvolved Worker		General Public	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	1.3E-05	1.3E-04	2.1E-07	9.2E-06	5.8E-10	8.6E-07
Remove tank	1.0E-02	No scenario	1.6E-06	4.0E-05	9.3E-10	4.2E-06
Remove ancillary equipment	1.6E-03	No scenario	5.9E-07	1.4E-05	3.4E-10	1.5E-06

Table 5.1.46. Radiological Point-Estimate LCF Risk from In Situ Soil Treatment (Option 2b) – Accident (cont'd)

Activity	Involved Worker		Noninvolved Worker		General Public	
	MEI	Population	MEI	Population	MEI	Population
Preprocessing	No scenario	No scenario	1.4E-10	6.2E-09	1.3E-13	2.5E-09
Grout soil	No appreciable emissions	No appreciable emissions	No appreciable emissions	No appreciable emissions	No appreciable emissions	No appreciable emissions
Total	Not additive	Not additive	Not additive	Not additive	Not additive	Not additive

Table 5.1.47. Occupational Injury/Illness and Fatalities from In Situ Soil Treatment (Option 2b)

Activity	Total Recordable Cases	Lost Workday Cases	Fatalities
Retrieval	3.4E+01	1.5E+01	2.5E-02
Remove tank	2.0E+01	8.6E+00	1.5E-02
Remove ancillary equipment	6.1E+00	2.6E+00	4.4E-03
Preprocessing	2.6E+02	1.1E+02	1.9E-01
Grout soil	3.9E+00	1.7E+00	2.9E-03
Total	3.2E+02	1.4E+02	2.4E-01

Table 5.1.48. Transportation Injuries and Fatalities from In Situ Soil Treatment (Option 2b)

Activity	Injuries	Fatalities
Retrieval	2.1E-02	1.4E-03
Remove tank	2.2E-01	8.0E-03
Remove ancillary equipment	6.4E-03	2.2E-04
Preprocessing	5.0E-01	3.2E-02
Grout soil	4.2E-03	2.6E-04
Total	7.5E-01	4.2E-02

Chemical Health Impacts from Normal Operations

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2b would be the same as Strategy 2 (Section 5.1.2). The chemical risk from normal operations for each of these activities in Option 2b therefore would be the same as Strategy 2. There were no chemical emissions data for grouting the soil in place. It was assumed that the chemical emissions would be less than those estimated for grouting the tanks, therefore the chemical health impacts from normal operations would be less.

Radiological Health Impacts from Normal Operations

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2b would be the same as Strategy 2 (Section 5.1.2). The LCF risk from normal operations for each of these activities in Option 2b therefore would be the same as Strategy 2. There were no emissions data developed for grouting the soil in place. It was assumed that the emissions would be small compared to those estimated for grouting the tanks, therefore the radiological LCF risk from normal operations would be less. The involved worker MEI was assumed to receive a dose of 1,500 mrem/yr for less than 2 yr.

Chemical Risk from Accidents

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2b would be the same as Strategy 2 (Section 5.1.2). The chemical risk from accidents for each of these activities in Option 2b therefore would be the same as Strategy 2. There were no emissions data developed for grouting the soil in place. It was assumed that the emissions would be small compared to those estimated for grouting the tanks, therefore the chemical health impacts from accidents would be less.

Radiological Risk from Accidents

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2b would be the same as Strategy 2 (Section 5.1.2). The point-estimate LCF risk from accidents for each of these activities in Option 2b therefore would be the same as Strategy 2. No emissions data were developed for grouting the soil in place. It was assumed that the emissions would be small compared to those estimated for grouting the tanks, therefore the radiological LCF risk from accidents would be less.

Occupational Accidents

Labor hour requirements for retrieval, tank removal, ancillary equipment removal, and preprocessing would be the same as Strategy 2 (Section 5.1.2). Labor hour requirements for grouting contaminated soil were calculated based on data provided in the Soil Remediation Engineering Study (Skelly 1999).

Transportation Accidents

Transportation requirements for retrieval, tank removal, ancillary equipment removal, and preprocessing would be the same as Strategy 2 (Section 5.1.2). Transportation requirements for grouting soil were calculated based on data provided in the Soil Remediation Engineering Study (Skelly 1999).

5.1.2.3 Nominal Losses/In Situ Soil Treatment (Option 2c)

A description of the retrieval and closure features of the Nominal Losses/In Situ Soil Treatment (Option 2c) is provided in Section 4.4.4. The major difference between Strategy 2 and Option 2c is a 30 m^3 (8,000 gal.) retrieval leakage loss is assumed to occur compared to no retrieval leak for Strategy 2, and contaminated soil under the tanks from past leaks would be grouted in place compared to being removed for Strategy 2.

The short-term human health risks associated with the various activities to support Option 2c are presented in Tables 5.1.49 through 5.1.54.

Table 5.1.49. Chemical Health Impacts from Nominal Losses/ In Situ Soil Treatment (Option 2c) – Normal Operations

Activity	Involved Worker MEI		Noninvolved Worker MEI		General Public MEI	
	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)
Retrieval	2.3E-01	1.8E-06	1.0E-02	7.9E-07	5.3E-05	2.4E-10
Remove tank	No exposure	No exposure	9.0E-04	1.7E-11	5.0E-07	9.3E-15
Remove ancillary equipment	No exposure	No exposure	2.2E-08	2.9E-15	1.3E-11	1.7E-18
Preprocessing	No appreciable exposure	No appreciable exposure	No appreciable emissions	No appreciable emissions	No appreciable emissions	No appreciable emissions
Grout soil	<1.2E-06	<9.0E-11	<5.3E-07	<3.9E-11	<2.9E-10	<2.2E-14

Table 5.1.50. Radiological LCF Risk from Nominal Losses/ In Situ Soil Treatment (Option 2c) – Normal Operations

Activity	Involved Worker (LCF)		Noninvolved Worker (LCF)		General Public (LCF)	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	6.0E-04	6.6E-01	2.6E-08	1.1E-06	1.5E-09	3.1E-05
Remove tank	1.8E-03	4.0E-03	6.4E-06	2.9E-04	5.5E-09	1.1E-04
Remove ancillary equipment	1.2E-03	4.7E-03	1.3E-07	5.6E-06	7.5E-11	2.1E-06
Preprocessing	6.0E-04	5.5E-03	2.0E-06	8.8E-05	1.9E-09	3.6E-05
Grout soil	1.2E-03	<1.1E-04	<8.8E-11	<3.8E-09	<4.2E-14	<1.1E-09
Total	Not additive	6.7E-01	8.6E-06	3.8E-04	9.0E-09	1.8E-04

Notes:
Grout soil would be similar to grout soil in Option 1g.

Table 5.1.51. Chemical Risk from Nominal Losses/In Situ Soil Treatment (Option 2c) – Accident

Activity	Involved Worker	Noninvolved Worker	General Public
Retrieval	Lethal radiological dose	7.3E+01 (ERPG-3)	1.1E-01 (ERPG-1)
Remove tank	Lethal radiological dose	1.3E-01 (ERPG-1)	7.0E-07 (ERPG-1)
Remove ancillary equipment	5.8E-06 (ERPG-1)	5.8E-08 (ERPG-1)	1.5E-11 (ERPG-1)
Preprocessing	No appreciable concentrations	No appreciable concentrations	No appreciable concentrations
Grout soil	<2.0E-05 (ERPG-1)	<1.9E-07 (ERPG-1)	<1.0E-12 (ERPG-1)

Table 5.1.52. Radiological Point-Estimate LCF Risk from Nominal Losses/ In Situ Soil Treatment (Option 2c) -Accident

Activity	Involved Worker		Noninvolved Worker		General Public	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	1.3E-05	1.3E-04	2.1E-07	9.2E-06	5.8E-10	8.6E-07
Remove tank	1.0E-02	No scenario	1.6E-06	4.0E-05	9.3E-10	4.2E-06
Remove ancillary equipment	1.6E-03	No scenario	5.9E-07	1.4E-05	3.4E-10	1.5E-06
Preprocessing	No scenario	No scenario	1.4E-10	6.2E-09	1.3E-13	2.5E-09
Grout soil	<6.0E-07	<6.0E-06	<1.6E-06	<4.0E-05	<9.3E-10	<4.2E-06
Total	Not additive	Not additive	Not additive	Not additive	Not additive	Not additive

Table 5.1.53. Occupational Injury/Illness and Fatalities from Nominal Losses/In Situ Soil Treatment (Option 2c)

Activity	Total Recordable Cases	Lost Workday Cases	Fatalities
Retrieval	3.4E+01	1.5E+01	2.5E-02
Remove tank	2.0E+01	8.6E+00	1.5E-02
Remove ancillary equipment	6.1E+00	2.6E+00	4.4E-03
Preprocessing	2.6E+02	1.1E+02	1.9E-01
Grout soil	2.6E+00	1.1E+00	1.9E-03
Total	3.2E+02	1.4E+02	2.4E-01

Table 5.1.54. Transportation Injuries and Fatalities from Nominal Losses/In Situ Soil Treatment (Option 2c)

Activity	Injuries	Fatalities
Retrieval	2.1E-02	1.4E-03
Remove tank	2.2E-01	8.0E-03
Remove ancillary equipment	6.4E-03	2.2E-04
Preprocessing	5.0E-01	3.2E-02
Grout soil	4.2E-02	2.7E-03
Total	7.9E-01	4.4E-02

Chemical Health Impacts from Normal Operations

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2c would be the same as Strategy 2 (Section 5.1.2). The chemical risk from normal operations for each of these activities in Option 2c therefore would be the same as Strategy 2. There were no chemical emissions data developed for grouting the soil in place. It was assumed that the chemical emissions would be small compared to those estimated for grouting the tanks, therefore the chemical health impacts from normal operations would be less.

Radiological Health Impacts from Normal Operations

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2c would be the same as Strategy 2 (Section 5.1.2). The LCF risk from normal operations for each of these activities in Option 2c therefore would be the same as Strategy 2. There were no emissions data developed for grouting the soil in place. It was assumed that the emissions would be small compared to those estimated for grouting the tanks, therefore the radiological LCF risk from normal operations would be less. The involved worker MEI was assumed to have received a dose of 1,500 mrem/yr for less 2 yr.

Chemical Risk from Accidents

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2c would be the same as Strategy 2 (Section 5.1.2). The chemical risk from accidents for each of these activities in Option 2c therefore would be the same as Strategy 2. There were no emissions data developed for grouting the soil in place. It was assumed that the emissions would be small compared to those estimated for grouting the tanks, therefore the chemical health impacts from accidents would be less.

Radiological Risk from Accidents

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2c would be the same as Strategy 2 (Section 5.1.2). The point-estimate LCF risk from accidents for each of these activities in Option 2c therefore would be the same as Strategy 2. There were no emissions data developed for grouting the soil in place. It was assumed that the emissions would be small compared to those estimated for grouting the tanks, therefore the radiological LCF risk from accidents would be less.

Occupational Accidents

Labor hour requirements for retrieval, tank removal, ancillary equipment removal, and preprocessing would be the same as Strategy 2 (Section 5.1.2). Labor hour requirements for grouting contaminated soil were calculated based on data provided in the Hanford Tanks Initiative Study Refinements (Norman 1999).

Transportation Accidents

Transportation requirements for retrieval, tank removal, ancillary equipment removal, and preprocessing would be the same as Strategy 2 (Section 5.1.2). Transportation requirements for grouting contaminated soil were calculated based on data provided in the Hanford Tanks Initiative Study Refinements (Norman 1999).

5.1.2.4 No Soil Treatment (Option 2d)

A description of the retrieval and closure features of the No Soil Treatment (Option 2d) is provided in Section 4.4.5. The major difference between Strategy 2 and Option 2d is a 30 m^3 (8,000 gal.) retrieval leakage loss is assumed to occur compared to no retrieval leakage loss for Strategy 2 and contaminated soil under the tanks from past leaks and retrieval leakage loss would not be removed or treated compared to being removed for Strategy 2, and the tank farm would be covered with an enhanced RCRA Subtitle C barrier compared to no cover barriers for Strategy 2.

The short-term human health risks associated with the various activities to support Option 2d are presented in Tables 5.1.55 through 5.1.60.

Table 5.1.55. Chemical Health Impacts from No Soil Treatment (Option 2d) – Normal Operations

Activity	Involved Worker MEI		Noninvolved Worker MEI		General Public MEI	
	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)	Noncancer hazard (HI)	Cancer risk (ILCR)
Retrieval	2.3E-01	1.8E-06	1.0E-02	7.9E-07	5.3E-05	2.4E-10
Remove tank	No exposure	No exposure	9.0E-04	1.7E-11	5.0E-07	9.3E-15
Remove ancillary equipment	No exposure	No exposure	2.2E-08	2.9E-15	1.3E-11	1.7E-18
Preprocessing	No appreciable exposure	No appreciable exposure	No appreciable emissions	No appreciable emissions	No appreciable emissions	No appreciable emissions
Enhanced RCRA Subtitle C barrier	No exposure	No exposure	No exposure	No exposure	No exposure	No exposure

Table 5.1.56. Radiological LCF Risk from No Soil Treatment (Option 2d) – Normal Operations

Activity	Involved Worker (LCF)		Noninvolved Worker (LCF)		General Public (LCF)	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	6.0E-04	6.6E-01	2.6E-08	1.1E-06	1.5E-09	3.1E-05
Remove tank	1.8E-03	4.0E-03	6.4E-06	2.9E-04	5.5E-09	1.1E-04
Remove ancillary equipment	1.2E-03	4.7E-03	1.3E-07	5.6E-06	7.5E-11	2.1E-06
Preprocessing	6.0E-04	5.5E-03	2.0E-06	8.8E-05	1.9E-09	3.6E-05
Enhanced RCRA Subtitle C barrier	No exposure	No exposure	No exposure	No exposure	No exposure	No exposure
Total	Not additive	6.7E-01	8.6E-06	3.8E-04	9.0E-09	1.8E-04

Table 5.1.57. Chemical Risk from No Soil Treatment (Option 2d) – Accident

Activity	Involved Worker	Noninvolved Worker	General Public
Retrieval	Lethal radiological dose	7.3E+01 (ERPG-3)	1.1E-01 (ERPG-1)
Remove tank	Lethal radiological dose	1.3E-01 (ERPG-1)	7.0E-07 (ERPG-1)
Remove ancillary equipment	5.8E-06 (ERPG-1)	5.8E-08 (ERPG-1)	1.5E-11 (ERPG-1)
Preprocessing	No appreciable concentrations	No appreciable concentrations	No appreciable concentrations
Enhanced RCRA Subtitle C barrier	No chemical accidents	No chemical accidents	No chemical accidents

Table 5.1.58. Radiological Point-Estimate LCF Risk from No Soil Treatment (Option 2d) Accident

Activity	Involved Worker		Noninvolved Worker		General Public	
	MEI	Population	MEI	Population	MEI	Population
Retrieval	1.3E-05	1.3E-04	2.1E-07	9.2E-06	5.8E-10	8.6E-07
Remove tank	1.0E-02	No scenario	1.6E-06	4.0E-05	9.3E-10	4.2E-06
Remove ancillary equipment	1.6E-03	No scenario	5.9E-07	1.4E-05	3.4E-10	1.5E-06
Preprocessing	No scenario	No scenario	1.4E-10	6.2E-09	1.3E-13	2.5E-09
Enhanced RCRA Subtitle C barrier	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents	No radiological accidents
Total	Not additive	Not additive	Not additive	Not additive	Not additive	Not additive

Table 5.1.59. Occupational Injury/Illness and Fatality from No Soil Treatment (Option 2d)

Activity	Total Recordable Cases	Lost Workday Cases	Fatalities
Retrieval	3.4E+01	1.5E+01	2.5E-02
Remove tank	2.0E+01	8.6E+00	1.5E-02
Remove ancillary equipment	6.1E+00	2.6E+00	4.4E-03
Preprocessing	2.6E+02	1.1E+02	1.9E-01
Enhanced RCRA Subtitle C barrier	5.6E-01	2.4E-01	4.1E-04
Total	3.2E+02	1.4E+02	2.3E-01

Table 5.1.60. Transportation Injuries and Fatalities from No Soil Treatment (Option 2d)

Activity	Injuries	Fatalities
Retrieval	2.1E-02	1.4E-03
Remove tank	2.2E-01	8.0E-03
Remove ancillary equipment	6.4E-03	2.2E-04
Preprocessing	5.0E-01	3.2E-02
Enhanced RCRA Subtitle C barrier	8.2E-02	4.4E-03
Total	8.3E-01	4.6E-02

Chemical Health Impacts from Normal Operations

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2d would be the same as Strategy 2 (Section 5.1.2). The chemical risk from normal operations for each of these activities in Option 2d therefore would be the same as Strategy 2.

Radiological Health Impacts from Normal Operations

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2d would be the same as Strategy 2 (Section 5.1.2). The LCF risk from normal operations for each of these activities in Option 2d therefore would be the same as Strategy 2.

Chemical Risk from Accidents

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2d would be the same as Strategy 2 (Section 5.1.2). The chemical risk from accidents for each of these activities in Option 2d therefore would be the same as Strategy 2.

Radiological Risk from Accidents

The parameters associated with retrieval, tank removal, ancillary equipment removal, and preprocessing for Option 2d would be the same as Strategy 2 (Section 5.1.2). The point-estimate LCF risk from accidents for each of these activities in Option 2d therefore would be the same as Strategy 2.

Occupational Accidents

Labor hour requirements for retrieval, tank removal, ancillary equipment removal, and preprocessing would be the same as Strategy 2 (Section 5.1.2). Labor hour requirements for constructing the enhanced RCRA Subtitle C barrier over the AX Tank Farm were calculated based on data provided in the Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas (DOE 1996a).

Transportation Accidents

Transportation requirements for retrieval, tank removal, ancillary equipment removal, and preprocessing would be the same as Strategy 2 (Section 5.1.2). Transportation requirements for constructing an enhanced RCRA Subtitle C barrier over the AX Tank Farm were calculated based on data provided in the Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas (DOE 1996a).

5.1.3 No Action (Strategy 3)

For the No Action strategy (Strategy 3), there would be no retrieval efforts or any attempt to stabilize the tanks. During the 100-yr institutional control period routine management and maintenance activities would be performed on the tanks. This strategy is described in more detail in Section 4.3.

Chemical Health Impacts from Normal Operations

Chemical emissions resulting from normal operations for the No Action strategy (Strategy 3) were assumed to be no greater than the emissions during normal tank farm operations evaluated for the No Action Alternative in the TWRS EIS. The chemical health impacts from tank farm operations evaluated in the TWRS EIS were based on the emissions from 177 tanks.
The chemical health impacts from emissions of the four tanks in the AX Tank Farm were scaled from those 177 tanks. The noncancer HI and the ILCR to the MEI receptors for the No Action (Strategy 3) are presented in Table 5.1.61.

Table 5.1.61. Chemical Health Impacts from No Action – Normal Operations

Receptor	Noncancer HI	ILCR
Involved worker MEI	1.7E-03	1.6E-08
Noninvolved worker MEI	7.5E-04	6.9E-09
General public MEI	4.0E-07	2.1E-12

Radiological Health Impacts from Normal Operations

Radiological emissions during normal operations for the No Action strategy were assumed to be no greater than the emissions during normal tank farm operations evaluated for the No Action Alternative in the TWRS EIS. The LCF risk from tank farm operations evaluated in the TWRS EIS was based on the emissions from 177 tanks. The LCF risk from four tanks in the AX Tank Farm was scaled from those 177 tanks. The involved worker population dose was based on a tank farm exposure rate of 14 mrem/person-yr, and the involved worker MEI dose was based on 500 mrem/yr for 30 yr. The LCF risk from normal operations for the No Action strategy is presented in Table 5.1.62.

Table 5.1.62. Radiological LCF Risk from No Action – Normal Operations

Receptor	LCF Risk
Involved worker MEI	6.0E-03
Involved worker population	5.6E-04
Noninvolved worker MEI	3.5E-09
Noninvolved worker population	2.3E-08
General public MEI	5.2E-11
General public population	1.8 E-06

Chemical Risk from Accidents

The chemical health impacts resulting from a potential storage accident for the No Action strategy were assumed to be the same as the health impacts calculated for a beyond-design-basis earthquake evaluated for the No Action Alternative in the TWRS EIS in which the tank dome collapses. The chemical risks, as related to ERPGs, given the occurrence of the beyond-design-basis earthquake, are presented in Table 5.1.63.

Table 5.1.63. Chemical Risk from No Action – Accident

Receptor	Chemical Risk
Involved worker MEI	Lethal radiological dose
Noninvolved worker MEI	Lethal radiological dose
General public MEI	1.8E+00 (ERPG-2)

Radiological Risk from Accidents

The point-estimate LCF risk resulting from a potential storage accident for the No Action strategy was assumed to be the same as the point-estimate LCF risk calculated for a beyond-design-basis earthquake evaluated for the No Action Alternative in the TWRS EIS in which the tank dome collapses. The point-estimate LCF risks evaluated in the TWRS EIS are presented in Table 5.1.64.

Table 5.1.64. Radiological Point-Estimate LCF Risk from No Action – Accident

Receptor	Point-Estimate LCF Risk
Involved worker MEI	1.4E-02
Involved worker population	1.4E-02
Noninvolved worker MEI	1.4E-02
Noninvolved worker population	1.5E-01
General public MEI	3.3E-05
General public population	2.9E-02

Occupational Accidents

Labor hour requirements for surveillance and maintenance activities were assumed (Jacobs 1998b). The occupational health impacts were estimated and are presented in Table 5.1.65.

Table 5.1.65. Occupational Injury/Illness and Fatalities from No Action

Type of Incidence	Number of Incidence
Total recordable cased	10.8
Lost workday cases	4.8
Fatalities	0.01

Transportation Accidents

Because there would be no transportation requirements, there would be no risk of transportation accidents.

5.2 VADOSE ZONE AND GROUNDWATER CONTAMINATION

The section discusses results of the vadose zone and groundwater contaminant transport calculations for each waste retrieval and tank farm closure strategy and option. An overview of the methodology used is provided in Section 3.5. The details of the vadose zone and groundwater conceptual models and their numerical implementation are provided in Appendix B. Conclusions, performance measures, and data needs based on the analysis presented in this section are presented in Section 6.0. This discussion includes 1) the definition of the existing data; 2) identification of data gaps; 3) assumptions and enabling methodologies that were used to overcome data gaps; and 4) an evaluation of the results for each strategy including the components (i.e., source terms) associated with each strategy.

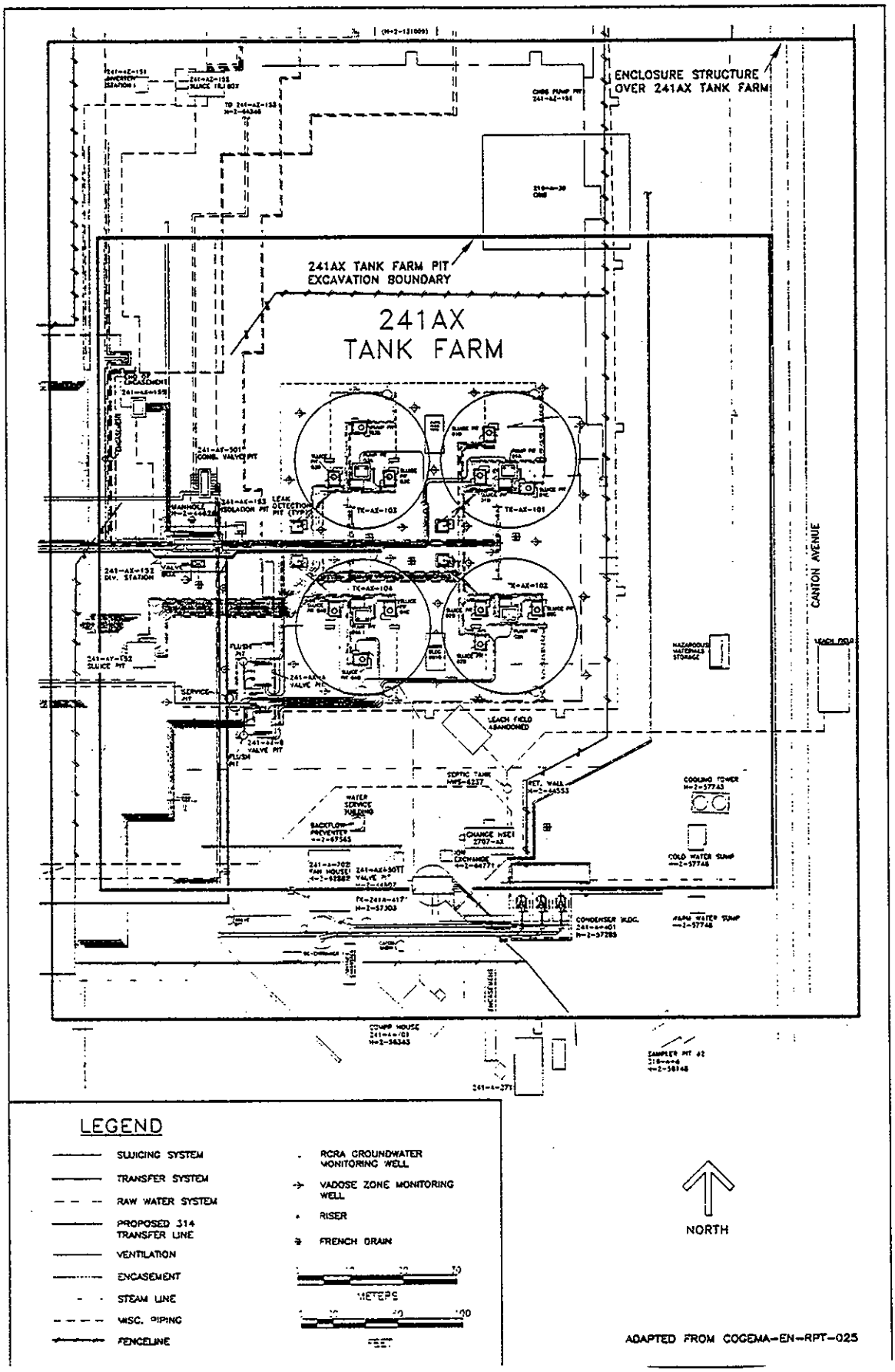
Understanding and knowledge of the subsurface conditions are never complete until, for some limited cases, the site in question has been fully excavated. The lack of subsurface knowledge often results in either taking a bounding approach, where very conservative assumptions are made concerning the missing or uncertain data, or a probabilistic approach where the data uncertainty are considered. The approach taken here is a combination of the two, in that deterministic results have been calculated for each strategy based on reasonably conservative best-estimate parameter values and the uncertainty has been calculated for one strategy based on a probabilistic methodology (Section 5.4). The data on which the deterministic calculations are based are summarized in this section and in greater detail in Appendix B. The means by which contaminants are transported in the vadose zone and groundwater are the same for all of the options. The vadose zone and groundwater contaminant transport for all of the strategies thus are based on the same vadose zone and groundwater conceptual models are described in Appendix B.

The AX Tank Farm is a group of four SSTs located near the eastern boundary of the 200 East Area (Figure 5.2.1). Each of the four tanks is 33.83 m (75 ft) in diameter and has a capacity of 3,785,000 L (1 Mgal). The tank domes are covered by at least 1.83 m (6 ft) of soil, and the bottoms of the tanks are at approximately 16.77 m (55 ft) belowgrade. Additional detail information on the location and description of the AX Tank Farm is provided in Section 4.0.

Two of the four SSTs (Figure 5.2.1), tanks 241-AX-104 and 241-AX-102, were declared leakers in 1977 and 1988, respectively (Hanlon 1998). The leaks are estimated to be approximately 30 m^3 (8,000 gal.) and 11 m^3 (3,000 gal.) from tanks 241-AX-104 and 241-AX-102, respectively (Hanlon 1998). The activity of the waste and the constituents in the waste that leaked from these tanks is provided in Appendix A.

For purposes of analysis, administrative controls or institutional controls are assumed to be maintained on the tank farms, the surrounding 200 Area exclusive-use WMA, and the groundwater for drinking water and other uses for a period of 100 yr following completion of closure. Administrative controls or institutional controls also refer to deed and other restrictions that can be used to limit land use. All groundwater quality concentration values are reported from the end of institutional controls until the end of the 10,000-yr period of interest. Over the period of interest, groundwater contaminant concentration values are reported for nine points in

Figure 5.2.1. Layout of Tanks and Piping in the AX Tank Farm



time (150; 200; 400; 600; 1,200; 2,600; 5,000; 7,600; and 10,000 yr from 1963, when the tanks were constructed), which were selected to allow for the identification of general trends in impacts to groundwater quality and long-term human health risks.

5.2.1 Baseline Retrieval/Restricted Land Use Strategy (Strategy 1)

This is a waste retrieval and tank farm closure strategy that includes past leaks and a residual volume equal to 10 m^3 (360 ft^3). It is assumed there are no losses during retrieval. The tanks would be backfilled and the tank farm area covered with an enhanced RCRA Subtitle C barrier. The data and enabling assumptions associated with this strategy include:

- The past leak and residual inventory discussed in Appendix A and the nature of the releases (e.g., timing and position in the vadose zone)
- The vadose zone conceptual model as discussed in Appendix B
- The groundwater conceptual model as discussed in Appendix B.

Enabling assumptions such as the selection of tank backfill material as discussed in Section 5.2.1.5.

5.2.1.1 Past Leaks

Each tank within the AX Tank Farm is connected to a ventilation system consisting of nominal 0.5-m (20-in.)-diameter piping that removed condensation generated by the hot tank waste. This piping enters the tank through the tank domes. The invert of the piping is approximately 2 m (6 ft) belowground surface. Past leaks from this tank farm considered in the impact assessment are reported as header leaks from tanks AX-102 and AX-104. Approximately 11 m^3 (3,000 gal.) from tank AX-102 and 30 m^3 (8,000 gal.) from tank AX-104 are attributed to these leaks. The header leaks are believed to have occurred at: 1) the tee connection of the ventilation system midway between tanks AX-102 and AX-101; and 2) two locations associated with the header connected to tank AX-104. The tank AX-104 header leaks occurred at the tee that connects the ventilation system header midway between tanks AX-104 and AX-103 and at the dresser coupling that connects the header over the dome of the tank. The distribution of the total leak volume between these two locations is assumed to be divided equally between the dresser coupling over the tank dome and the tee midway between tanks AX-104 and AX-103. The cumulative contaminant mass from all of the header leaks (i.e., header leaks from both tanks AX-102 and AX-104) are simulated as if they were the tank AX-104 header leaks. This reduced the number of required vadose zone simulations with very little, if any, sacrifice to calculated first arrival or time to peak concentration estimates.

5.2.1.2 Retrieval Leakage Loss

For Strategy 1, it is assumed that there would be no tank waste loss during retrieval.

5.2.1.3 Residual Loss

The residual tank waste that remains in the tank is assumed to be equal to 10 m^3 (360 ft^3). The composition and solubility of the residuals are provided in Appendix A. It is assumed that

the residual waste would be moist from retrieval operations and tank backfill, and moisture recharging through the enhanced RCRA Subtitle C barrier would reach the waste 10 yr after surface barrier construction. At this time, dissolution of the contaminants would begin and the waste would be released in the recharging liquid over the full area of the base of the tank at the concentration equal to the concentrations specified in Appendix A. The base of the tank is approximately 17 m (55 ft) belowground surface.

5.2.1.4 Recharge

Recharge has been shown to be an important aspect of the overall system with respect to long-term impacts to the groundwater (Jacobs 1998a). The RPE analysis has incorporated a relatively detailed recharge history in each vadose zone transport simulation. The assumed recharge history for Strategy 1 is summarized in Table 5.2.1. A detailed discussion on the rational and basis for the recharge values listed in this table is provided in Appendix B.

Table 5.2.1. Precipitation Recharge History Assumed for the Baseline Retrieval/Restricted Land Use Strategy (Strategy 1)

Period	Assumed Recharge Rate (mm/yr)	Duration	Comment
Before installation of AX Tank Farm	3.0	Until steady state moisture conditions are achieved for the year 1963	Vadose zone flow was simulated at this rate to develop initial moisture conditions for subsequent simulations.
Transition to current conditions	3.0 to 100	1963 to 1964	Recharge is assumed to increase during tank construction over this 1-yr period to the current value of 100 mm/yr.
Current conditions	100	1963 to 2020	During this period, the ground cover is gravel with no vegetation. Enhanced RCRA Subtitle C barrier is assumed to be constructed in 2020.
Transition to conditions of restricted recharge due to the enhanced RCRA Subtitle C barrier	100 to 1	2020 to 2021	Recharge is assumed to decrease during barrier construction over this 1-yr period to the barrier design value of 1 mm/yr.
Capped conditions	1.0	2021 to 2521	Period in which enhanced RCRA Subtitle C barrier is assumed to be intact
Postcap transition	1.0 to 3.0	2521 to 2531	Recharge is assumed to increase over a 10-yr period at the end of the barrier design life back to pre-Hanford recharge rate of 3.0 mm/yr.
Postcap	3.0	2531 to 10,000	The enhanced RCRA Subtitle C barrier is assumed to have failed, and the recharge rate reverts back to that of natural conditions (i.e., pre-Hanford) for the remainder of the simulation.

Common to all of the strategies is the assumed recharge rate prior to construction of the AX Tank Farm. Prior to 1963, when the AX Tank Farm was constructed, it was assumed that natural ground conditions (i.e., silty sand with naturally established vegetation) existed at the AX Tank Farm and recharge from natural precipitation averaged 3 mm/yr (0.12 in./yr). After the tanks were constructed the surface area over the tanks was kept free of vegetation and covered with a layer of gravel. Under these conditions, it is assumed recharge averaged 10 cm/yr

(3.9 in./yr). For this strategy, the recharge rate of 10 cm/yr (3.9 in./yr) was maintained until construction of the enhanced RCRA Subtitle C barrier, at which time the recharge rate is assumed to be reduced to 0.1 cm/yr (0.039 in./yr) for a 500-yr period. After this 500-yr period, the recharge rate returns to the pre-Hanford assumed rate of 3 mm/yr (0.12 in./yr) for the remainder of the simulation. Recharging precipitation was assumed to have reached the residual waste after a 10-yr period.

5.2.1.5 Enabling Assumptions

In this section, strategy-specific enabling assumptions are discussed.

- Recharge transitions are linear. When recharge changes, for instance from the pre-tank rate of 3 to 10 mm/yr (0.12 to 0.4 in./yr), a period of time is specified (typically 1 or 10 yr) over which the change occurs, and the change is linear over that specified period.

- Residual waste is assumed to be distributed and released uniformly over the full tank base.

- For residual waste releases, the tank was assumed to be absent with regard to flow of moisture across the tank dome, base, and sides.

- Following retrieval, the tanks are assumed to be filled with a structural fill that would consist of a clean sand/gravel material.

- Backfill replacing the tanks in the residual simulations was initialized by setting the pressure to P = -1.26 m (4.1 ft), equivalent to the pressure predicted by the model in backfill away from the influence of the tanks (i.e., the influence of enhance recharge and saturation near the tank perimeter from the shedding of recharge off of the domes). Actual backfill material to fill the tanks may have different moisture content, which might effect the rate of dissolution and migration of residual waste.

- Separate leak component simulations require passing of moisture/pressure conditions between component runs. Intermingling of contaminant plumes is assumed not to effect each of the other contaminant transport simulations.

- The location of clastic dike(s), their width, orientation, vertical continuity, and hydraulic properties are all unknown and were assumed to enable calculation of contaminant transport in the presence of a clastic dike.

- No-flow boundary conditions on each side of the model domain implicitly assume lateral migration of waste beneath the tanks to the model boundary would be insignificant.

- The contaminant mass flux from the AX Tank Farm sources was assumed to enter the unconfined aquifer directly beneath the tank farm.

- Surface barriers (i.e., enhanced RCRA Subtitle C barrier and the Hanford Barrier) were assumed to be constructed as one continuous structure over all four of the tanks.

- The depth of the near-field zone was assumed to be approximately 36.5 m (120 ft) belowground surface and is time invariant.

5.2.1.6 Strategy-Specific Data Gaps

The following strategy-specific data gaps were identified:

- Site-specific field data that could be used to verify or modify the assumption that changes in recharge are linear.
- The locations of residual leaks and the area over which they occur.
- Site-specific information on clastic dike location, frequency, vertical continuity, and hydraulic properties.
- Potential preferential flow phenomena with focus on fingering and funnel flow literature review.

5.2.1.7 Results for Strategy 1

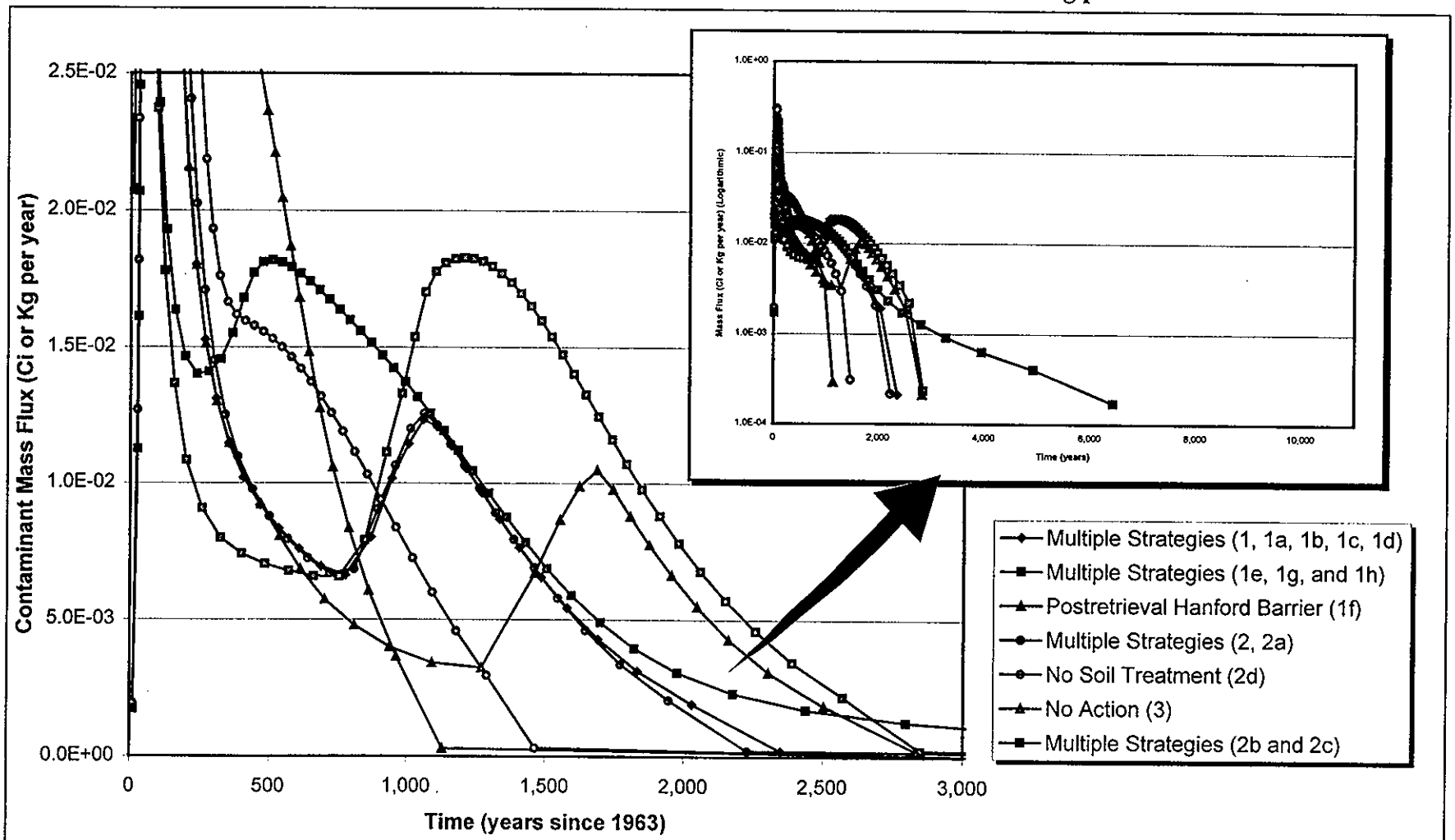
In this section, the long-term groundwater impact results are discussed for each of the applicable source components and for the strategy as a whole (i.e., composite of all the source components). Results are discussed first for the vadose zone in the form of mass flux through the vadose zone and then for the saturated zone in the form of maximum concentrations in the groundwater as a function of time.

Past Leaks Source Term

The CoCs from past leaks include all of those listed in Appendix B except EDTA and cyanide, for which there is no inventory data (see Appendix A for a discussion of the inventory). Presented on Figures 5.2.2, 5.2.3, and 5.2.4 are the calculated mass flux versus time for this strategy as well as the others for an initial concentration of one (dimensionless) for each of the three K_d groups used on the analysis. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant mass flux trend to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2), the mass flux peak occurs at approximately 65 yr. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately 7,400 yr (Figure 5.2.3). All uranium isotopes are assumed to have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for the uranium isotopes (Figure 5.2.4) occurs at approximately 8,750 yr. The time to peak mass flux and the relative mass flux rate at the peak rate are tabulated on Table 5.2.2 for the three K_d groups. The relative peak mass flux rates are on the same order of magnitude for K_d groups 1 and 2 (I-129, C-14, and the uranium series, respectively). The relative mass flux peak rates for the K_d groups 0 contaminants (Tc-99, Se-79, NO_3, and NO_2) are about two orders of magnitude higher than the other K_d groups.

The trends illustrated in the plots of contaminant mass flux versus time through the vadose zone also are reflected in the groundwater results as shown on the plots of maximum contaminant concentration versus time. Figure 5.2.5 illustrates the maximum groundwater concentration for

Figure 5.2.2. Contaminant Mass Flux Through the Vadose Zone for the Past Leak Source Term Component for Zero K_d and Initial Contaminant Concentration of 1 Ci or Kg per Cubic Meter



Note: The contaminant mass flux was calculated for an initial contaminant concentration of 1 Ci or Kg for all the strategies and options except for Options 1g, 1h, 2b, and 2c. For these options the initial contaminant concentration was adjusted downward from 1 Ci to account for model overprediction of mass associated with the grouted sediments.

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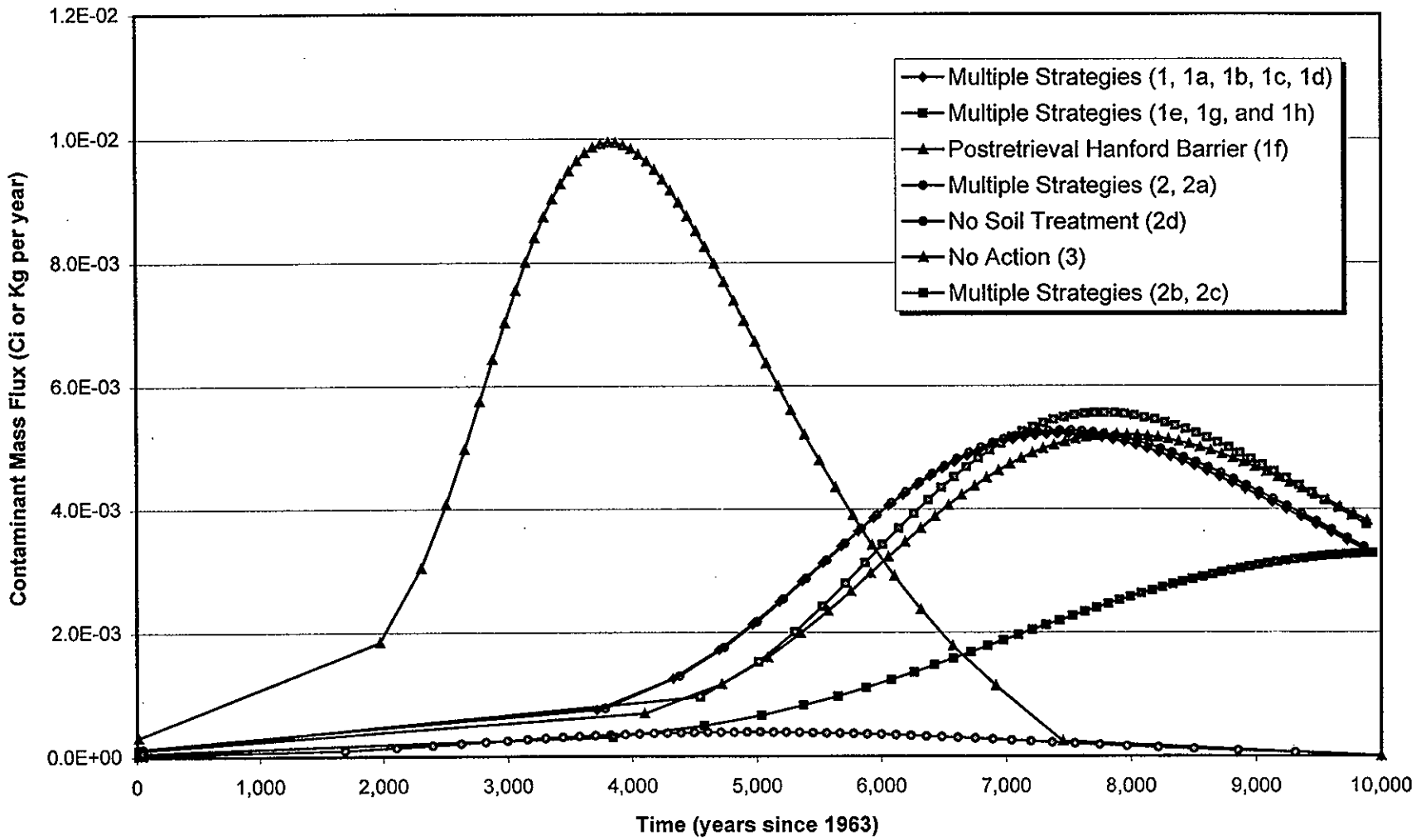
Figure 5.2.3. Contaminant Mass Flux Through the Vadose Zone for the Past Leak Source Term Component for Zero K_d in Near-Field and 0.6 mL/g Far-Field K_d



Note: The contaminant mass flux was calculated for an initial contaminant concentration of 1 Ci or Kg for all the strategies and options except for Options 1g, 1h, 2b, and 2c. For these options the initial contaminant concentration was adjusted downward from 1 Ci to account for model overprediction of mass associated with the grouted sediments.

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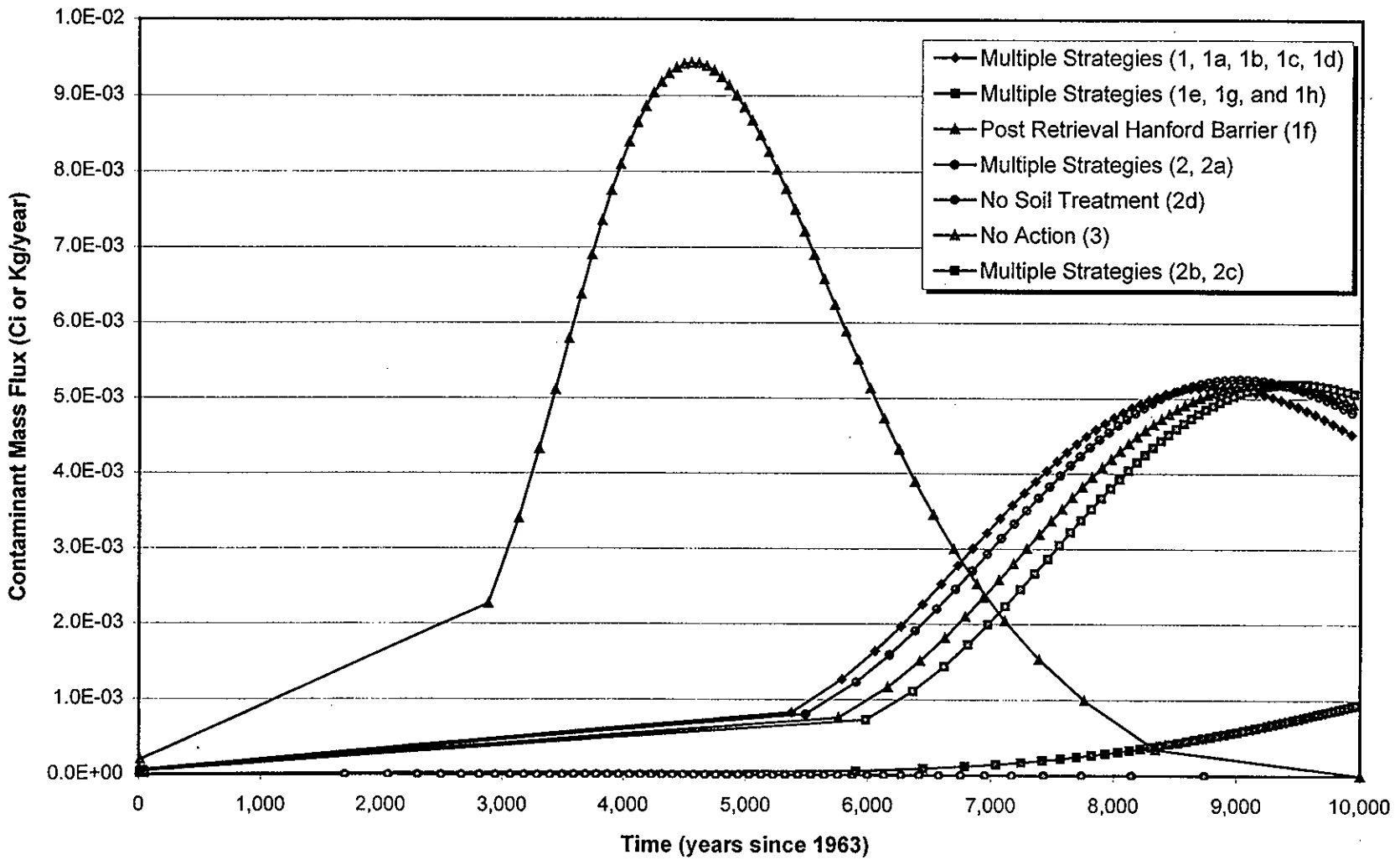
Figure 5.2.4. Contaminant Mass Flux Through the Vadose Zone for the Past Leak Source Term Component for 0.6 mL/g K_d and Initial Contaminant Concentration of 1 Ci or Kg per Cubic Meter



Note: The contaminant mass flux was calculated for an initial contaminant concentration of 1 Ci or Kg for all the strategies and options except for Options 1g, 1h, 2b, and 2c. For these options the initial contaminant concentration was adjusted downward from 1 Ci to account for model overprediction of mass associated with the grouted sediments.

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Table 5.2.2. Mass Flux Characteristics for the Past Leak Component and the Three K_d Groups (Strategy 1)

	K_d Group 0 (Tc-99, Se-79, NO3/NO2, EDTA, CN)	K_d Group 1 (C-14, I-129)	K_d Group 2 (Uranium Isotopes)
Time to peak mass flux (yr)	65	7,400	8,750
Relative mass flux at peak for C = 1 initial source concentration	2.35E-01	5.22E-03	5.15E-03

Tc-99 versus time for the past leak source component. Note that the maximum contaminant concentration locations vary with time, but are generally at or near the AX Tank Farm. Refer to Section 5.5.4 for a discussion on point-of-compliance. The Tc-99 groundwater concentrations from the past leak source term decrease in nearly a log-linear pattern from about 4.4E+01 pCi/L at 150 yr to 9.69 pCi/L at 600 yr. The small increase in maximum concentration beginning at approximately 800 yr and peaking at 1,000 yr is probably due to the assumed degradation of the enhanced RCRA Subtitle C barrier. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99, as illustrated in Figure 5.2.5.

The contaminants I-129, C-14, and the uranium isotopes are all assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated on Figures 5.2.6 and 5.2.7. The I-129 peak concentration is approximately 1.17E-02 pCi/L and occurs at approximately 7,600 yr. The U-238 maximum concentration is approximately 6.18E-03 and occurs at approximately 10,000 yr and may not have peaked.

Retrieval Source Term

There are no impacts from retrieval leakage losses because for this strategy it is assumed that there would be no retrieval leakage loss.

Residual Source Term

The CoC from the residual waste source term include all of those listed in Appendix B including EDTA and cyanide (see Appendix A for a discussion of the inventory). The residual mass flux values, as presented in this section, are not directly comparable to the past leak mass flux values because the residual source term mass flux values are based on the estimated inventory and solubility of each CoC, whereas the past leak source term mass flux is based on an initial concentration of one. The residual mass flux versus time figures presented in the following paragraphs are contaminant-specific (i.e., Tc-99 representing K_d zero contaminants, I-129 representing K_d zero in the near-field and K_d 0.6 mL/g in the far-field contaminants, and U-238 representing K_d 0.6 mL/g contaminants). Presented in Figures 5.2.8, 5.2.9, and 5.2.10 are plots of mass flux versus time for this strategy. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For Tc-99, a K_d zero contaminant, the maximum mass flux occurs at approximately 2,300 yr. For I-129, the peak mass flux occurs at approximately 8,700 yr (Figure 5.2.9).

All the uranium isotopes are assumed to have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for U-238 (Figure 5.2.10) occurs at some time after 10,000 yr. The time to peak mass flux and the relative mass flux rate at the peak rate are tabulated on Table 5.2.3 for the three K_d groups.

Figure 5.2.5. Maximum Tc-99 Concentrations in Groundwater for the Past Leak Source Term

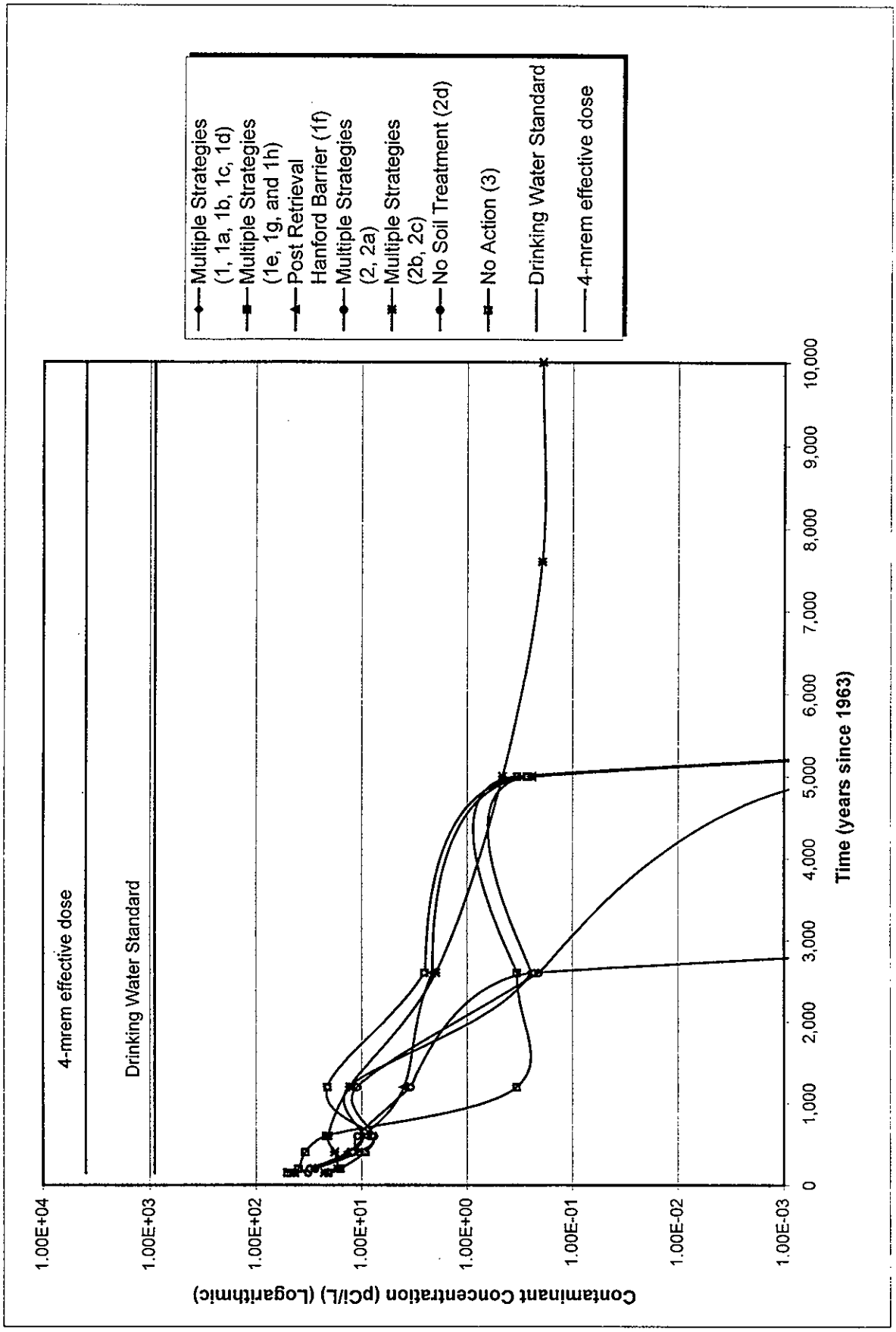

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Figure 5.2.6. Maximum I-129 Concentrations in Groundwater for the Past Leak Source Term

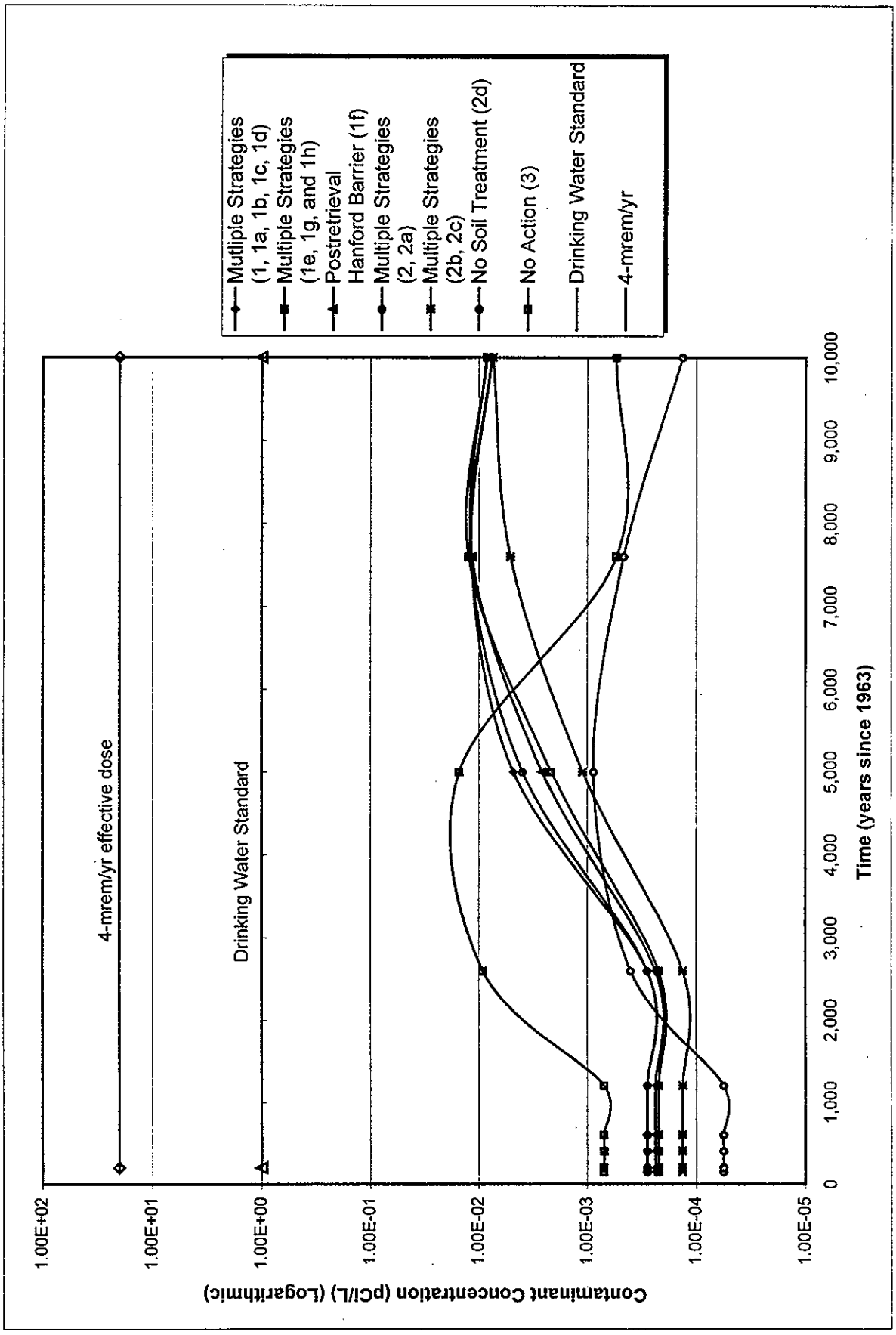
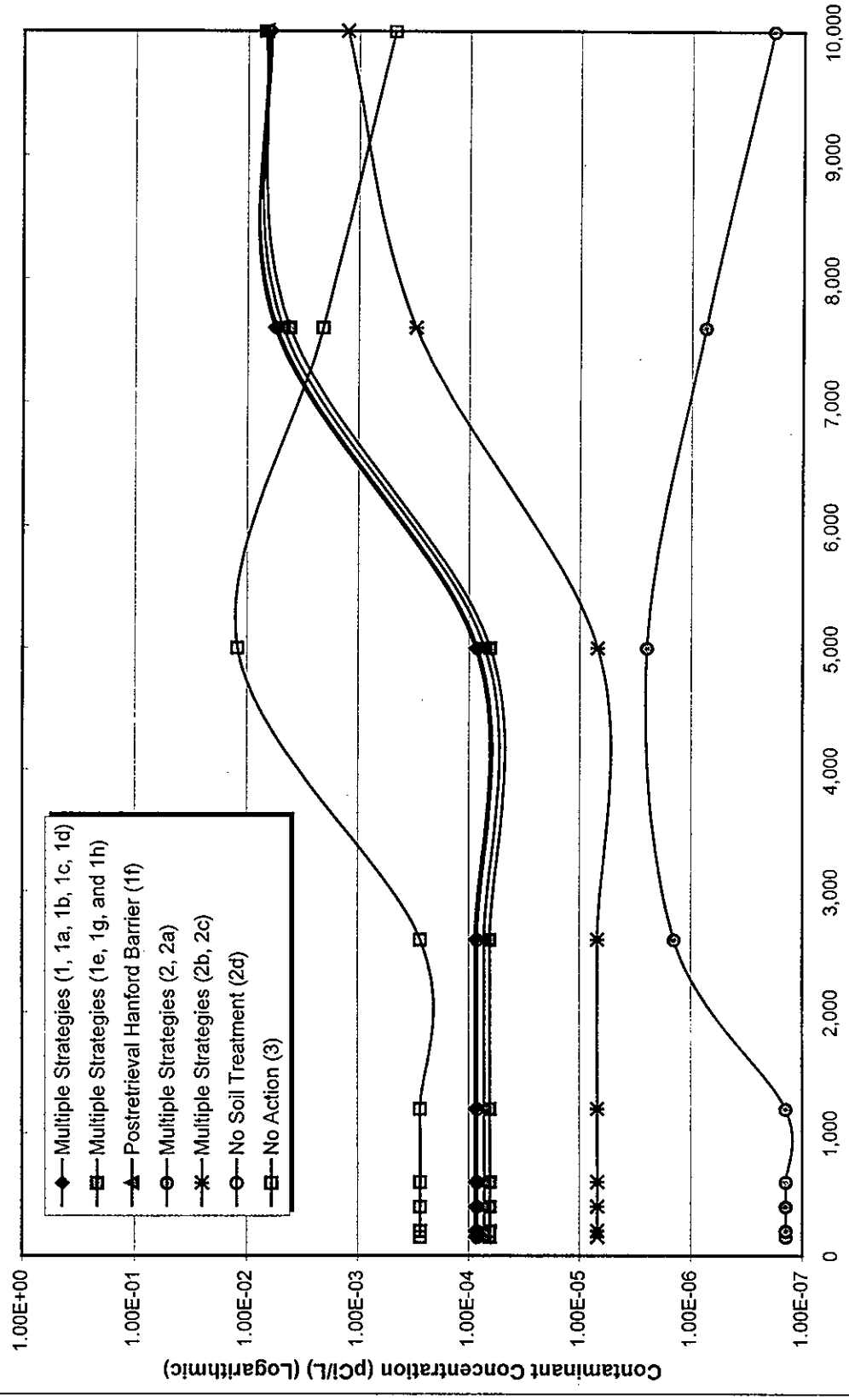
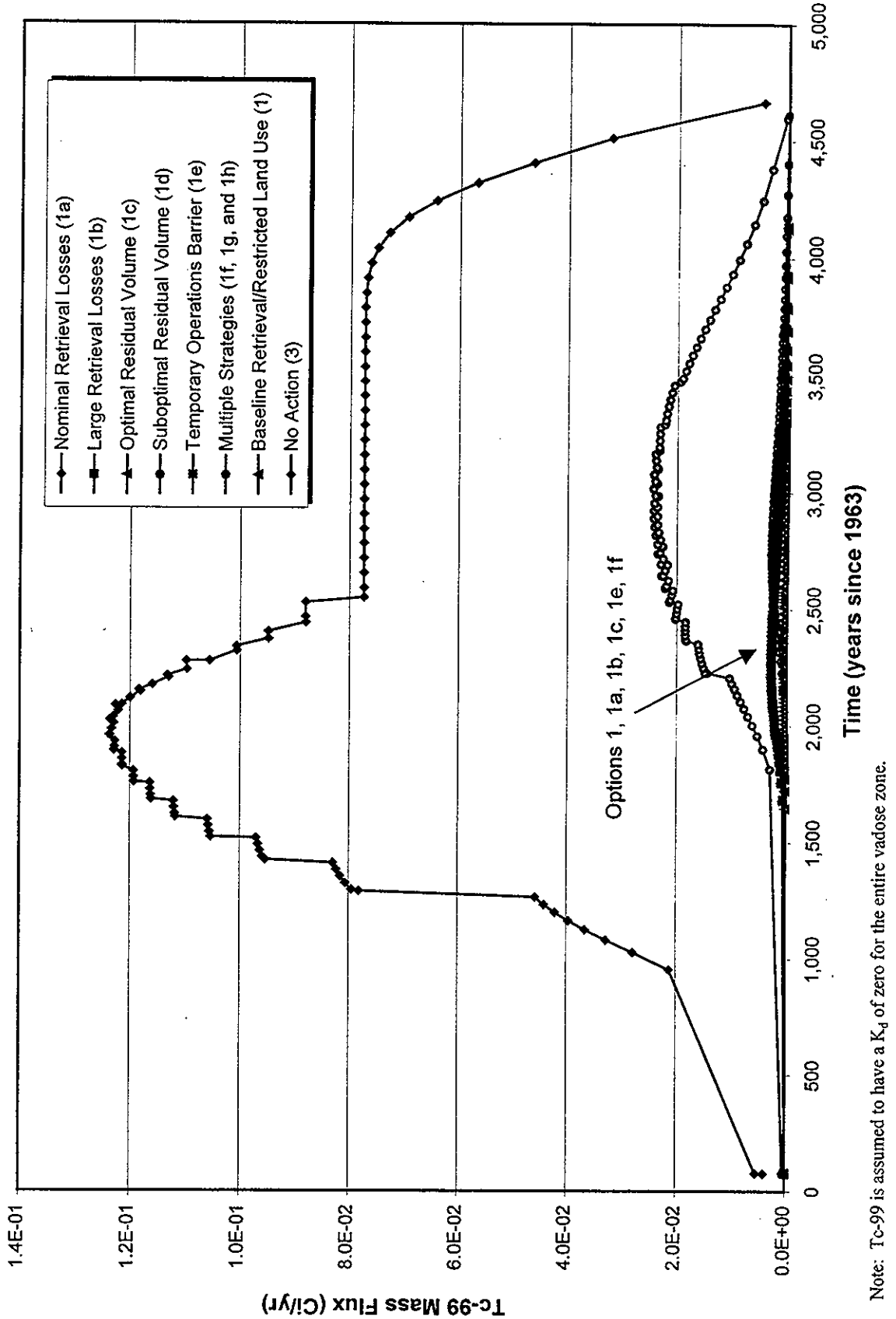


Figure 5.2.7. Maximum U-238 Concentrations in Groundwater for the Past Leak Source Term



Note: Drinking water standard for uranium is 0.02 mg/L. This is equivalent to 6.7 pCi/L of U-238.
The 4-mrem effective dose of U-238 is approximately 24 pCi/L.

Figure 5.2.8. Tc-99 Mass Flux Through the Vadose Zone for the Residual Source Term Component



Note: Tc-99 is assumed to have a K_d of zero for the entire vadose zone.

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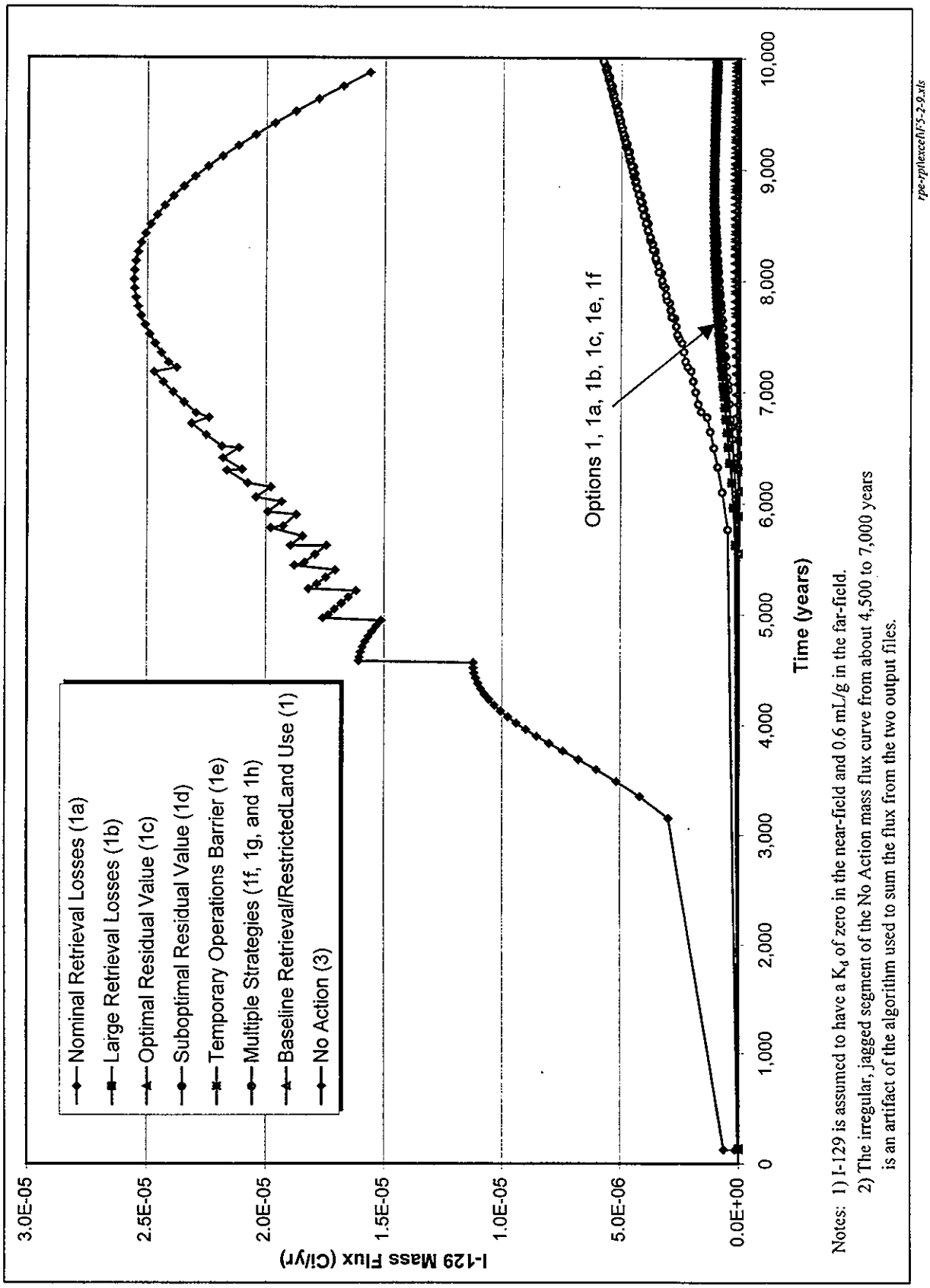
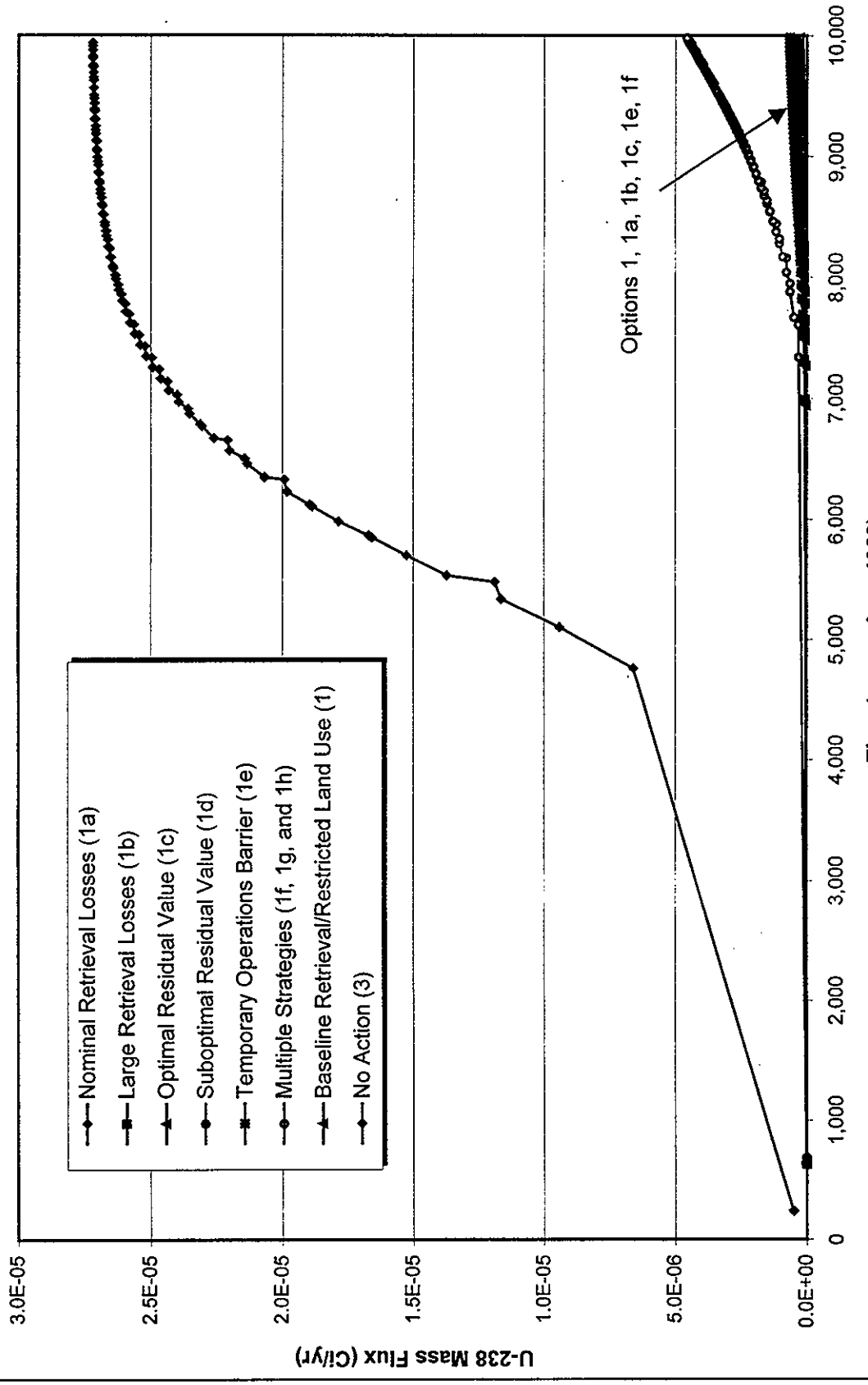
Figure 5.2.9. I-129 Mass Flux Through the Vadose Zone for the Residual Source Term Component



Notes: 1) I-129 is assumed to have a K_d of zero in the near-field and 0.6 mL/g in the far-field.
2) The irregular, jagged segment of the No Action mass flux curve from about 4,500 to 7,000 years is an artifact of the algorithm used to sum the flux from the two output files.

Figure 5.2.10. U-238 Mass Flux Through the Vadose Zone for the Residual Source Term Component



Note: U-238 is assumed to have a K_d of 0.6 mL/g for the entire vadose zone.

Table 5.2.3. Mass Flux Characteristics for the Residual Leakage Loss Component of Strategy 1

	Tc-99	I-129	U-238
Time to peak mass flux (yr)	2,300	8,700	>10,000
Mass flux at peak (Ci/yr)	2.69E-03	1.08E-06	6.39E-07

Figure 5.2.11 illustrates the maximum groundwater concentration for Tc-99 versus time for the residual source component. The trend illustrated in this figure is consistent with the mass flux through the vadose zone for a K_d group zero contaminant. The mass flux peak that occurred after about 2,300 yr is evident as a maximum concentration from residual releases that occurs at about 2,600 yr in the groundwater. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99 as illustrated in the maximum groundwater concentration versus time figure (Figure 5.2.11).

The contaminants I-129, C-14, and the uranium isotopes are all assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated on Figures 5.2.12 and 5.2.13, respectively. The maximum concentrations for I-129 and U-238 are 7.39E-03 and 4.99E-03, respectively and occur at 10,000 yr.

Composite Results

The composite mass flux through the vadose zone for this strategy is presented in Figure 5.2.14 for three selected contaminants. The y-axis values of mass flux on these figures are not comparable to the previously presented mass flux versus time plots for past leaks because the composite results are contaminant-specific. They are, however, comparable to the mass flux versus time plots for the residual source component.

Figures 5.2.15, 5.2.16, and 5.2.17 illustrate the maximum groundwater concentrations for Tc-99, I-129, and U-238 versus time for the composite of the source components. The Tc-99 groundwater concentrations for the composite of the past leak and residual waste volume source terms decrease in nearly a log-linear pattern from about 4.43E+01 pCi/L at 150 yr to 9.97 pCi/L at 600 yr. A secondary peak occurs at about 2,500 yr at a concentration of about 1.75E+01 pCi/L. From there, the maximum concentrations decrease gradually to about 4.7E-01 pCi/L at 5,000 yr and then decline sharply thereafter.

5.2.2 Nominal Retrieval Losses (Option 1a)

This waste retrieval and tank farm closure option includes past leaks, a 30 m^3 (8,000 gal.) retrieval leakage loss from each of the four tanks, and a residual waste volume of 10 m^3 (360 ft^3). The tanks would be backfilled and the tank farm area covered with an enhanced RCRA Subtitle C barrier. A brief discussion is provided here concerning the retrieval leakage loss source component and additional enabling assumptions.

5.2.2.1 Past Leaks

The groundwater impacts of the past leak source component for Option 1a are assumed to be identical to those which were calculated for the Baseline Retrieval/Restricted Land Use strategy (Strategy 1) in Section 5.2.1. It is assumed that the change in vadose zone moisture conditions

Figure 5.2.11. Maximum Tc-99 Concentrations in Groundwater for the Residual Source-Term

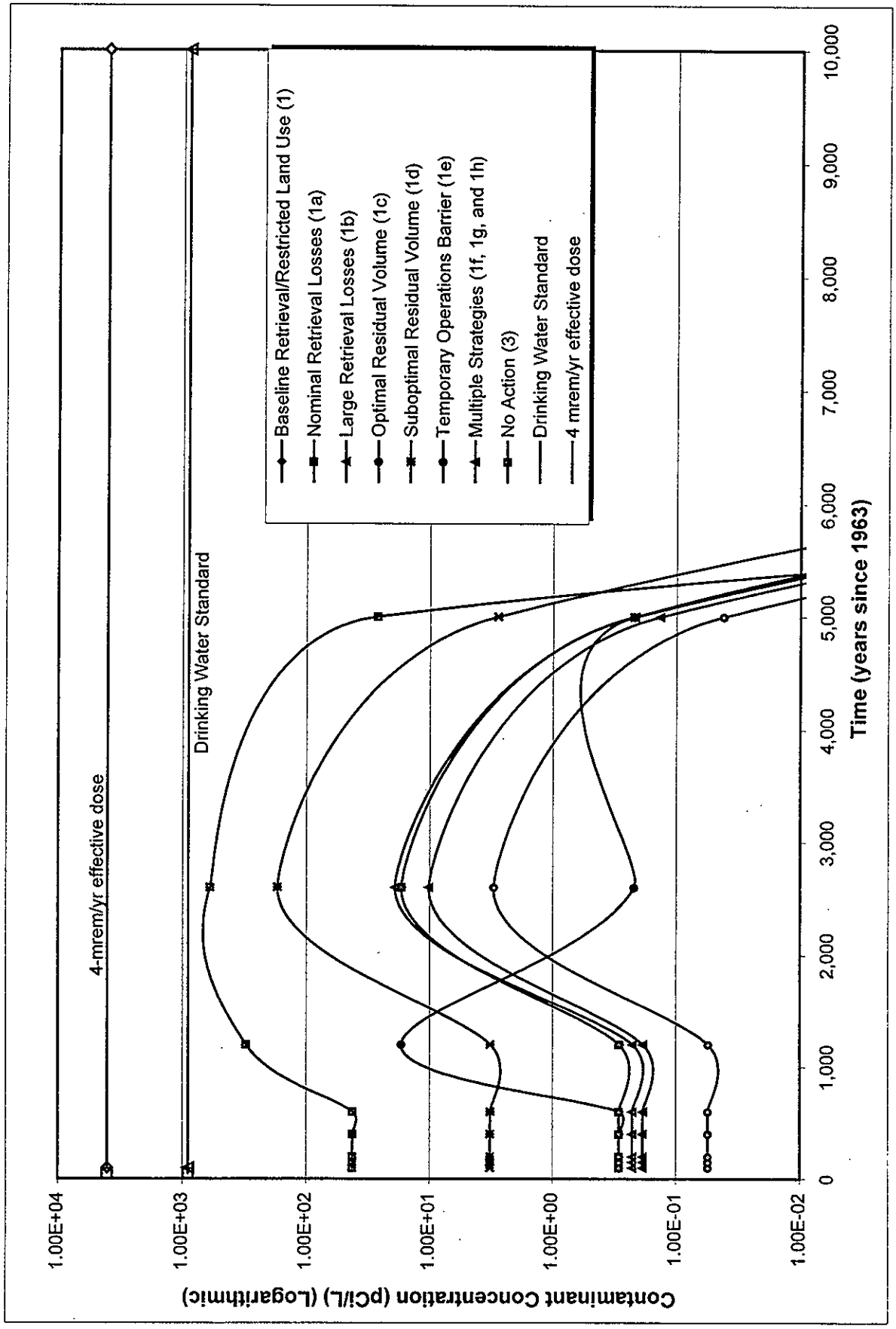


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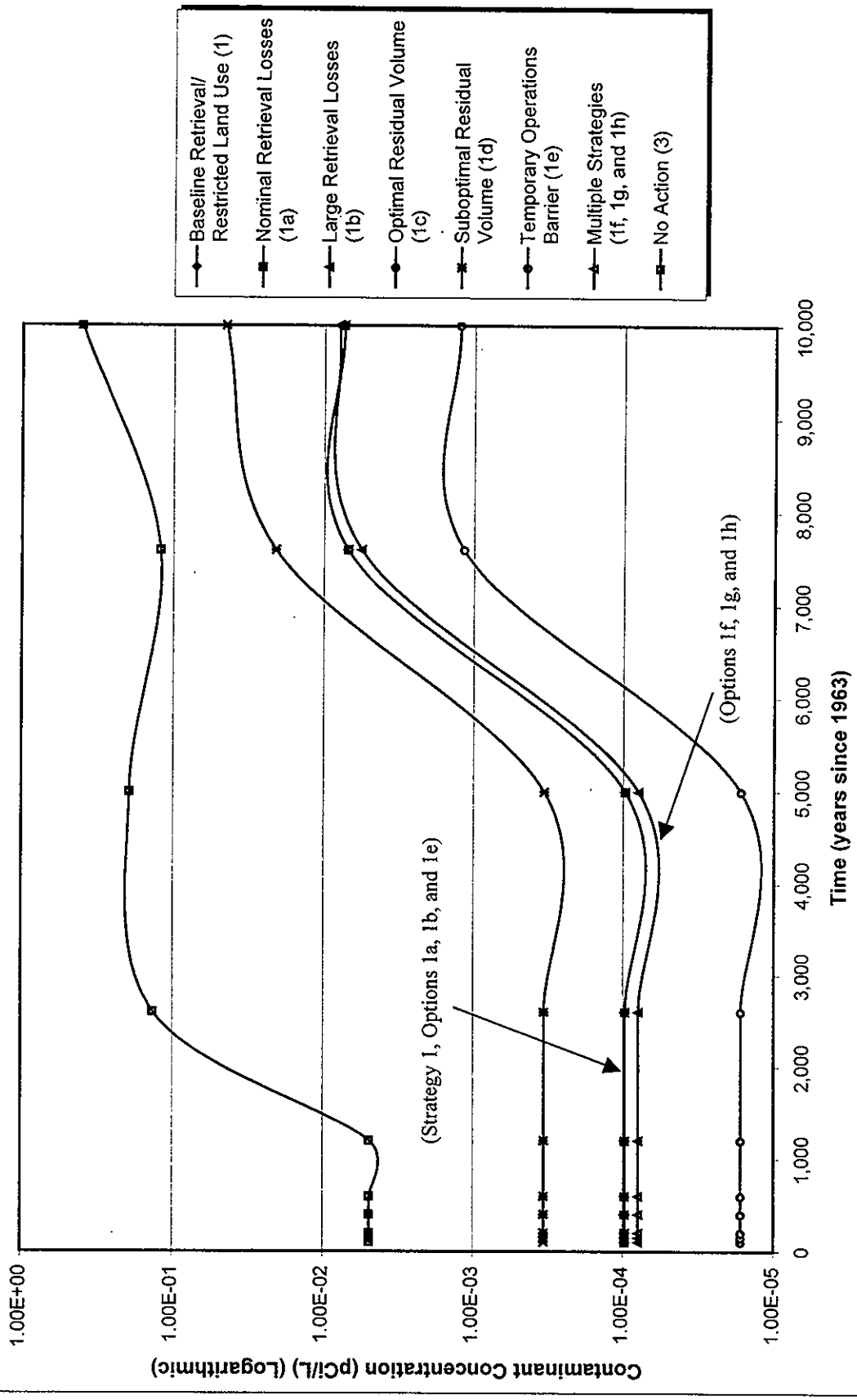
Figure 5.2.12. Maximum I-129 Concentrations in Groundwater for the Residual Source Term



Note: Drinking Water Standard for I-129 is 1.0 pCi/L. The 4-mrem effective dose of I-129 is approximately 20 pCi/L.

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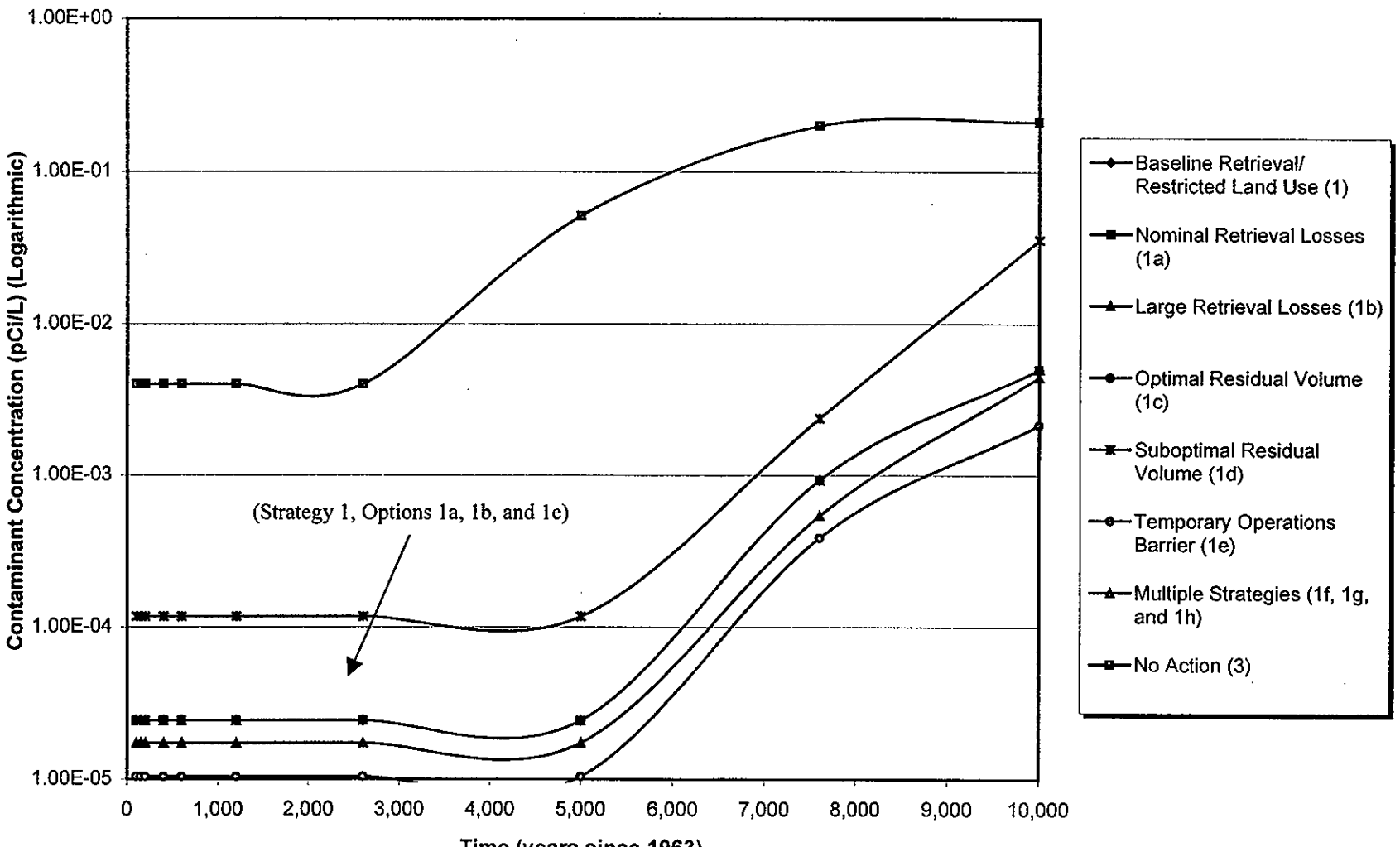
Figure 5.2.13. Maximum U-238 Concentrations in Groundwater for the Residual Source Term



Note: Drinking Water Standard for uranium is 0.02 mg/L. This is equivalent to 6.7 pCi/L of U-238.
The 4-mrem effective dose of U-238 is approximately 24 pCi/L.

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Figure 5.2.14. Mass Flux Versus Time for Tc-99, I-129, and U-238 for the Composite of All Source Terms - Baseline Retrieval/Restricted Land Use (Strategy 1)

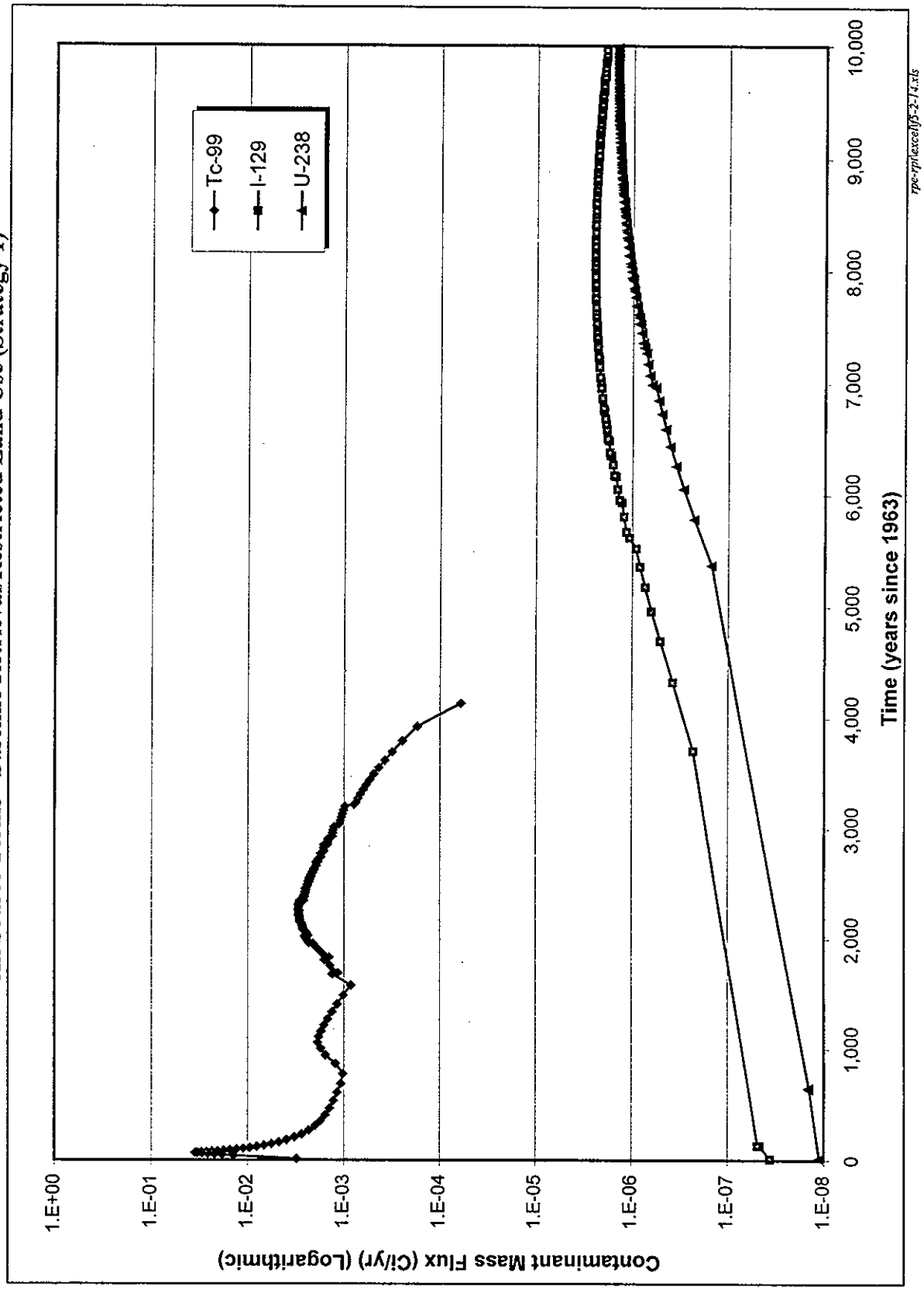

Figure 5.2.15. Maximum Tc-99 Concentrations in Groundwater for the Composite of Source Term

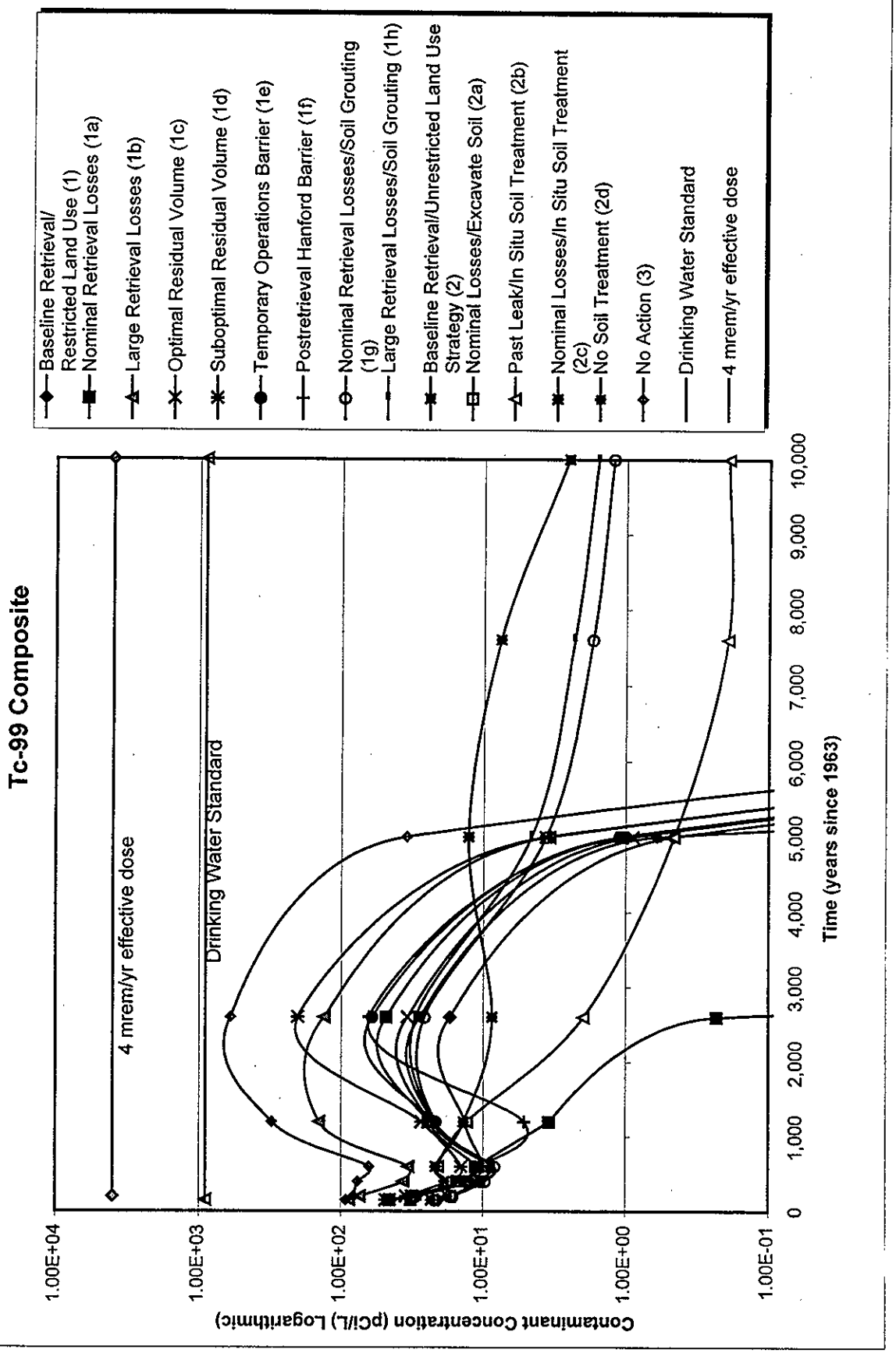

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Figure 5.2.16. Maximum I-129 Concentrations in Groundwater for the Composite of Source Terms

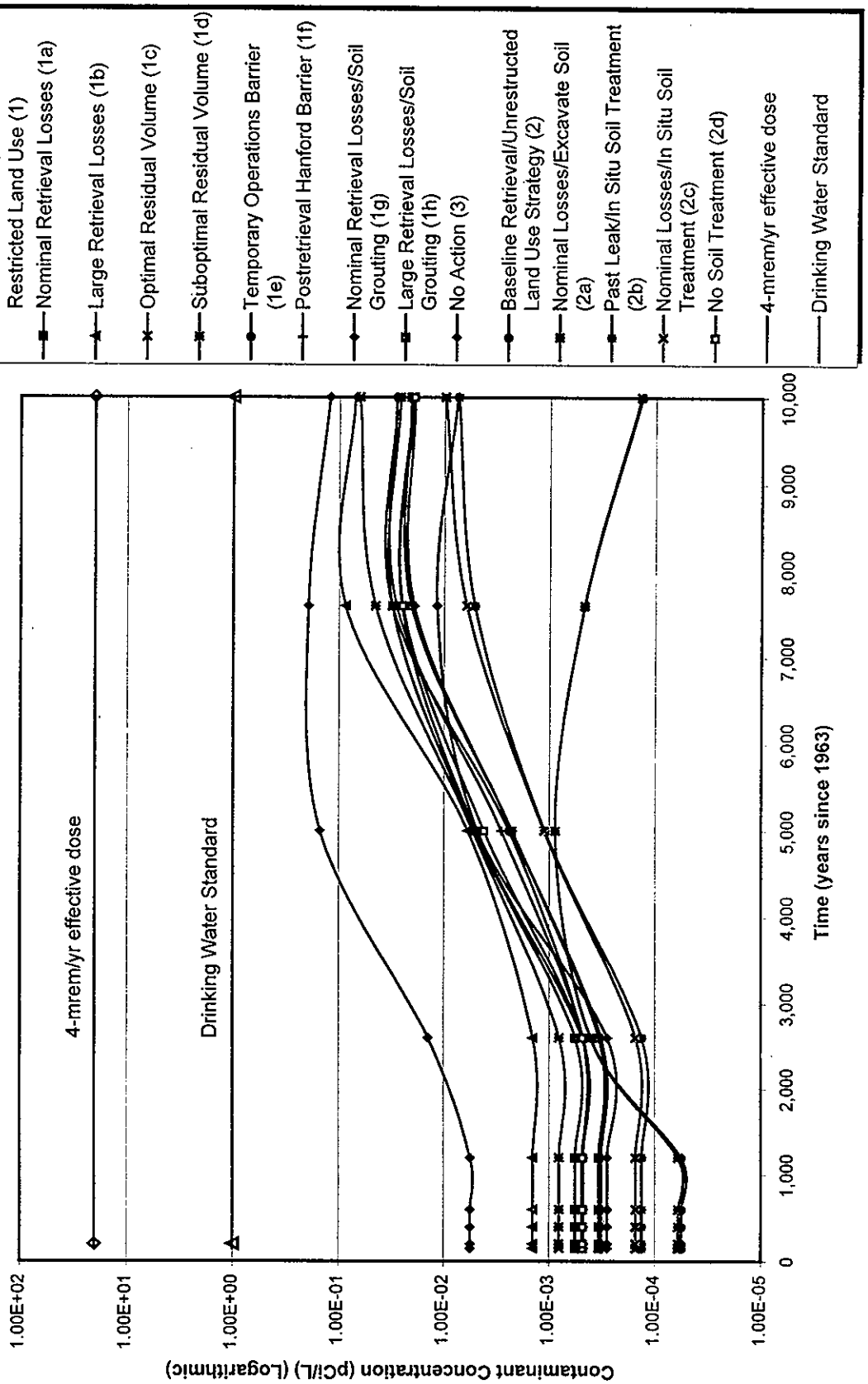
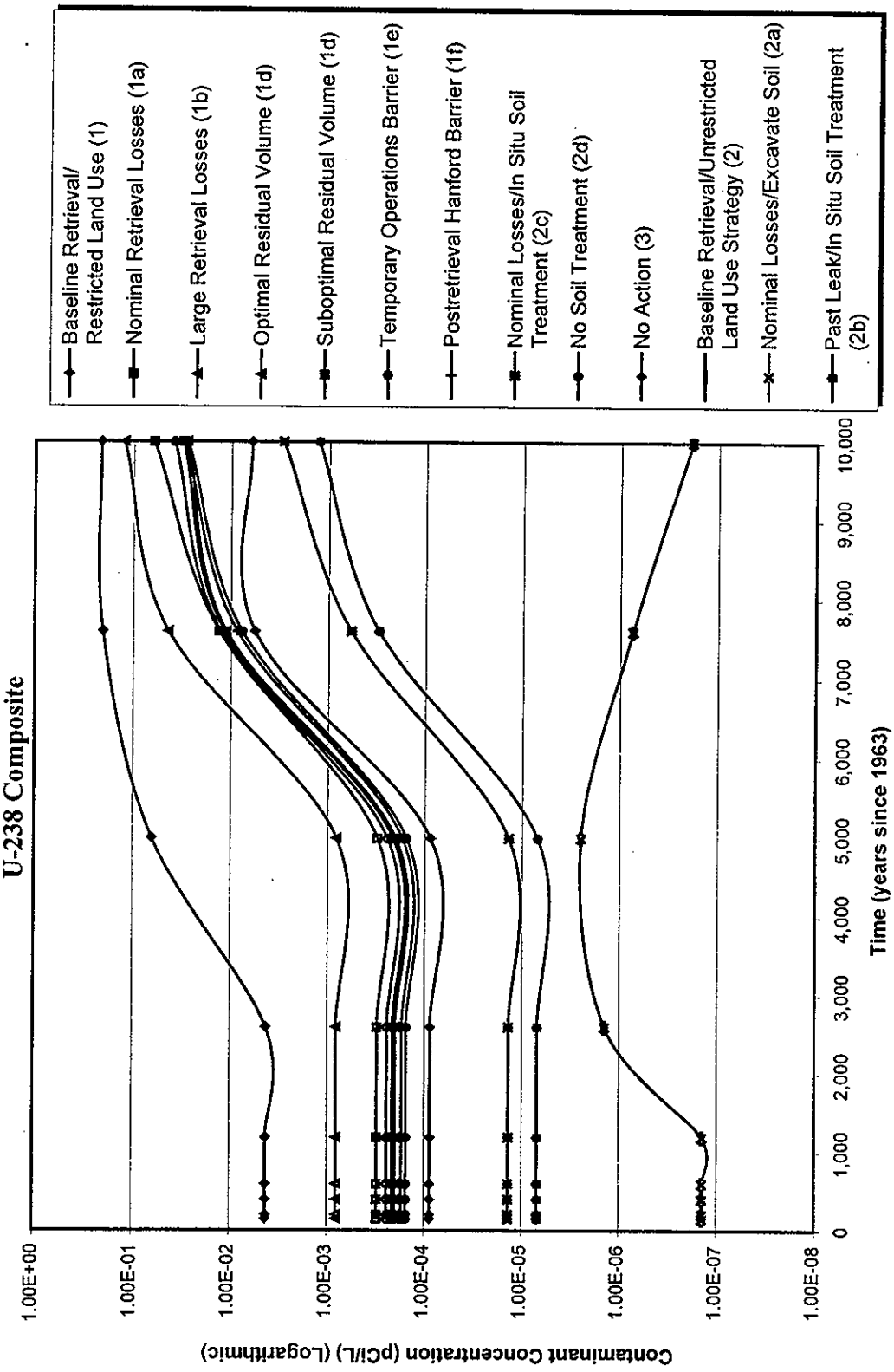


Figure 5.2.17. Maximum U-238 Concentrations in Groundwater for the Composite of Source Terms



Note: Drinking Water Standard for uranium is 0.02 mg/L. This is equivalent to 6.7 pCi/L of U-238. The 4-mrem effective dose of U-238 is approximately 24 pCi/L.

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due to potential retrieval leakage loss would be insignificant with respect to the fate and transport of contaminants from past leaks because of the spatial and temporal differences. Past leaks are assumed to have began in 1973, approximately 10 yr after starting of the simulation.
The retrieval leakage loss for this strategy is assumed to begin in 2004, approximately 41 yr after starting the simulation. Past leaks are near-surface (i.e., 2 m [6 ft] belowground surface) whereas potential retrieval leakage losses are assumed to leak from the base of the tank at approximately 17 m (55 ft) belowground surface. Past leaks are assumed to begin approximately 30 yr before potential retrieval leakage loss occurs.

5.2.2.2 Retrieval Leakage Loss

Retrieval leakage loss is assumed to leak out of the tanks from a nominal 30 percent area of the base of the tank near the inside edge which is closest to the assumed clastic dike in the model domain. Retrieval operations are expected to take approximately 6 months for tanks AX-102, AX-103, and AX-104. Retrieval from tank AX-101 is assumed to require 1 yr due to its greater volume. The retrieval sequence begins with tank AX-103, followed by tanks AX-104, AX-102, and AX-101. Potential retrieval leakage loss begins in 2004 and continues continuously for 2.5 yr. Moisture conditions that were calculated to exist after the past leaks are assumed for the initial moisture conditions for the retrieval leakage loss simulation.

5.2.2.3 Residual Loss

Residual loss occurs and are simulated, with one exception, the same way as described for Strategy 1 discussed in Section 5.2.1.3. For this strategy, the moisture conditions that were calculated to exist after the retrieval leakage loss were used as the initial moisture conditions for simulating the residual loss.

5.2.2.4 Recharge

The recharge assumptions are the same as indicated for Strategy 1 and as discussed in Section 5.2.1.4.

5.2.2.5 Enabling Assumptions

The enabling assumptions include those as provided for Strategy 1 discussed in Section 5.2.1.5. The following is an enabling assumption that is specific to this option and strategies and options that would include a retrieval leakage loss.

- Location of retrieval leaks on outer edge of tanks and assumption that leak would be released from a tank base area of 30 percent. The location of the leak at the outer edge of the tank was selected because it would result in the potential interaction between the retrieval leak and the enhanced recharge rate for the shedding of recharge off the tank domes. The placement also would result in potential interaction between the two adjacent tanks in the model domain. And, the placement puts the leaking waste in the close vicinity of the clastic dike that was located midway between the two tanks in the model domain. Assuming a leakage area something much less than the full tank area is consistent with the limited field data.

5.2.2.6 Option-Specific Data Gaps

The option-specific data gaps include those as provided for the Baseline Retrieval/Restricted Land Use strategy and as discussed in Section 5.2.1.6. The following is a data gap that is specific to this option and strategies and options that would include a retrieval leakage loss.

- The locations of retrieval leakage loss and the area from which they occur. These characteristics, taken in conjunction with tank farm layout (e.g., distance between tanks) and subsurface conditions (e.g., sloping layers and presence of clastic dike[s]) can be important to the rate of transport for a specific waste retrieval leakage loss event.

5.2.2.7 Results of the Nominal Retrieval Losses Option (Option 1a)

In this section, long-term groundwater impact results are discussed for each of the applicable source components and for the strategy as a whole (i.e., composite of all the source components). The following discussions focus on the comparison between the results of Option 1a and Strategy 1.

Past Leaks Source Term

The CoCs in the past leaks are the same as for Strategy 1. The vadose zone mass flux and contaminant concentrations in groundwater are the same as described for the past leak impacts in Section 5.2.1.7.

Retrieval Source Term

Strategy 1 did not have a retrieval source term, therefore, a detailed discussion of the impacts from the retrieval source term is provided in this section. The CoCs in the retrieval source term include all of those listed in Appendix B and details on the inventory are provided in Appendix A. Presented on Figures 5.2.18, 5.2.19, and 5.2.20 are the mass flux versus time for this strategy as well as the others for an initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2), the maximum mass flux occurs at approximately 1,950 yr.

The K_d zero contaminants would have completely passed through the vadose zone after about 5,000 yr. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately 8,300 yr (Figure 5.2.19). The uranium isotopes are assumed to have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for the uranium isotopes (Figure 5.2.20) occurs sometime after the 10,000-yr period of interest. The time to peak mass flux and the relative mass flux rate at the peak rate are tabulated on Table 5.2.4 for the three K_d groups and include the past leak source term results for comparison.

The comparisons between past leak and retrieval leakage source terms in Table 5.2.4 illustrate the large effect of quickly reducing recharge after a tank leak event. The peak groundwater concentrations of key contaminants are delayed by over 1,000 yr in response to the immediate reduction of recharge with the installation of a RCRA-compliant cover.

Figure 5.2.18. Contaminant Mass Flux Through the Vadose Zone for the Retrieval Leakage Loss Source Term Component for Zero K_d and Initial Contaminant Concentration of 1 Ci or Kg per Cubic Meter

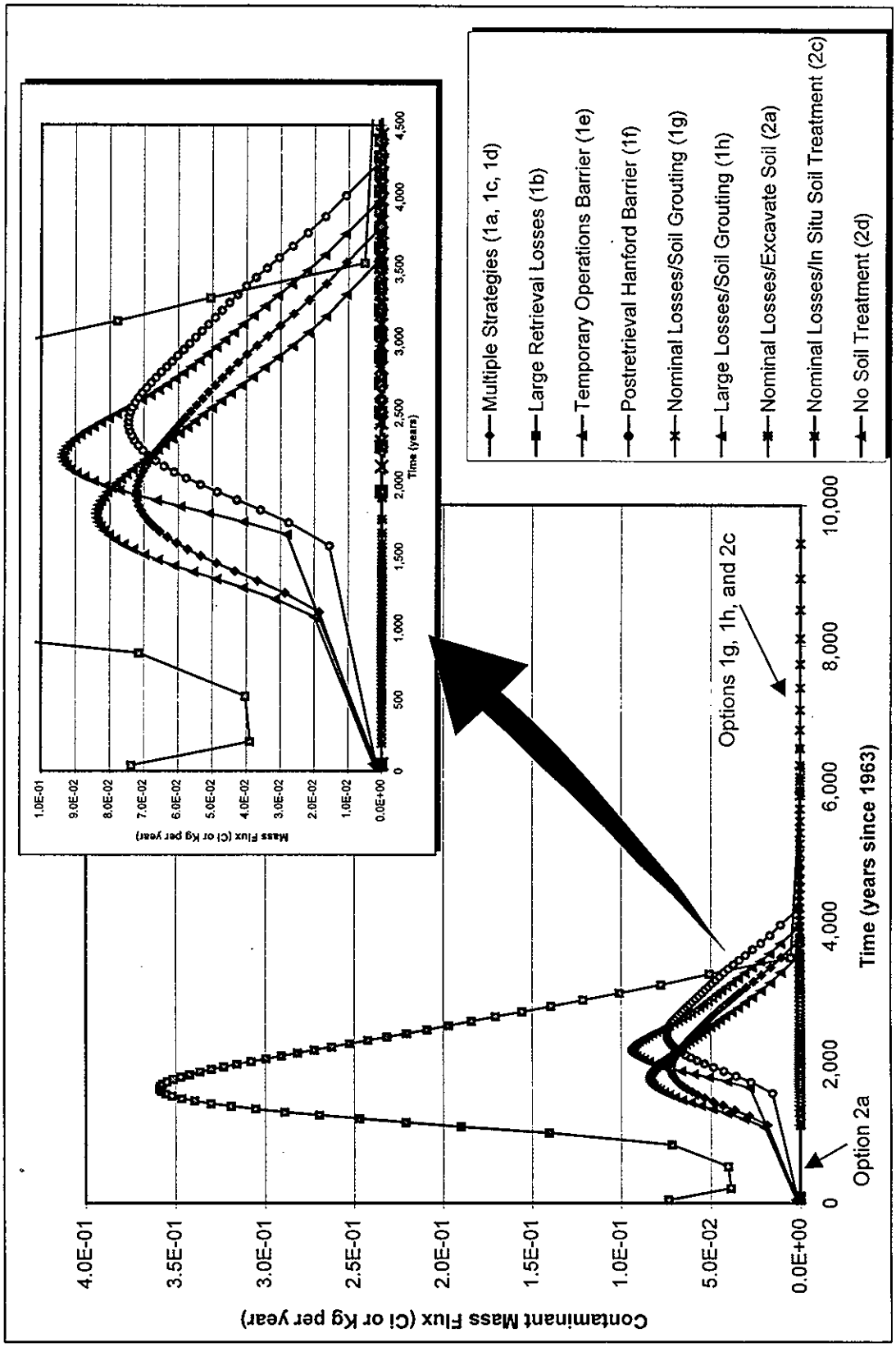


Figure 5.2.19. Contaminant Mass Flux Through the Vadose Zone for the Retrieval Leakage Loss Source Term Component for Zero Kd in the Near-Field and 0.6 mL/g K_d in the Far-Field and Initial Contaminant Concentration of 1 Ci or Kg per Cubic Meter

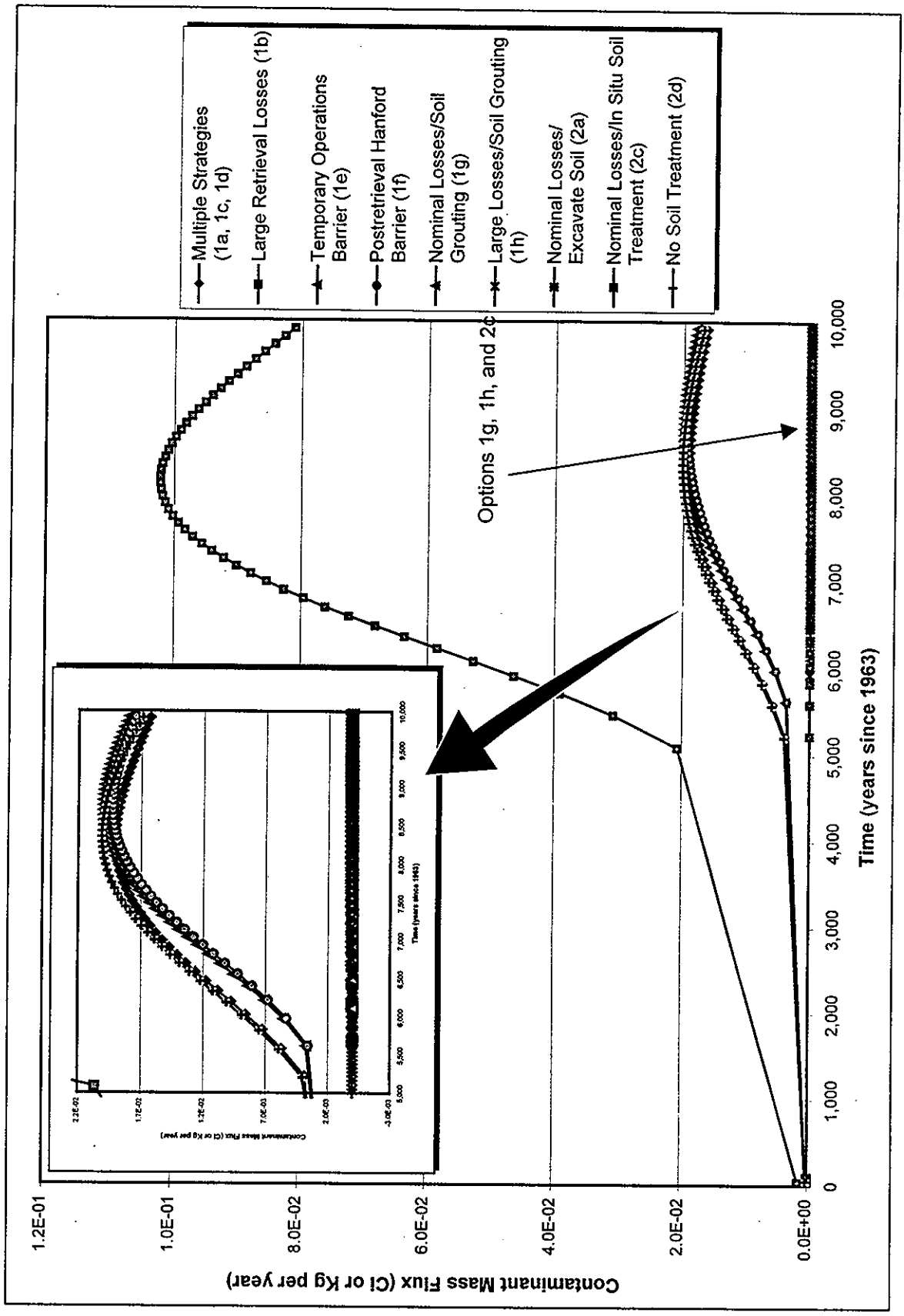


Figure 5.2.20. Contaminant Mass Flux Through the Vadose Zone for the Retrieval Leakage Loss Source Term Component for 0.6 mL/g K_d and Initial Contaminant Concentration of 1 Ci or Kg per Cubic Meter

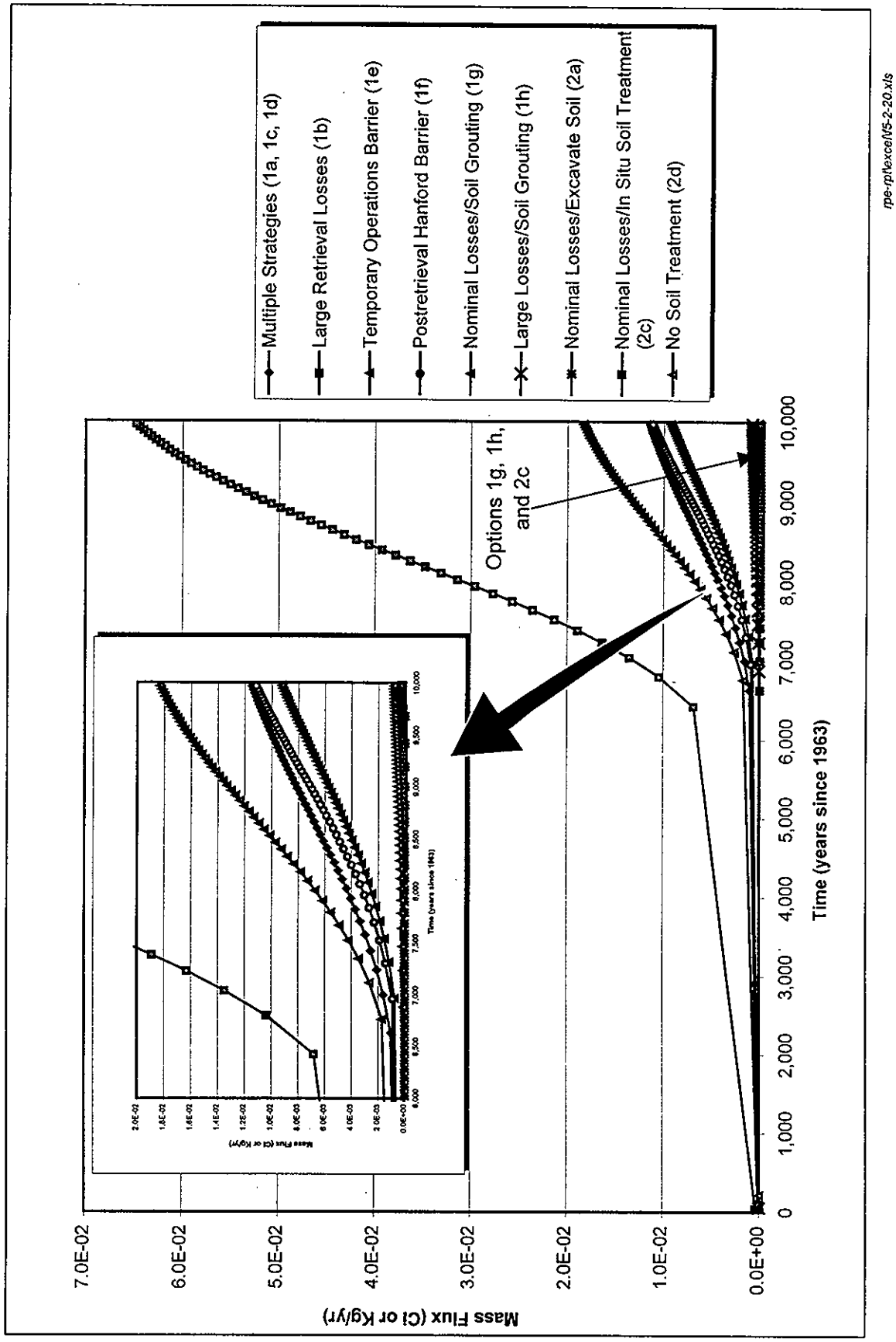


Table 5.2.4. Comparison of Mass Flux Characteristics for Past Leak and Retrieval Leakage Loss, Nominal Retrieval Losses Option (Option 1a)

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Past leak source term component (would be the same for both Strategy 1 and Option 1a)			
Time to peak mass flux (yr)	65	7,400	8,750
Relative mass flux at Peak for C = 1 initial source concentration	2.35E-01	5.22E-03	5.15E-03
Retrieval leakage source term component for Restricted Land Use–Nominal Retrieval Losses Strategy (Option 1a)			
Time to peak mass flux (yr)	1,950	8,300	>10,000
Relative mass flux at Peak for C = 1 initial source concentration	7.22E-02	1.90E-02	1.15E-02

Figure 5.2.21 illustrates the maximum groundwater concentration for Tc-99 versus time for the potential retrieval leakage loss source component. The trend illustrated in this figure is consistent with the mass flux through the vadose zone for a K_d group zero contaminant. The Tc-99 groundwater peak concentration of approximately 3.09E+01 pCi/L occurs at approximately 2,500 yr in response to the maximum mass flux through the vadose zone, which occurs at approximately 1,900 yr. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99, as illustrated on Figure 5.2.21.

The contaminants I-129, C-14, and the uranium isotopes are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated on Figures 5.2.22 and 5.2.23. The peak concentrations are approximately 1.24E-02 and 1.99E-02 pCi/L for I-129 and U-238, respectively. Maximum peaks would occur at approximately 7,600 yr and 10,000 yr for I-129 and U-238, respectively.

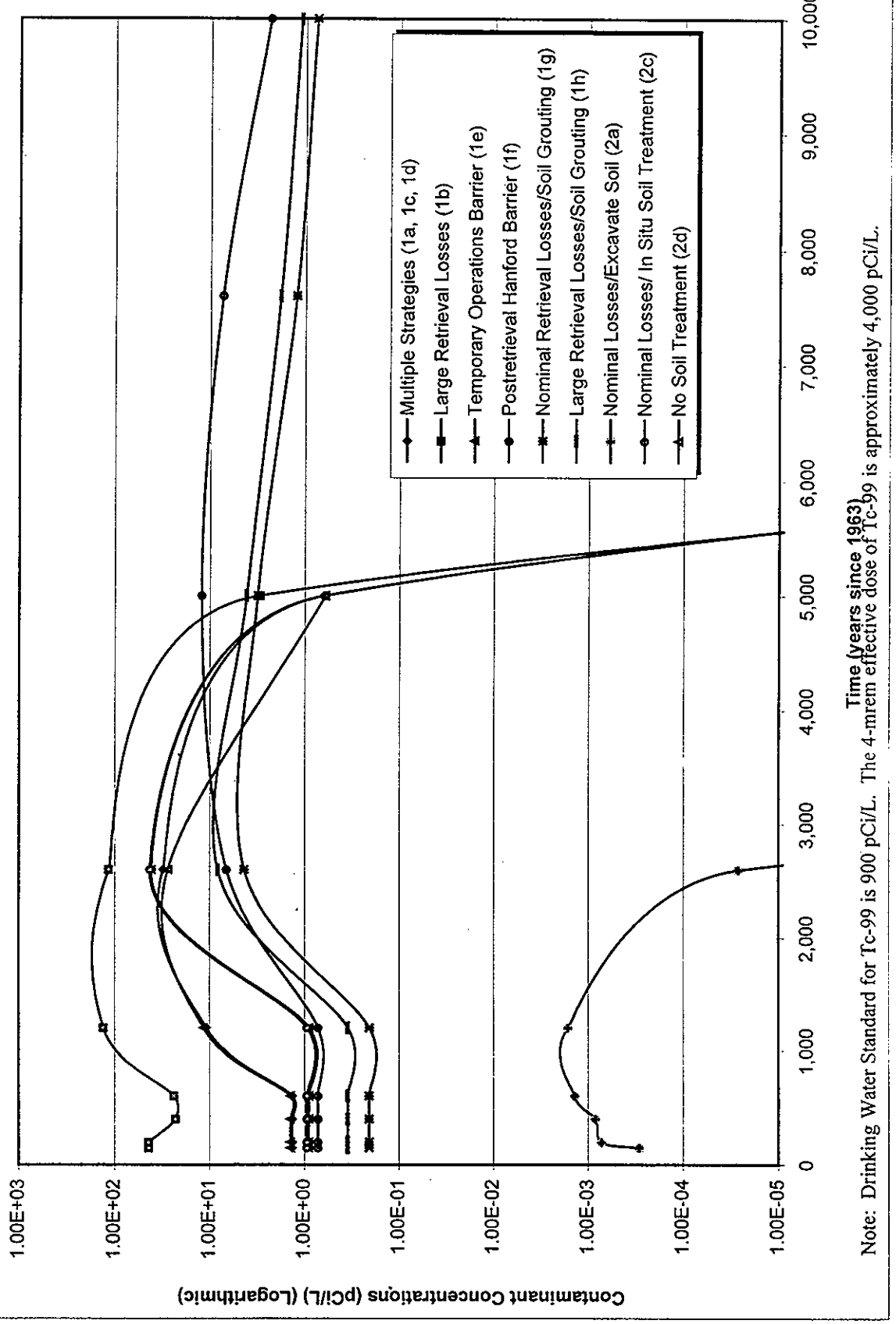
Residual Source Term

The CoC for the residual source term include all of those listed in Appendix B (see Appendix A for a discussion of the inventory). Previously presented on Figures 5.2.8, 5.2.9, and 5.2.10 are the mass flux versus time for this strategy as well as the others for contamination from each of the three K_d groups. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. The difference in vadose zone moisture contents between this option (Nominal Retrieval Losses – Option 1a) and Strategy 1, which has no retrieval leakage loss, does not appear to be significant with respect to contaminant mass flux through the vadose zone and maximum groundwater contaminant concentrations because both the vadose zone mass flux and groundwater contaminant concentrations are nearly the same as described for the residual source term impacts for Strategy 1 in Section 5.2.1.7.

Composite Results

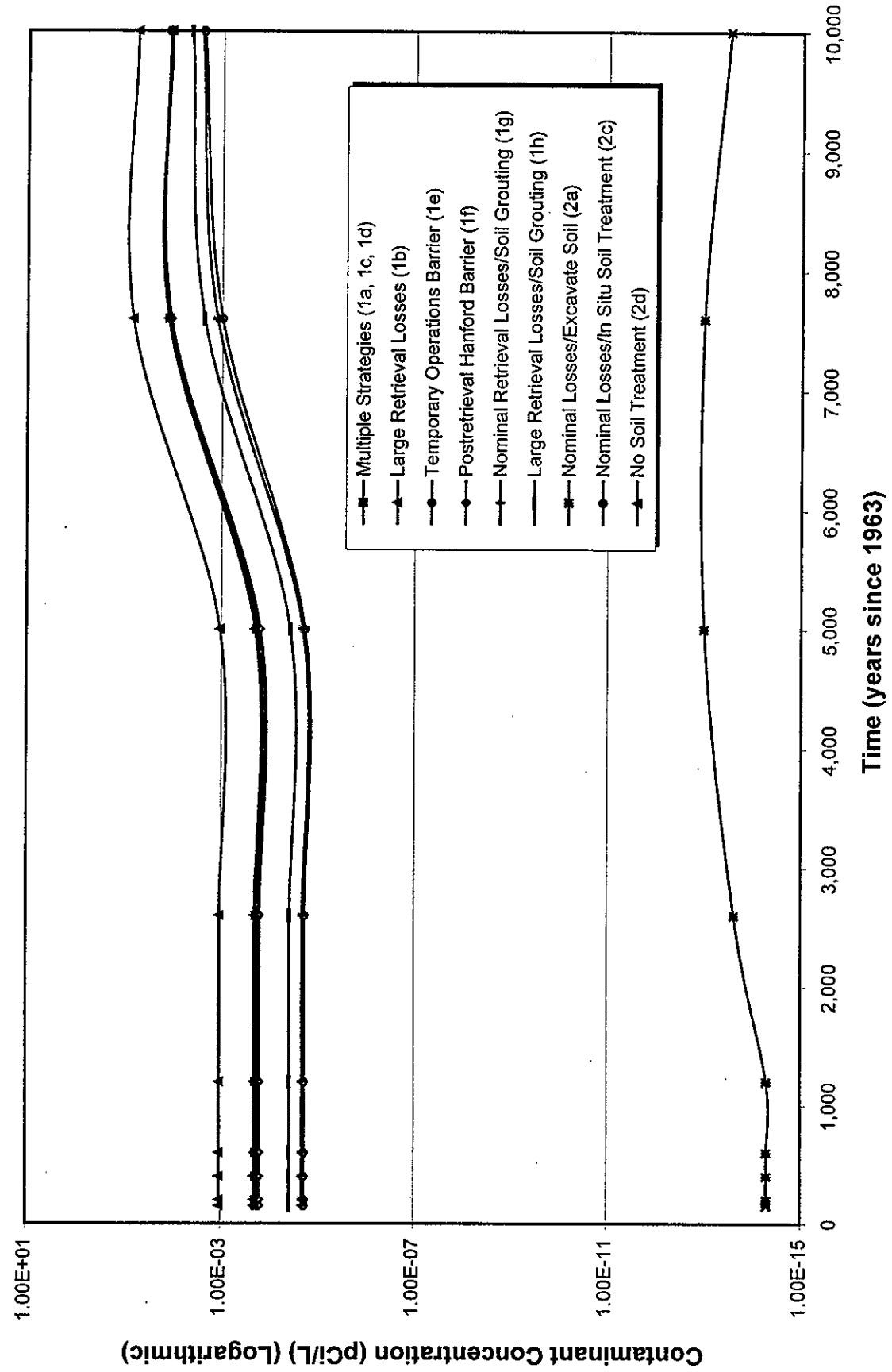
The composite mass flux through the vadose zone for this option is presented in Figure 5.2.24 for three selected contaminants (i.e., Tc-99, I-129, and C-14). The y-axis values of mass flux on these figures are not comparable to the previously presented mass flux versus time plots for past

Figure 5.2.21. Maximum Tc-99 Concentrations in Groundwater for the Retrieval Leakage Loss Source Term



Note: Drinking Water Standard for Tc-99 is 900 pCi/L. The 4-mrem effective dose of Tc-99 is approximately 4,000 pCi/L.

Figure 5.2.22. Maximum I-129 Concentrations in Groundwater for the Retrieval Leakage Loss Source Term



Note: Drinking Water Standard for I-129 is 1.0 pCi/L. The 4-mrem effective dose of I-129 is approximately 20 pCi/L.

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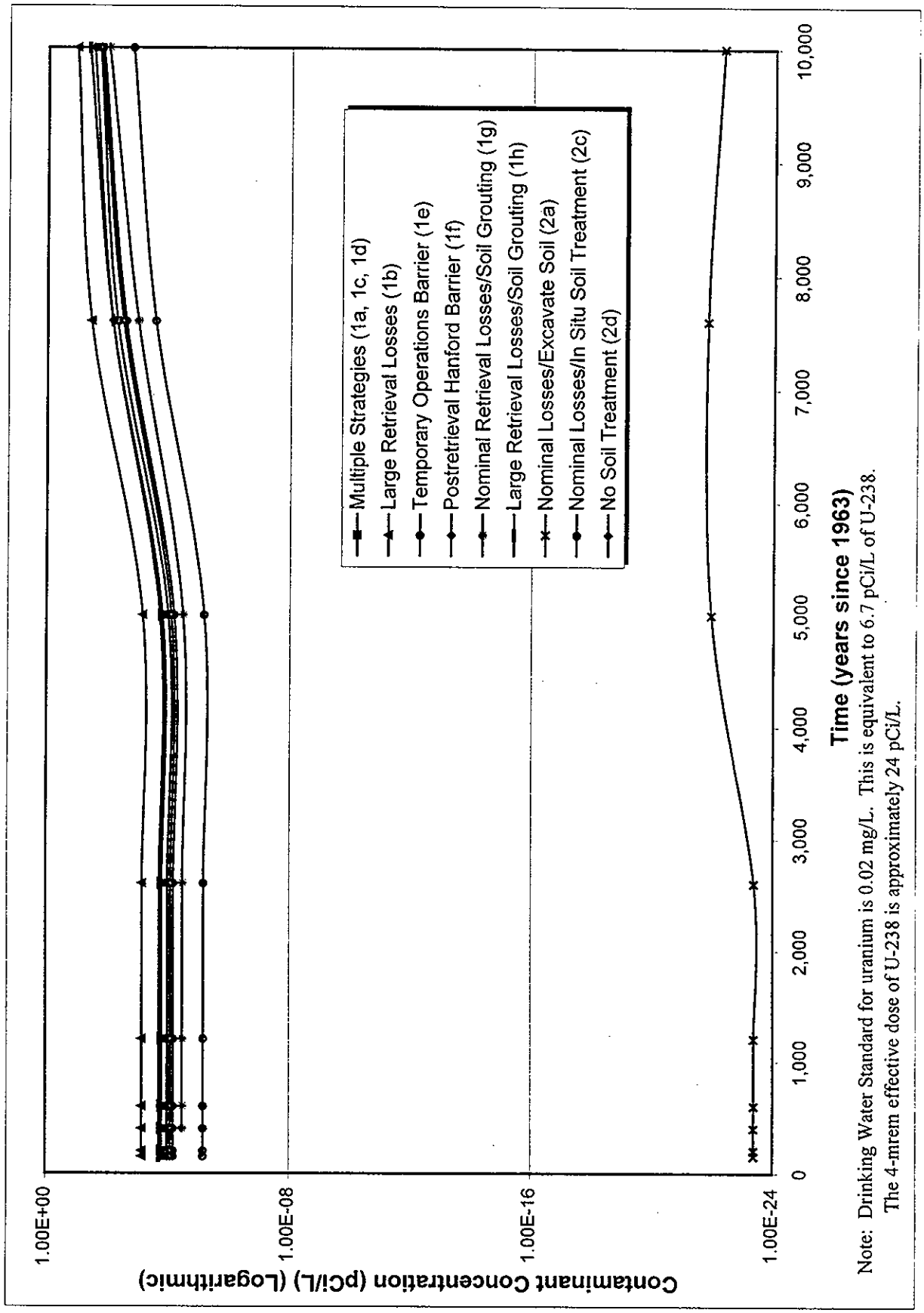
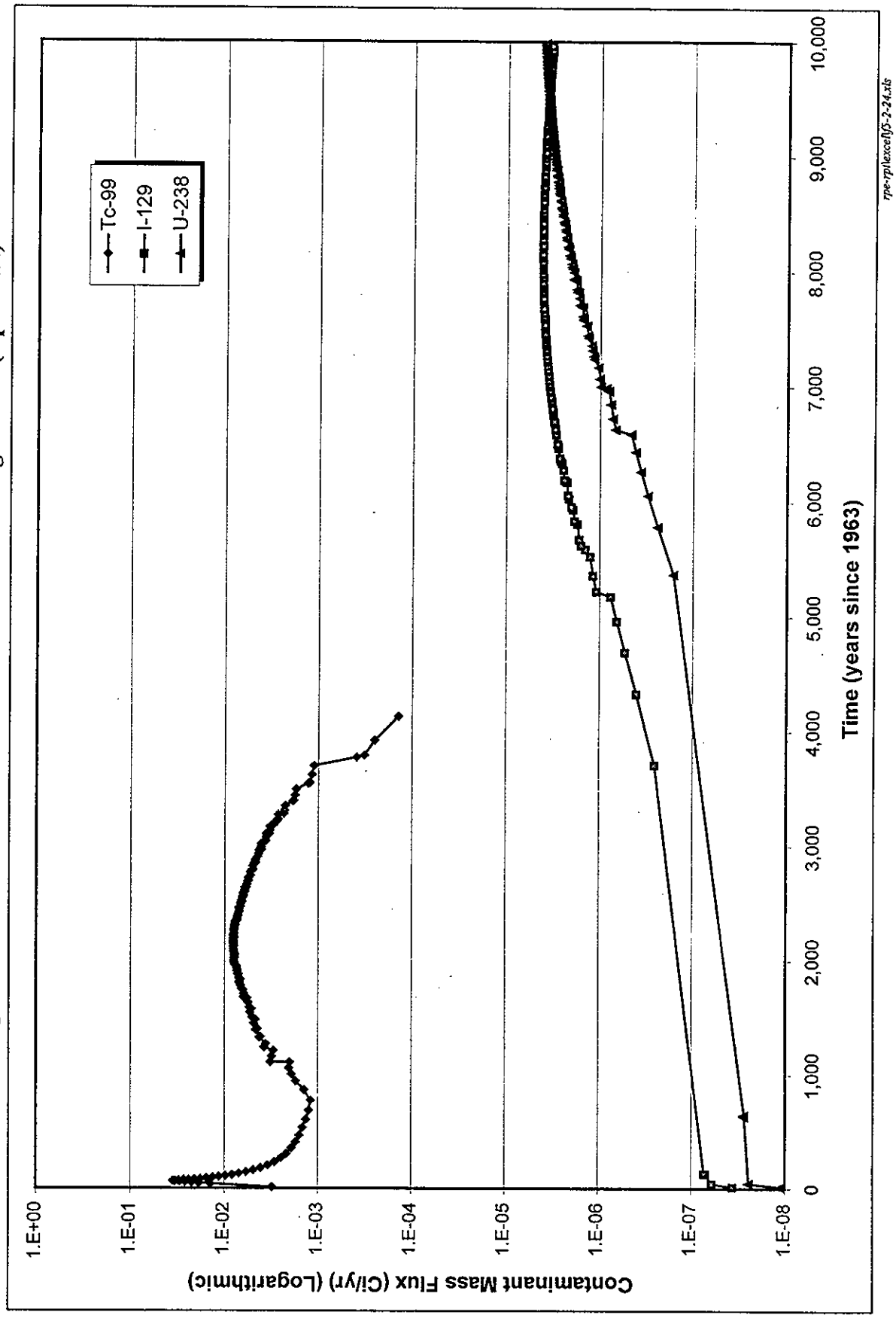
Figure 5.2.23. Maximum U-238 Concentrations in Groundwater for the Retrieval Leakage Loss Source Term



Note: Drinking Water Standard for uranium is 0.02 mg/L. This is equivalent to 6.7 pCi/L of U-238. The 4-mrem effective dose of U-238 is approximately 24 pCi/L.

Figure 5.2.24. Mass Flux Versus Time for Tc-99, I-129, and U-238 for the Composite of All Source Terms - Nominal Retrieval Leakage Losses (Option 1a)



leaks and potential retrieval leakage losses because the composite results are contaminant-specific and the past leak and potential retrieval leakage loss mass flux are for the whole K_d group and, as such, are based on a unit initial concentration.

The trends illustrated in Figure 5.2.24 are similar to those for Strategy 1 shown in Section 5.2.1.7. One important difference relates to the additional 30 m^3 (8,000 gal.) per tank retrieval leakage loss that is included in this strategy. There is an upward shift (i.e., greater mass flux) evident for all three contaminants illustrated in Figure 5.2.24 compared to the composite mass flux for Strategy 1 (see Figure 5.2.14). The areas under these curves represent the total mass for each of the contaminants and the upward shift is consistent with the greater overall mass associated with this option.

Figures 5.2.15, 5.2.16, and 5.2.17 illustrate the maximum groundwater concentration for Tc-99, I-129, and U-238 versus time for the composite of the source term components. The same type of trend is in these figures when a comparison is made between Option 1a and Strategy 1. Beginning at about 900 yr, the maximum composite groundwater concentration for Tc-99 increases compared to Strategy 1 in response to the greater mass input from potential retrieval leakage loss.

5.2.3 Large Retrieval Losses (Option 1b)

This option includes past leaks, 150 m^3 (40,000 gal.) retrieval leakage loss from each of the four tanks, and a residual waste volume of 10 m^3 (360 ft^3). The tanks would be backfilled, and the tank farm area covered with an enhanced RCRA Subtitle C barrier.

5.2.3.1 Past Leaks

The groundwater impacts of the past leak source component for this option are assumed to be identical to those calculated for Strategy 1 in Section 5.2.1. It is assumed that the change in vadose zone moisture conditions that could occur due to potential retrieval leakage loss would be insignificant with respect to the fate and transport of contaminants from past leaks because of the spatial and temporal differences. Past leaks are assumed to have began in 1973, approximately 10 yr after starting the simulation. The retrieval leakage loss for this strategy is assumed to begin in 2004, approximately 41 yr after starting the simulation. The past leaks are near-surface (i.e., 2 m (6 ft) belowground surface) whereas potential retrieval leakage losses are assumed to leak from the base of the tank at approximately 17 m (55 ft) belowground surface. Past leaks are assumed to begin approximately 30 yr before retrieval leakage losses are assumed to occur.

5.2.3.2 Retrieval Loss

Retrieval leakage loss from retrieval operations is assumed to leak out of the tanks from a nominal 30 percent area at the base of the tank near the inside edge, which is closest to the assumed clastic dike in the model domain. Waste retrieval operations are expected to take approximately 6 months for tanks AX-102, -103, and -104. Waste retrieval from tank AX-101 is assumed to require 1 yr due to its greater volume. The retrieval sequence begins with tank AX-103, followed by tanks AX-104, -102, and -101. Potential retrieval leakage loss begins in 2004 and continue continuously for 2 ½ yr. Moisture conditions that were calculated to exist

after the past leaks are assumed for the initial moisture conditions for the retrieval leakage loss simulation.

5.2.3.3 Residual Loss

Residual loss occurs and is simulated, with one exception, in the same way as described for the Baseline Retrieval/Restricted Land Use strategy (Strategy 1) discussed in Section 5.2.1.3. The one difference in the simulation for this option is that the moisture conditions that were calculated to exist after the large retrieval leakage losses were used as the initial moisture conditions for the residual loss.

5.2.3.4 Recharge

The recharge assumptions are the same as indicated for the Baseline Retrieval/Restricted Land Use strategy (Strategy 1) and as discussed in Section 5.2.1.4.

5.2.3.5 Enabling Assumptions

The enabling assumptions are the same as provided for the Baseline Retrieval/Restricted Land Use strategy and Option 1a as discussed in Sections 5.2.1.5 and 5.2.2.5, respectively.

5.2.3.6 Option-Specific Data Gaps

The option-specific data gaps are the same as provided for the Baseline Retrieval/Restricted Land Use strategy and Option 1 a as discussed in Sections 5.2.1.6 and 5.2.2.6, respectively.

5.2.3.7 Results for the Large Retrieval Losses Strategy (Option 1b)

In this section, long-term groundwater impact results are discussed for each of the applicable source components and for the option as a whole (i.e., composite of all the source components). The following discussion focuses on the comparison between the results of this option and the results of the Baseline Retrieval/Restricted Land Use strategy (Strategy 1) (past leak, residual, and composite source terms) and Option 1a (retrieval source term).

Past Leaks Source Term

The CoCs from past leaks are the same as for the Baseline Retrieval/ Restricted Land Use strategy. The vadose zone mass flux and contaminant concentrations in groundwater are the same as described for the past leak impacts in Section 5.2.1.7.

Retrieval Source Term

The CoCs in the retrieval source term include all of those listed in Appendix B (see Appendix A for a discussion of the inventory). Presented in Figures 5.2.18, 5.2.19, and 5.2.20 are the mass flux versus time for this strategy as well as the others for an initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2), the maximum mass flux occurs at approximately 1,650 yr. The K_d zero contaminants would have completely passed through the vadose zone after about 6,000 yr. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately

8,100 yr (Figure 5.2.19). All the uranium isotopes are assumed to have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for the uranium isotopes (Figure 5.2.20) occurs sometime after the 10,000-yr period of interest. The time to peak mass flux and the relative mass flux rate at the peak rate for the past leak and retrieval source terms are tabulated in Table 5.2.5 for the three K_d groups.

Table 5.2.5. Comparison of Mass Flux Characteristics between Past Leak and Retrieval Leakage Loss Components, Large Retrieval Losses (Option 1b)

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Past leak source term component–Option 1b			
Time to peak mass flux (yr)	65	7,400	8,750
Relative mass flux at Peak for C = 1 initial source concentration	2.35E-01	5.22E-03	5.15E-03
Retrieval source term component–Large Retrieval Losses Option 1b			
Time to peak mass flux (yr)	1,650	8,100	>10,000
Relative mass flux at Peak for C = 1 initial source concentration	3.59E-01	1.02E-01	6.48E-02

As illustrated previously, Figure 5.2.21 presents the maximum groundwater concentration for Tc-99 versus time for the retrieval leakage loss source component. The Tc-99 groundwater peak maximum concentration of about 1.35E+02 pCi/L occurs at approximately 2,000 yr. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99 as illustrated on Figure 5.2.21.

The contaminants I-129, C-14, and the uranium isotopes are all assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.22 and 5.2.23. The peak I-129 groundwater concentration is approximately 6.8E-02 pCi/L and occurs at approximately 7,600 yr. The U-238 groundwater concentration is approximately 1.1E-01 pCi/L at 10,000 yr, and appears to still be increasing.

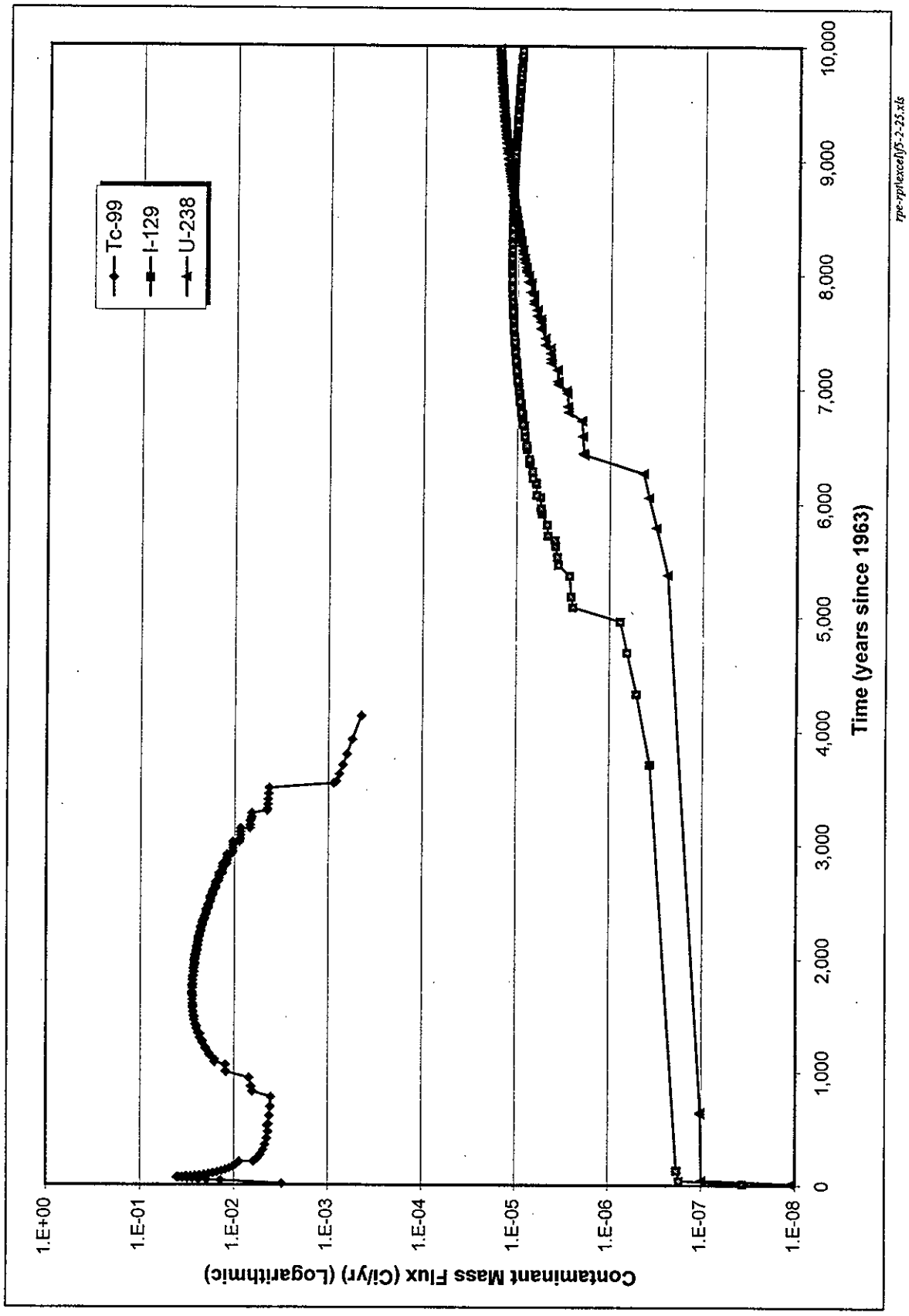
Residual Source Term

The CoC for the residual source term are listed in Appendix B (see Appendix A for a discussion of the inventory). Figures 5.2.8, 5.2.9, and 5.2.10 are the mass flux versus time for the residual source term associated with this option as well as the others. The large retrieval leakage of 151 m^3 (40,000 gal.) per tank has only a very minor impact on the residual time to peak and peak mass flux compared when compared to the Baseline Retrieval/Restricted Land Use strategy, as illustrated in these figures. The maximum Tc-99 groundwater concentrations resulting from the residual source term are equal to or slightly lower than those of Strategy 1 for the corresponding times (Figure 5.2.11).

Composite Results

The composite mass flux through the vadose zone for this strategy is presented in Figure 5.2.25 for three selected contaminants (i.e., Tc-99, I-129, and C-14). The y-axis values of mass flux on these figures are not comparable to the previously presented mass flux versus time plots for past

Figure 5.2.25. Mass Flux Versus Time for Tc-99, I-129, and U-238 for the Composite of All Source Terms - Large Retrieval Losses (Option 1b)



leaks and potential retrieval leak losses. The composite results are contaminant-specific and the past leaks and potential retrieval leak loss mass flux are for the entire K_d group and, as such, are based on a unit initial concentration.

The trends illustrated in Figure 5.2.25 depart noticeably from those for the Baseline Retrieval/Restricted Land Use strategy shown in Section 5.2.1.7, primarily because of the large retrieval leakage loss (i.e., 151 m^3 [40,000 gal.]) per tank associated with this option. The upward shift (i.e., greater mass flux) of the curves is even more evident for this option when a comparison is made between Figures 5.2.25, 5.2.14, and 5.2.24.

Figures 5.2.15, 5.2.16, and 5.2.17 illustrate the maximum groundwater concentration for Tc-99, I-129, and U-238 versus time for the composite of the source components. The Tc-99 maximum groundwater concentrations decrease uniformly from about 87 pCi/L at 150 yr to about 34 pCi/L after 600 yr. The concentration then begins to increase, reaching a peak of about 144 pCi/L after about 2,000 yr compared to the Strategy 1 Tc-99 concentration, which reaches a peak of about 18 pCi/L also after about 2,000 yr. The I-129 maximum groundwater concentrations follow the same type of trend as illustrated by Strategy 1, except that the peak is somewhat greater. This option (Option 1b) has a I-129 peak of about 8.65E-02 pCi/L at 7,600 yr compared to Strategy 1, which has a peak I-129 concentration of about 1.2E-02 pCi/L, also at 7,600 yr.

The U-238 groundwater concentrations for both Strategy 1 and Option 1b continue to increase at 10,000 yr. At 10,000 yr, the U-238 concentrations are 1.24E-01 and 6.18E-03 for Option 1b and Strategy 1, respectively.

5.2.4 Optimal Residual Volume (Option 1c)

This option includes the past leaks, 30 m^3 (8,000 gal.) retrieval loss from each of the four tanks, and a 1 m^3 (36 ft^3) residual volume that is considered optimal. The tanks would be backfilled, and the tank farm area would be covered with an enhanced RCRA Subtitle C barrier. This option is closely related to Option 1a and Strategy 1. The only variants are in the retrieval loss and the amount of residual waste that would remain after retrieval. This strategy included a 30 m^3 (8,000 gal.) per tank retrieval loss, whereas there would be no retrieval loss under Strategy 1. This option includes a 0.1 percent residual waste volume (1 m^3 [36 ft^3]), whereas there would be a 1 percent (10 m^3 [360 ft^3]) residual left in the tanks for Strategy 1 and Option 1a. A comparison of Option 1c with Strategy 1 is provided in the following sections.

5.2.4.1 Past Leaks

The groundwater impacts of the past leak source component for Option 1c are assumed to be identical to the impacts calculated for Strategy 1 in Section 5.2.1.

5.2.4.2 Retrieval Leakage Loss

There was no retrieval leakage loss for Strategy 1, therefore the 30 m^3 (8,000 gal.) per tank retrieval leakage loss assumed for this option represents an additional source term. Retrieval leakage loss is assumed to be identical to losses assumed for Option 1a (Section 5.2.2.1).

5.2.4.3 Residual Losses

With two exceptions, the residual loss occurs and is simulated in the same way as described for Strategy 1 discussed in Section 5.2.1.3. The first difference in the simulation for this strategy is in the initial moisture content in the vadose zone. For Option 1c the moisture conditions that were calculated to exist after the retrieval leakage loss were used as the initial moisture conditions for the residual loss. Secondly, Option 1c assumes that there would be a 0.1 percent residual waste volume remaining in the tank versus the 1 percent residual waste volume assumed for Strategy 1.

5.2.4.4 Recharge

The recharge assumptions are the same as indicated for Strategy 1, as discussed in Section 5.2.1.4.

5.2.4.5 Enabling Assumptions

The enabling assumptions are the same as provided for Strategy 1 and Option 1a, as discussed in Sections 5.2.1.4 and 5.2.2.5, respectively.

5.2.4.6 Option-Specific Data Gaps

The option-specific data gaps are the same as provided for Strategy 1 and Option 1a, as discussed in Sections 5.2.1.6 and 5.2.2.6, respectively.

5.2.4.7 Results for the Optimal Residual Losses (Option 1c)

In this section, the long-term groundwater impact results are discussed for each of the applicable source components and for the option as a whole (i.e., composite of all the source components). The following discussions focus on the comparison between the results of Option 1c and the results of Strategy 1.

Past Leaks Source Term

The CoCs in the past leaks are the same as for Strategy 1. The vadose zone mass flux and contaminant concentrations in groundwater are the same as described for the past leak impacts in Section 5.2.1.7.

Retrieval Source Term

Strategy 1 did not have a retrieval loss, thus the 30 m^3 (8,000 gal.) per tank retrieval loss assumed for this option represents an additional source term when compared to Strategy 1. Option 1a included an assumed retrieval loss source identical to that assumed for this option. The impacts from the retrieval loss source term for Option 1c are identical to those calculated for Option 1a, as discussed in Section 5.2.2.7.

Residual Source Term

The CoCs in the residual waste are the same as Strategy 1 listed in Appendix B (see Appendix A for a discussion of the inventory). Figures 5.2.8, 5.2.9, and 5.2.10 are the mass flux versus time for Option 1c for Tc-99, I-129, and U-238, respectively. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined

aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2) the maximum mass flux occurs at approximately 2,260 yr, about the same time calculated for Strategy 1. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately 8,750 yr (Figure 5.2.9). The uranium isotopes are assumed to all have a K_d of 0.6 mL/g for the entire vadose zone. The mass flux for the uranium isotopes (Figure 5.2.10) is still increasing at 10,000 yr. For comparison the time to peak mass flux and flux rate at the peak for Option 1c and Strategy 1 are provided in Table 5.2.6.

Table 5.2.6. Comparison of Mass Flux Characteristics for Residual Source Term Components, Strategy 1 and Option 1c

	Tc-99	I-129	U-238
Restricted Land Use (Strategy 1) (No Retrieval loss)			
Time to peak mass flux (yr)	2,300	8,700	>10,000
Mass flux at peak (Ci/yr)	2.69E-03	1.08E-06	6.39E-07
Restricted Land Use–Optimal Residual Volume (Option 1c)			
Time to peak mass flux (yr)	2,260	8,750	>10,000
Mass flux at peak (Ci/yr)	4.75E-04	1.80E-07	2.74E-07

When comparing Strategy 1 to Option 1c it is apparent that the time to peak mass flux is virtually the same. The mass flux rate for Option 1c is lower, which is expected given that the residual mass is approximately one-tenth that assumed for Strategy 1.

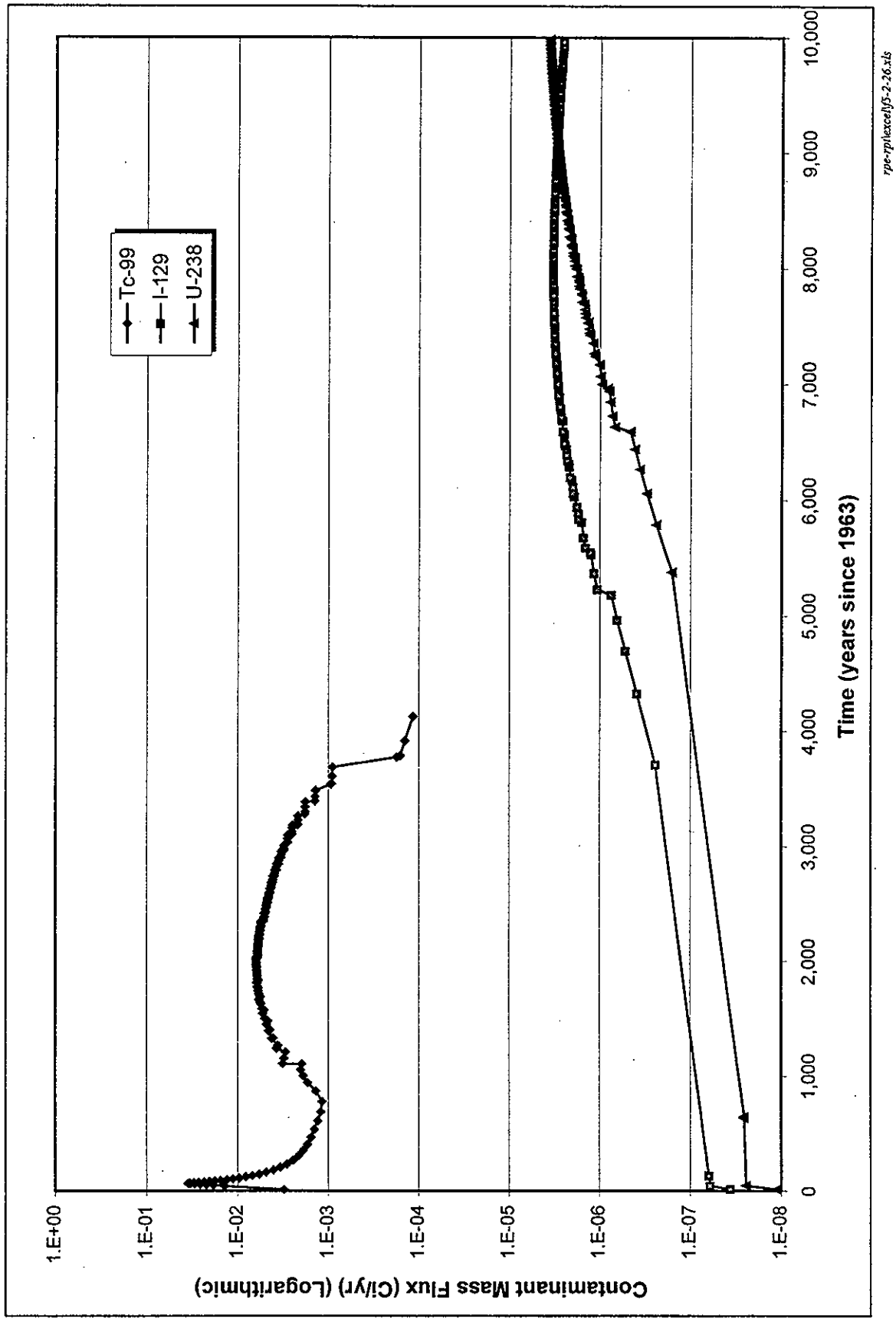
The same types of trends are reflected in the groundwater, as illustrated by contaminant mass flux through the vadose zone plots. Figure 5.2.11 illustrates the maximum groundwater concentration for Tc-99 versus time for the residual source component. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99, as illustrated in the maximum groundwater concentration versus time figure (Figure 5.2.11). The peak concentration in the groundwater occurs at approximately the same time as it does for Strategy 1 (Figure 5.2.11). When compared to Strategy 1, the magnitude of the peak is correspondingly smaller due to the smaller residual volume.

The contaminants I-129, C-14, and the uranium isotopes are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated on Figures 5.2.12 and 5.2.13, respectively. The peak concentration occurs at approximately 10,000 yr (as it does for Strategy 1) and the magnitude is correspondingly smaller.

Composite Results

The composite mass flux through the vadose zone for this option is presented in Figure 5.2.26 for three selected contaminants (i.e., Tc-99, I-129, and C-14). The y-axis values of mass flux on these figures are not comparable to the previously presented mass flux versus time plots for past leaks and retrieval losses because the composite results are contaminant-specific and the past leak and sluicing loss mass flux are for the whole K_d group and are based on a unit initial concentration.

Figure 5.2.26. Mass Flux Versus Time for Tc-99, I-129, and U-238 for the Composite of All Source Terms - Optimal Residual Volume (Option 1c)



rpe-rplexcel/f5-2-26.xls

Comparing the mass flux (illustrated previously on Figure 5.2.14) for Strategy 1 with the mass flux shown on Figure 5.2.26 for this option indicates the greatest difference is between the curves for Tc-99. The Tc-99 mass flux curve illustrated in Figure 5.2.26 is shifted upward compared to that of Strategy 1 (Figure 5.2.14), in response to the addition of the 30 m^3 (8,000 gal.) per tank retrieval loss residual assumed for this option. Figure 5.2.24 illustrates the mass flux through the vadose zone for Option 1a, which includes retrieval loss and a 10 m^3 (360 ft^3) residual volume. By comparing the mass flux for the composite source term in Figure 5.2.24 with the mass flux in Figure 5.2.26 it becomes evident that the difference between mass fluxes for a 1 m^3 (36 ft^3) residual volume assumed for this option compared to that of Option 1a (a 10 m^3 [360 ft^3] residual volume) is small.

The impact of the 1 m^3 (36 ft^3) residual volume on maximum groundwater concentrations compared to that of 10 m^3 (360 ft^3) residual volume (Option 1a) is likewise small for the composite of the source terms as shown in Figures 5.2.15, 5.2.16, and 5.2.17.

5.2.5 Suboptimal Residual Volume (Option 1d)

This option includes the past leaks, a 30-m^3 (8,000-gal.) retrieval leakage loss from each of the four tanks, and a 100 m^3 (3,600 ft^3) residual volume, which is considered suboptimal. The tanks would be backfilled and the tank farm area would be covered with an enhanced RCRA Subtitle C barrier. This option is closely related to Option 1a and Strategy 1. The only variants are in the retrieval leakage loss and the amount of residual waste that would remain after retrieval. This option included a 30 m^3 (8,000 gal.) per tank retrieval leakage loss, whereas there would be no retrieval loss under Strategy 1. This option includes a 100 m^3 (3,600 ft^3) residual waste volume, whereas there would be a 10 m^3 (360 ft^3) residual volume left in the tanks for both Strategy 1 and Option 1a. This option is compared to Strategy 1 in the following sections.

5.2.5.1 Past Leaks

Groundwater impacts of the past leak source component for this option are assumed to be identical to those calculated for Strategy 1 in Section 5.2.1.

5.2.5.2 Retrieval Leakage Loss

There was no retrieval leakage loss for Strategy 1, therefore the 30 m^3 (8,000 gal.) per tank retrieval leakage loss assumed for this option represents an additional source term. The retrieval leakage loss is assumed to be identical to those assumed for Option 1a (Section 5.2.2.1).

5.2.5.3 Residual Loss

The residual loss occurs and is simulated in the same way as described for Strategy 1, discussed in Section 5.2.1.3, with two exceptions. First, for this option the simulation relies on an initial moisture content in the vadose zone that was calculated to exist after the 30 m^3 (8,000 gal.) retrieval leakage loss. Secondly, this option assumes that there would be a 100 m^3 (3,600 ft^3) residual volume remaining in the tank versus the 10 m^3 (360 ft^3) residual volume assumed for Strategy 1.

5.2.5.4 Recharge

The recharge assumptions are the same as indicated for Strategy 1 as discussed in Section 5.2.1.4.

5.2.5.5 Enabling Assumptions

The enabling assumptions are the same as provided for Strategy 1 and Option 1a, as discussed in Sections 5.2.1.4 and 5.2.1.6, respectively.

5.2.5.6 Option-Specific Data Gaps

The option-specific data gaps are the same as provided for Strategy 1 and Option 1a, as discussed in Sections 5.2.1.6 and 5.2.2.6, respectively.

5.2.5.7 Results for the Suboptimal Residual Losses Option (Option 1d)

In this section the long-term groundwater impact results are discussed for each of the applicable source components and for the option as a whole (i.e., composite of all the source components). The following discussions focus on the comparison between the results of this option and the results of Strategy 1.

Past Leaks Source Term

The CoCs in the past leaks are the same as for Strategy 1. The vadose zone mass flux and contaminant concentrations in groundwater are the same as described for the past leak impacts in Section 5.2.1.7.

Retrieval Source Term

The CoCs in the retrieval source term are the same as for Option 1a (see Appendix A for a discussion of the inventory). Strategy 1 did not have a retrieval loss, thus the 30 m^3 (8,000 gal.) per tank retrieval loss assumed for this option represents an additional source term when compared to Strategy 1. Option 1a included an assumed retrieval leakage loss source identical to that assumed for this option. The impacts from the retrieval leakage loss source term for this option are identical to those calculated for Option 1a and discussed in Section 5.2.2.7.

Residual Source Term

The CoCs in the residual waste source term are the same as for Strategy 1 (see Appendix A for a discussion of the inventory). Figures 5.2.8, 5.2.9, and 5.2.10 are the mass flux versus time for Tc-99, I-129, and U-238 for this option as well as the others. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2) the maximum mass flux occurs at approximately 3,000 yr, which is approximately 775 yr later than the peak was calculated to occur for Strategy 1. For Tc-99 the mass would be completely through the vadose zone after about 5,000 yr. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the mass flux rate is still increasing at 10,000 yr, the end of the period of interest (Figure 5.2.9). The uranium isotopes are assumed to have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for the uranium isotopes

(Figure 5.2.10) also are still increasing after 10,000 yr. For comparison the time to peak mass flux and flux rate at the peak for Option 1d and Strategy 1 are provided in Table 5.2.7.

Table 5.2.7 Comparison of Mass Flux Characteristics for Residual Source Term Components, Strategy 1 and Option 1d

	Tc-99	I-129	U-238
Baseline Retrieval/Restricted Land Use (Strategy 1) (No Retrieval Loss)			
Time to peak mass flux (yr) (Ci/yr)	2,300	8,700	>10,000
Mass flux at peak (Ci/yr)	2.69E-03	1.08E-06	6.39E-07
Baseline Retrieval/Restricted Land Use-Suboptimal Residual Volume (Option 1d)			
Time to peak mass flux (yr)	3,000	>10,000	>10,000
Mass flux at peak (Ci/yr)	2.43E-02	5.78E-06	4.65E-06

The mass flux rate for Option 1d is higher as is expected given that the residual mass is approximately 10 times the volume that was assumed for Strategy 1.

The same types of trends are reflected in the groundwater as illustrated by contaminant mass flux through the vadose zone plots. Figure 5.2.11 illustrates the maximum groundwater concentration for Tc-99 versus time for the residual source component. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99 as illustrated in the maximum groundwater concentration versus time figure (Figure 5.2.11). The peak concentration in the groundwater occurs at a slightly later time than it does for Strategy 1 (Figure 5.2.11). The magnitude of the peak, when compared to Strategy 1, is correspondingly larger due to the larger residual volume.

The contaminants I-129, C-14, and the uranium isotopes are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated on Figures 5.2.12 and 5.2.13, respectively. The peak concentration occurs at approximately 10,000 yr, similar to Strategy 1, and the magnitude is correspondingly larger.

Composite Results

The composite mass flux through the vadose zone for this option is presented in Figure 5.2.27 for three selected contaminants (i.e., Tc-99, I-129, and C-14). The y-axis values of mass flux on these figures are not comparable to the previously presented mass flux versus time plots for past leaks and retrieval sluicing losses. This is because the composite results are contaminant-specific and the past leak and sluicing loss mass flux are for the whole K_d group and, as such, are based on a unit initial concentration.

The source terms between this option and Strategy 1 differ in two ways. Option 1d would have a 30 m^3 (8,000 gal.) per tank retrieval leakage loss and Strategy 1 would not have any retrieval leakage loss, in addition, Option 1d would have a 100 m^3 (3,600 ft^3) residual waste volume, whereas Strategy 1 would have a 10 m^3 (360 ft^3) residual waste volume. When comparing the composite mass fluxes the most noticeable difference between the two options is for Tc-99. Compared to that of Strategy 1 (Figure 5.2.14), the Tc-99 mass flux curve illustrated in Figure 5.2.27 (Option 1d) is shifted upward in response to the addition of the 30 m^3 (8,000 gal.)

per tank retrieval leakage loss assumed for this option and the larger (i.e., a 100 m^3 [3,600 ft^3] residual volume) residual waste volume.

Assessing the impact of the larger 100 m^3 (3,600 ft^3) residual waste volume requires comparing this option and Option 1a, which would have the same retrieval leakage loss (i.e., 30 m^3 [8,000 gal.] per tank) but only a 10 m^3 (360 ft^3) residual waste volume. Figure 5.2.24 illustrates the mass flux for the composite source terms through the vadose zone for Option 1a.

The Tc-99 mass flux for this option (Option 1d) is significantly shifted upwards (Figure 5.2.27) compared to the Tc-99 mass flux for Option 1a. The differences between mass fluxes for I-129 and U-238 for the two options appears much smaller.

The maximum groundwater concentrations for Tc-99 also shows an upward shift after about 1,200 yr when compared to the maximum Tc-99 groundwater concentrations associated with Strategy 1 (Figure 5.2.15). There is also a relatively small upward shift of the I-129 and U-238 groundwater concentration curves when compared to Strategy 1 and Option 1a (Figures 5.2.16 and 5.2.17, respectively).

5.2.6 Temporary Operations Barrier (Option 1e)

This option includes the past leaks, 30 m^3 (8,000 gal.) retrieval leakage loss from each of the four tanks, and 10 m^3 (360 ft^3) residual volume. In addition, prior to retrieval a temporary operations barrier would be applied over the tank farm in the year 2000 to reduce the infiltration of precipitation. Following retrieval, the tanks would be backfilled and the tank farm area covered with an enhanced RCRA Subtitle C barrier.

5.2.6.1 Past Leaks

The simulation of past leaks is similar to that of Strategy 1, the Baseline Retrieval/Restricted Land Use strategy discussed in Section 5.2.1, with the exception in the reduced recharge beginning in the year 2000 due to installation of a temporary barrier. Otherwise the simulation of past leaks is conducted in the same way as for Strategy 1.

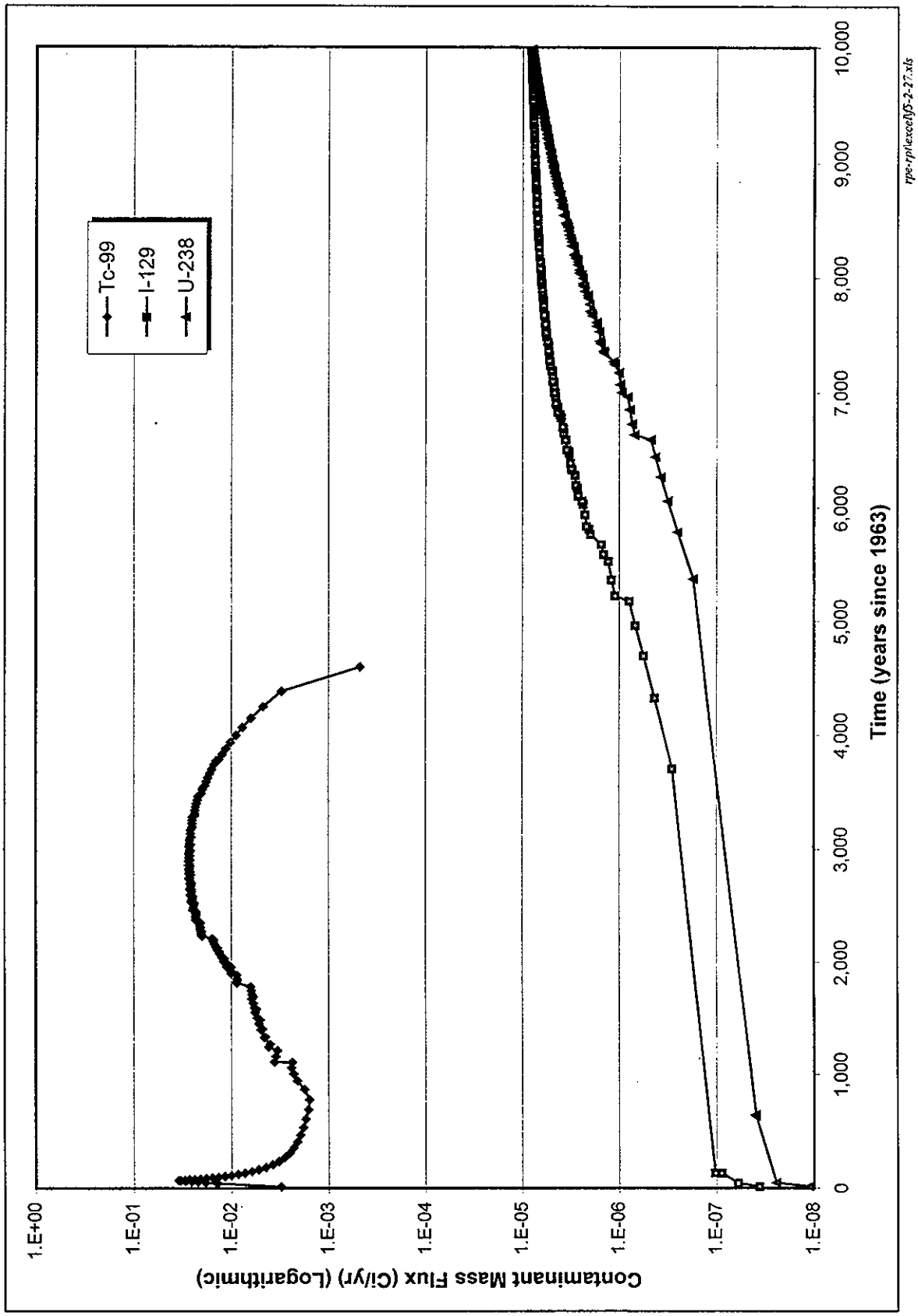
5.2.6.2 Retrieval Leakage Loss

There was no retrieval leakage loss for Strategy 1, therefore the 30 m^3 (8,000 gal.) per tank retrieval leakage loss assumed for this option represents an additional source term.
The simulation of retrieval leakage loss is identical to that for the Option 1a discussed in Section 5.2.2, except for the reduction of recharge that comes with installing the temporary barrier in 2000. The moisture conditions that were calculated to exist after the past leak and after the temporary barrier is installed are assumed for the initial moisture conditions for the retrieval leakage loss simulation. The temporary barrier is installed in 2000, resulting in a reduction of recharge from current conditions until the enhanced RCRA Subtitle C barrier is installed in 2020, which further reduces recharge.

5.2.6.3 Residual Loss

Residual loss occurs and is simulated in the same way as described for Strategy 1 discussed in Section 5.2.1.3, with two exceptions. Option 1e includes a retrieval leakage loss whereas Strategy 1 did not. Thus, for this option the simulation of residual loss considers the moisture

Figure 5.2.27. Mass Flux Versus Time for Tc-99, I-129, and U-238 for the Composite of All Source Terms - Suboptimal Residual Volume (Option 1d)



conditions that would exist after the retrieval leakage loss. Secondly, the simulations of residual loss also considers the effect of the temporary barrier on moisture conditions. Thus, for Option 1e the moisture conditions that were calculated to exist after the retrieval leakage loss, including the effect of the temporary barrier, were used as the initial moisture conditions for the residual loss.

5.2.6.4 Recharge

The recharge assumptions for this option are as follows.

- Prior to 1963, the year construction began on the AX Tank Farm, recharge is assumed to be a steady 3 mm/yr (0.12 in./yr) (same as for Strategy 1).
- Recharge is assumed to increase during tank construction from 3 to 100 mm/yr (0.12 to 3.94 in./yr) over a 1-yr period from 1963 to 1964 (same as for Strategy 1).
- Recharge remains at 100 mm/yr (3.94 in./yr) until the temporary surface barrier is assumed to be installed in the year 2000. Recharge drops to 3 mm/yr (0.12 in./yr) over a 1-yr period from 2000 to 2001 in response to the temporary surface barrier.
- Recharge remains at 3 mm/yr (0.12 in./yr) until the year 2020 when the enhanced RCRA Subtitle C barrier is assumed to be installed.
- Recharge is assumed to drop from 3 to 1 mm/yr (0.12 to 0.04 in./yr) over a 1-yr period from 2020 to 2021 in response to the enhanced RCRA Subtitle C barrier (same as Strategy 1).
- Recharge is assumed to remain at 1 mm/yr (0.04 in./yr) for 500 yr (same as Strategy 1).
- Recharge is assumed to increase from 1 to 3 mm/yr (0.04 to 0.12 in./yr) over a 10-yr period from 2521 to 2531 as the enhanced RCRA Subtitle C barrier is assumed to degrade to a natural conditions state (same as Strategy 1).
- Recharge remains at 3 mm/yr (0.12 in./yr) for the duration of the simulation (same as Strategy 1).

5.2.6.5 Enabling Assumptions

The enabling assumptions are the same as provided for Strategy 1 and Option 1a, as discussed in Sections 5.2.1.4 and 5.2.1.6, respectively.

5.2.6.6 Option-Specific Data Gaps

The option-specific data gaps are the same as provided for Strategy 1 and Option 1a, as discussed in Sections 5.2.1.6 and 5.2.2.6, respectively.

5.2.6.7 Results for the Temporary Barrier (Option 1e)

In this section, the long-term groundwater impact results are discussed for each of the applicable source components and for the option as a whole (i.e., composite of all the source components). The following discussions focus on the comparison between the results of Option 1e and the results of Strategy 1.

Past Leaks Source Term

The CoCs in the past leaks include all of those listed in Section 5.2.1 except EDTA and cyanide, for which there are no inventory data (see Appendix A for a discussion of the inventory). Figures 5.2.2, 5.2.3, and 5.2.4 present the calculated mass flux versus time for this option as well as the others for an initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant mass flux trend to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2), the mass flux peak occurs at approximately 40 yr. The K_d zero contaminants would have completely passed through the vadose zone after about 5,000 yr. For the contaminants with K_d of zero in the near-field and K_d of 0.6 mL/g in the far-field (i.e., I-129 and C-14), the peak mass flux occurs at approximately 7,800 yr (Figure 5.2.3). The uranium isotopes are assumed to have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for the uranium isotopes (Figure 5.2.4) occurs at approximately 9,500 yr. The time to peak mass flux and the relative mass flux rate at the peak rate for this option and Strategy 1 are tabulated on Table 5.2.8 for the three K_d groups.

Table 5.2.8. Comparison of Mass Flux Characteristics for Past Leak Components, Strategy 1 and Option 1e

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Past leak source term component (Strategy 1)			
Time to peak mass flux (yr)	65	7,400	8,750
Relative mass flux at peak for C = 1 initial source concentration	2.35E-01	5.22E-03	5.15E-03
Past leak source term component–Temporary Operations Barrier (Option 1e)			
Time to peak mass flux (yr)	40	7,800	9,460
Relative mass flux at peak for C = 1 initial source concentration	9.11E-02	5.56E-03	5.19E-03

The relative peak mass flux rates for Strategy 1 and Option 1e are on the same order of magnitude for K_d groups 1 and 2 (I-129, C-14, and the uranium series, respectively). The relative mass flux peak rates for the K_d group zero contaminants (i.e., Tc-99, Se-79, NO_3, and NO_2) are slightly lower for this option when compared to Strategy 1.

The same type of trends are reflected in the groundwater as illustrated in the contaminant mass flux through the vadose zone plots. Figure 5.2.5 illustrates the maximum groundwater concentration for Tc-99 versus time for the past leak source component. Tc-99 maximum concentrations in groundwater decrease uniformly from about 21 pCi/L at 150 yr to 7.9 pCi/L at 600 yr. The concentrations then increase to a peak value of about 21 pCi/L at 1,200 yr followed by a gradual decrease to about 2.68E-01 pCi/L at 5,000 yr, and sharply declining thereafter.

For approximately the first 400 yr, the maximum Tc-99 concentration in groundwater tracks slightly lower than for any of the other restricted land use strategies, except for Nominal Losses/Soil Grouting (Option 1g) and Large Losses/Soil Grouting (Option 1h), in response to the effect of the reduced recharge attributed to the temporary barrier. From approximately 400 to 5,000 yr the maximum Tc-99 groundwater concentrations for this option track at or slightly above the Restricted Land Use strategy and options.

The contaminants I-129, C-14, and the uranium isotopes all are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.6 and 5.2.7. The I-129 peak concentration is approximately 1.24E-02 pCi/L and occurs at approximately 7,600 yr. The U-238 maximum concentration is approximately 6.91E-03 and occurs at approximately 10,000 yr and may not have peaked.

Retrieval Source Term

The CoCs in the retrieval source term are the same as those for Option 1a (see Appendix A for a discussion of the inventory). Figures 5.2.18, 5.2.19, and 5.2.20 present the mass flux versus time for this option as well as the others for an initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2), the maximum mass flux occurs at approximately 2,200 yr. For the contaminants with K_d of zero in the near-field and 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately 8,760 yr (Figure 5.2.19). The uranium isotopes are assumed to all have a K_d of 0.6 mL/g for the entire vadose zone. The mass flux for the uranium isotopes appears to continue to increase at 10,000 yr, the end of the period of interest (Figure 5.2.20). The time to peak mass flux and the relative mass flux rate at the peak rate are tabulated on Table 5.2.9 for the three K_d groups and for Option 1a for comparison.

Table 5.2.9. Comparison of Mass Flux Characteristics for Retrieval Source Term Components, Option 1a and Option 1e

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Retrieval source term component for Restricted Land Use–Nominal Retrieval Losses (Option 1a)			
Time to peak mass flux (yr)	1,950	8,300	>10,000
Relative mass flux at peak for C = 1 initial source concentration	7.22E-02	1.90E-02	1.15E-02
Retrieval source term component for Temporary Operations Barrier (Option 1e)			
Time to peak mass flux (yr)	2,200	8,760	>10,000
Relative mass flux at peak for C = 1 initial source concentration	9.35E-02	2.01E-02	9.26E-03

Notes:
Strategy 1 assumes there would be no retrieval leakage loss, thus there is no comparison between Strategy 1 and Option 1e on the basis of retrieval leakage loss.

Figure 5.2.21 illustrates the maximum groundwater concentration for Tc-99 versus time for the retrieval leakage loss source component. The Tc-99 groundwater peak concentration of approximately 4.1E+01 pCi/L occurs at approximately 2,600 yr. The other mobile contaminants

considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99, as illustrated in Figure 5.2.21.

The contaminants I-129, C-14, and the uranium isotopes all are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.22 and 5.2.23. The peak groundwater concentration for I-129 is approximately 1.24E-02 pCi/L and occurs at approximately 10,000 yr. The peak groundwater concentration for U-238, during the 10,000-yr period of interest, is approximately 1.6E-02 pCi/L and occurs at approximately 10,000 yr.

Residual Source Term

The CoCs in the residual waste are the same as those listed for Strategy 1 in Section 5.2.1 (see Appendix A for a discussion of the inventory). Figures 5.2.8, 5.2.9, and 5.2.10 present the mass flux versus time for this option as well as the others for Tc-99, I-129 and U-238. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2) the maximum mass flux occurs at approximately 2,300 yr. All of the Tc-99 would have passed through the vadose zone by about 5,000 yr. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately 8,800 yr (Figure 5.2.9). The uranium isotopes are assumed to all have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for the uranium isotopes (Figure 5.2.10) occurs at approximately 9,500 yr. Table 5.2.10 provides the times to peak mass flux and relative peak mass flux for this option and, for comparison, for Strategy 1 for the three K_d groups.

Table 5.2.10. Comparison of Mass Flux Characteristics for Residual Loss Components, Strategy 1 and Option 1e

	Tc-99	I-129	U-238
Residual source term component Strategy 1			
Time to peak mass flux (yr)	2,300	8,700	>10,000
Mass flux at peak (Ci/yr)	2.69E-03	1.08E-06	6.39E-07
Residual source term component–Temporary Operations Barrier (Option 1e)			
Time to peak mass flux (yr)	2,300	8,800	9,460
Mass flux at peak (Ci/yr)	2.71E-03	1.09E-06	5.19E-03

The same types of trends are reflected in the groundwater as illustrated by contaminant mass flux through the vadose zone plots. Figure 5.2.11 illustrates the maximum groundwater concentration for Tc-99 versus time for the residual source component. The peak Tc-99 maximum groundwater concentration is about 17 pCi/L and occurs at about 1,200 yr. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99 as illustrated in the maximum groundwater concentration versus time figure (Figure 5.2.11).

The contaminants I-129, C-14, and the uranium isotopes all are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated on Figures 5.2.12 and 5.2.13, respectively. The peak maximum I-129 concentration is approximately 7.4E-03 pCi/L and occurs at 10,000 yr, the end of the period of

interest. The groundwater concentration of U-238 also peaks at 10,000 yr and appears to increase beyond this period of interest.

Composite Results

The composite mass flux through the vadose zone for this option is presented in Figure 5.2.28 for three selected contaminants (i.e., Tc-99, I-129, and C-14). The y-axis values of mass flux on these figures are not comparable to the previously presented mass flux versus time plots for past leaks and retrieval leakage loss because the composite results are contaminant-specific and the past leak and retrieval leakage loss mass flux are for the whole K_d group and, as such, are based on a unit initial concentration.

The trends illustrated in Figure 5.2.28 are similar to those for Option 1a shown in Section 5.2.2.7, which also includes a 30 m^3 (8,000 gal.) per tank retrieval leakage loss as does this option. The effect of the temporary barrier is seen as a slight downward shift of the Tc-99 mass flux curve until approximately 1,500 yr after the simulation begins.

Figures 5.2.15, 5.2.16, and 5.2.17 illustrate the maximum groundwater concentration for Tc-99, I-129, and U-238 versus time for the composite of the source components. The same type of trend is in these figures when a comparison is made between this option and Strategy 1.

5.2.7 Postretrieval Hanford Barrier (Option 1f)

This option includes the past leaks, 30 m^3 (8,000 gal.) retrieval leakage loss from each of the four tanks, and residual waste volume equal to 10 m^3 (360 ft^3). In addition, the end state would include construction of a Hanford Barrier over the tank farm instead of the enhanced RCRA Subtitle C barrier that would be constructed under all of the other restricted land use options. The Hanford Barrier would allow approximately one-half the recharge rate and would have a design life twice as long as an enhanced RCRA Subtitle C barrier. As with the other options, the tanks would be backfilled with a structural fill prior to constructing the Hanford Barrier.

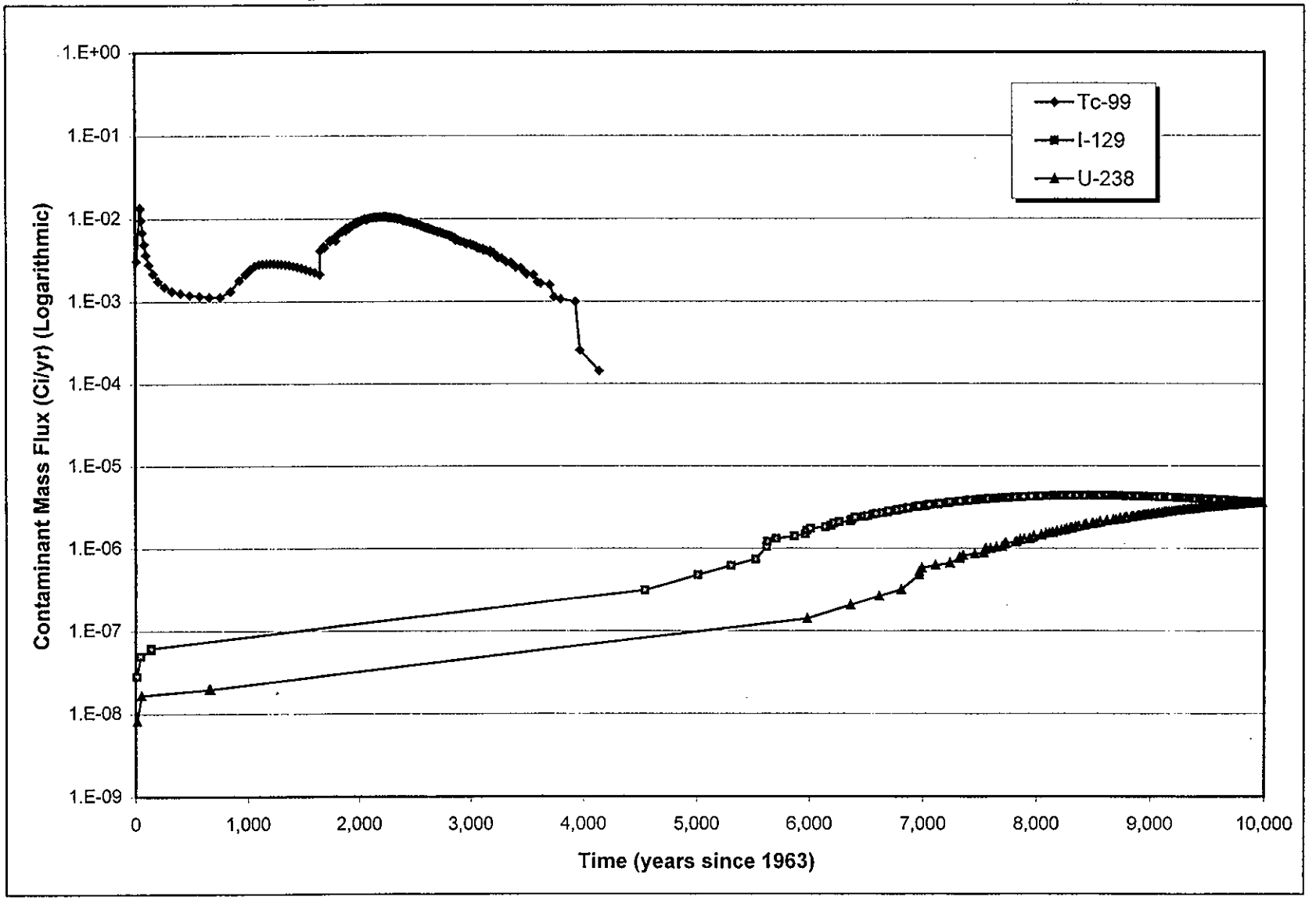
5.2.7.1 Past Leaks

The simulation of past leaks is similar to that for Strategy 1 discussed in Section 5.2.1 with the exception in the reduced recharge beginning in 2020 when the Hanford Barrier would be installed. The lower recharge rate (lower than the enhanced RCRA Subtitle C barrier) is assumed to remain constant for 1,000 yr compared to the 500-yr period for the enhanced RCRA Subtitle C barrier. Otherwise, the simulation of past leaks is done in the same way as for Strategy 1.

5.2.7.2 Retrieval Leakage Loss

The simulation of retrieval leakage loss is identical to that for Option 1a discussed in Section 5.2.2.2, except for the greater reduction of recharge that comes with the installation of the Hanford Barrier in 2020.

Figure 5.2.28. Mass Flux Versus Time for Tc-99, I-129, and U-238 for the Composite of All Source Terms - Temporary Operations Barrier (Option 1e)



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5.2.7.3 Residual Loss

Residual loss occurs and is simulated in the same way as described for Strategy 1, discussed in Section 5.2.1.3, with two exceptions. First, this option includes a retrieval leakage loss whereas Strategy 1 did not. Thus, for this option the simulation of residual loss considers the moisture conditions that would exist after the leakage losses. Secondly, the simulations of residual loss also reduces recharge in response to using the Hanford Barrier.

5.2.7.4 Recharge

The recharge assumptions for this option are as follows.

- Prior to 1963, the year construction of the AX Tank Farm began, recharge is assumed to be a steady 3 mm/yr (0.12 in./yr) (same as Strategy 1).
- Recharge is assume to increase during tank construction from 3 to 100 mm/yr (0.12 to 3.94 in./yr) over a 1-yr period from 1963 to 1964 (same as Strategy 1).
- Recharge remains at 100 mm/yr (3.94 in./yr) until the Hanford Barrier is assumed to be installed in the year 2020.
- Recharge drops to 100 to 0.5 mm/yr (3.94 to 0.02 in./yr) over a 1-yr period from 2020 to 2021 in response to the construction of the Hanford Barrier.
- Recharge is assumed to remain at 0.5 mm/yr (0.02 in./yr) for 1,000 yr.
- Recharge is assumed to increase from 0.5 to 3 mm/yr (0.02 to 0.12 in./yr) over a 10-yr period from 3021 to 3031 as the Hanford Barrier is assumed to degrade to a natural conditions state.
- Recharge remains at 3 mm/yr (0.12 in./yr) for the duration of the simulation (same as Strategy 1).

5.2.7.5 Enabling Assumptions

The enabling assumptions are the same as provided for Strategy 1 and Option 1a, as discussed in Sections 5.2.1.5 and 5.2.2.5, respectively.

5.2.7.6 Option-Specific Data Gaps

The option-specific data gaps are the same as provided for Strategy 1 and Option 1a, as discussed in Sections 5.2.1.6 and 5.2.2.6, respectively.

5.2.7.7 Results for the Postretrieval Hanford Barrier (Option 1f)

In this section, the long-term groundwater impact results are discussed for each of the applicable source components and for the option as a whole (i.e., composite of all the source components). The following discussions focus on the comparison between the results of Option 1f and the results of Strategy 1.

Past Leaks Source Term

The CoCs in the past leaks are the same as for Strategy 1 (see Appendix A for a discussion of the inventory). Previously presented on Figures 5.2.2, 5.2.3, and 5.2.4 are the calculated mass flux versus time for this option as well as the others for a initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant mass flux trend to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2), the mass flux peak occurs at approximately 65 yr. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately 8,000 yr (Figure 5.2.3). The uranium isotopes are assumed to all have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for the uranium isotopes (Figure 5.2.4) occurs at approximately 9,200 yr. The time to peak mass flux and the relative mass flux rate at the peak rate for Option 1f and Strategy 1 are tabulated on Table 5.2.11 for the three K_d groups. The relative peak mass flux rates are on the same order of magnitude for K_d Groups 1 and 2 (I-129, C-14, and the uranium series, respectively). The relative mass flux peak rates for the K_d groups 0 contaminants (Tc-99, Se-79, NO_3, and NO_2) are about two orders of magnitude higher that the other K_d groups.

Figure 5.2.5 illustrates the maximum groundwater concentration for Tc-99 versus time for the past leak source component.

Table 5.2.11. Comparison of Mass Flux Characteristics for Past Leak Components, Strategy 1 and Option 1f

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium isotopes)
Past leak source term component, Strategy 1			
Time to peak mass flux (yr)	65	7,400	8,750
Relative mass flux at peak for C = 1 initial source concentration	2.35E-01	5.22E-03	5.15E-03
Past leak source term component–Postretrieval Hanford Barrier (Option 1f)			
Time to peak mass flux (yr)	65	8,000	9,200
Relative mass flux at peak for C = 1 initial source concentration	2.35E-01	5.21E-03	5.19E-03

The Tc-99 groundwater concentrations from the past leak source term decrease in nearly a log-linear pattern from about 4.33E+01 pCi/L at 150 yr to 9.35 pCi/L at 600 yr. Also, for approximately the first 600 yr, the maximum Tc-99 concentration in groundwater tracks nearly the same as that for Strategy 1. From approximately 600 to 2,600 yr, the maximum Tc-99 groundwater concentrations for this option track below that of Strategy 1. The maximum Tc-99 groundwater concentrations in the period from 2,600 to 10,000 yr are very similar to those of Strategy 1 (Figure 5.2.5).

The contaminants I-129, C-14, and the uranium isotopes are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.6 and 5.2.7. The I-129 peak concentration is approximately 1.16E-02 pCi/L and occurs at approximately 7,600 yr. The U-238 maximum concentration is approximately 6.73E-03 and occurs at approximately 10,000 yr and may not have peaked.

Retrieval Source Term

The CoCs in the retrieval source term are the same as Option 1a (see Appendix A for a discussion of the inventory). Figures 5.2.18, 5.2.19, and 5.2.20 present the mass flux versus time for this option as well as the others for a initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown in these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2), the maximum mass flux occurs at approximately 2,400 yr. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately 8,800 yr (Figure 5.2.19). The uranium isotopes are assumed to all have a K_d of 0.6 mL/g for the entire vadose zone. The mass flux for the uranium isotopes (Figure 5.2.20) is still increasing at 10,000 yr. The time to peak mass flux and the relative mass flux rate at the peak rate are tabulated on Table 5.2.12 for the three K_d groups for this option (Option 1f) and Option 1a for comparison.

Table 5.2.12. Comparison of Mass Flux Characteristics for Retrieval Leakage Loss Components, Option 1a and Option 1f

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Retrieval source term component for Restricted Land Use–Nominal Retrieval Losses (Option 1a)			
Time to peak mass flux (yr)	1,950	8,300	>10,000
Relative mass flux at peak for C = 1 initial source concentration	7.22E-02	1.90E-02	1.15E-02
Retrieval source term component for Restricted Land Use–Postretrieval Hanford Barrier (Option 1f)			
Time to peak mass flux (yr)	2,400	8,800	>10,000
Relative mass flux at peak for C = 1 initial source concentration	7.45E-02	1.93E-02	1.15E-02

Notes:
Strategy 1 assumes there would be no retrieval leakage loss, thus there is no comparison between Strategy 1 and Option 1f on the basis of retrieval leakage loss.

Figure 5.2.21 illustrates the maximum groundwater concentration for Tc-99 versus time for the retrieval leakage loss source component. The Tc-99 groundwater peak concentration of approximately 4.2E+01 pCi/L occurs at approximately 2,600 yr. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99, as illustrated in Figure 5.2.21.

The contaminants I-129, C-14, and the uranium isotopes all are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.22 and 5.2.23. The peak groundwater concentration for I-129 is approximately 1.21E-02 pCi/L and occurs at 10,000 yr. The peak groundwater concentration for U-238, during the 10,000-yr period of interest, is approximately 1.94E-02 pCi/L and occurs at approximately 10,000 yr.

Residual Source Term

The CoCs in the residual waste are the same as Strategy 1 listed in Section 5.2.1 (see Appendix A for a discussion of the inventory). Figures 5.2.8, 5.2.9, and 5.2.10 present the mass

flux versus time for Tc-99, I-129, and U-238 for this option and the other under consideration. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For Tc-99, a K_d zero contaminant, the maximum mass flux occurs at approximately 2,700 yr. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately 9,200 yr (Figure 5.2.9). The uranium isotopes are assumed to have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for the uranium isotopes (Figure 5.2.10) occurs at approximately 10,000 yr. Provided in Table 5.2.13 are the times to peak mass flux rates for the residual source component of Option 1f and that of Strategy 1 for comparison.

Table 5.2.13. Comparison of Mass Flux Characteristics for Residual Loss, Strategy 1 and Option 1f

	Tc-99	I-129	U-238
Baseline Retrieval/Restricted Land Use strategy (Strategy 1)			
Time to peak mass flux (yr)	2,300	8,700	>10,000
Mass flux at peak (Ci/yr)	2.69E-03	1.08E-06	6.39E-07
Residual source term component–Postretrieval Hanford Barrier (Option 1f)			
Time to peak mass flux (yr)	2,700	9,200	>10,000
Mass flux at peak (Ci/yr)	2.71E-03	1.09E-06	5.68E-07

Figure 5.2.11 illustrates the maximum groundwater concentration for Tc-99 versus time for the residual source component. The Tc-99 mass flux peak occurred after about 2,300 yr and is reflected in the maximum Tc-99 groundwater concentration from residual releases source term 19 pCi/L which occurs at about 2,600 yr in the groundwater. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99 as illustrated in the maximum groundwater concentration versus time figure (Figure 5.2.11).

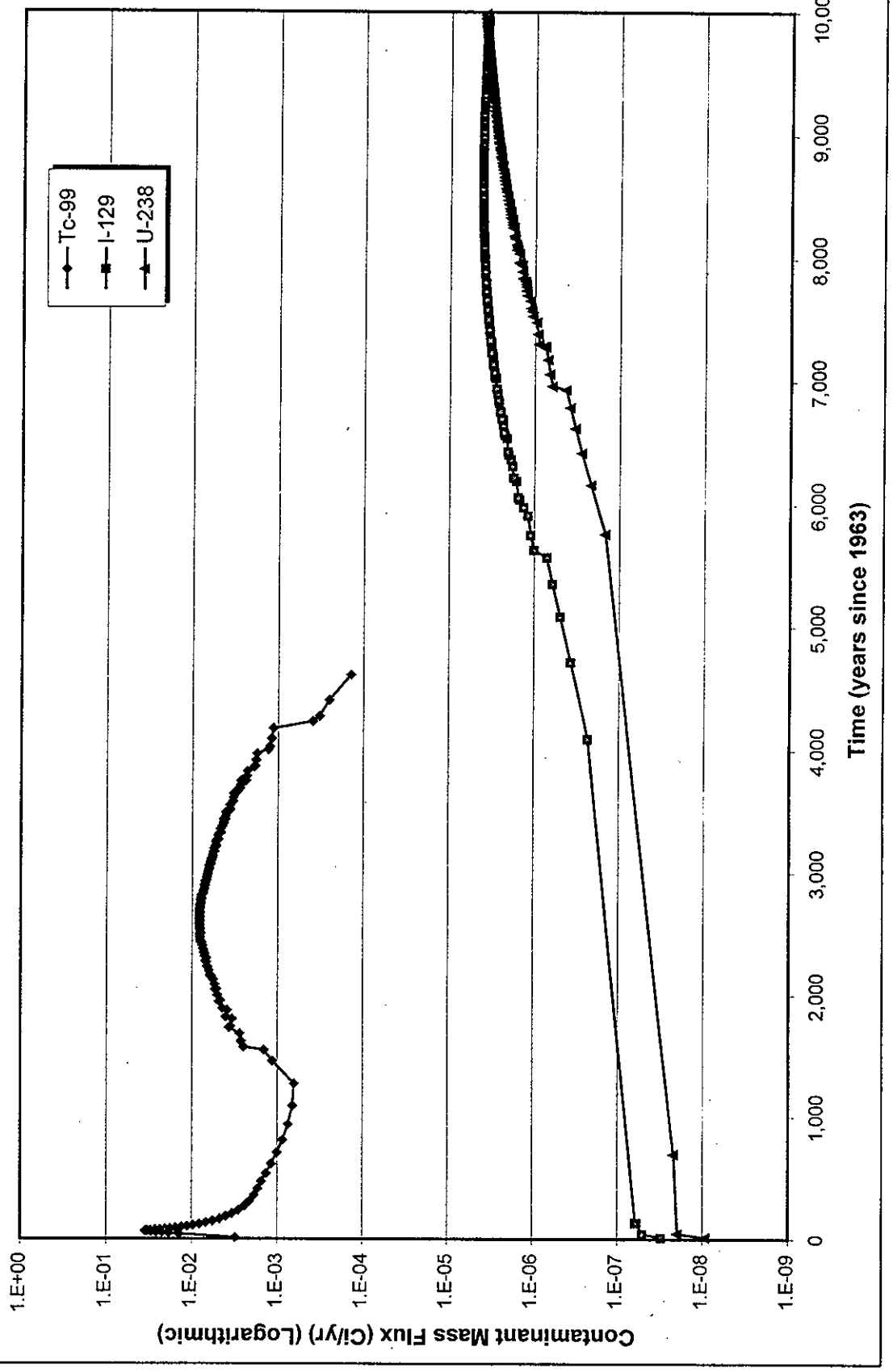
The contaminants I-129, C-14, and the uranium isotopes are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.12 and 5.2.13, respectively. The peak concentration, within the period of interest, is approximately 8.0E-03 pCi/L and 4.4E-03 pCi/L for I-129 and U-238, respectively. Both of the values occur at 10,000 yr.

Composite Results

The composite mass flux through the vadose zone for this option is presented in Figure 5.2.29 for three selected contaminants (i.e., Tc-99, I-129, and C-14). The y-axis values of mass flux in these figures are not comparable to the previously presented mass flux versus time plots for past leaks and retrieval leakage losses because the composite results are contaminant-specific and the past leak and sluicing loss mass flux are for the whole K_d group and, as such, are based on a unit initial concentration.

The trends illustrated in Figure 5.2.29 are similar to those for Option 1a shown in Section 5.2.2.7. The mass flux peaks appear to occur slightly later for this option, but the reduced recharge does little to reduce the magnitude of the peaks.

Figure 5.2.29. Mass Flux Versus Time for Tc-99, I-129, and U-238 for the Composite of All Source Terms - Postretrieval Hanford Barrier (Option 1f)



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Figures 5.2.15, 5.2.16, and 5.2.17 illustrate the maximum groundwater concentration for Tc-99, I-129, and U-238 versus time for the composite of the source components. From about 600 yr to 2,000 yr, the maximum Tc-99 composite groundwater concentration for Option 1f is less than for any of the Restricted Land Use strategy and options. At approximately 2,000 yr, the Tc-99 concentrations increase and then peak at 6.36E+01 pCi/L at approximately 2,600 yr.

5.2.8 Nominal Losses/Soil Grouting Option (Option 1g)

This option includes the past leaks, 30 m^3 (8,000 gal.) retrieval leakage loss from each of the four tanks, and 10 m^3 (360 ft^3) residual waste volume. In addition, prior to retrieval a horizontal grout blanket and leachate collection system would be installed approximately 7.6 m (25 ft) below the base of the tanks. It is assumed this system would be installed between the years 2000 to 2002 prior to retrieval operations, which would begin in the year 2004. Following retrieval, the tanks would be backfilled and the tank farm area covered with an enhanced RCRA Subtitle C barrier. The concept developed by Norman (1999) for the Nominal Losses/Soil Grouting option (Option 1g) is described in Section 4.3.8. It includes a sloping blanket that would direct flow toward a central collection point and would have a leachate collection system that would recover some of the retrieval leakage.

Fate and transport modeling for the Nominal Losses/Soil Grouting option (Option 1g) was not conducted in the same fashion as it was for Strategy 1 primarily because of the inability to adequately simulate the performance of the grouted mass. The approach to evaluating the contaminant fate and transport for this option involved some limited simulations combined with results of results from other analogous options. The approach used the following:

- The results from Option 1e for the past leak source term impacts
- An approximation of the retrieval loss impacts was developed using assumed grouted material parameters and limited simulations
- The results from Option 1f for the tank waste residuals source term impacts.

The subsurface grout blanket and drain system are assumed to be installed at least 2 yr prior to retrieval. These structures would be designed to intercept the retrieval leakage loss from the tanks as well as recharge that would percolate into the tank farm gravel surface. Thus, for the past leak source term, it is assumed the effects of the grout blanket/leachate collection system would be analogous to the Temporary Operations Barrier option (Option 1e). Likewise, for the residual source term, the grout blanket and grouted soil mass above the grout blanket are assumed to be stable, long-lived (i.e., 1,000-yr life), and would reduce the recharge. As such, the tank waste residual source term for the Postretrieval Hanford Barrier option (Option 1f) would be analogous to the Option 1g residual source term.

There are no options that would be analogous to retrieval leakage loss source term combined with the effects of the grout blanket/leachate collection system and subsequent grouted soil mass. Therefore, the impacts of this source term were approximated with a four-step vadose zone simulation approach. Normally, the assessment of the impacts could be accomplished with a two-step simulation; however, large numerical errors occurred when contaminant transport was

simulated with the grouted material properties. The four-step approach allows for some adjustment to the input parameters that reduce the numerical error. Because of this adjustment, the results carry more uncertainty than do the assessments for the other options. The results are commensurate with the current understanding of this option and associated implementability issues. Additional parameter value development (e.g., grouted soil hydraulic properties and contaminant mobility in grouted soil) as well as model development are required should this option be carried forward.

5.2.8.1 Past Leaks

The effect of past leaks is assumed to be the same as that of the Temporary Operations Barrier option (Option 1e) as discussed in Section 5.2.6.

5.2.8.2 Retrieval Leakage Loss

There was no retrieval leakage loss for Strategy 1, therefore the per tank 30-m^3 (8,000-gal.) retrieval leakage loss assumed for this option represents an additional source term. A grout blanket and leachate collection system are installed approximately 6.1 m (20 ft) below the base of the tanks prior to retrieval. The leachate collection system is assumed to be operational for a period of approximately 5 yr after the last tank is retrieval and is assumed to be effective in removing a portion of the retrieval leakage loss from the vadose zone. At the end of the 5-yr leachate collection period, vertical holes are drilled and the contaminated soils between the base of the tank and the grout blanket are grouted.

The assumptions concerning how the retrieval leakage loss occurs are identical to those of Option 1(as discussed in Section 5.2.2), except for the interception of some of the loss by the leachate collection system and release of the remaining retrieval leakage loss from the grouted soil mass between the tank base and the grout blanket. The moisture conditions that were calculated to exist after the past leak and after the temporary barrier is installed are assumed for the initial moisture conditions for the retrieval leakage loss simulation. The grout blanket and leachate collection system are assumed to be installed prior to retrieval operations and as early as the year 2000. An enhanced RCRA Subtitle C barrier is installed over the tanks in 2020. This complicated option requires a four-step approach to approximate the impact of retrieval leakage loss. These steps are as follows.

- Step one is to simulate the movement of contaminants from retrieval operations until the grout blanket/leachate collection system operations are discontinued 5 yr after waste from the last tank is retrieved. This initial concentration of the retrieval leakage loss fluid is set to one. The vadose zone hydraulic and transport parameters are the same as Strategy 1. The final concentration conditions within the entire domain are saved and the amount of mass passing the plane that corresponds to the elevation of the grout blanket is noted.

- Step two is to initiate the simulation in the year 2011.4, which is approximately 5 yr after waste from the last tank has been retrieved. Initial contaminant concentrations in the domain above the grout blanket are those that were saved from step one. Below the grout blanket, the initial contaminant concentration is set to zero. The vadose zone properties for the materials in the zone beneath the tanks, from base of the tanks to the grout

blanket, are set to those assumed for a grouted soil mass. The simulation is continued for the above conditions for the remainder of the 10,000-yr period of interest. At this time, the mass passing the plane of the grout blanket is noted. It is at this point in the assessment that large numerical errors are noted. Invariably, the mass passing the plane of the grout blanket is greater than what was initially input in step one.

- Step three is taken to adjust the mass observed in step two. This is accomplished by reducing the concentration of the retrieval leakage loss fluid. The simulation in step one is repeated with the reduced initial concentration to simulate the movement of contaminants from the retrieval operations until the grout blanket/leachate collection system operations are discontinued 5 yr after waste from the last tank is retrieved. The final concentration conditions within the entire domain are saved for the final step.

- Step four is similar to step two in that the simulation is initiated in the year 2011.4. Initial contaminant concentrations in the domain above the grout blanket are those that were saved from step three. Below the grout blanket, the contaminant concentration is set to zero. The vadose zone properties for the materials in the zone beneath the tanks, from base of the tanks to the grout blanket, are set to those assumed for a grouted soil mass. The simulation is continued for the above conditions for the remainder of the 10,000-yr period of interest and the total mass that reaches the water table is saved as input to the groundwater model.

5.2.8.3 Residual Loss

The effect of the residual loss is assumed to be the same as described for the Postretrieval Hanford Barrier option (Option 1f), as discussed in Section 5.2.7.

5.2.8.4 Recharge

The recharge assumptions for the retrieval leakage loss simulation for this option are as follows.

- Prior to 1963, the year construction of the AX Tank Farm began, recharge is assumed to be a steady 3 mm/yr (0.12 in./yr) (same as Strategy 1).

- Recharge is assumed to increase during tank construction from 3 to 100 mm/yr (0.12 to 3.94 in./yr) over a 1-yr period from 1963 to 1964 (same as Strategy 1).

- Recharge remains at 100 mm/yr (3.94 in./yr) until 2011.5, which is about 5 yr after waste has been retrieved from the last tank.

- Recharge is assumed to remain at zero for a period of about 9.5 yr prior to the installation of the enhanced RCRA Subtitle C barrier (in 2011.5) in the year 2021.

- Recharge is assumed to increase from zero to 1 mm/yr (0.04 in/yr) over a 1-yr period from 2020 to 2021 at which time the enhanced RCRA Subtitle C barrier construction would be complete.

- Recharge is assumed to remain at 1 mm/yr (0.04 in./yr) for 500 yr.

- Recharge is assumed to increase from 1 to 3 mm/yr (0.04 to 0.12 in./yr) over a 10-yr period from 2521 to 2531 as the enhanced RCRA Subtitle C barrier is assumed to degrade to a natural conditions state.

- Recharge remains at 3 mm/yr (0.12 in./yr) for the duration of the simulation (same as Strategy 1).

5.2.8.5 Enabling Assumptions

The enabling assumptions include those provided for Strategy 1 as discussed in Section 5.2.1.5. In addition, grout-related assumptions are provided in the following text. Key underlying assumptions for this option are 1) a continuous relatively impermeable grout blanket with a functional leachate collection system can be constructed in situ beneath all of the tanks; and 2) the soil mass between the grout blanket and base of the tank containing contaminants from retrieval leakage loss can be grouted in situ to form a continuous monolithic mass that effectively encapsulates the contaminants. Both of these assumptions are believed to be optimistic and the uncertainty associated with them should be considered in the context of discussion of the assumed grout mass parameter values that follows.

Grouted sediment hydraulic and transport properties have been assumed because there are no site-specific data. Grout properties could vary with the type of sediments underlying AX Tank Farm. They would be very difficult to test in situ because of the long test times that would be required and laboratory tests would not reveal the large scale properties of a large volume (i.e., several tens of cubic meters) of grouted vadose zone sediment. Especially important are the hydraulic conductivity and soil moisture retention curves for the grout and these are not available. Also of potential importance is the diffusion coefficient for contaminants in grout. Advective flow and retardation (also unknown in grout) are not expected to control contaminant migration, and diffusion processes are assumed to dominate.

Hanford Site soils, with their relatively high hydraulic conductivity (10^{-2} cm/sec) and low percentage of fines (approximately 5 percent) are expected to be groutable with the lower viscosity montan wax grout or sodium silicate grout formulations. Soils with relatively low hydraulic conductivity (i.e., $<10^{-5}$ cm/sec) generally are not amenable to in situ injection grouting. Data in Khaleel and Freeman (1995) for Hanford formation sands show a range in K_{sat} of about 1.38E-05 cm/sec to 0.058 cm/sec, with an average value of about 6.0E-03 cm/sec and a standard deviation of about 0.011 cm/sec. Voss et al. (1994) reports that the conductivity of Hanford Site bulk soil samples grouted with sodium silicate ranged from 6.2E-05 cm/sec to 5.1E-05 cm/sec. For Hanford Site soils, this represents a reduction in hydraulic conductivity of over three orders of magnitude. The hydraulic conductivity of Hanford Site soil samples grouted with montan wax grout were generally lower than their sodium silicate-grouted counterparts, with hydraulic conductivity values ranging from 3.7E-08 cm/sec to 1.6E-04 cm/sec, a two to five order of magnitude decrease in hydraulic conductivity.

For the purpose of modeling the options with grouted vadose zone sediment (Options 1g, 1h, 2b, and 2c), it was assumed that the Voss et al. (1994) test results indicating a K_{sat} reduction of two to three orders of magnitude would be applicable given the unconsolidated coarse grained sediments at the Hanford Site. The K_{sat} and the van Genuchten moisture retention parameters for grouted AX Tank Farm sediments were assumed to be the same as that for the Ringold

Formation sediments (Kincaid et al. 1995) and are presented in Table 5.2.14. The grouted soil was assigned a diffusion coefficient of 3.156 m^2/yr.

Table 5.2.14. Assumed Hydraulic Properties of Grouted Soil Mass[1]

Lithology	θ_s	θ_r	α (1/cm)	N	K_{sat} (cm/s)	Computed Bulk Density[2]
Grouted sediments	0.4982	0.0283	0.0176	1.338	2.42E-06	1.53

Notes:
[1] Source: Kincaid et al. (1995)
[2] Bulk density = $(1-\theta_s)$ • particle density, where the particle density is assumed to be 2.65 g/cm^3.

5.2.8.6 Option-Specific Data Gaps

The option-specific data gaps included those provided for the Baseline Retrieval/Restricted Land Use strategy (Strategy 1) as discussed in Section 5.2.1.6. In addition, site-specific data on the diffusion coefficient of grouted sediments representative of those below the AX Tank Farm may be significant in the transport calculation. Also, the grouted mass is assumed to be continuous and homogeneous. Implementability issues associated with obtaining a continuous homogeneous grout mass need further investigation should this option receive further consideration.

5.2.8.7 Results for the Nominal Losses/Soil Soil (Option 1g)

In this section, long-term groundwater impact results are discussed for each of the applicable source components and for the option as a whole (i.e., composite of all the source components). The following discussion focuses on the comparison between the results of this option and the results of the Baseline Retrieval/Restricted Land Use strategy (Strategy 1) (past leak, residual, and composite source terms) and Option 1a (retrieval source term).

Past Leaks Source Term

The CoCs in the past leaks are the same as for Strategy 1. The vadose zone mass flux and contaminant concentrations in groundwater are the same as described for the past leak impacts in Section 5.2.6.7 for the Temporary Operation Barrier option (Option 1e).

Retrieval Source Term

The CoCs in the retrieval source term include all of those listed in Section 5.2.1 (see Appendix A for a discussion of the inventory). Presented in Figures 5.2.18, 5.2.19, and 5.2.20 are the mass flux versus time for this option as well as the others. As previously described, the initial concentration of one (dimensionless) for each of the three K_d groups was adjusted downward to compensate for numerical errors encountered when attempting to simulate contaminant transport through the grout material. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2), the maximum mass flux occurs at approximately 3,300 yr. There still would be a flux of K_d zero contaminants to the water table at the end of the period of interest and the flux rate would be declining at the 10,000 yr time. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux would occur sometime after the 10,000-yr period of interest (Figure 5.2.19). All the uranium isotopes are assumed to have a K_d of 0.6 mL/g for the entire

vadose zone. The peak mass flux for the uranium isotopes (Figure 5.2.20) occurs sometime after the 10,000-yr period of interest. The time to peak mass flux and the relative mass flux rate at the peak rate for the past leak and retrieval source terms are tabulated in Table 5.2.15 for the three K_d groups.

Table 5.2.15. Comparison of Mass Flux Characteristics for Retrieval Leakage Loss Components, Option 1a and Option 1g

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Retrieval source term component for Restricted Land Use–Nominal Retrieval Losses (Option 1a)			
Time to peak mass flux (yr)	1,950	8,300	>10,000
Relative mass flux at peak for C = 1 initial source concentration	7.22E-02	1.90E-02	1.15E-02
Retrieval source term component for Restricted Land Use–Nominal Losses/Soil Grouting (Option 1g)			
Time to peak mass flux (yr)	3,300	>10,000	>10,000
Relative mass flux at peak for C = 1 initial source concentration	3.50E-04	1.29E-04	1.98E-04

Notes:

Strategy 1 assumes there would be no retrieval leakage loss, thus there is no comparison between Strategy 1 and Option 1g on the basis of retrieval leakage loss.

As illustrated previously, Figure 5.2.21 presents the maximum groundwater concentration for Tc-99 versus time for the retrieval leakage loss source component. The Tc-99 groundwater peak maximum concentration of about 4.4 pCi/L occurs at approximately 3,000 yr. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99 as illustrated on Figure 5.2.21. The contaminants I-129, C-14, and the uranium isotopes are all assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.22 and 5.2.23. The peak I-129 groundwater concentration is approximately 2.67E-03 pCi/L at 10,000 yr and may still be increasing. The U-238 groundwater concentration is approximately 1.0E-02 pCi/L at 10,000 yr, the end of the period of interest, and may still be increasing.

Residual Source Term

The CoCs in the residual waste source term are the same as those listed for Strategy 1 in Section 5.2.1 (see Appendix A for a discussion of the inventory). The vadose zone mass flux and contaminant concentrations in groundwater for the residual source term are the same as described for the residual source term impacts in Section 5.2.7.7 for the Postretrieval Hanford Barrier option (Option 1f).

Composite Results

The composite mass flux through the vadose zone for this option is presented in Figure 5.2.30 for three selected contaminants (i.e., Tc-99, I-129, and C-14). The y-axis values of mass flux in these figures are not comparable to the previously presented mass flux versus time plots for past leaks and retrieval leakage loss because the composite results are contaminant-specific and the past leak and retrieval leakage loss mass flux are for the whole K_d group and, as such, are based on an adjusted unit initial concentration.

The I-129 and U-238 trends illustrated in Figure 5.2.30 are similar to those for Option 1a shown in Section 5.2.2.7. The Tc-99 trend for this option trends lower (i.e., lower mass flux) at the second peak that occurs around 2,500 yr, compared to that of Option 1a due to the mass that was captured by the leachate collection system. There continues to be a slow Tc-99 flux to the groundwater for the entire period of interest due to the slow release of Tc-99 entrapped in the grouted soil.

Figures 5.2.15, 5.2.16, and 5.2.17 illustrate the maximum groundwater concentration for Tc-99, I-129, and U-238 versus time for the composite of the source components. From about 5,000 yr to 10,000 yr, the maximum Tc-99 composite groundwater concentrations for Option 1g slowly decrease from approximately 3.6 pCi/L at 5,000 yr to 1.2 pCi/L at 10,000 yr in contrast to the Strategy 1 Tc-99 maximum groundwater concentrations that dramatically decrease at 5,000 yr.

5.2.9 Large Losses/Soil Grouting Option (Option 1h)

This option includes the past leaks, 150 m^3 (8,000 gal.) retrieval leakage loss from each of the four tanks, and 10 m^3 (360 ft^3) residual waste volume. In addition, prior to retrieval a horizontal grout blanket and leachate collection system would be installed approximately 6.1 m (20 ft) below the base of the tanks. The concept developed by Norman (1999) for the Large Losses/Soil Grouting option (Option 1h) is described in Section 4.3.9 and is similar to Option 1g except for the larger retrieval loss.

Fate and transport modeling for the Large Losses/Soil Grouting option (Option 1h) was not conducted in the same fashion as it was for Strategy 1 for the same reasons discussed in Section 5.2.8 that being the inability to adequately simulate the performance of the grouted mass. The approach to evaluating the contaminant fate and transport for this option followed that developed for Option 1g and involved some limited simulations combined with results of results from other analogous options. The approach used the following:

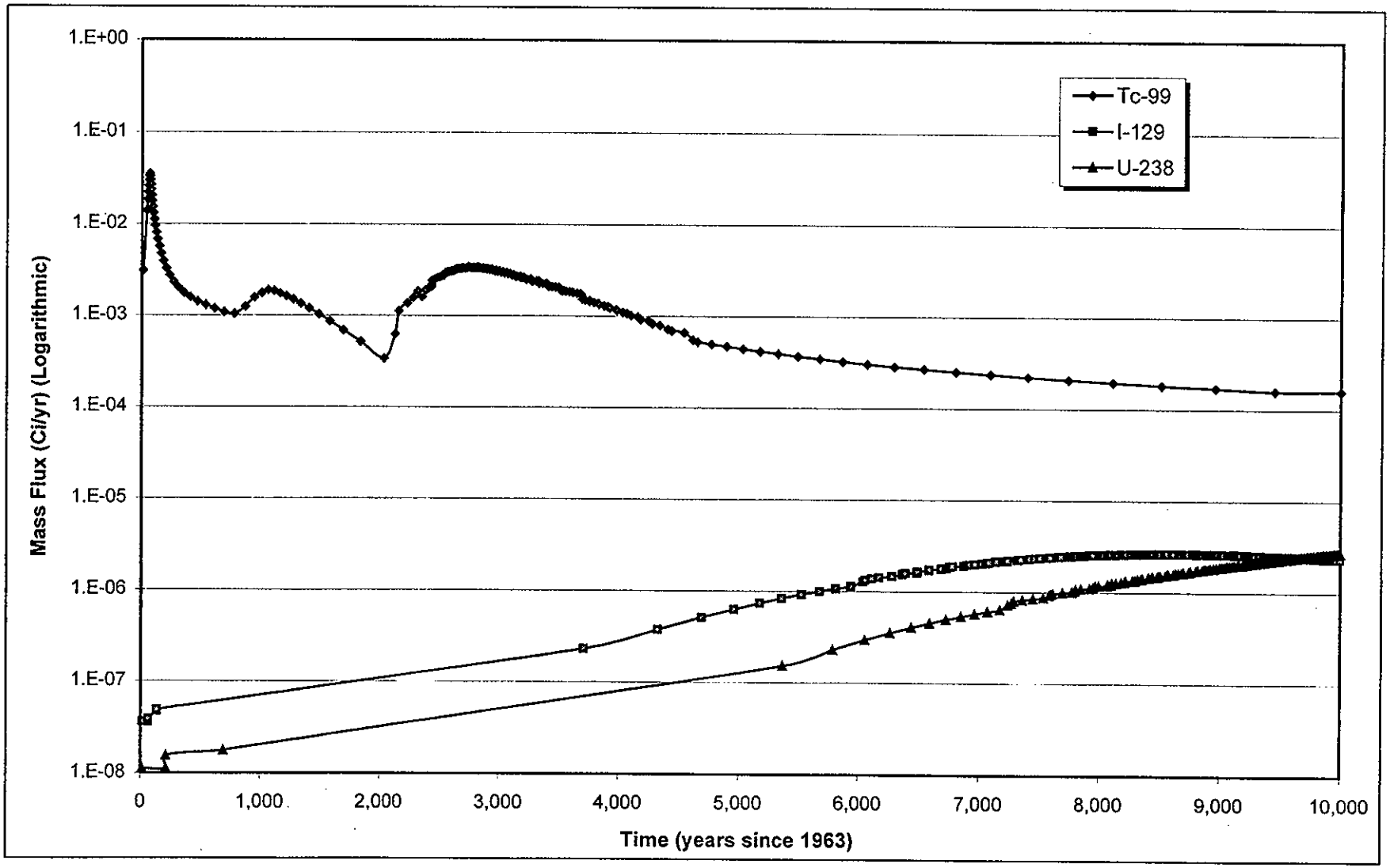
- The results from Option 1e for the past leak source term impacts
- An approximation of the large retrieval loss impacts was developed using assumed grouted material parameters and limited simulations
- The results from Option 1f for the tank waste residuals source term impacts.

There are no options that would be analogous to retrieval leakage loss source term combined with the effects of the grout blanket/leachate collection system and subsequent grouted soil mass. Therefore, the impacts of this source term were approximated with a four-step vadose zone simulation approach as described in Section 5.2.8 for Option 1g. The results are commensurate with the current understanding of this option and associated implementability issues. Additional parameter value development (e.g., grouted soil hydraulic properties and contaminant mobility in grouted soil) as well as model development are required should this option be carried forward.

5.2.9.1 Past Leaks

The effect of past leaks is assumed to be the same as that of the Temporary Operations Barrier option (Option 1e) as discussed in Section 5.2.6.

Figure 5.2.30. Mass Flux Versus Time for Tc-99, I-129, and U-238 for the Composite of All Source Terms - Nominal Losses/Soil Grouting (Option 1g)



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5.2.9.2 Retrieval Leakage Loss

There was no retrieval leakage loss for Strategy 1, therefore the 150 m^3 (40,000 gal.) per tank retrieval leakage loss assumed for this option represents an additional source term. A grout blanket and leachate collection system are installed approximately 6.1 m (20 ft) below the base of the tanks prior to retrieval. The leachate collection system is assumed to be operational for a period of approximately 5 yr after the last tank is sluiced and is assumed to be effective in removing a portion of the retrieval leakage loss from the vadose zone. At the end of the 5-yr leachate collection period, vertical holes are drilled and the contaminated soils between the base of the tank and the grout blanket are grouted.

The assumptions concerning how the retrieval leakage loss occurs are identical to those used by Option 1a discussed in Section 5.2.2, except for the interception of some of the losses by the leachate collection system and release of the remaining retrieval leakage loss from the grouted soil mass between the tank base and the grout blanket. The moisture conditions that were calculated to exist after the past leak and after the temporary barrier is installed are assumed for the initial moisture conditions for the retrieval leakage loss simulation. The same four-step approach used for the Nominal Losses/Soil Grouting option (Option 1g) was used for this option (Section 5.2.8.2).

5.2.9.3 Residual Loss

The effect of the residual loss is assumed to be the same as described for the Postretrieval Hanford Barrier option (Option 1f), as discussed in Section 5.2.7.

5.2.9.4 Recharge

The recharge assumptions for the retrieval leakage loss simulation for this option are the same as for Option 1g discussed in Section 5.2.8.4.

5.2.9.5 Enabling Assumptions

The enabling assumptions include those provided for Strategy 1 and Option 1g as discussed in Sections 5.2.1.5 and 5.2.8.5, respectively.

Grouted sediment hydraulic and transport properties have been assumed because there are no site-specific data. The assumed values are the same as provide for in Section 5.2.8.5 for Option 1g.

5.2.9.6 Option-Specific Data Gaps

The option-specific data gaps included those provided for Strategy 1 and Option 1g as discussed in Sections 5.2.1.6 and 5.2.8.6, respectively.

5.2.9.7 Results for the Nominal Losses/Soil Soil (Option 1h)

In this section, long-term groundwater impact results are discussed for each of the applicable source components and for the option as a whole (i.e., composite of all the source components). The following discussion focuses on the comparison between the results of this option and the

results of the Baseline Retrieval/Restricted Land Use strategy (Strategy 1) (past leak, residual, and composite source terms) and Option 1a (retrieval source term).

Past Leaks Source Term

The CoCs in the past leaks are the same as for Strategy 1. The vadose zone mass flux and contaminant concentrations in groundwater are the same as described for the past leak impacts in Section 5.2.6.7 for the Temporary Operation Barrier option (Option 1e).

Retrieval Source Term

The CoCs in the retrieval source term include all of those listed for Strategy 1 in Section 5.2.1 (see Appendix A for a discussion of the inventory). Presented in Figures 5.2.18, 5.2.19, and 5.2.20 are the mass flux versus time for this option. As previously described, the initial concentration of one (dimensionless) for each of the three K_d groups was adjusted downward to compensate for numerical errors encountered when attempting to simulate contaminant transport through the grout material. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2), the maximum mass flux occurs at approximately 3,100 yr. There still would be a flux of K_d zero contaminants to the water table at the end of the period of interest and the flux rate would be declining at the 10,000-yr time period. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux would occur sometime after the 10,000-yr period of interest (Figure 5.2.19). All the uranium isotopes are assumed to have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for the uranium isotopes (Figure 5.2.20) occurs sometime after the 10,000-yr period of interest. The time to peak mass flux and the relative mass flux rate at the peak rate for the past leak and retrieval source terms are tabulated in Table 5.2.16 for the three K_d groups.

Table 5.2.16. Comparison of Mass Flux Characteristics for Retrieval Leakage Loss Components, Option 1a and Option 1h

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Retrieval source term component for Restricted Land Use–Nominal Retrieval Losses (Option 1a)			
Time to peak mass flux (yr)	1,950	8,300	>10,000
Relative mass flux at peak for C = 1 initial source concentration	7.22E-02	1.90E-02	1.15E-02
Retrieval source term component for Restricted Land Use–Large Losses/Soil Grouting (Option 1h)			
Time to peak mass flux (yr)	3,100	>10,000	>10,000
Relative mass flux at peak for C = 1 initial source concentration	5.50E-04	2.13E-04	8.53E-04

Notes:
Strategy 1 assumes there would be no retrieval leakage loss, thus there is no comparison between Strategy 1 and Option 1h on the basis of retrieval leakage loss.

As illustrated previously, Figure 5.2.21 presents the maximum groundwater concentration for Tc-99 versus time for the retrieval leakage loss source component. The Tc-99 groundwater peak maximum concentration of about 8.5 pCi/L occurs at approximately 3,000 yr. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99 as illustrated

on Figure 5.2.21. The contaminants I-129, C-14, and the uranium isotopes are all assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.22 and 5.2.23. The peak I-129 groundwater concentration is approximately 4.4E-03 pCi/L at 10,000 yr and may still be increasing. The U-238 groundwater concentration is approximately 4.5E-02 pCi/L at 10,000 yr, the end of the period of interest, and may still be increasing.

Residual Source Term

The CoCs in the residual waste source term are the same as those listed for Strategy 1 in Section 5.2.1 (see Appendix A for a discussion of the inventory). The vadose zone mass flux and contaminant concentrations in groundwater for the residual source term are the same as described for the residual source term impacts in Section 5.2.7.7 for the Postretrieval Hanford Barrier option (Option 1f).

Composite Results

The composite mass flux through the vadose zone for this option is presented in Figure 5.2.31 for three selected contaminants (i.e., Tc-99, I-129, and C-14). The y-axis values of mass flux in these figures are not comparable to the previously presented mass flux versus time plots for past leaks and retrieval leakage loss because the composite results are contaminant-specific and the past leak and sluicing loss mass flux are for the whole K_d group and, as such, are based on an adjusted unit initial concentration.

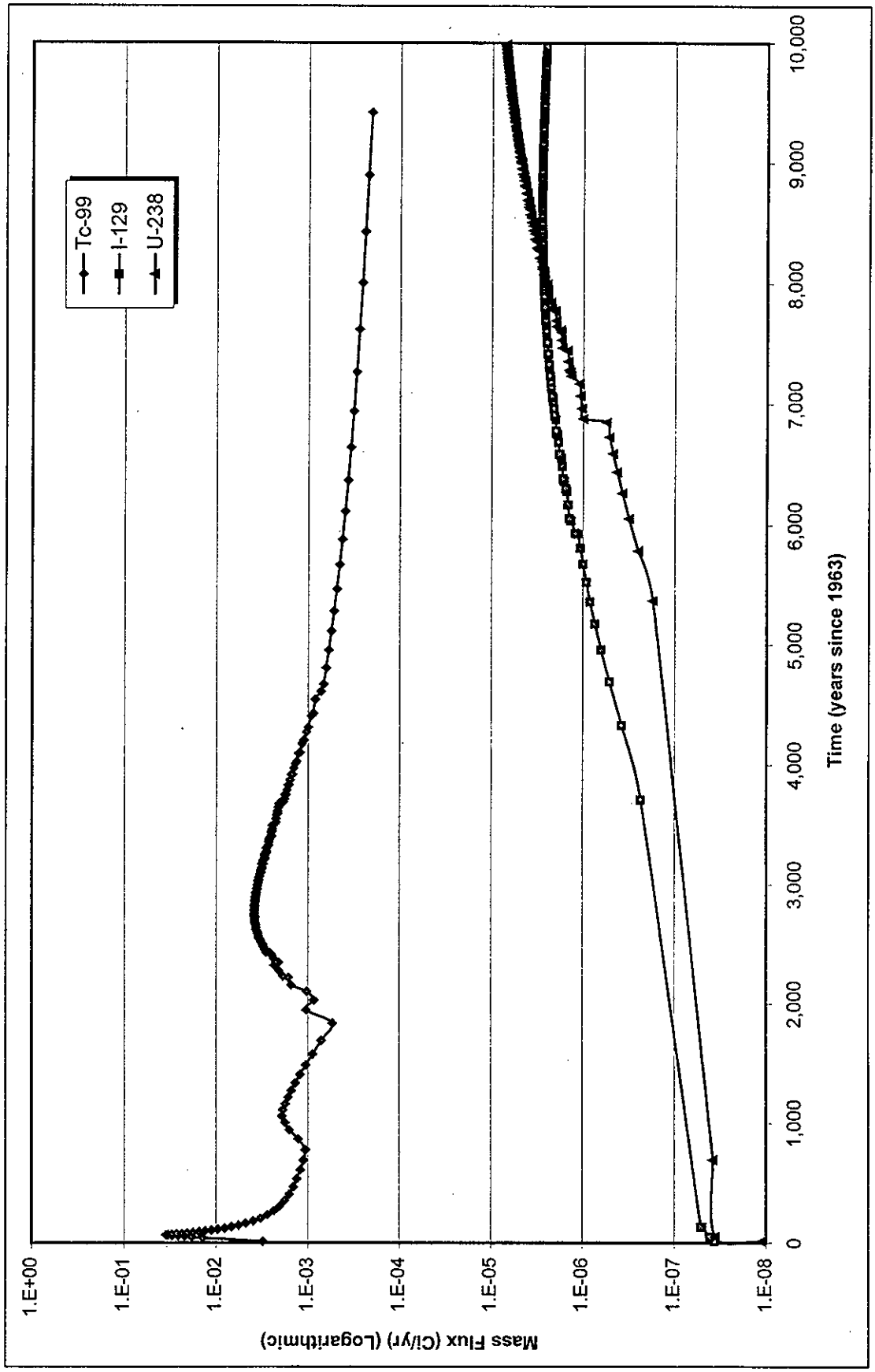
The I-129 and U-238 trends illustrated in Figure 5.2.31 are similar to those for Option 1a shown in Section 5.2.2.7. The Tc-99 trend for this option trends lower (i.e., lower mass flux) at the second peak that occurs around 2,500 yr, compared to that of Option 1a due to the mass that was captured by the leachate collection system. There continues to be a slow Tc-99 flux to the groundwater for the entire period of interest due to the slow release of Tc-99 entrapped in the grouted soil.

Figures 5.2.15, 5.2.16, and 5.2.17 illustrate the maximum groundwater concentration for Tc-99, I-129, and U-238 versus time for the composite of the source components. From about 5,000 yr to 10,000 yr, the maximum Tc-99 composite groundwater concentrations for Option 1g slowly decrease from approximately 4.6 pCi/L at 5,000 yr to 1.6 pCi/L at 10,000 yr in contrast to the Strategy 1 Tc-99 maximum groundwater concentrations that dramatically decrease at 5,000 yr.

5.2.10 Baseline Retrieval/Unrestricted Land Use (Strategy 2)

This strategy includes only a portion of past leaks. There would be no retrieval leakage loss, the tanks would be removed, there would be no residual waste volume, and soil beneath the tanks contaminated from the past leaks would be removed to a depth of approximately 36.6 m (120 ft) below the base of the tanks. Clean backfill material would be placed following removal of the contaminated soil and the tank farm would be revegetated. There would be no surface barrier installed for this strategy.

Figure 5.2.31. Mass Flux Versus Time for Tc-99, I-129, and U-238 for the Composite of All Source Terms - Large Retrieval Losses/Soil Grouting (Option 1h)



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5.2.10.1 Past Leaks

The vadose zone simulation for past leaks is performed in two steps. Step 1 is similar to that for Strategy 1 discussed in Section 5.2.1, with the exception that the simulation is for 48.5 yr, stopping in the year 2011.5. The contaminant mass flux that passes completely through the vadose zone during this 48.5-yr period is saved and is one of the contaminant source inputs to the groundwater model. Also, moisture conditions and contaminant concentrations within the vadose zone are saved as the initial conditions for subsequent steps.

Step 2 begins after the tanks have been removed, excavation of contaminated soil completed, and clean backfill placed to ground surface. Everywhere within the backfilled material the initial contaminant concentration is set to zero. Outside of the backfill, the initial contaminant concentrations for this second step are set to the values calculated in Step 1. This second step of simulating the past leaks starts at year 2011.4 and continues for the 10,000-yr period of interest. The contaminant mass flux that passes completely through the vadose zone during this 9,951-yr period is saved and is the other contaminant source input to the groundwater model.

5.2.10.2 Retrieval Leakage Loss

There would be no retrieval leakage loss associated with this strategy.

5.2.10.3 Residual Waste

There would be no residual waste associated with this strategy. Following retrieval of the waste the tanks would be removed.

5.2.10.4 Recharge

The recharge assumptions for this strategy are as follows.

- Prior to 1963, the year construction of the AX Tank Farm began, recharge is assumed to be a steady 3 mm/yr (0.12 in./yr) (same as Strategy 1).
- Recharge is assumed to increase during tank construction from 3 to 100 mm/yr (0.12 to 3.94 in./yr) over a 1-yr period from 1963 to 1964 (same as Strategy 1).
- Recharge remains at 100 mm/yr (3.94 in./yr) for 48.5 yr until the 2011.5, at which time the tank removal and soil excavation process would begin.
- Recharge is reduced from 100 mm/yr (3.94 in./yr) to 0 from the year 2011.5 to 2011.51 and remains at 0 mm/yr until the year 2014.17.
- Recharge is assumed to increase from 0 to 3 mm/yr (0.12 in./yr) over a 1-yr period from 2014.17 to 2015.17.
- Recharge is assumed to remain at 3 mm/yr (0.12 in./yr) for the duration of the simulation until the year 11,963.

5.2.10.5 Enabling Assumptions

The enabling assumptions are the same as provided for Strategy 1 discussed in Section 5.2.1.5. Additional assumptions include the following.

- The assumed backfill characteristics discussed in Section 5.2.1.5 also would apply to the backfill materials that would replace the excavated soil below the tank, the void left by the removal of the tanks, and the material excavated around the tanks, as applicable to the various clean closure strategies.

- Tank removal and subsequent backfilling and/or in situ grouting occur instantaneously in the model. Changing hydraulic conditions and other potential impacts to contaminant distributions that might occur during this transition are unknown.

- Backfill placed to replace tanks removed as part of the clean closure strategies was initialized by setting pressure at P = -1.00 m (-3.28 ft), while grouted soils were initialized at a saturation of S = 0.85. These were the lowest pressure and saturation levels that the model could solve efficiently. Actual conditions may be different and would probably be lower, effecting the predicted rate of contaminant migration.

- Excavation of soil and/or emplacement of grout in clean closure strategies was uniformly to a depth of 36.6 m (120 ft) below the base of the tanks. Width of soil excavation strategies was the full width of model. Width of grout strategies was 23 m (75 ft), approximately 85 percent of total model width. Width and placement of grouting may be important when considering interaction of the grout, moisture flux along the edges of the grouted mass, and contaminant migration alongside and through the grouted soils.

5.2.10.6 Option-Specific Data Gaps

The option-specific data gaps are the same as provided for Strategy 1 and Option 1a, as discussed in Sections 5.2.1.6 and 5.2.2.6, respectively.

5.2.10.7 Results for the Baseline Retrieval/Unrestricted Land Use Strategy (Strategy 2)

In this section, the long-term groundwater impact results are discussed for each of the applicable source components and for the strategy as a whole (i.e., composite of all the source components). The following discussions focus on the comparison between the results of this strategy and the results of Strategy 1.

Past Leaks Source Term

The CoCs in the past leaks are the same as for Strategy 1 (see Appendix A for a discussion of the inventory). Figures 5.2.2, 5.2.3, and 5.2.4 present the calculated mass flux versus time for this strategy as well as the others for an initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown on these figures is at the vadose zone/water table interface. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2), the mass flux peak occurs at approximately 52 yr, and by about 1,500 yr nearly all of the K_d zero contaminants would have passed through the vadose zone. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14), the peak mass flux occurs at

approximately 4,900 yr (Figure 5.2.3), and by about 10,000 yr nearly all these contaminants would have passed through the vadose zone. The uranium isotopes are assumed to have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for the uranium isotopes (Figure 5.2.4) occurs at approximately 4,200 yr, and by about 9,000 yr nearly all of these contaminants would have passed through the vadose zone. The time to peak mass flux and the relative mass flux rate at the peak rate for Strategies 1 and 2, are tabulated on Table 5.2.17 for the three K_d groups.

Table 5.2.17. Comparison of Mass Flux Characteristics for Past Leak Components, Strategies 1 and 2

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Past leak source term component–Baseline Retrieval/Restricted Land Use (Strategy 1)			
Time to peak mass flux (yr)	65	7,400	8,750
Relative mass flux at peak for C = 1 initial source concentration	2.35E-01	5.22E-03	5.15E-03
Past leak source term component–Baseline Retrieval/Unrestricted Land Use (Strategy 2)			
Time to peak mass flux (yr)	52	4,920	4,230
Relative mass flux at peak for C = 1 initial source concentration	3.03E-01	3.90E-04	1.94E-06

Figure 5.2.5 illustrates the maximum groundwater concentration for Tc-99 versus time for the past leak source component. Tc-99 groundwater concentrations show nearly a log-linear decline from about 32 pCi/L at 150 yr to 3.43 pCi/L at about 1,200 yr. Beyond 1,200 yr, the maximum Tc-99 groundwater concentrations decrease at a more rapid rate to about 2.3E-01 at 2,600 yr, to nearly 0 at 5,000 yr. This is in response to the cessation of the source from the vadose zone at 1,500 yr. For approximately the first 2,600 yr, the maximum Tc-99 concentration in groundwater from past leaks is somewhat similar (i.e., concentrations are on the same order of magnitude) to that of the other landfill strategies. Sometime between 2,600 yr and 5,000 yr, the concentration for this strategy decrease rapidly, compared to that of the landfill strategies.

The contaminants I-129, C-14, and the uranium isotopes are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.6 and 5.2.7. The I-129 peak concentration is approximately 8.78E-04 pCi/L and occurs at approximately 5,000 yr. The U-238 maximum concentration is approximately 2.49E-06 and also occurs at approximately 5,000 yr.

Retrieval Source Term

This strategy would not have any retrieval leakage loss, therefore there would be no retrieval impacts.

Residual Source Term

This strategy would not have any residual waste volume therefore there would be no residual waste impacts.

Composite

Because the only source term is past leaks, the composite is represented in the discussion of past leaks.

5.2.11 Nominal Losses/Excavate Soil (Option 2a)

This option includes the past leaks and 30 m^3 (8,000 gal.) per tank retrieval leakage loss. The tanks would be removed, thus there would be no residual waste volume and soil below the tanks contaminated from the past leaks. Retrieval leakage loss would be removed to a depth of approximately 36.6 m (120 ft) below the base of the tanks. Clean backfill material would be placed following removal of the contaminated soil and the tank farm would be revegetated. There would be no surface barrier installed for this option. Much of the removed waste, including portions of the tank, concrete base, and contaminated soil beneath the tanks, would be taken to the ERDF. The estimated inventories taken to the ERDF are provided in Appendix F. Appendix F also includes a scoping calculation that provides an upper estimate of potential groundwater impacts resulting from disposal of these waste at the ERDF.

5.2.11.1 Past Leaks

The groundwater impacts from the past leak source component for this option is assumed to be identical to that which was calculated for Strategy 2 discussed in Section 5.2.10.

5.2.11.2 Retrieval Leakage Loss

The vadose zone simulation for retrieval leakage loss is performed in two steps. Step 1 is similar to that performed for the past leaks source term for Strategy 2 discussed in Section 5.2.10.1. The simulation duration of this step is for 48.5 yr, stopping in the year 2011.5. The contaminant mass flux that passes completely through the vadose zone during this 48.5-yr period is saved and is one of the contaminant source inputs to the groundwater model. Also, moisture conditions and contaminant concentrations within the vadose zone are saved as the initial conditions for the subsequent step.

Step 2 begins after the tanks have been removed; excavation of contaminated soil completed, and clean backfill placed to ground surface. Everywhere within the backfilled material the initial contaminant concentration is set to zero. Outside of the backfill, the initial contaminant concentrations for this second step are set to the values calculated in Step 1. This second step of simulating the past leaks starts at year 2011.4 and continues for the 10,000-yr period of interest. The contaminant mass flux that passes completely through the vadose zone during this 9,951-yr period is saved and with the results from Step 1, becomes the contaminant source inputs to the groundwater model.

5.2.11.3 Residual Waste

There would be no residual waste associated with this option. Following retrieval of the waste the tanks would be removed.

5.2.11.4 Recharge

The recharge assumptions for this option are the same as Strategy 2 provided in Section 5.2.10.4.

5.2.11.5 Enabling Assumptions

The enabling assumptions are the same as provided for Strategy 1 and Option 1a, as discussed in Sections 5.2.1.5 and 5.2.2.5, respectively. Additional assumptions relative to this unrestricted land use option were provided for Strategy 2 in Section 5.2.10.5.

5.2.11.6 Option-Specific Data Gaps

The option-specific data gaps are the same as provided for Strategy 1 and Option 1a, as discussed in Sections 5.2.1.6 and 5.2.2.6, respectively.

5.2.11.7 Results for the Nominal Losses/Excavate Soil (Option 2a)

In this section, the long-term groundwater impact results are discussed for each of the applicable source components and for the option as a whole (i.e., composite of all the source components). The following discussions focus on the comparison between the results of this option and the results of Strategy 1.

Past Leaks Source Term

The CoCs in the past leaks are the same as those listed for Strategy 1 in Section 5.2.1 (see Appendix A for a discussion of the inventory). Figures 5.2.2, 5.2.3, and 5.2.4 are the calculated mass flux versus time for this option as well as the others for a initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown in these figures is at the vadose zone/water table interface and represents the contaminant mass flux trend to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2), the mass flux peak occurs at approximately 52 yr, and by about 1,500 yr nearly all of the K_d zero contaminants would have passed through the vadose zone. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately 4,900 yr (Figure 5.2.3), and by about 10,000 yr nearly all these contaminants would have passed through the vadose zone. The uranium isotopes are assumed to all have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for the uranium isotopes (Figure 5.2.4) occurs at approximately 4,200 yr, and by about 9,000 yr nearly all of these contaminants would have passed through the vadose zone. The time to peak mass flux and the relative mass flux rate at the peak rate for Strategy 1 and Option 2a, are tabulated on Table 5.2.18 for the three K_d groups.

Figure 5.2.5 illustrates the maximum groundwater concentration for Tc-99 versus time for the past leak source component. Tc-99 groundwater concentrations show nearly a log-linear decline from about 32 pCi/L at 150 yr to 3.43 pCi/L at about 1,200 yr. Beyond 1,200 yr, the maximum Tc-99 groundwater concentrations decrease at a more rapid rate to about 2.3E-01 at 2,600 yr, to nearly 0 at 5,000 yr. This is in response to the cessation of the source from the vadose zone in about 1,500 yr. For approximately the first 2,600 yr, the maximum Tc-99 concentration in groundwater from past leaks is somewhat similar (i.e., concentrations are on the same order of magnitude) to that of the Restricted Land Use strategy and options. Sometime between 2,600 yr and 5,000 yr the concentration for this option decrease rapidly, compared to that of the Restricted Land Use strategy and options.

Table 5.2.18. Comparison of Mass Flux Characteristics for Past Leak Components, Strategy 1 and Option 2a

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Past leak source term component–Baseline Retrieval/Restricted Land Use (Strategy 1)			
Time to peak mass flux (yr)	65	7,400	8,750
Relative mass flux at peak for C = 1 initial source concentration	2.35E-01	5.22E-03	5.15E-03
Past leak source term component–Baseline Retrieval/Unrestricted Land Use strategy–Nominal Losses/Excavate Soil (Option 2a)			
Time to peak mass flux (yr)	52	4,900	4,200
Relative mass flux at peak for C = 1 initial source concentration	3.03E-01	3.90E-04	1.94E-06

The contaminants I-129, C-14, and the uranium isotopes all are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.6 and 5.2.7. The I-129 peak concentration is approximately 8.78E-04 pCi/L and occurs at approximately 5,000 yr. The U-238 maximum concentration is approximately 2.49E-06 and also occurs at approximately 5,000 yr.

Retrieval Source Term

The CoCs in the retrieval source term are the same as those listed for Option 1a in Section 5.2.1 (see Appendix A for a discussion of the inventory). Previously presented in Figures 5.2.18, 5.2.19, and 5.2.20 are the mass flux versus time for this option as well as the others for a initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2) the maximum mass flux occurs at approximately 1,000 yr, and these contaminants would have passed completely through the vadose zone by about 3,500 yr. For the contaminants with K_d of zero in the near-field and 0.6 mL/g in the far-field (i.e., I-129 and C-14) the maximum mass flux occurs at approximately 6,200 yr, and nearly all of the contaminants would have passed through the vadose zone by 10,000 yr (Figure 5.2.19). The uranium isotopes are assumed to have a K_d of 0.6 mL/g for the entire vadose zone. The maximum mass flux for the uranium isotopes (Figure 5.2.20) occurs at approximately 6,500 yr, and nearly all of the contaminants would have passed through the vadose zone by 10,000 yr. The time to peak mass flux and the relative mass flux rate at the peak rate are tabulated on Table 5.2.19 for the three K_d groups and for Option 1a for comparison.

Figure 5.2.21 illustrates the maximum groundwater concentration for Tc-99 versus time for the retrieval leakage loss source component. The Tc-99 groundwater peak concentration of approximately 1.65E-03 pCi/L occurs at approximately 1,000 yr. The maximum Tc-99 groundwater concentrations decreases to about 2.65E-05 at 2,600 yr and then rapidly decreases to nearly 0 at 5,000 yr. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99, as illustrated in Figure 5.2.21.

Table 5.2.19. Comparison of Mass Flux Characteristics for Retrieval Leakage Loss Component, Options 1a and 2a

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Retrieval source term component for Baseline Retrieval/Restricted Land Use–Nominal Retrieval Loss (Option 1a)			
Time to peak mass flux (yr)	1,950	8,300	>10,000
Relative mass flux at peak for C = 1 initial source concentration	7.22E-02	1.90E-02	1.15E-02
Retrieval source term component for Nominal Losses/Excavate Soil (Option 2a)			
Time to peak mass flux (yr)	100	6,200	6,500
Relative mass flux at peak for C = 1 initial source concentration	3.35E-06	2E-13	1E-22

Notes:
Strategy 1 assumes there would be no retrieval leakage loss, thus for comparison results for Option 1a are provided for comparison to Option 2a.

The contaminants I-129, C-14, and the uranium isotopes all are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.22 and 5.2.23. The maximum I-129 groundwater concentration of about 1.0E-13 pCi/L is reached at about 7,000 yr. Likewise for U-238, the peak groundwater concentration during the 10,000-yr period of interest, is approximately 1.5E-22 pCi/L and occurs at about 7,000 yr.

Residual Source Term

This option would not have any residual volume therefore there would be no residual waste impacts.

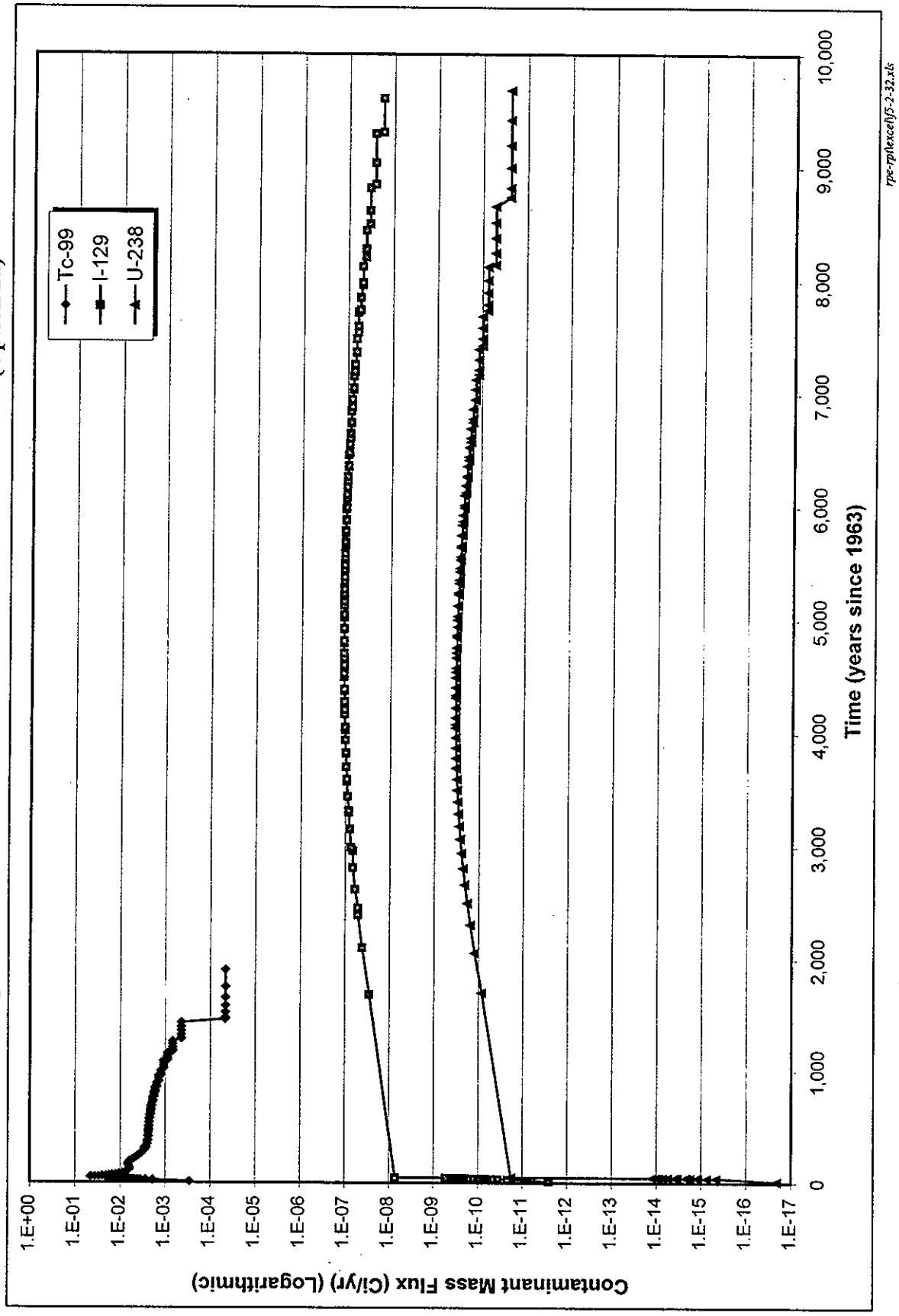
Composite

This option's composite impact on the groundwater system stems from the past leaks and retrieval leakage loss source terms. The composite mass flux through the vadose zone from these two source terms is illustrated in Figure 5.2.32 for Tc-99, I-129, and U-128.
The composite Tc-99 mass flux reaches a peak rate at about 45 yr at a rate of 4.4E-02 Ci/yr compared to Strategy 1, for which the Tc-99 peaks at about 65 yr at a rate of 3.5E-02 Ci/yr. All of the Tc-99 would have passed through the vadose zone by after about 2,000 yr compared to Strategy 1, in which nearly all the Tc-99 would have passed through the vadose zone by about 4,100 yr.

The composite I-129 mass flux rate would peak at about 4,800 yr at a rate of 1.12E-07 Ci/yr. At 10,000 yr some I-129 would still be entering the groundwater from the vadose zone. The composite U-238 mass flux rate would peak at about 4,400 yr at a rate of 3.4E-10 Ci/yr. At 10,000 yr some U-238 still would be entering the groundwater from the vadose zone.

Maximum Tc-99 groundwater concentrations for this option are shown in Figure 5.2.15. Tc-99 groundwater concentrations drop at a steady rate from 32 pCi/L at 150 yr to 11 pCi/L at 600 yr. The rate of decrease becomes larger beginning at about 1,000 yr. After 2,600 yr the concentration has dropped to 2.3E-01 pCi/L and at 5,000 yr it is nearly zero.

Figure 5.2.32. Mass Flux Versus Time for Tc-99, I-129, and U-238 for the Composite of All Source Terms - Nominal Losses/Excavate Soil (Option 2a)



Maximum I-129 groundwater concentrations for this option are shown in Figure 5.2.16. The I-129 groundwater concentrations are a near-constant of about 6E-05 pCi/L from 150 to 1,200 yr. After that time, the concentrations increase to a maximum of about 8.8E-04 pCi/L at 5,000 yr. The U-238 maximum groundwater concentrations for this option (Figure 5.2.17) follow a trend similar to that of I-129. The U-238 groundwater concentrations are a near-constant of about 1.4E-07 pCi/L from 150 to 1,200 yr. After that time, the concentrations increase to a maximum of about 2.5E-06 pCi/L at 5,000 yr.

5.2.12 Past Leak/In Situ Soil Treatment (Option 2b)

This option includes the past leaks only. The tanks would be removed, thus there would be no residual waste volume. The sediments beneath the tank would be grouted with a micro-fine Portland cement grout using a systematic arrangement of grout pipes installed by the sonic-drilling method. The grout would alter the vadose zone material properties including a major reduction of the K_{sat} in the grouted region. Following the grouting operations, clean backfill material would be placed from the elevation of the tank base to ground surface. The area would be revegetated, but there would be no surface barrier.

Fate and transport modeling for the Past Leak/In Situ Soil Grouting option (Option 2b) was not conducted in the same fashion as it was for Strategy 1 for the same reasons discussed in Section 5.2.8 due to the inability to adequately simulate the performance of the grouted mass. The approach to evaluating the contaminant fate and transport for this option followed that developed for Option 1g and involved simulations that were used to approximate the impacts of the past leaks source term.

The impacts of the past leaks source term were approximated with a four-step vadose zone simulation approach as described in Section 5.2.8 for Option 1g. The results are commensurate with the current understanding of this option and associated implementability issues. Additional parameter value development (e.g., grouted soil hydraulic properties and contaminant mobility in grouted soil) as well as model development are required should this option be carried forward.

5.2.12.1 Past Leaks

The assumptions concerning how the past leak losses occur are the same as those used by Strategy 1 discussed in Section 5.2.1 and the simulations are identical until the year 2011.5. This is the year work begins on tank removal and in situ grouting. Beyond this time, an alternative approach is required to approximate the impacts of past leak losses with grouted material beneath the tanks. A four-step approach to approximate the impact of retrieval leakage loss has been used. The steps are the same as those provided in Section 5.2.8 for Option 1g.

5.2.12.2 Retrieval Leakage Loss

There would be no retrieval leakage loss for this option.

5.2.12.3 Residual Waste

There would be no residual waste associated with this option. Following retrieval of the waste the tanks would be removed.

5.2.12.4 Recharge

The recharge assumptions for this option are as follows.

- Prior to 1963, the year construction of the AX Tank Farm began, recharge is assumed to be a steady 3 mm/yr (0.12 in./yr) (same as Strategy 1).
- Recharge is assumed to increase during tank construction from 3 to 100 mm/yr (0.12 to 3.94 in./yr) over a 1-yr period from 1963 to 1964 (same as Strategy 1).
- Recharge remains at 100 mm/yr (3.94 in./yr) for 48.5 yr until the year 2011.5, at which time the tank removal and soil grouting process would begin.
- Recharge is reduced from 100 mm/yr (3.94 in./yr) to 0 from the year 2011.5 to 2011.51 and remains at 0 mm/yr until the year 2014.17.
- Recharge is assumed to increase from 0 to 3 mm/yr (0.12 in./yr) over a 1-yr period from 2014.17 to 2015.17 and remain at this rate for the duration of the 10,000 simulation until the year 11,963 (same as Strategy 1).

5.2.12.5 Enabling Assumptions

Enabling assumptions include those as provided for Strategy 1 discussed in Section 5.2.1.5. Additional assumptions relative to this unrestricted land use option were provided for Strategy 2 in Section 5.2.10.5. Grout-related assumptions relative to this option were provided in Section 5.2.8.5.

Grouted sediment hydraulic and transport properties have been assumed because there are no site-specific data. Grout properties could vary with the type of sediments underlying AX Tank Farm as discussed in Section 5.2.8.5

After removing the tanks, contaminated soils would be grouted from just below the base of the tanks to a depth of about 37 m (120 ft) below the base of the tanks. The grout would be placed across a width of 22.6 m (74 ft) centered between the two tanks simulated in the model domain. The area above the grouted soil where the tanks were formerly located would be filled with backfill material assumed to have the same hydraulic properties as the backfill in place prior to removal of the tanks. The grouted soil was assigned an initial saturation of 0.85.

5.2.12.6 Option-Specific Data Gaps

The option-specific data gaps are the same as provided for the Baseline Retrieval/Restricted Land Use strategy (Strategy 1) as discussed in Sections 5.2.1.6. In addition, site-specific data on the diffusion coefficient of grouted sediments representative of those below the AX Tank Farm may be significant in the transport calculation.

5.2.12.7 Results for the Past Leak/In Situ Soil Treatment (Option 2b)

In this section, the long-term groundwater impact results are discussed. The past leaks source term is the only source term for this option. The following discussions focus on the comparison between the results of this option and the results of Strategy 1 for the past leaks source term only.

Past Leaks Source Term

The CoCs in the past leaks are the same as for Strategy (see Appendix A for a discussion of the inventory). Figures 5.2.2, 5.2.3, and 5.2.4 present the calculated mass flux versus time for this option as well as the others for an initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant mass flux to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2) the mass flux peak occurs at approximately 48 yr and these contaminants would have passed completely through the vadose zone by 10,000 yr. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the mass flux is still increasing at the end of the 10,000-yr period of interest (Figure 5.2.3), and some of these contaminants would still be in transport within the vadose zone at the end of 10,000 yr. The uranium isotopes are assumed to have a K_d of 0.6 mL/g for the entire vadose zone. The mass flux for the uranium isotopes (Figure 5.2.4) is still increasing at 10,000 yr, and as with I-129, some of these contaminants would still be in transport within the vadose zone at the end of the 10,000-yr period of interest. The time to peak mass flux and the relative mass flux rate at the peak rate for Option 2b and Strategy 1 are tabulated on Table 5.2.20 for the three K_d groups.

Table 5.2.20. Comparison of Mass Flux Characteristics for Past Leak Components, Strategy 1 and Option 2b

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Past leak source term component–Baseline Retrieval/Restricted Land Use (Strategy 1)			
Time to peak mass flux (yr)	65	7,400	8,750
Relative mass flux at peak for C = 1 initial source concentration	2.35E-01	5.22E-03	5.15E-03
Past leak source term component–Baseline Retrieval/Unrestricted Land Use–Past Leak/In Situ Soil Treatment (Option 2b)			
Time to peak mass flux (yr)	48	>10,000	>10,000
Relative mass flux at peak for C = 1 initial source concentration	1.1E-01	3.28E-03	9.32E-04

Figure 5.2.5 illustrates the maximum groundwater concentration for Tc-99 versus time for the past leak source component. Tc-99 groundwater concentrations show nearly a log-linear decline from about 2.2E+01 pCi/L at 150 yr to 2.1E+01 pCi/L at about 600 yr. For the remainder of the period of interest the maximum Tc-99 groundwater concentrations continue to decline to approximately 1.9E-01 pCi/L at 10,000 yr.

The contaminants I-129, C-14, and the uranium isotopes all are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.6 and 5.2.7. The I-129 concentration is approximately 7.4E-03 pCi/L at 10,000 yr and appears to be still increasing. The U-238 maximum groundwater concentration is approximately 1.27E-03 at 10,000 yr and also appears to be increasing.

Retrieval Source Term

This option would not include retrieval leakage loss.

Composite

This option only has the past leaks as a source term, therefore the composite impact on the groundwater system is the same as previously discussed for the past leaks impacts.

5.2.13 Nominal Losses/In Situ Soil Treatment (Option 2c)

This option includes the past leaks and 30 m^3 (8,000 gal.) per tank retrieval leakage loss. The tanks would be removed, thus there would be no residual waste volume. The sediments beneath the tank would be grouted with a micro-fine Portland cement grout using a systematic arrangement of grout pipes installed by the sonic-drilling method. The grout would alter the vadose zone material properties including a major reduction of the K_{sat} in the grouted region. Following the grouting operations clean backfill material would be placed from the elevation of the tank base to ground surface. The area would be revegetated, but there would be no surface barrier.

Fate and transport modeling for the Nominal Losses/In Situ Soil Treatment option (Option 2c) was not conducted in the same fashion as it was for Strategy 1 for the same reasons discussed in Section 5.2.8 due to the inability to adequately simulate the performance of the grouted mass. The approach to evaluating the contaminant fate and transport for this option followed that developed for Option 1g and involved simulations that were used to approximate the impacts of the past leaks source term.

The impacts of the past leaks and retrieval leakage loss source terms were approximated with a four-step vadose zone simulation approach as described in Section 5.2.8 for Option 1g. The results are commensurate with the current understanding of this option and associated implementability issues. Additional parameter value development (e.g., grouted soil hydraulic properties and contaminant mobility in grouted soil) as well as model developments are required should this option be carried forward.

5.2.13.1 Past Leaks

The past leaks source term is simulated in the same manner as was done for Option 2b, as described in Section 5.2.12.1. The associated impacts from the past leaks source term are the same as described for Option 2b in Section 5.2.12.7.

5.2.13.2 Retrieval Leakage Loss

Retrieval leakage loss of 30 m^3 (8,000 gal.) per tank is assumed to leak out of the tanks from a nominal 30 percent area of the base of the tank near the inside edge, which is closest to the assumed clastic dike in the model domain. The retrieval operations are expected to take approximately 6 months for tanks AX-102, -103, and -104. Waste retrieval from tank AX-101 is assumed require 1 yr due to its greater volume. The retrieval sequence begins with tank AX-103 followed by tanks AX-104, -102, and -101. Retrieval leakage loss begins in 2004 and continue uninterrupted for 2 ½ yr. The moisture conditions that were calculated to exist after the past leak are assumed for the initial moisture conditions for the retrieval leakage loss simulation.

The assumptions concerning how the retrieval leakage loss occurs are the same as those used by Strategy 1 discussed in Section 5.2.1 and the simulations are identical until the year 2011.5. This is the year work begins on tank removal and in situ grouting. Beyond this time, an alternative

approach is required to approximate the impacts of retrieval leakage loss with grouted material beneath the tanks. A four-step approach to approximate the impact of retrieval leakage loss has been used. The steps are the same as those provided in Section 5.2.8 for Option 1g.

5.2.13.3 Residual Waste

There would be no residual waste associated with this option. Following retrieval of the waste the tanks would be removed.

5.2.13.4 Recharge

The recharge assumptions for this option are the same as those provided for Option 2b (Section 5.2.12.4).

5.2.13.5 Enabling Assumptions

The enabling assumptions are the same as provided for Option 2b, Section 5.2.12.5.

5.2.13.6 Option-Specific Data Gaps

The option-specific data gaps are the same as provided for Option 2b, Section 5.2.12.6.

5.2.13.7 Results for the Nominal Losses/In Situ Soil Treatment (Option 2c)

In this section the long-term groundwater impact results are discussed for each of the applicable source components and for the option as a whole (i.e., composite of all the source components). The following discussions focus on the comparison between the results of this option and the results of Strategy 1 for the past leaks source term and Option 1a for comparison with retrieval leakage loss source term.

Past Leaks Source Term

The impacts from the past leak source term are identical to those described for Option 2b, Section 5.2.12.7.

Retrieval Source Term

The CoCs in the retrieval source term are the same as those listed for Strategy 1 in Section 5.2.1 (see Appendix A for a discussion of the inventory). Figures 5.2.18, 5.2.19, and 5.2.20 are the mass flux versus time for this option as well as the others for a initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown in these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2), the maximum mass flux occurs at approximately 5,300 yr, and these contaminants would have passed completely through the vadose zone by about 10,000 yr. For the contaminants with K_d of zero in the near-field and 0.6 mL/g in the far-field (i.e., I-129 and C-14) it appears that the mass flux would continue to increase at the end of the period of interest at 10,000 yr (Figure 5.2.19). The uranium isotopes are assumed to all have a K_d of 0.6 mL/g for the entire vadose zone. The mass flux for the uranium isotopes (Figure 5.2.20) also appear to be increasing at the end of the 10,000-yr period of interest. The time to peak mass flux and the relative mass flux rate at the peak rate are tabulated in Table 5.2.21 for the three K_d groups and for Option 1a for comparison.

Table 5.2.21. Comparison of Mass Flux Characteristics for the Retrieval Source Term Component of Options 1a and 2c

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Retrieval source term component–Baseline Retrieval/Restricted Land Use–Nominal Retrieval Loss (Option 1a)			
Time to peak mass flux (yr)	1,950	8,300	>10,000
Relative mass flux at peak for C = 1 initial source concentration	7.22E-02	1.90E-02	1.15E-02
Retrieval source term component–Baseline Retrieval/Unrestricted Land Use–Nominal Losses/In Situ Soil Treatment (Option 2c)			
Time to peak mass flux (yr)	5,300	>10,000	>10,000
Relative mass flux at peak for C = 1 initial source concentration	7.11E-04	1.18E-04	3.20E-05

Note:
Strategy 1 assumes there would be no retrieval leakage loss, thus for comparison results for Option 1a are provided for comparison to Option 2c.

Figure 5.2.21 illustrates the maximum groundwater concentration for Tc-99 versus time for the retrieval leakage loss source component. The Tc-99 groundwater peak concentration of approximately 1.22E+01 pCi/L occurs at approximately 5,000 yr. The other mobile contaminant considered (i.e., Se-79, NO_3, NO_2) mirror the behavior of Tc-99, as illustrated on Figure 5.2.21.

The contaminants I-129, C-14, and the uranium isotopes all are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.22 and 5.2.23. At 10,000 yr the groundwater concentration of I-129 is approximately 2.45E-03 pCi/L and appears to be continuing to increase.

Likewise for U-238, the peak groundwater concentration during the 10,000-yr period of interest is approximately 1.66E-03 pCi/L and occurs at 10,000 yr.

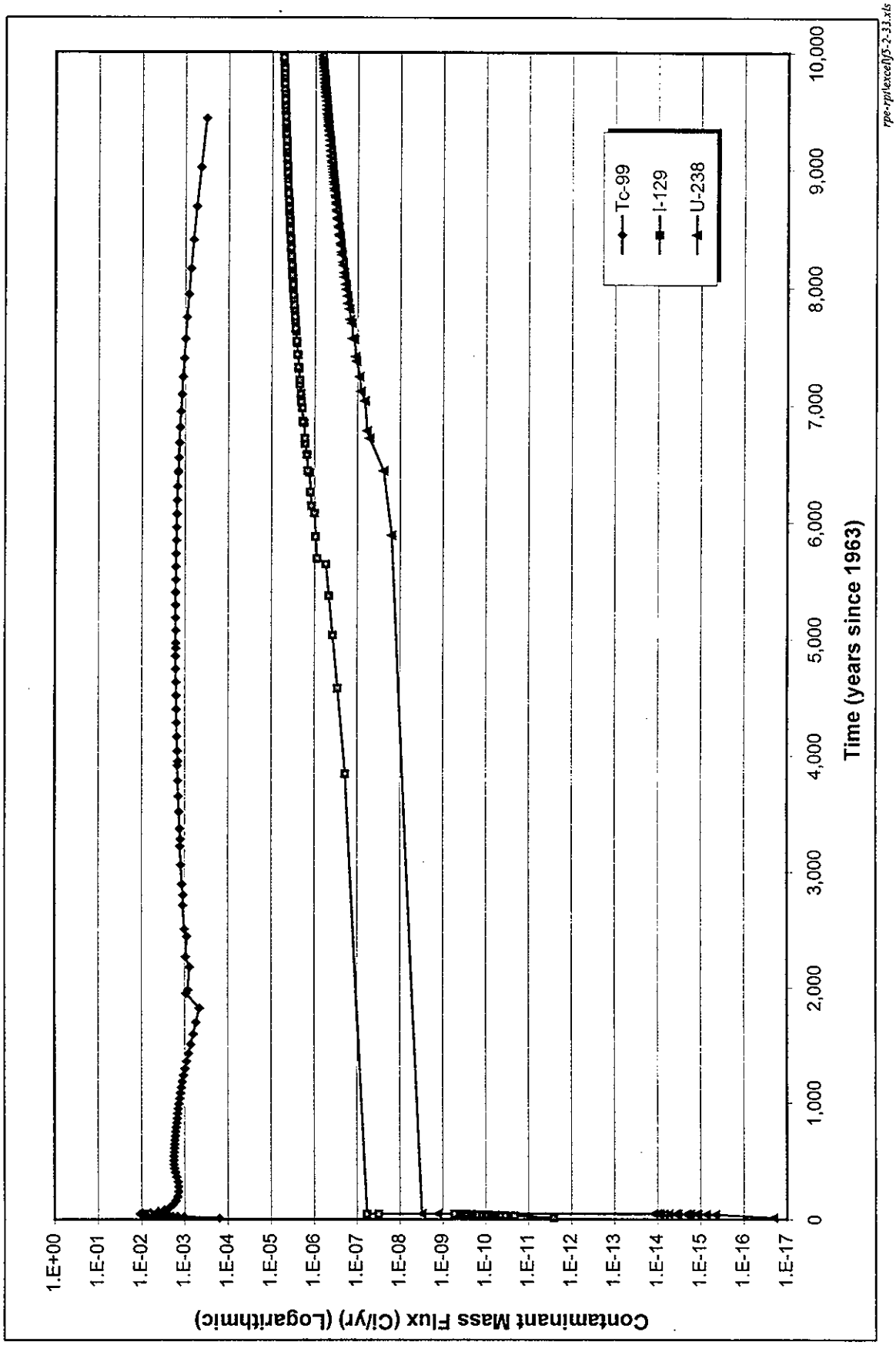
Composite

This option's composite impact on the groundwater system stems from the past leaks and retrieval leakage loss source terms. The composite mass flux through the vadose zone from these two source terms is illustrated in Figure 5.2.33 for Tc-99, I-129, and U-128.

The composite Tc-99 mass flux reaches a peak rate at about 50 yr at a rate of 2.0E-02 Ci/yr compared to Strategy 1, for which the Tc-99 peaks at about 65 yr at a rate of 3.5E-02 Ci/yr. This option also has a secondary Tc-99 peak of about 7.6E-03 Ci/L at about 5,000 yr (Figure 5.2.33). At the end of the 10,000-yr period of interest, Tc-99 still would be entering the groundwater from the vadose zone compared to Strategy 1, in which nearly all the Tc-99 would have passed through the vadose zone by about 4,100 yr.

The composite I-129 mass flux rate appears to be increasing at 10,000 yr and would be at the peak rate for the 10,000-yr period of interest. The I-129 mass flux at 10,000 yr is 5.34E-06 Ci/yr.

Figure 5.2.33. Mass Flux Versus Time for Tc-99, I-129, and U-238 for the Composite of All Source Terms - Nominal Losses/In Situ Soil Treatment (Option 2c)



Maximum Tc-99 groundwater concentrations for the composite of the two source terms for this are shown in Figure 5.2.15. The Tc-99 groundwater concentrations range is small compared to most of the other strategies, ranging from about 2.3E+01 to 2.5E+00 pCi/L over the period from 150 to 10,000 yr.

Maximum I-129 groundwater concentrations for this option are shown in Figure 5.2.16. The I-129 groundwater concentrations are a near-constant of about 1.5E-04 pCi/L from 150 to 2,600 yr. After that time, the concentrations increase to a maximum of about 9.8E-03 pCi/L at 10,000 yr. The U-238 maximum groundwater concentrations for this option (Figure 5.2.17) follow a trend similar to that of I-129. The U-238 groundwater concentrations are a near constant of about 1.4E-05 pCi/L from 150 to 5,000 yr. After that time, the concentrations increase to a maximum of about 2.9E-03 pCi/L at 10,000 yr.

5.2.14 No Soil Treatment Strategy (Option 2d)

This option includes the past leaks and 30 m^3 (8,000 gal.) per tank retrieval leakage loss only. The tanks would be removed, thus there would be no residual waste volume. Clean backfill material would be placed following removal of the contaminated soil and an enhanced RCRA Subtitle C barrier would be installed for this option.

5.2.14.1 Past Leaks

The vadose zone simulation for past leaks is performed in two steps. This approach is the same as the approach used for Strategy 2 and described in Section 5.2.10.1.

5.2.14.2 Retrieval Leakage Loss

Retrieval leakage loss of 30 m^3 (8,000 gal.) per tank is assumed to leak out of the tanks from a nominal 30 percent area of the base of the tank near the inside edge, which is closest to the assumed clastic dike in the model domain. The retrieval operations are expected to take approximately 6 months for tanks AX-102, -103, and -104. Retrieval from tank AX-101 is assumed require 1 yr due to its greater volume. The retrieval sequence begins with tank AX-103 followed by AX-104, -102, and -101. Retrieval leakage loss begins in 2004 and continue uninterrupted for 2 ½ yr. The moisture conditions that were calculated to exist after the past leak are assumed for the initial moisture conditions for the retrieval leakage loss simulation. Vadose zone transport from the retrieval leakage loss are simulated in two parts, as with the past leak simulations, and are the same as those described for Option 2a (Section 5.2.11.2).

5.2.14.3 Residual Loss

There would be no residual loss associated with this option. Following retrieval of the waste the tanks would be removed.

5.2.14.4 Recharge

The recharge assumptions for this option are as follows.

- Prior to 1963, the year construction of the AX Tank Farm began, recharge is assumed to be a steady 3 mm/yr (0.12 in./yr) (same as Strategy 1).

- Recharge is assumed to increase during tank construction from 3 to 100 mm/yr (0.12 to 3.94 in./yr) over an over a 1-yr period from 1963 to 1964 (same as Strategy 1).

- Recharge remains at 100 mm/yr (3.94 in./yr) for 48.5 yr until the year 2011.5, at which time the tank removal process would begin.

- Recharge is reduced from 100 mm/yr (3.94 in./yr) to 0 from the year 2011.5 to 2011.51 and remains at 0 mm/yr until the year 2014.17.

- Recharge is assumed to increase from 0 to 100 mm/yr (3.94 in./yr) over a 1-yr period from 2014.17 to 2015.17 and remain at this rate until the year 2020 when the surface barrier would be constructed.

- Recharge is assumed to decrease 100 to 1 mm/yr (3.94 to 0.4 in./yr) over a 1-yr period from 2020 to 2021 and remain at this rate until the year 2521 when the surface barrier would begin to degradate.

- Recharge is assumed to increase from 1 to 3 mm/yr (0.04 to 0.12 in./yr) over a 10-yr period from 2521 to 2531 and remain at this rate until the year for the duration of the 10,000-yr simulation until the year 11,963 (same as Strategy 1).

5.2.14.5 Enabling Assumptions

The enabling assumptions are the same as provided for Strategy 1 and Option 1a, as discussed in Section 5.2.1.5 and 5.2.2.5, respectively. Additionally, assumptions provided for Strategy 2 (Section 5.2.8.5) would apply.

5.2.14.6 Option-Specific Data Gaps

The option-specific data gaps are the same as provided for Strategy 1 and Option 1a, as discussed in Sections 5.2.1.6 and 5.2.2.6, respectively. Additionally, data gaps provided for Strategy 2 (Section 5.2.10.6) would apply.

5.2.14.7 Results for the No Soil Treatment (Option 2d)

In this section the long-term groundwater impact results are discussed for each of the applicable source components and for the option as a whole (i.e., composite of all the source components). The following discussions focus on the comparison between the results of this option and the results of Strategy 1.

Past Leaks Source Term

The CoCs in the past leaks are the same as those listed in Section 5.2.1 for Strategy 1 (see Appendix A for a discussion of the inventory). Figures 5.2.2, 5.2.3, and 5.2.4 are the calculated mass flux versus time for this option as well as the others for an initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown on these figures is at the vadose zone/water table interface and represents the contaminant mass flux to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2) the mass flux peak occurs at approximately 70 yr, and these contaminants would have passed completely through the vadose zone by about 2,300 yr. For the contaminants with K_d zero in the near-field and K_d

0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately 7,430 yr (Figure 5.2.3), and some of these contaminants would still be in transport within the vadose zone at the end of 10,000-yr the period of interest. The uranium isotopes are assumed to all have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for the uranium isotopes (Figure 5.2.4) occurs at approximately 9020 yr, and as for I-129 some of these contaminants would still be in transport within the vadose zone at the end of 10,000-yr the period of interest. The time to peak mass flux and the relative mass flux rate at the peak rate for this option (Option 2d), and for comparison of Strategy 1, are tabulated on Table 5.2.22 for the three K_d groups.

Figure 5.2.5 illustrates the maximum groundwater concentration for Tc-99 versus time for the past leak source component. The Tc-99 groundwater concentrations show nearly a log-linear decline from about 4.38+01 pCi/L at 150 yr to 2.09E-01 pCi/L at about 2,600 yr. Beyond 2,600 yr the maximum Tc-99 groundwater concentrations decrease at a more rapid rate to about 2.0E-04 at 5,000 yr to nearly zero at 7,600 yr. This is in response to the cessation of the source from the vadose zone in about the year 2,300.

Table 5.2.22. Comparison of Mass Flux Characteristics for Past Leak Components, Strategy 1 and Option 2d

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium isotopes)
Past leak source term component–Baseline Retrieval/Restricted Land Use (Strategy 1)			
Time to peak mass flux (yr)	65	7,400	8,750
Relative mass flux at peak for C = 1 initial source concentration	2.35E-01	5.22E-03	5.15E-03
Past leak source term component–Baseline Retrieval/Unrestricted Land Use–No Soil Treatment (Option 2d)			
Time to peak mass flux (yr)	71	7,430	9,020
Relative mass flux at peak for C = 1 initial source concentration	1.84E-01	5.27E-03	5.26E-03

The contaminants I-129, C-14, and the uranium isotopes all are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.6 and 5.2.7. The I-129 peak concentration is approximately 1.2E-02 pCi/L and occurs at approximately 7,600 yr, in response to the peak mass for through the vadose zone, which would occur in about the year 7,300. The U-238 maximum groundwater concentration is approximately 6.58E-03 and occurs at approximately 10,000 yr.

Retrieval Source Term

The CoCs in the retrieval source term are the same as those listed in Section 5.2.1 for Strategy 1 (see Appendix A for a discussion of the inventory). Figures 5.2.18, 5.2.19, and 5.2.20 are the mass flux versus time for this option as well as the others for an initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown in these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2) the maximum mass flux occurs at approximately 1,800 yr and these contaminants would have passed completely through the vadose zone by about 4,000 yr. For the contaminants with K_d of zero in the near-field and 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately

8,360 yr (Figure 5.2.19) and some of these contaminants would still be in transport within the vadose zone at the end of 10,000-yr the period of interest. The uranium isotopes are assumed to all have a K_d of 0.6 mL/g for the entire vadose zone. The mass flux for the uranium isotopes (Figure 5.2.20) continues to increase at the end of the 10,000-yr period of interest. The time to peak mass flux and the relative mass flux rate at the peak rate are tabulated on Table 5.2.23 for the three K_d groups and for Option 1a for comparison.

Table 5.2.23. Comparison of Mass Flux Characteristics for Retrieval Source Term Components, Option 1a and Option 2d

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Retrieval source term component–Baseline Retrieval/Restricted Land Use–Nominal Retrieval Losses (Option 1a)			
Time to peak mass flux (yr)	1,950	8,300	>10,000
Relative mass flux at peak for C = 1 initial source concentration	7.22E-02	1.90E-02	1.15E-02
Retrieval source term component–Baseline Retrieval/Unrestricted Land Use–No Soil Treatment (Option 2d)			
Time to peak mass flux (yr)	1,800	8,360	>10,000
Relative mass flux at peak for C = 1 initial source concentration	8.37E-02	2.01E-02	1.83E-02

Notes:

Strategy 1 assumes there would be no retrieval leakage loss, thus results for Option 1a are provided for comparison to Option 2d.

Figure 5.2.21 illustrates the maximum groundwater concentration for Tc-99 versus time for the retrieval leakage loss source component. The Tc-99 groundwater peak concentration of approximately 2.8E+01 pCi/L occurs at approximately 2,600 yr. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99, as illustrated in Figure 5.2.21.

The contaminants I-129, C-14, and the uranium isotopes all are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.22 and 5.2.23. The peak groundwater concentration for I-129 is approximately 1.28E-02 pCi/L and occurs at approximately 7,600 yr. The peak groundwater concentration for U-238 during the 10,000-yr period of interest is approximately 3.2E-02 pCi/L and occurs at approximately 10,000 yr. It appears that the groundwater concentration of U-238 increases beyond the 10,000-yr period.

Composite

This option's composite impact on the groundwater system stems from the past leaks and retrieval leakage loss source terms. The composite mass flux through the vadose zone from these two source terms is illustrated in Figure 5.2.34 for Tc-99, I-129, and U-128.
The composite Tc-99 mass flux reaches a peak rate at about 70 yr at a rate of 2.75E-02 Ci/yr compared to Strategy 1, for which the Tc-99 peaks at about 65 yr at a rate of 3.5E-02 Ci/yr. This option also has a secondary Tc-99 peak of about 7.0E-03 Ci/L at 1,700 yr (Figure 5.2.34). Nearly all of the Tc-99 would completely passed through the vadose zone by about 3,500 yr compared to 4,100 yr for Strategy 1.

The composite I-129 mass flux reaches a peak rate at about 8,000 yr at a rate of 3.24E-06 Ci/yr. At the end of the 10,000-yr period of interest I-129 is still entering the groundwater from the vadose zone but at a decreasing mass flux rate. At 10,000 yr the composite U-238 mass flux rate is 4.92E-06 Ci/yr and is still increasing.

Maximum Tc-99 groundwater concentrations for this option are shown in Figure 5.2.15. The Tc-99 groundwater concentrations result in nearly a log-linear decline from about 9.5E+01 pCi/L at 150 yr to 9 pCi/L at about 600 yr, at which time they increase to a peak of 2.78E+01 pCi/L at about 2,600 yr, probably in response to the secondary Tc-99 mass flux peak that occurs at about 1,700 yr.

Maximum I-129 groundwater concentrations for this option are shown in Figure 5.2.16. The I-129 groundwater concentrations are a near-constant of about 4.8E-04 pCi/L from 150 to 2,600 yr. After that time, the concentrations increase to a maximum of about 2.5E-02 pCi/L at 7,600 yr and then decrease to about 2.0E-02 pCi/L at 10,000 yr. The U-238 maximum groundwater concentrations for this option (Figure 5.2.17) follow a trend similar to that of I-129. The U-238 groundwater concentrations are a near constant of about 2.4 E-04 pCi/L from 150 to 5,000 yr. After that time, the concentrations increase to a maximum of about 3.8E-02 pCi/L at 10,000 yr.

5.2.15 No Action Strategy (Strategy 3)

The No Action strategy includes completion of saltwell pumping and maintaining the tanks until the end of institutional control. There would be no waste retrieval and thus no retrieval leakage loss. There would be no tank backfilling nor installation of a surface barrier of any kind. The retrieval source term component of the No Action strategy is identical to that of Strategy 1 in that there would be no retrieval leakage loss for either strategy.

5.2.15.1 Past Leaks

The simulation of past leaks is similar to that for Strategy 1 discussed in Section 5.2.1. However, there would be comparatively greater recharge beginning in the year 2020 because this strategy would not include a surface barrier of any type. Otherwise, the simulation of past leaks is conducted in the same way as for Strategy 1.

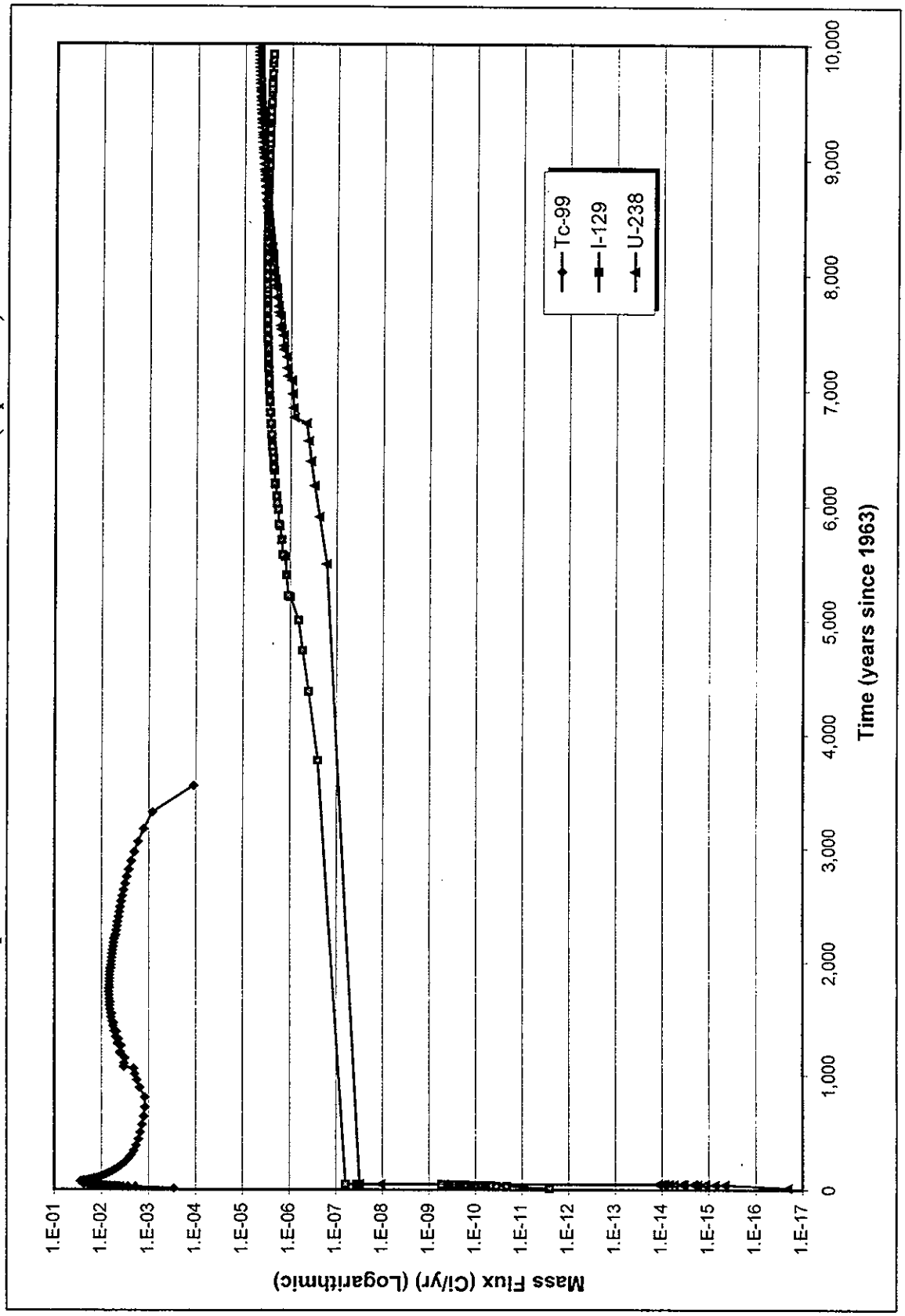
5.2.15.2 Retrieval Leakage Loss

For this strategy there would be no retrieval and thus no retrieval leakage loss.

5.2.15.3 Residual Waste

The residual tank waste that remain in the tank are assumed to be 100 percent of the inventory. The composition and concentration values for the residual source terms are provided in Appendix A. It is assumed that the residual waste would be moist after saltwell pumping was completed. Dissolution of the contaminants would begin in 2031, and the waste would be released over the full area of the base of the tank in the recharging liquid at the concentration specified in Appendix A. The base of the tank is approximately 17 m (55 ft) belowground surface.

Figure 5.2.34. Mass Flux Versus Time for Tc-99, I-129, and U-238 for the Composite of All Source Terms - No Soil Treatment (Option 2d)



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5.2.15.4 Recharge

The recharge assumptions for this strategy are as follows.

- Prior to 1963, the year construction began on the AX Tank Farm, recharge is assumed to be a steady 3 mm/yr (0.12 in./yr) (same as Strategy 1).
- Recharge is assumed to increase during tank construction from 3 to 100 mm/yr (0.12 to 3.94 in./yr) over a 1-yr period from 1963 to 1964 (same as Strategy 1).
- Recharge remains at 100 mm/yr (3.94 in./yr) until the year 2020.
- Recharge is reduced from 100 to 6 mm/yr (3.94 to 0.24 in./yr) from the year 2020 to 2021 and remains at 6 mm/yr (0.24 in./yr) for the duration of the period of interest.
  The recharge is reduced by the wind-blown silt and sand infiltrating the gravel followed by the reestablishment of surface vegetation.

5.2.15.5 Enabling Assumptions

The enabling assumptions are the same as provided for Strategy 1 as discussed in Section 5.2.1.5.

5.2.15.6 Strategy-Specific Data Gaps

The strategy-specific data gaps are the same as provided for Strategy 1 as discussed in Section 5.2.1.6.

5.2.15.7 Results for the No Action Strategy (Strategy 3)

In this section, the long-term groundwater impact results are discussed for each of the applicable source components and for the option as a whole (i.e., composite of all the source components). The following discussions focus on the comparison between the results of this strategy and the results of Strategy 1.

Past Leaks Source Term

The CoCs in the past leaks source term are the same as those listed in Section 5.2.1 for Strategy 1 (see Appendix A for a discussion of the inventory). Figures 5.2.2, 5.2.3, and 5.2.4 are the calculated mass flux versus time for this strategy as well as the others for an initial concentration of one (dimensionless) for each of the three K_d groups. The mass flux shown in these figures is at the vadose zone/water table interface and represents the contaminant mass flux trend to the unconfined aquifer. For a K_d zero contaminant (i.e., Tc-99, Se-79, NO_3, and NO_2) the mass flux peak occurs at approximately 65 yr. The K_d zero contaminants would have completely passed through the vadose zone after about 3,200 yr. For the contaminants with K_d of zero in the near-field and K_d of 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately 3,800 yr (Figure 5.2.3). The uranium isotopes are assumed to all have a K_d of 0.6 mL/g for the entire vadose zone. The peak mass flux for the uranium isotopes (Figure 5.2.4) occurs at approximately 4,600 yr. The time to peak mass flux and the relative mass flux rate at the peak rate for this strategy and for Strategy 1 are tabulated on Table 5.2.24 for the three K_d groups.

Table 5.2.24. Comparison of Mass Flux Characteristics for Past Leak Components, Strategies 1 and 3

	K_d Group Zero (Tc-99, Se-79, NO_3/NO_2, EDTA, and CN)	K_d Group One (C-14, I-129)	K_d Group Two (Uranium Isotopes)
Past leak source term component–Baseline Retrieval/Restricted Land Use (Strategy 1)			
Time to peak mass flux (yr)	65	7,400	8,750
Relative mass flux at peak for C = 1 initial source concentration	2.35E-01	5.22E-03	5.15E-03
Past leak source term component–No Action (Strategy 3)			
Time to peak mass flux (yr)	65	3,800	4,600
Relative mass flux at peak for C = 1 initial source concentration	2.35E-01	9.9E-03	9.4E-03

Figure 5.2.5 illustrates the maximum groundwater concentration for Tc-99 versus time for the past leak source component. The Tc-99 maximum concentrations in groundwater decrease uniformly from about 51 pCi/L at 150 yr to 22 pCi/L after 600 yr. The concentrations then decrease at a more rapid rate between 600 and 1,200 yr to a value of about 3.36E-01 at 1,200 yr. This is followed by a relatively steady concentration of about 3.3E-01 pCi/L until 5,000 yr. At 5,000 yr, the Tc-99 maximum concentrations drop off sharply. For approximately the first 600 yr the maximum Tc-99 concentration in groundwater tracks slightly higher than for any of the other strategies or options in response to the effect of the increased recharge attributed to the lack of a surface barrier coupled with the relatively large residual inventory.

The contaminants I-129, C-14, and the uranium isotopes are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.6 and 5.2.7. The I-129 peak concentration is approximately 1.55E-02 pCi/L and occurs at approximately 4,800 yr. The U-238 maximum concentration is approximately 1.2E-02 and occurs at approximately 5,000 yr and may not have peaked.

Retrieval Source Term

There would be no retrieval and thus no retrieval leakage loss or associated impacts for this strategy.

Residual Source Term

The CoCs in the residual waste source term are the same as those listed in Section 5.2.1 for Strategy 1 (see Appendix A for a discussion of the inventory). Figures 5.2.8, 5.2.9, and 5.2.10 are the mass flux versus time for this strategy as well as the others for Tc-99, I-129 and U-238. The mass flux shown in these figures is at the vadose zone/water table interface and represents the contaminant flux to the unconfined aquifer. For Tc-99, a K_d zero, the maximum mass flux occurs at approximately 2,000 yr. All of the Tc-99 would have passed through the vadose zone by about 5,000 yr. For the contaminants with K_d zero in the near-field and K_d 0.6 mL/g in the far-field (i.e., I-129 and C-14) the peak mass flux occurs at approximately 8,100 yr (Figure 5.2.10). The uranium isotopes are assumed to have a K_d of 0.6 mL/g for the entire vadose zone. The mass flux for the uranium isotopes (Figure 5.2.9) is still increasing at 10,000 yr, the end of the period of interest. Provided in Table 5.2.25 are the times to peak mass

flux and relative peak mass flux for Strategy 3 and, for comparison, for Strategy 1, for the three K_d groups.

Table 5.2.25. Comparison of Mass Flux Characteristics for Residual Loss Components, Strategies 1 and 3

	Tc-99	I-129	U-238
Residual source term component–Baseline Retrieval/Restricted Land Use (Strategy 1)			
Time to peak mass flux (yr)	2,300	8,700	10,000
Mass flux at peak (Ci/yr)	2.69E-03	1.08E-06	6.39E-07
Residual source term component–No Action (Strategy 3)			
Time to peak mass flux (yr)	2,000	8,100	10,000
Mass flux at peak (Ci/yr)	1.24E-01	2.55E-05	2.7E-05

Figure 5.2.11 illustrates the maximum groundwater concentration for Tc-99 versus time for the residual source component. The peak Tc-99 maximum groundwater concentration is about 600 pCi/L and occurs at about 2,600 yr. The other mobile contaminants considered (i.e., Se-79, NO_3, and NO_2) mirror the behavior of Tc-99, as illustrated in the maximum groundwater concentration versus time figure (Figure 5.2.11).

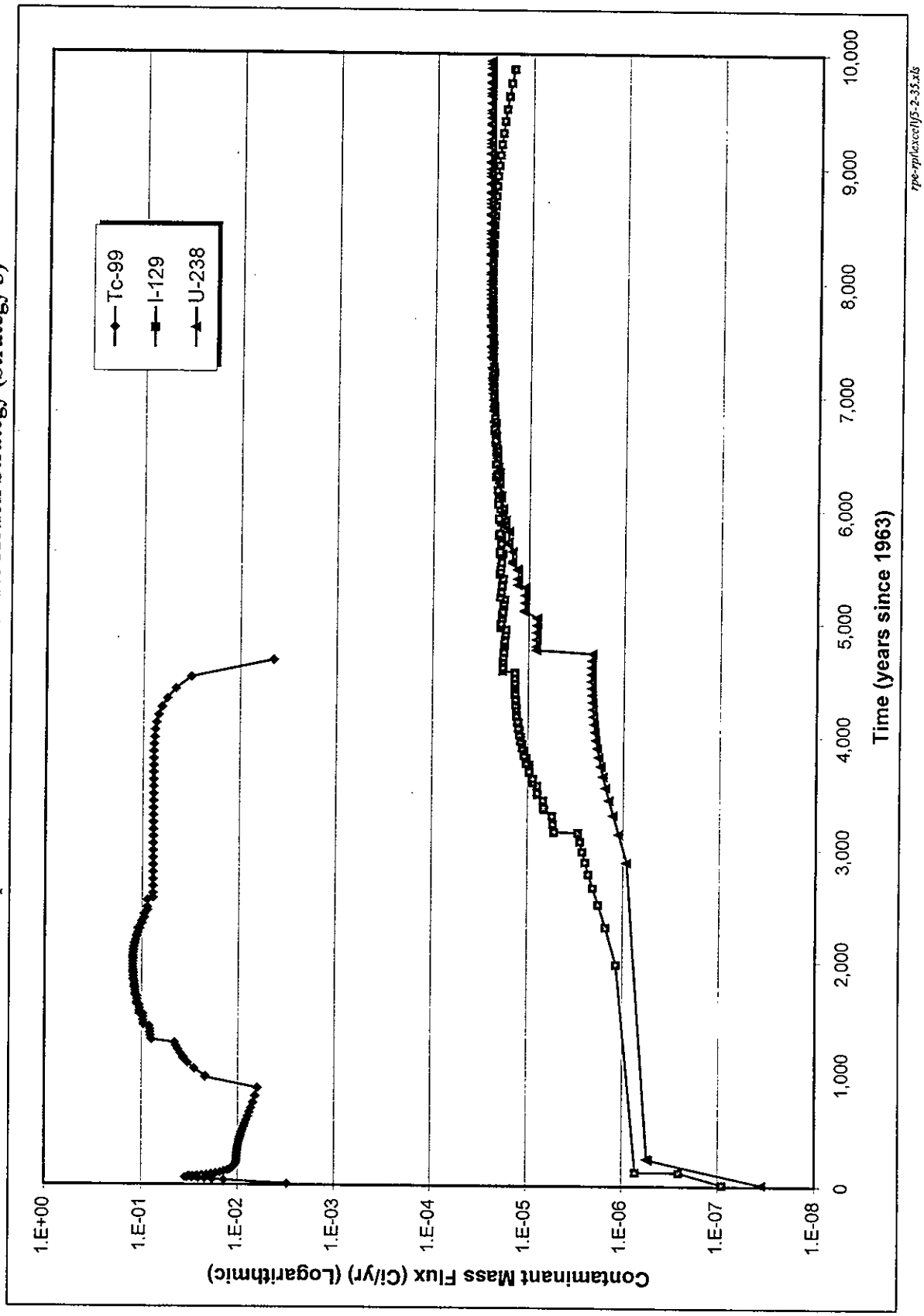
The contaminants I-129, C-14, and the uranium isotopes are assumed to have a K_d of 0.6 mL/g in the groundwater. The maximum groundwater concentrations versus time for I-129 and U-238 are illustrated in Figures 5.2.12 and 5.2.13, respectively. The maximum I-129 groundwater concentration is approximately 4.0E-01 pCi/L at 10,000 yr and appears to continue to increase beyond the period of interest. The groundwater concentration of U-238 also peaks at 10,000 yr at about 2.1E-01 pCi/L and appears to be increase beyond this period of interest.

Composite Results

The composite mass flux through the vadose zone for this strategy is presented in Figure 5.2.35 for three selected contaminants (i.e., Tc-99, I-129, and C-14). The y-axis values of mass flux on these figures are not comparable to the mass flux versus time plots for past leaks and retrieval leakage loss because the composite results are contaminant-specific and the past leak and leakage loss mass flux are for the whole K_d group and, as such, are based on a unit initial concentration. There is a step in the composite mass flux curve as the past leak contribution to the composite wanes and the residual contribution becomes dominant. This step can be observed for all three of the contaminants.

Figures 5.2.15, 5.2.16, and 5.2.17 illustrate the maximum groundwater concentration for Tc-99, I-129, and U-238 versus time for the composite of the source components. The maximum Tc-99 groundwater concentrations decrease uniformly from about 93 pCi/L at 150 yr to 65 pCi/L at 600 yr and, as expected, these concentrations are greater than would be for any of the other strategies. At 600 yr the Tc-99 concentrations begin to increase and reach a peak value of about 600 pCi/L at 2,600 yr. Groundwater concentrations of Tc-99 then decline for the remainder of the period of interest.

Figure 5.2.35. Mass Flux Versus Time for Tc-99, I-129, and U-238 for the Composite of All Source Terms - No Action Strategy (Strategy 3)



The I-129 groundwater concentrations follow much the same trend as the other landfill strategies except with a shift upward due to the greater overall mass being released. From 150 yr to about 1,200 yr the I-129 concentration is a steady 5.6E-03 pCi/L. From 1,200 yr the concentrations increase to a peak value of 2.0E-01 pCi/L at 7,600 yr and then sharply decline at 10,000 yr.

The U-238 groundwater concentrations also follow much the same trend as the other landfill strategies, except with a shift upward due to the greater overall mass being released. From 150 yr to about 1,200 yr, the I-129 concentration is a steady 4.3E-03 pCi/L. From 1,200 yr the concentrations increase to a peak value of about 2.1E-01 pCi/L at 10,000 yr.

5.3 LONG-TERM HUMAN HEALTH RISKS

This section describes the potential risk to human health after the AX Tank Farm waste retrieval and SST closure actions are completed. A discussion of the methodology and assumptions used to develop the risk calculations is presented in Section 3.6. Conclusions, performance measures, and data needs based on the analysis presented in this section are provided in Section 6.0. Long-term human health risk was calculated for two types of health effects: 1) the potential for ILCR; and 2) toxic effects. The ILCR is expressed as the increased probability of an individual developing cancer over a lifetime from exposure to radionuclides or nonradioactive carcinogenic chemicals. The CoCs for this assessment did not include nonradioactive carcinogenic chemicals. Therefore, the ILCR calculations presented in this section were based on the radionuclide CoCs (C-14, I-129, Se-79, Tc-99, U-233, U-234, U-235, U-236, and U-238).

There is no universal standard for the level of risk that is considered acceptable. Generally acceptable exposure levels suggested by Federal (55 FR 8666 and 40 CFR 300) and State (WAC 173-340) standards for known or suspected carcinogens, are those that represent an ILCR in the range of 1.0E-04 and 1.0E-06, which indicates a probability of 1 in 10,000 to 1 in 1,000,000, respectively. Washington State generally sets the upper limit of risk at 1.0E-05 (1 in 100,000 probability). An ILCR of 1.0 means that an individual's lifetime probability of developing cancer approaches 100 percent. For purposes of this assessment, a risk less than 1.0E-06 (1 in 1,000,000) was considered low. A risk greater than 1.0E-04 (1 in 10,000) was considered high.

Toxic effects from exposure to noncarcinogenic chemicals were evaluated in terms of an HI, which is the ratio of chemical intake to a reference dose below which no adverse health effects would be expected. The noncarcinogenic chemical CoCs for this assessment were cyanide, EDTA, and nitrate. For an HI greater than 1.0, adverse health effects would be expected. For an HI less than 1.0, no adverse health effects would be expected. A health effect could be fatal or it could be a minor temporary effect on the human body, depending on the specific chemical and the amount of exposure involved.

As discussed in Section 3.6, long-term human health risk was calculated for a range of potential future site users using an MRA methodology. The MRA methodology independently evaluates the three components (modules) of risk (source term, transport, and exposure) and then multiplies the components together to compute the total risk. The source term is the amount and type of contaminant that may be released to the environment. For this assessment the source term was the AX Tank Farm waste that would be left onsite after waste retrieval and tank farm closure activities are completed. Past tank leaks and spills, retrieval leakage loss, and residual waste (in tanks and ancillary equipment) were evaluated separately and as a composite source term for each retrieval and closure option. The source terms of the options would vary because of the differences in the quantity, form, or manner of containment of the waste left onsite. The source term releases are described in Section 3.2 and in Appendix A.

Transport refers to the movement of contaminants in the environment from the source to the receptor. Transport was evaluated for potential contaminant releases occurring before (past tank leaks), during (retrieval leakage loss), and after (residual waste) waste retrieval and tank farm closure activities. The releases would enter the vadose zone soil surrounding the tanks and be

available for transport to groundwater from infiltration of precipitation and percolation through the soil column. Based on the existing depth of the tanks, resulting soil contamination would be below the maximum depth of soil likely to be contacted by all potential receptors. The only credible way for contaminants to reach receptors would be via groundwater. Groundwater was therefore the only exposure medium considered for this analysis. Computer modeling of contaminant fate and transport in the vadose zone and groundwater is described in Section 3.5 and Appendix B, and modeling results are presented in Section 5.2.

Because the groundwater pathway can take hundreds or thousands of years to result in exposures, and because contaminants in the waste are persistent, human health risk was calculated for a number of extended time periods over a 10,000-yr period of interest. This shows how potential risk may increase or decrease over time as contaminants move through the groundwater and as radioactive decay changes the characteristics of the contaminants. To show these changes, risks were calculated for 9 time periods: 150; 200; 400; 600; 1,200; 2,600; 5,000; 7,600; and 10,000 yr from 1963 when the tanks were constructed.

Exposure involves the pathway, duration, and intensity of potential exposure from contaminants that have been transported into and through the groundwater. The types and amount of exposure would be dependent on future potential land uses. Four exposure scenarios were evaluated: 1) Native American; 2) residential farmer; 3) industrial worker; and 4) recreational shoreline user. The potential risk for each of these future land uses would be different because each scenario would involve different levels of consumption and contact with contaminated groundwater or surface water contaminated by discharge of groundwater. There would be no groundwater or surface water pathway for a recreational land user, thus there were no risks for this exposure scenario under any of the waste retrieval and tank farm closure options. Therefore, this scenario was not addressed in this analysis.

The data input for calculation of the total risk to each receptor consisted of the groundwater concentration grid files generated by the contaminant transport modeling discussed in Section 3.5. Separate groundwater input files were used for the individual and composite source terms. Using the MRA methodology, the risk to a receptor at a given time in a given grid cell was calculated by multiplying the predicted groundwater concentration for each constituent by the corresponding unit risk factor. Risk from carcinogenic constituents was summed and reported as the ILCR. Risk from noncarcinogenic constituents was summed and reported as an HI. Each grid cell represents an area of interest with a uniform risk level for a particular receptor at a particular time.

It is assumed that institutional controls would be maintained on the tank farms, the surrounding 200 Areas exclusive WMA, and groundwater for drinking water and other uses for a period of 100 yr following the completion of closure. Administrative controls or institutional controls also refer to deed and other restrictions that can be used to limit land use. For this report, all long-term human health risks are reported from the end of institutional controls until the end of the 10,000-yr period of interest.

The year 1963 was used as the starting point for the contaminant transport simulations and long-term risk calculations because this is the year that the AX Tank Farm was constructed.

All time periods specified in this report are in reference to elapsed time since 1963. For example, the end of the 10,000-yr period of interest corresponds to the year 11,963.

For this report, closure is assumed to occur at 50 yr (corresponding to 2013) and the 100-yr institutional control period is assumed to end at 150 yr (corresponding to 2113). Although the long-term risk results presented in this report begin at 150 yr, an analysis was conducted at 50- and 100-yr to examine potential impacts during the period of institutional controls. Results of the analysis are presented in Table 5.3.1, which shows maximum residential farmer risk (ILCR) at the start (50 yr), midway point (100 yr), and end (150 yr) of institutional controls.

Table 5.3.1. Long-Term Human Health Risks During Institutional Controls (Residential Farmer Incremental Lifetime Cancer Risk)

Strategy	50 yr from 1963	100 yr from 1963	150 yr from 1963
Baseline Retrieval/Restricted Land Use (Strategy 1)	3.8E-05	2.7E-05	1.2E-05
Nominal Retrieval Losses (Option 1a)	3.8E-05	2.7E-05	1.2E-05
Large Retrieval Losses (Option 1b)	5.0E-05	3.9E-05	2.3E-05
Optimal Residual Losses (Option 1c)	3.8E-05	2.7E-05	1.2E-05
Suboptimal Residual Losses (Option 1d)	3.9E-05	2.8E-05	1.3E-05
Temporary Operations Barrier (Option 1e)	2.8E-05	7.7E-06	5.8E-06
Postretrieval Hanford Barrier (Option 1f)	3.8E-05	2.7E-05	1.2E-05
Nominal Losses/Soil Grouting (Option 1g)	2.7E-05	7.4E-06	5.6E-06
Large Losses/Soil Grouting (Option 1h)	2.7E-05	7.5E-05	5.7E-06
Baseline Retrieval/ Unrestricted Land Use (Strategy 2)	2.9E-05	1.0E-5	8.5E-06
Nominal Losses/Excavate Soil (Option 2a)	2.9E-05	1.0E-5	8.5E-06
Past Leak/In Situ Soil Treatment (Option 2b)	3.5E-05	9.7E-06	5.9E-06
Nominal Losses/In Situ Soil Treatment (Option 2c)	3.5E-05	9.7E-06	5.9E-06
No Soil Treatment (Option 2d)	3.6E-05	2.5E-05	1.2E-05
No Action (Strategy 3)	4.9E-05	3.9E-05	2.5E-05

Based on the State regulatory risk standard (1.0E-05), these results support maintaining institutional controls for the AX Tank Farm until 150 yr for nearly all of the Strategy 1 options and one of the Strategy 2 options. For certain options under both Strategy 1 (Options 1g, 1h) and Strategy 2 (Strategy 2 and Options 2a, 2b, 2c), release of the groundwater could occur before the end of institutional controls. For these six options, the residential farmer ILCR would fall below 1.0E-05 before 150 yr and remain below this level through 10,000 yr. For all other options, the residential farmer ILCR would exceed 1.0E-05 either for the duration of institutional controls or for one or more time periods over 10,000 yr following the end of institutional controls.

Results of the long-term human health risk assessment are provided using two separate presentation methods: 1) presentation by maximum ILCR risks and health hazards and 2) presentation by risk isopleths (lines connecting points of equal risk). Risk maximums, which are given in tables and graphs, show the maximum anticipated ILCR and health risk to a given receptor at a given time without respect to location. Risk maximums are a good means of

illustrating how risks would vary over time and are useful for comparing among the large set of waste retrieval and tank farm closure options. In reviewing the tables and graphs showing risk maximums, it should be noted that for all time periods and receptors under each retrieval and closure option considered, the location of maximum risk was calculated to be at the source (i.e., groundwater directly beneath the AX Tank Farm). Results of the risk analysis showed that risk levels would be expected to decrease at locations east of the AX Tank Farm.
The groundwater gradient beneath the AX Tank Farm is generally from west to east, toward the Columbia River. Downgradient decreases in risk reflect downgradient decreases in predicted groundwater contaminant concentrations caused by plume dispersion and decay during transport toward the river. Following the end of institutional controls (i.e., after 150 yr), risk levels at the AX Tank Farm would be approximately one order of magnitude higher than risk levels at the Columbia River shoreline (Table 5.3.2).

Table 5.3.2. ILCR for the Residential Farmer at the AX Tank Farm and at the Shoreline of the Columbia River

Strategy or Option	150 Yr from 1963		1,200 Yr from 1963		5,000 Yr from 1963		10,000 Yr from 1963	
	Residential farmer at AX Tank Farm	Residential farmer at shoreline	Residential farmer at AX Tank Farm	Residential farmer at shoreline	Residential farmer at AX Tank Farm	Residential farmer at shoreline	Residential farmer at AX Tank Farm	Residential farmer at shoreline
Nominal Retrieval Losses (Option 1a)	1.2E-05	1.6E-06	6.5E-06	6.7E-07	5.0E-07	4.8E-08	1.2E-06	1.3E-07
Nominal Losses/ Excavate Soil (Option 2a)	8.5E-06	8.6E-07	9.1E-07	1.0E-07	3.3E-08	3.4E-09	3.6E-09	3.7E-10
No Action (Strategy 3)	2.5E-05	2.8E-06	9.0E-05	9.3E-06	1.7E-05	1.6E-06	1.2E-05	1.2E-06

Risk isopleths, which are given in contour maps, show the anticipated location and extent of the areas affected by each risk level for a given receptor at a given time. While risk contour maps provide a good means of illustrating the risk extent, they do not facilitate easy comparison among the RPE options. This is primarily due to the large number of contour maps that would be needed if all of the RPE risk results were shown. Providing contour maps for all cases considered would result in 540 maps for the composite source term ILCR calculations alone (based on 15 options, 4 receptors, and 9 time periods). To reduce the number of figures presented, contour maps are provided for three waste retrieval and tank farm closure options: 1) Nominal Retrieval Losses (Option 1a); 2) Nominal Losses/Excavate Soil (Option 2a); and 3) No Action (Strategy 3). These options are representative of each of the three distinct retrieval and closure strategies addressed in the RPE (i.e., restricted land use, unrestricted land use, and No Action) and were chosen to provide a basis for reference and comparison. As described in the following paragraphs, two additional steps were taken to reduce the number of contour map figures presented.

First, the variations in ILCR with time were examined to identify whether all 9 time periods were equally informative. Figures 5.3.1 through 5.3.8 show the maximum ILCR plots for all exposure scenarios and retrieval and closure options. These curves are moderately flat between 150 and

400 yr and between 7,500 and 10,000 yr indicating little variation in risk during these time periods. Therefore, contour maps were included for the 150-, 600-, 1,200-, 2,600-, 5,000-, and 10,000-yr time periods but were omitted for the 200-, 400-, and 7,600-yr time periods.

Next, the variations in ILCR between the exposure scenarios were examined. As shown in Figures 5.3.9 and 5.3.10 for Options 1a and 1b, the maximum risk values for the four exposure scenarios vary over the 10,000-yr period by a roughly constant factor. The curves for the four scenarios are nearly parallel at all time periods for these two options, and similar relationships were found to exist for the other options considered. The risk values for the Native American scenario were consistently higher by a factor of 10, 300, and 2,000 than the risk values for the residential farmer, industrial worker, and recreational shoreline user. Because the risk to one receptor can be related to the risks to the other receptors with a scaling factor, it was considered sufficient to provide contour maps for one scenario. The residential farmer scenario was selected as the primary scenario for presentation because 1) the risk values for this scenario were intermediate between the Native American and industrial worker scenarios; 2) the Native American scenario has not received a complete review by the scientific community or Tribal Nations; and 3) the residential farmer scenario is based on the risk scenario used by Washington State for waste site risk assessments and by EPA for Superfund site risk assessments.

5.3.1 Long-Term Human Health Risk Results by Strategy

This section describes the risk to each receptor from the composite source term for all waste retrieval and tank farm closure strategies and options. Table 5.3.3 shows the maximum calculated potential ILCR and HI from the composite source term for each receptor, time period, and retrieval and closure option. Table 5.3.4 shows the time of peak risk from the composite source term for each receptor under each retrieval and closure option. It should be noted that for all but the Suboptimal Residual Volume option (Option 1d) and the No Action strategy (Strategy 3) peak risks were calculated to occur during the period of time when institutional controls would be in place, thus preventing the use of Site groundwater. The peak risks shown in Table 5.3.4 are the peaks that would occur after institutional controls end at 150 yr (from 1963).

The ILCR data shown in Table 5.3.3 are plotted graphically for Strategy 1 and its options in Figures 5.3.1 through 5.3.4 for the Native American, residential farmer, industrial worker, and recreational shoreline user scenarios. The ILCR data shown in Table 5.3.3 are plotted graphically for Strategy 1 and its options in Figures 5.3.5 through 5.3.8 for the Native American, residential farmer, industrial worker, and recreational shoreline user scenarios. The No Action strategy is plotted in Figures 5.3.1 through 5.3.8 for reference.

5.3.1.1 Baseline Retrieval/Restricted Land Use Strategy (Strategy 1)

The ILCR for each receptor scenario would peak within 150 yr. At 150 yr, the ILCR would exceed 1.0E-04 for the Native American scenario, 1.0E-05 for the residential farmer scenario, 1.0E-07 for the industrial worker scenario, and 1.0E-08 for the recreational shoreline user scenario.

Figure 5.3.1. Baseline Retrieval/Restricted Land Use Strategy and Options, Native American Scenario, Maximum ILCR from Composite Source Term

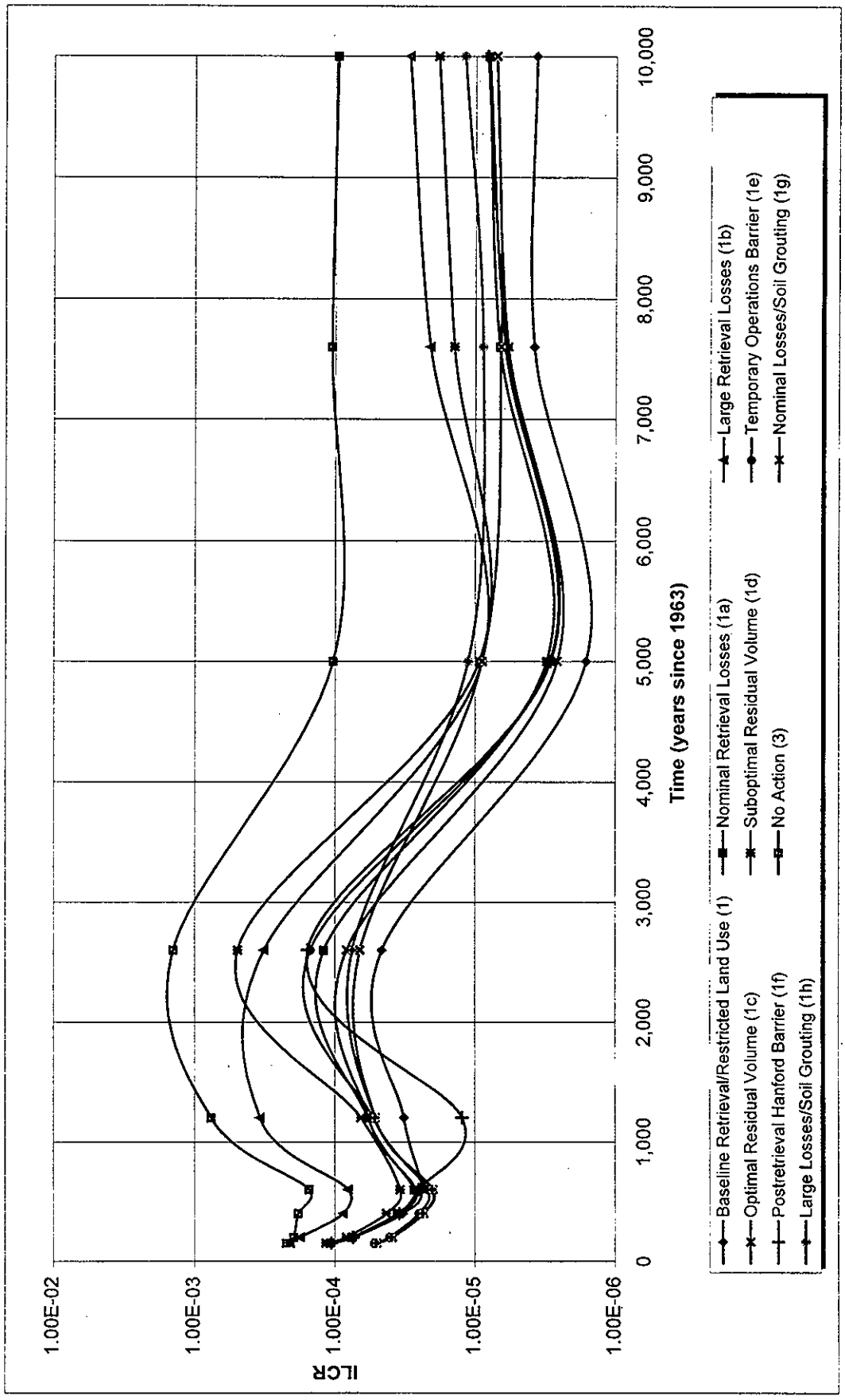


Figure 5.3.2 Baseline Retrieval/Restricted Land Use Strategy and Options, Residential Farmer Scenario, Maximum ILCR from Composite Source Term

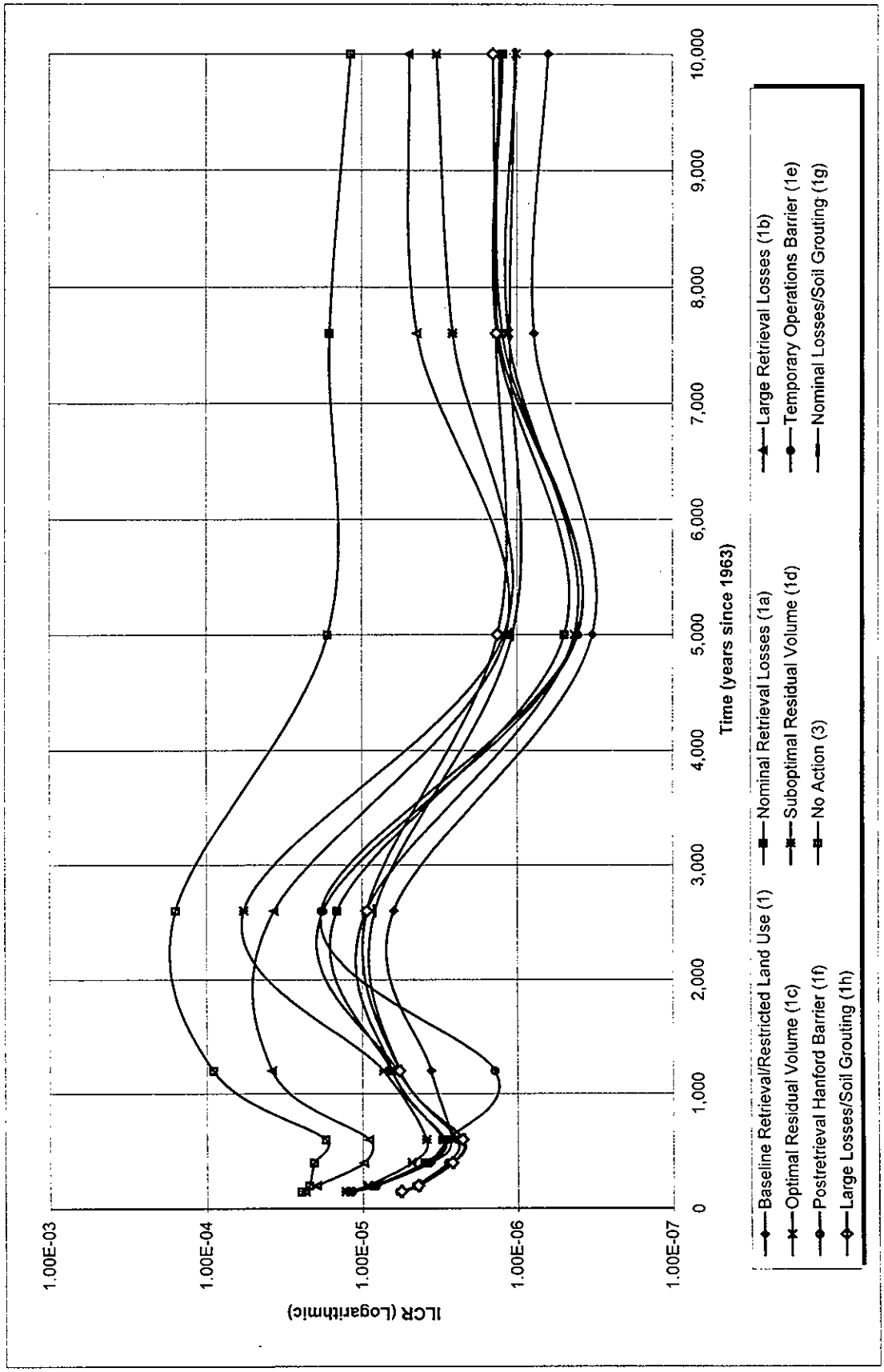


Figure 5.3.3. Baseline Retrieval/Restricted Land Use Strategy and Options, Industrial Worker Scenario, Maximum ILCR from Composite Source Term

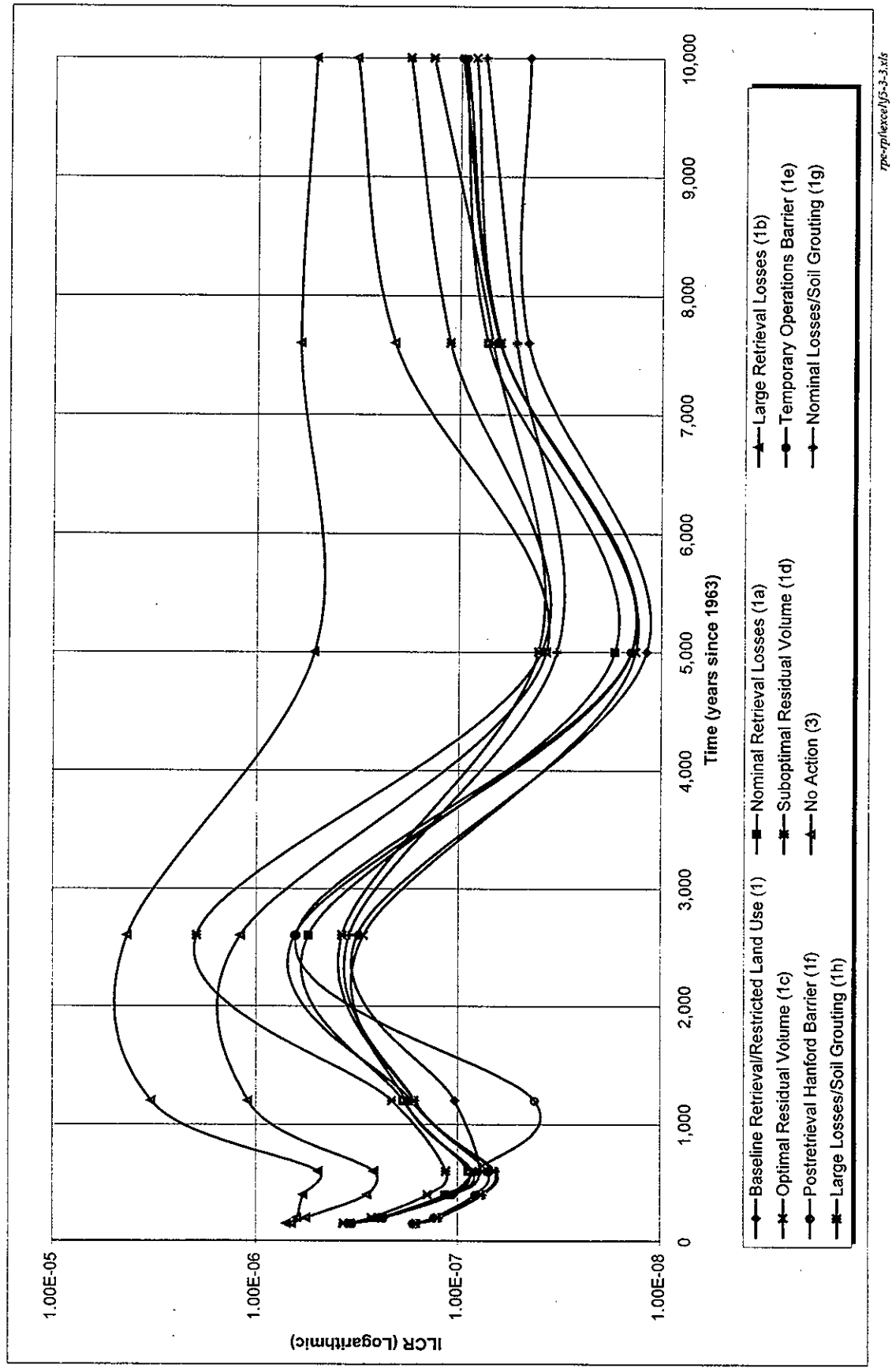


Figure 5.3.4. Baseline Retrieval/Restricted Land Use Strategy and Options, Recreational Shoreline User Scenario, Maximum ILCR from Composite Source Term

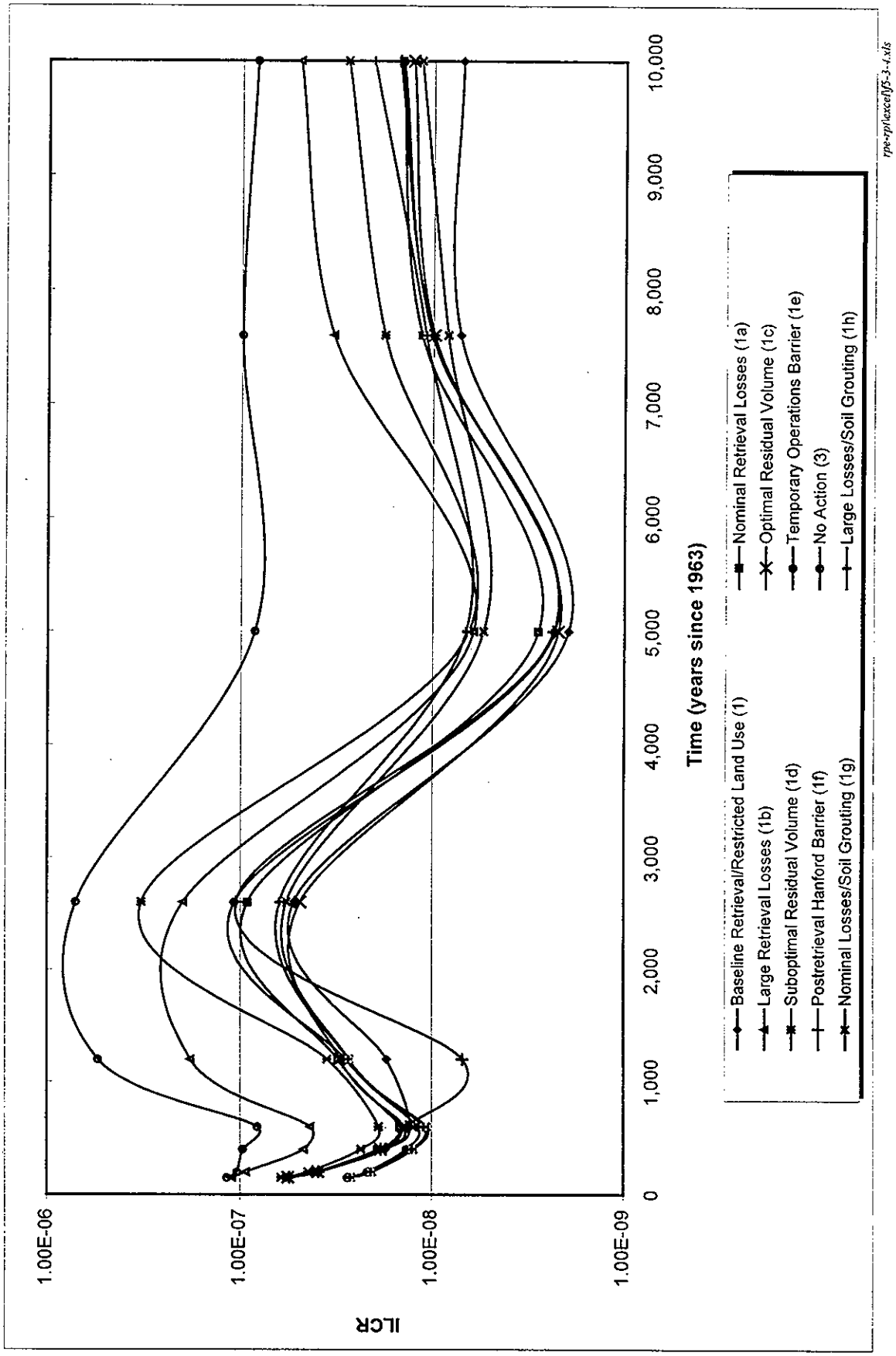


Figure 5.3.5. Baseline Retrieval/Unrestricted Land Use Strategy and Options, Native American Scenario, Maximum ILCR from Composite Source Term

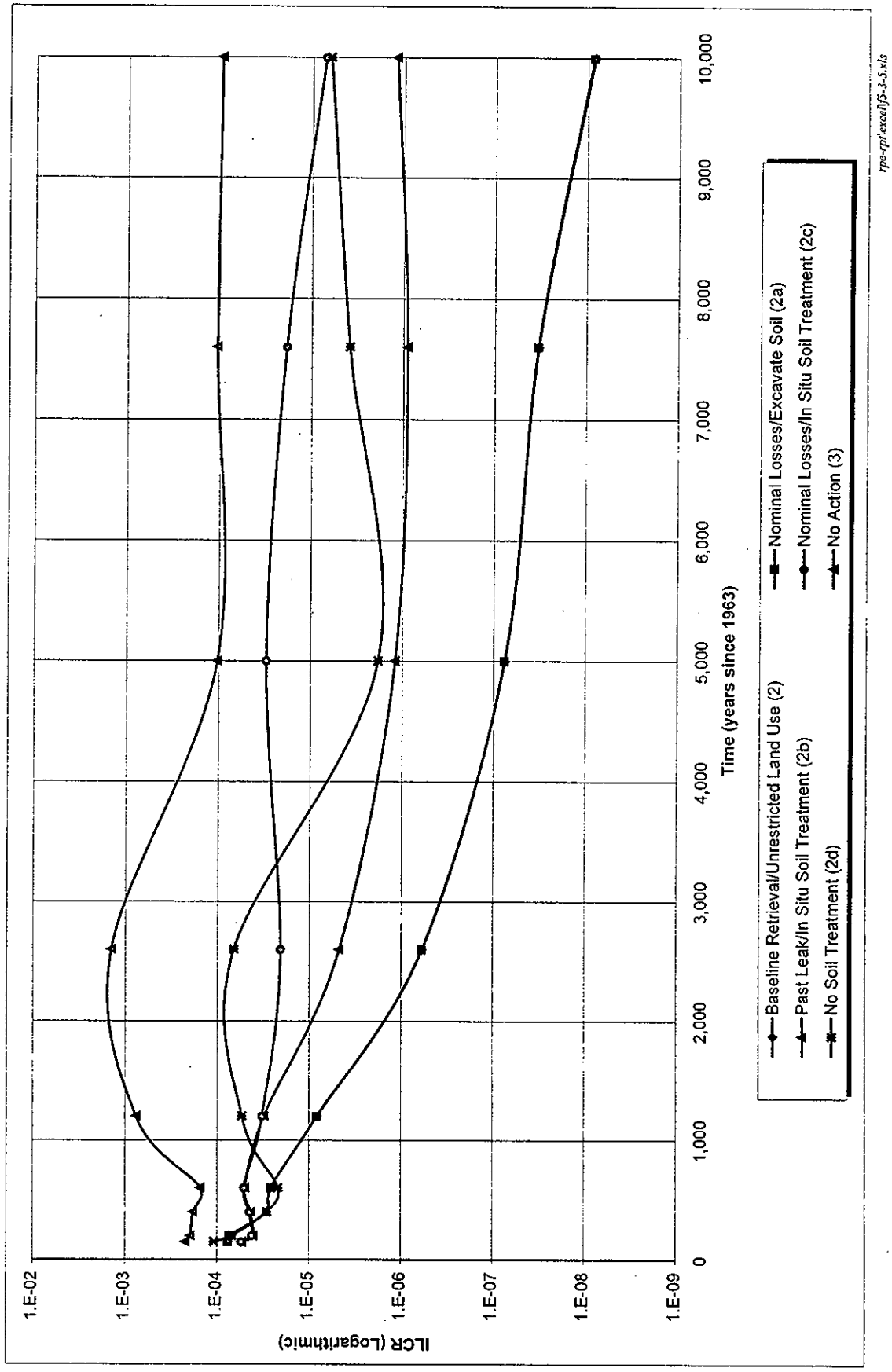


Figure 5.3.6. Baseline Retrieval/Unrestricted Land Use Strategy and Options, Residential Farmer Scenario, Maximum ILCR from Composite Source Term

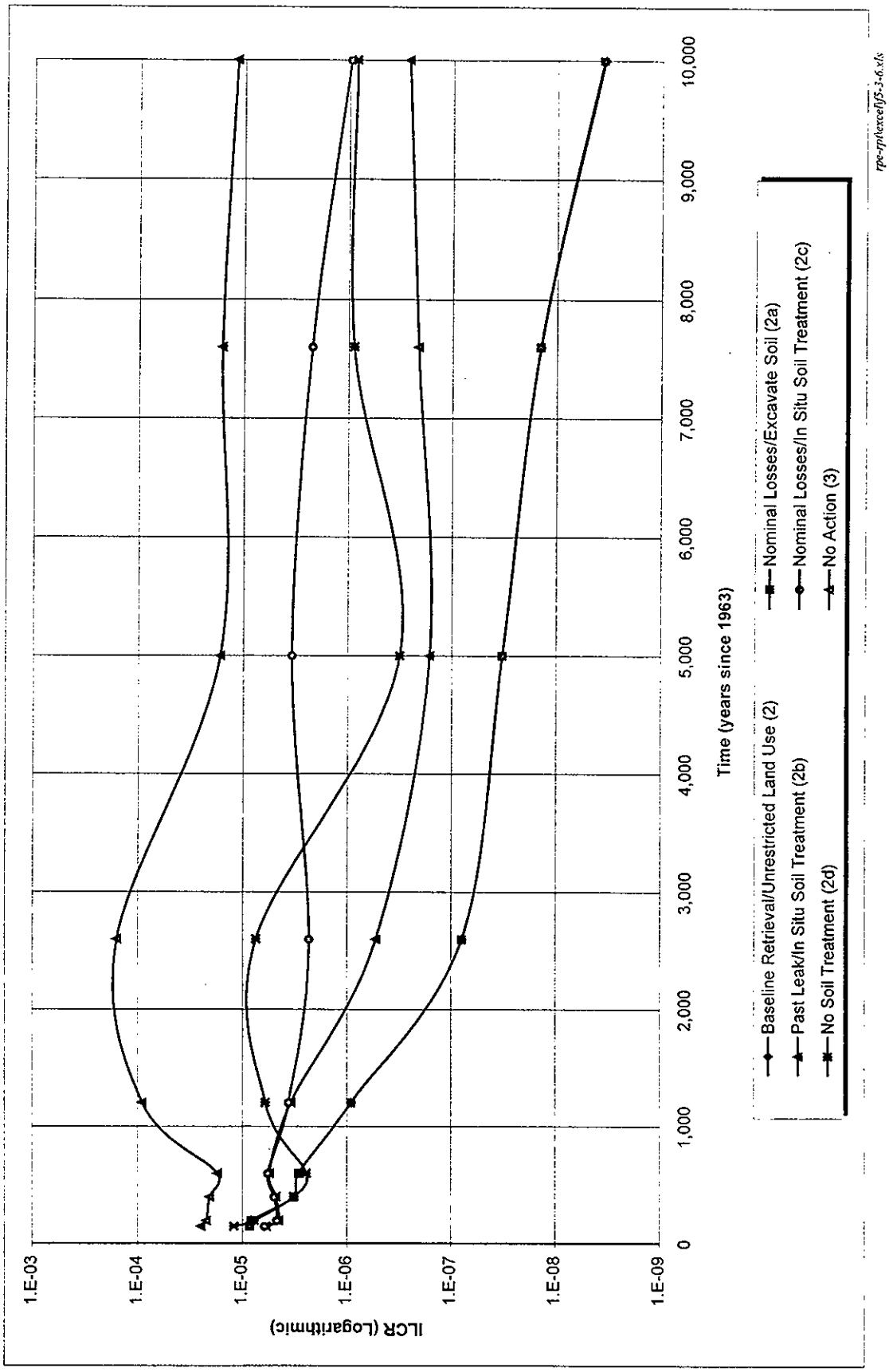


Figure 5.3.7. Baseline Retrieval/Unrestricted Land Use Strategy and Options, Industrial Worker Scenario, Maximum ILCR from Composite Source Term

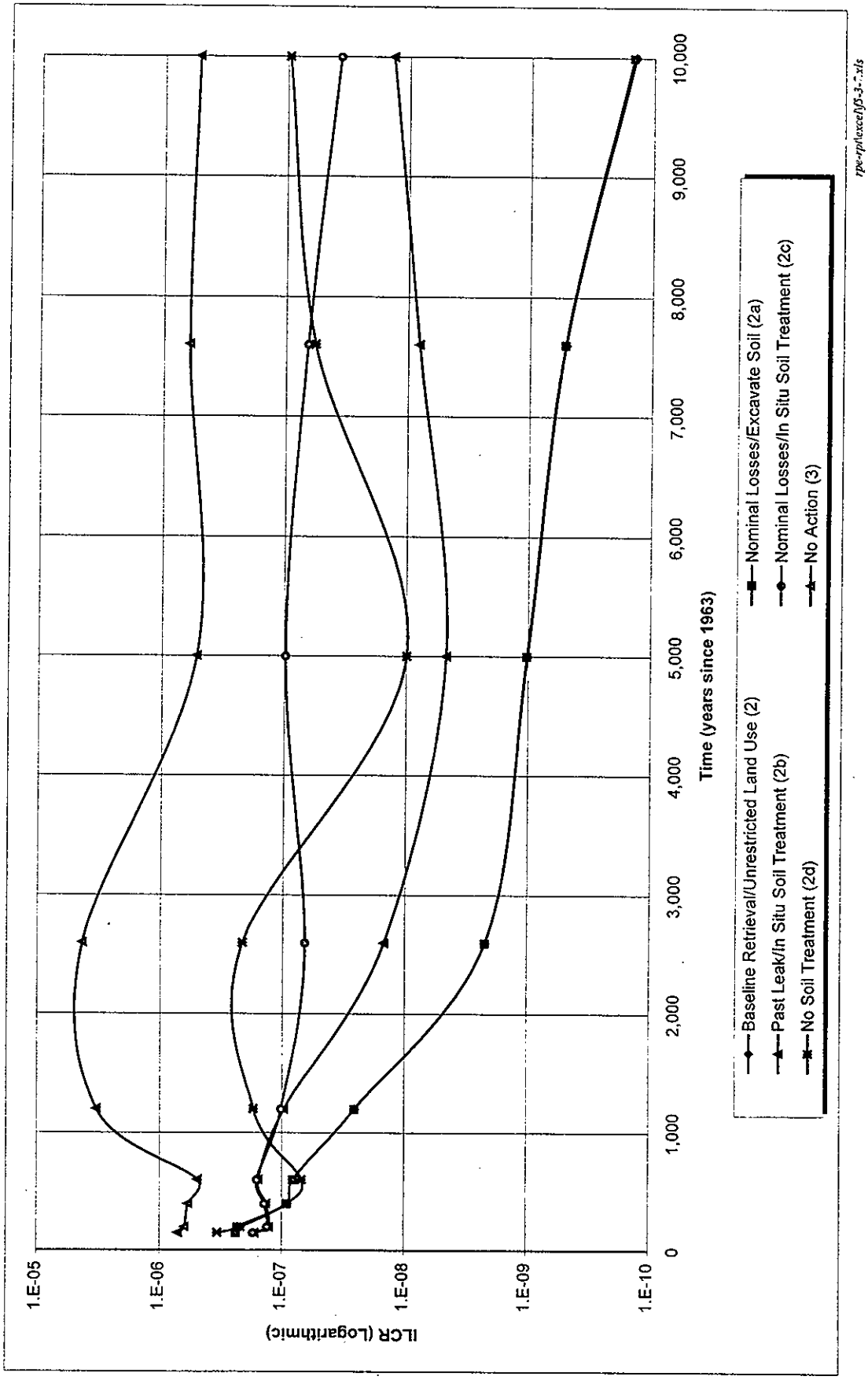


Figure 5.3.8. Baseline Retrieval/Unrestricted Land Use Strategy and Options, Recreational User Scenario, Maximum ILCR from Composite Source Term

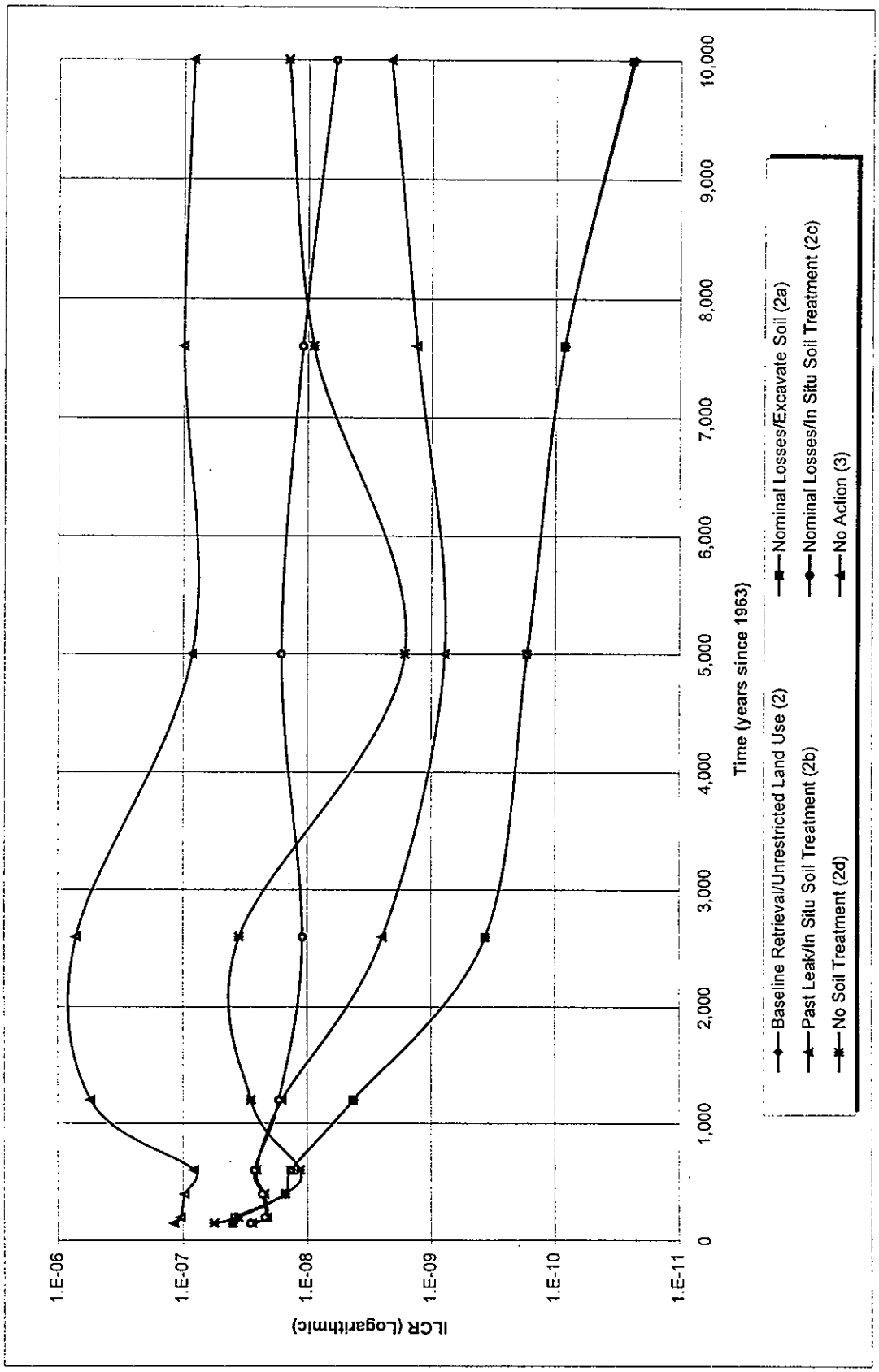


Figure 5.3.9. Long-Term Human Health Risk Variations Between Exposure Scenarios, Composite Source Term Nominal Retrieval Losses (1a)

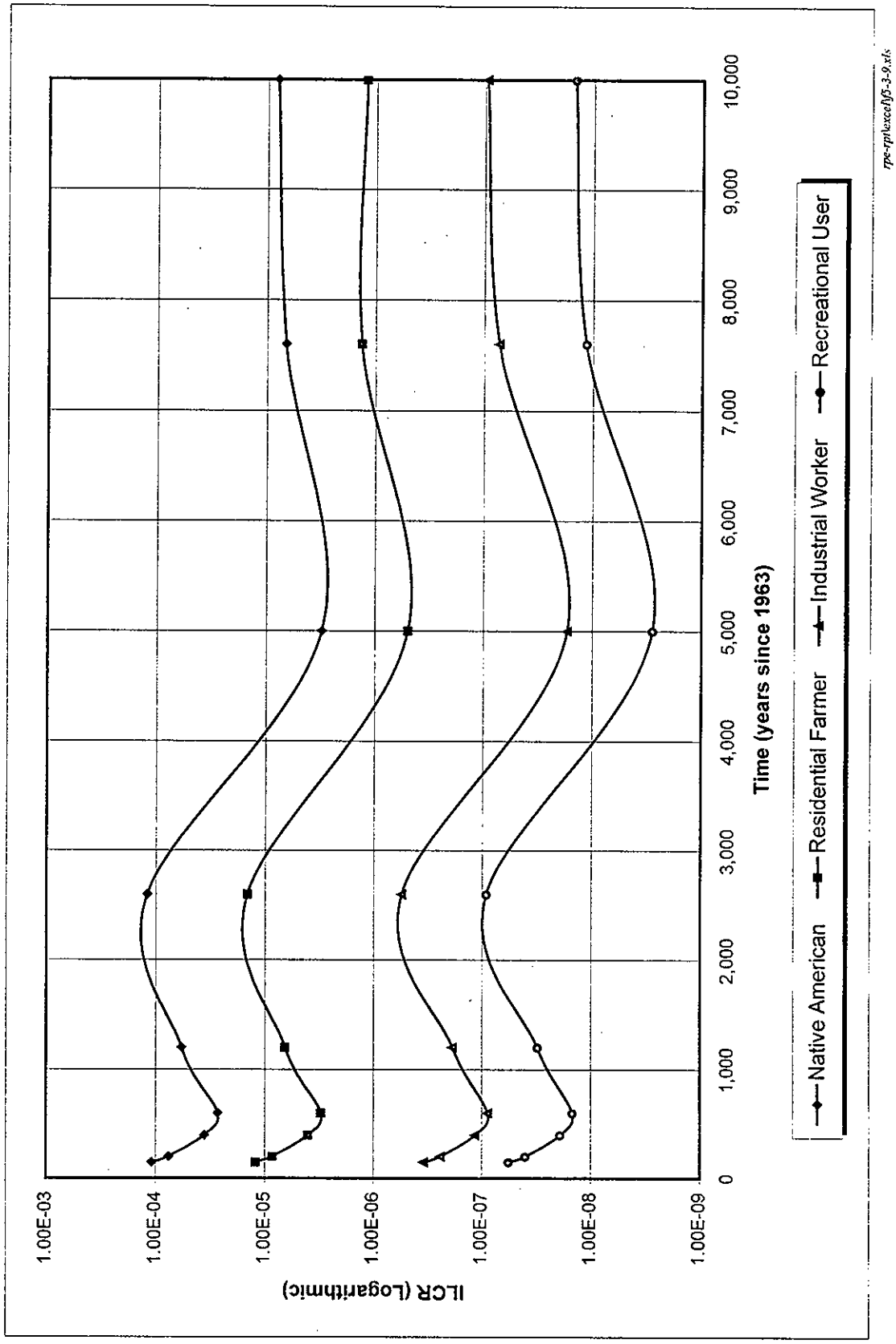


Figure 5.3.10. Long-Term Human Health Risk Variations Between Exposure Scenarios, Composite Source Term Large Retrieval Losses (1b)

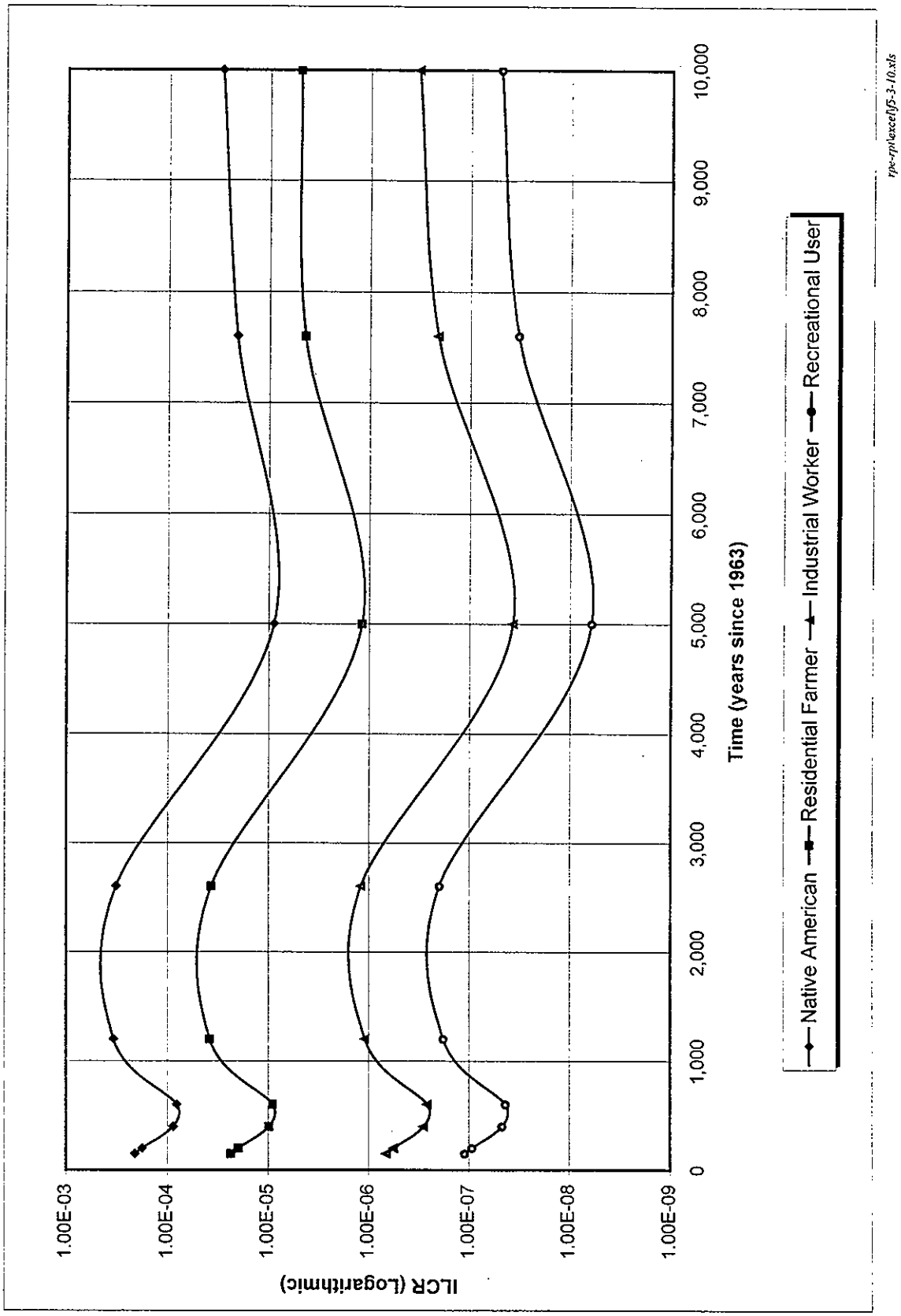


Table 5.3.3 Summary of ILCRs and HIs from Composite Source Terms

Strategies/Options	150 Yr from 1963 Maximum ILCRs			
	Native American	Residential Farmer	Industrial Worker	Recreational Shoreline
Baseline Retrieval/Restricted Land Use (1)	1.1E-04	1.2E-05	3.3E-07	5.5E-08
Nominal Retrieval Losses (1a)	1.1E-04	1.2E-05	3.4E-07	5.7E-08
Large Retrieval Losses (1b)	2.1E-04	2.3E-05	6.6E-07	1.1E-07
Optimal Residual Volume (1c)	1.1E-04	1.2E-05	3.4E-07	5.6E-08
Suboptimal Residual Volume (1d)	1.2E-04	1.3E-05	3.7E-07	6.1E-08
Temporary Operations Barrier (1e)	5.2E-05	5.8E-06	1.7E-07	2.8E-08
Postretrieval Hanford Barrier (1f)	1.1E-04	1.2E-05	3.3E-07	5.5E-08
Nominal Losses/Soil Grouting (1g)	5.0E-05	5.6E-06	1.6E-07	2.7E-08
Large Losses/Soil Grouting (1h)	5.1E-05	5.7E-06	1.6E-07	2.7E-08
Baseline Retrieval/Unrestricted Land Use (2)	7.6E-05	8.5E-06	2.4E-07	4.0E-08
Nominal Losses/Excavate Soil (2a)	7.6E-05	8.5E-06	2.4E-07	4.0E-08
Past Leak/In Situ Soil Treatment (2b)	5.3E-05	5.9E-06	1.7E-07	2.8E-08
Nominal Losses/In Situ Soil Treatment (2c)	5.5E-05	6.1E-06	1.7E-07	2.9E-08
No Soil Treatment (2d)	1.1E-04	1.2E-05	3.4E-07	5.6E-08
No Action (3)	2.2E-04	2.5E-05	7.0E-07	1.2E-07
	Maximum HI			
Baseline Retrieval/Restricted Land Use (1)	9.3E-01	1.6E-01	5.3E-04	3.1E-05
Nominal Retrieval Losses (1a)	2.8E+00	3.9E-01	6.0E-03	1.5E-04
Large Retrieval Losses (1b)	6.0E+01	7.5E+00	1.8E-01	3.8E-03
Optimal Residual Volume (1c)	2.7E+00	3.7E-01	5.9E-03	1.4E-04
Suboptimal Residual Volume (1d)	3.1E+00	4.4E-01	6.1E-03	1.7E-04
Temporary Operations Barrier (1e)	1.8E+00	2.4E-01	4.1E-03	1.0E-04
Postretrieval Hanford Barrier (1f)	2.2E+00	3.1E-01	4.2E-03	1.1E-04
Nominal Losses/Soil Grouting (1g)	7.9E-01	1.2E-01	1.2E-03	3.8E-05
Large Losses/Soil Grouting (1h)	9.9E-01	1.4E-01	1.8E-03	5.1E-05
Baseline Retrieval/Unrestricted Land Use (2)	5.1E-01	9.5E-02	7.7E-05	1.1E-05
Nominal Losses/Excavate Soil (2a)	5.1E-01	9.5E-02	7.8E-05	1.1E-05
Past Leak/In Situ Soil Treatment (2b)	3.6E-01	6.6E-02	5.4E-05	7.4E-06
Nominal Losses/In Situ Soil Treatment (2c)	1.3E+00	1.9E-01	3.0E-03	7.1E-05
No Soil Treatment (2d)	2.6E+00	3.7E-01	5.8E-03	1.4E-04
No Action (3)	5.4E+00	9.0E-01	2.5E-03	2.1E-04

Table 5.3.3. Summary of ILCRs and HIs from Composite Source Terms (cont'd)

Strategies/Options	200 Yr from 1963 Maximum ILCRs			
	Native American	Residential Farmer	Industrial Worker	Recreational Shoreline
Baseline Retrieval/Restricted Land Use (1)	7.3E-05	8.2E-06	2.3E-07	3.9E-08
Nominal Retrieval Losses (1a)	7.6E-05	8.5E-06	2.4E-07	4.0E-08
Large Retrieval Losses (1b)	1.8E-04	2.0E-05	5.6E-07	9.3E-08
Optimal Residual Volume (1c)	7.5E-05	8.4E-06	2.4E-07	3.9E-08
Suboptimal Residual Volume (1d)	8.3E-05	9.3E-06	2.7E-07	4.4E-08
Temporary Operations Barrier (1e)	4.1E-05	4.6E-06	1.3E-07	2.2E-08
Postretrieval Hanford Barrier (1f)	7.4E-05	8.3E-06	2.3E-07	3.9E-08
Nominal Losses/Soil Grouting (1g)	3.9E-05	4.3E-06	1.2E-07	2.1E-08
Large Losses/Soil Grouting (1h)	3.9E-05	4.4E-06	1.3E-07	2.1E-08
Baseline Retrieval/Unrestricted Land Use (2)	7.4E-05	8.2E-06	2.3E-07	3.8E-08
Nominal Losses/Excavate Soil (2a)	7.4E-05	8.2E-06	2.3E-07	3.8E-08
Past Leak/In Situ Soil Treatment (2b)	4.1E-05	4.5E-06	1.3E-07	2.1E-08
Nominal Losses/In Situ Soil Treatment (2c)	4.2E-05	4.7E-06	1.3E-07	2.2E-08
No Soil Treatment (2d)	6.9E-05	7.7E-06	2.2E-07	3.6E-08
No Action (3)	2.0E-04	2.2E-05	6.3E-07	1.0E-07
	Maximum HI			
Baseline Retrieval/Restricted Land Use (1)	7.2E-01	1.2E-01	5.0E-04	2.7E-05
Nominal Retrieval Losses (1a)	2.5E+00	3.5E-01	6.0E-03	1.5E-04
Large Retrieval Losses (1b)	6.0E+01	7.5E+00	1.8E-01	3.8E-03
Optimal Residual Volume (1c)	2.4E+00	3.3E-01	5.9E-03	1.4E-04
Suboptimal Residual Volume (1d)	2.9E+00	4.0E-01	6.1E-03	1.6E-04
Temporary Operations Barrier (1e)	1.7E+00	2.3E-01	4.1E-03	1.0E-04
Postretrieval Hanford Barrier (1f)	1.9E+00	2.7E-01	4.2E-03	1.1E-04
Nominal Losses/Soil Grouting (1g)	7.2E-01	1.1E-01	1.2E-01	3.6E-05
Large Losses/Soil Grouting (1h)	9.1E-01	1.3E-01	1.8E-03	4.9E-05
Baseline Retrieval/Unrestricted Land Use (2)	4.9E-01	9.1E-02	7.5E-05	1.0E-05
Nominal Losses/Excavate Soil (2a)	4.9E-01	9.1E-02	7.7E-05	1.0E-05
Past Leak/In Situ Soil Treatment (2b)	2.7E-01	5.0E-02	4.1E-05	5.6E-06
Nominal Losses/In Situ Soil Treatment (2c)	1.5E+00	1.7E-01	3.0E-03	6.9E-05
No Soil Treatment (2d)	2.4E+00	3.2E-01	5.8E-03	1.3E-04
No Action (3)	5.2E+00	8.7E-01	2.5E-03	2.0E-04

Table 5.3.3. Summary of ILCRs and HIs from Composite Source Terms (cont'd)

Strategies/Options	400 Yr from 1963 Maximum ILCRs			
	Native American	Residential Farmer	Industrial Worker	Recreational Shoreline
Baseline Retrieval/Restricted Land Use (1)	3.2E-05	3.6E-06	1.0E-07	1.7E-08
Nominal Retrieval Losses (1a)	3.6E-05	4.0E-06	1.2E-07	1.9E-08
Large Retrieval Losses (1b)	8.7E-05	9.8E-06	2.8E-07	4.7E-08
Optimal Residual Volume (1c)	3.5E-05	3.9E-06	1.1E-07	1.8E-08
Suboptimal Residual Volume (1d)	4.3E-05	4.8E-06	1.4E-07	2.3E-08
Temporary Operations Barrier (1e)	2.5E-05	2.8E-06	8.2E-08	1.4E-08
Postretrieval Hanford Barrier (1f)	3.5E-05	3.9E-06	1.1E-07	1.8E-08
Nominal Losses/Soil Grouting (1g)	2.3E-05	2.6E-06	7.5E-08	1.3E-08
Large Losses/Soil Grouting (1h)	2.4E-05	2.6E-06	7.7E-08	1.3E-08
Baseline Retrieval/Unrestricted Land Use (2)	2.9E-05	3.2E-06	9.0E-08	1.5E-08
Nominal Losses/Excavate Soil (2a)	2.9E-05	3.2E-06	9.0E-08	1.5E-08
Past Leak/In Situ Soil Treatment (2b)	4.3E-05	4.8E-06	1.3E-07	2.2E-08
Nominal Losses/In Situ Soil Treatment (2c)	4.5E-05	5.0E-06	1.4E-07	2.3E-08
No Soil Treatment (2d)	2.9E-05	3.2E-06	9.1E-08	1.5E-08
No Action (3)	1.8E-04	2.0E-05	5.8E-07	9.7E-08
	Maximum HI			
Baseline Retrieval/Restricted Land Use (1)	4.4E-01	6.8E-02	4.6E-04	2.1E-05
Nominal Retrieval Losses (1a)	2.3E+00	3.0E-01	5.9E-03	1.4E-04
Large Retrieval Losses (1b)	3.2E+01	4.0E+00	9.3E-02	2.0E-03
Optimal Residual Volume (1c)	2.2E+00	2.8E-01	5.9E-03	1.3E-04
Suboptimal Residual Volume (1d)	2.6E+00	3.5E-01	6.0E-03	1.6E-04
Temporary Operations Barrier (1e)	1.6E+00	2.1E-01	4.1E-03	9.9E-05
Postretrieval Hanford Barrier (1f)	1.7E+00	2.2E-01	4.2E-03	1.0E-04
Nominal Losses/Soil Grouting (1g)	6.1E-01	8.6E-02	1.2E-03	3.4E-05
Large Losses/Soil Grouting (1h)	8.0E-01	1.1E-01	1.8E-03	4.7E-05
Baseline Retrieval/Unrestricted Land Use (2)	1.9E-01	3.6E-02	2.9E-05	4.0E-06
Nominal Losses/Excavate Soil (2a)	1.9E-01	3.6E-02	3.3E-05	4.1E-06
Past Leak/In Situ Soil Treatment (2b)	2.9E-01	5.3E-02	4.3E-05	6.0E-06
Nominal Losses/In Situ Soil Treatment (2c)	1.3E+00	1.8E-01	3.0E-03	6.9E-05
No Soil Treatment (2d)	2.1E+00	2.7E-01	5.7E-03	1.3E-04
No Action (3)	5.1E+00	8.5E-01	2.5E-03	2.0E-04

Table 5.3.3. Summary of ILCRs and HIs from Composite Source Terms (cont'd)

Strategies/Options	600 Yr from 1963 Maximum ILCRs			
	Native American	Residential Farmer	Industrial Worker	Recreational Shoreline
Baseline Retrieval/Restricted Land Use (1)	2.4E-05	2.7E-06	7.8E-08	1.3E-08
Nominal Retrieval Losses (1a)	2.7E-05	3.0E-06	8.9E-08	1.5E-08
Large Retrieval Losses (1b)	8.1E-05	9.0E-06	2.6E-07	4.3E-08
Optimal Residual Volume (1c)	2.6E-05	3.0E-06	8.4E-08	1.4E-08
Suboptimal Residual Volume (1d)	3.4E-05	3.9E-06	1.1E-07	1.9E-08
Temporary Operations Barrier (1e)	2.2E-05	2.4E-06	7.1E-08	1.2E-08
Postretrieval Hanford Barrier (1f)	2.5E-05	2.8E-06	8.2E-08	1.4E-08
Nominal Losses/Soil Grouting (1g)	2.0E-05	2.2E-06	6.5E-08	1.1E-08
Large Losses/Soil Grouting (1h)	2.0E-05	2.3E-06	6.6E-08	1.1E-08
Baseline Retrieval/Unrestricted Land Use (2)	2.6E-05	2.9E-06	8.1E-08	1.4E-08
Nominal Losses/Excavate Soil (2a)	2.6E-05	2.9E-06	8.1E-08	1.4E-08
Past Leak/In Situ Soil Treatment (2b)	5.0E-05	5.5E-06	1.6E-07	2.6E-08
Nominal Losses/In Situ Soil Treatment (2c)	5.1E-05	5.7E-06	1.6E-07	2.7E-08
No Soil Treatment (2d)	2.2E-05	2.4E-06	6.9E-08	1.1E-08
No Action (3)	1.5E-04	1.7E-05	4.9E-07	8.1E-08
	Maximum HI			
Baseline Retrieval/Restricted Land Use (1)	3.9E-01	5.8E-02	4.5E-04	2.0E-05
Nominal Retrieval Losses (1a)	2.2E+00	2.9E-01	5.9E-03	1.4E-04
Large Retrieval Losses (1b)	3.3E+01	4.1E+00	9.6E-02	2.1E-03
Optimal Residual Volume (1c)	2.1E+00	2.7E-01	5.8E-03	1.3E-04
Suboptimal Residual Volume (1d)	2.6E+00	3.4E-01	6.0E-03	1.6E-04
Temporary Operations Barrier (1e)	1.6E+00	2.1E-01	4.1E-03	9.8E-05
Postretrieval Hanford Barrier (1f)	1.6E+00	2.1E-01	4.2E-03	9.9E-05
Nominal Losses/Soil Grouting (1g)	5.9E-01	8.1E-02	1.2E-03	3.4E-05
Large Losses/Soil Grouting (1h)	7.8E-01	1.1E-01	1.8E-03	4.6E-05
Baseline Retrieval/Unrestricted Land Use (2)	1.8E-01	3.2E-02	2.6E-05	3.6E-06
Nominal Losses/Excavate Soil (2a)	1.8E-01	3.3E-02	3.2E-05	3.8E-06
Past Leak/In Situ Soil Treatment (2b)	3.3E-01	6.2E-02	5.0E-05	6.9E-06
Nominal Losses/In Situ Soil Treatment (2c)	1.3E+00	1.8E-01	3.0E-03	7.0E-05
No Soil Treatment (2d)	2.0E+00	2.6E-01	5.7E-03	1.3E-04
No Action (3)	4.9E+00	8.1E-01	2.4E-03	2.0E-04

Table 5.3.3. Summary of ILCRs and HIs from Composite Source Terms (cont'd)

Strategies/Options	1,200 Yr from 1963 Maximum ILCRs			
	Native American	Residential Farmer	Industrial Worker	Recreational Shoreline
Baseline Retrieval/Restricted Land Use (1)	3.2E-05	3.6E-06	1.0E-07	1.7E-08
Nominal Retrieval Losses (1a)	5.8E-05	6.5E-06	1.9E-07	3.1E-08
Large Retrieval Losses (1b)	3.4E-04	3.8E-05	1.1E-06	1.8E-07
Optimal Residual Volume (1c)	5.7E-05	6.4E-06	1.8E-07	3.0E-08
Suboptimal Residual Volume (1d)	6.5E-05	7.3E-06	2.1E-07	3.5E-08
Temporary Operations Barrier (1e)	5.3E-05	5.9E-06	1.7E-07	2.8E-08
Postretrieval Hanford Barrier (1f)	1.2E-05	1.4E-06	4.2E-08	6.9E-09
Nominal Losses/Soil Grouting (1g)	5.1E-05	5.7E-06	1.6E-07	2.7E-08
Large Losses/Soil Grouting (1h)	5.2E-05	5.8E-06	1.6E-07	2.7E-08
Baseline Retrieval/Unrestricted Land Use (2)	8.2E-06	9.1E-07	2.6E-08	4.2E-09
Nominal Losses/Excavate Soil (2a)	8.2E-06	9.1E-07	2.6E-08	4.2E-09
Past Leak/In Situ Soil Treatment (2b)	3.1E-05	3.4E-06	9.7E-08	1.6E-08
Nominal Losses/In Situ Soil Treatment (2c)	3.3E-05	3.6E-06	1.0E-07	1.7E-08
No Soil Treatment (2d)	5.4E-05	6.0E-06	1.7E-07	2.8E-08
No Action (3)	7.6E-04	9.0E-05	3.3E-06	5.4E-07
	Maximum HI			
Baseline Retrieval/Restricted Land Use (1)	4.4E-01	6.8E-02	4.6E-04	2.1E-05
Nominal Retrieval Losses (1a)	1.5E+01	1.9E+00	4.4E-02	9.8E-04
Large Retrieval Losses (1b)	1.8E+02	2.2E+01	5.3E-01	1.2E-02
Optimal Residual Volume (1c)	1.5E+01	1.9E+00	4.4E-02	9.7E-04
Suboptimal Residual Volume (1d)	1.6E+01	2.0E+00	4.5E-02	9.9E-04
Temporary Operations Barrier (1e)	1.8E+00	2.4E-01	4.1E-03	1.0E-04
Postretrieval Hanford Barrier (1f)	1.5E+00	1.9E-01	4.2E-03	9.7E-05
Nominal Losses/Soil Grouting (1g)	8.0E-01	1.2E-01	1.2E-03	3.8E-05
Large Losses/Soil Grouting (1h)	9.9E-01	1.5E-01	1.8E-03	5.1E-05
Baseline Retrieval/Unrestricted Land Use (2)	5.5E-02	1.0E-02	8.3E-06	1.1E-06
Nominal Losses/Excavate Soil (2a)	5.7E-02	1.0E-02	1.5E-05	1.3E-06
Past Leak/In Situ Soil Treatment (2b)	2.1E-01	3.8E-02	3.1E-05	4.3E-06
Nominal Losses/In Situ Soil Treatment (2c)	1.2E+00	1.6E-01	3.0E-03	6.8E-05
No Soil Treatment (2d)	1.6E+01	2.0E+00	4.7E-02	1.0E-03
No Action (3)	2.1E+01	3.8E+00	8.1E-03	5.6E-04

Table 5.3.3. Summary of ILCRs and HIs from Composite Source Terms (cont'd)

Strategies/Options	2,600 Yr from 1963 Maximum ILCRs			
	Native American	Residential Farmer	Industrial Worker	Recreational Shoreline
Baseline Retrieval/Restricted Land Use (1)	4.6E-05	6.2E-06	3.2E-07	5.3E-08
Nominal Retrieval Losses (1a)	1.2E-04	1.4E-05	5.5E-07	9.2E-08
Large Retrieval Losses (1b)	3.2E-04	3.7E-05	1.2E-06	2.0E-07
Optimal Residual Volume (1c)	8.3E-05	9.4E-06	2.9E-07	4.9E-08
Suboptimal Residual Volume (1d)	4.9E-04	5.8E-05	2.0E-06	3.3E-07
Temporary Operations Barrier (1e)	1.5E-04	1.8E-05	6.5E-07	1.1E-07
Postretrieval Hanford Barrier (1f)	1.6E-04	1.8E-05	6.3E-07	1.1E-07
Nominal Losses/Soil Grouting (1g)	6.6E-05	8.2E-06	3.5E-07	5.8E-08
Large Losses/Soil Grouting (1h)	7.5E-05	9.3E-06	3.8E-07	6.3E-08
Baseline Retrieval/Unrestricted Land Use (2)	5.9E-07	7.9E-08	2.2E-09	3.6E-10
Nominal Losses/Excavate Soil (2a)	5.9E-07	7.9E-08	2.2E-09	3.7E-10
Past Leak/In Situ Soil Treatment (2b)	4.7E-06	5.3E-07	1.5E-08	2.5E-09
Nominal Losses/In Situ Soil Treatment (2c)	2.1E-05	2.3E-06	6.6E-08	1.1E-08
No Soil Treatment (2d)	6.7E-05	7.4E-06	2.1E-07	3.5E-08
No Action (3)	1.4E-03	1.6E-04	4.3E-06	7.1E-07
	Maximum HI			
Baseline Retrieval/Restricted Land Use (1)	2.9E+00	4.2E-01	3.4E-03	1.6E-04
Nominal Retrieval Losses (1a)	4.5E+01	5.7E+00	1.3E-01	2.9E-03
Large Retrieval Losses (1b)	1.6E+02	2.0E+01	4.7E-01	1.0E-02
Optimal Residual Volume (1c)	4.5E+01	5.6E+00	1.3E-01	2.9E-03
Suboptimal Residual Volume (1d)	5.6E+01	7.7E+00	1.3E-01	3.2E-03
Temporary Operations Barrier (1e)	5.9E+01	7.5E+00	1.7E-01	3.8E-03
Postretrieval Hanford Barrier (1f)	6.0E+01	7.5E+00	1.7E-01	3.9E-03
Nominal Losses/Soil Grouting (1g)	7.7E+00	9.9E-01	1.9E-02	4.8E-04
Large Losses/Soil Grouting (1h)	1.3E+01	1.7E+00	3.5E-02	8.3E-04
Baseline Retrieval/Unrestricted Land Use (2)	3.7E-03	6.8E-04	5.6E-07	7.7E-08
Nominal Losses/Excavate Soil (2a)	3.7E-03	6.9E-04	6.7E-07	7.9E-08
Past Leak/In Situ Soil Treatment (2b)	3.2E-02	5.9E-03	4.8E-06	6.6E-07
Nominal Losses/In Situ Soil Treatment (2c)	9.2E+00	1.2E+00	2.7E-02	5.9E-04
No Soil Treatment (2d)	3.8E+01	4.7E+00	1.1E-01	2.5E-03
No Action (3)	7.0E+01	1.2E+01	2.6E-02	2.2E-03

Table 5.3.3. Summary of ILCRs and HIs from Composite Source Terms (cont'd)

Strategies/Options	5,000 Yr from 1963 Maximum ILCRs			
	Native American	Residential Farmer	Industrial Worker	Recreational Shoreline
Baseline Retrieval/Restricted Land Use (1)	1.6E-06	3.3E-07	1.2E-08	2.0E-09
Nominal Retrieval Losses (1a)	3.1E-06	5.0E-07	1.7E-08	2.8E-09
Large Retrieval Losses (1b)	8.9E-06	1.2E-06	3.7E-08	6.1E-09
Optimal Residual Volume (1c)	2.6E-06	4.3E-07	1.3E-08	2.2E-09
Suboptimal Residual Volume (1d)	9.3E-06	1.2E-06	3.9E-08	6.5E-09
Temporary Operations Barrier (1e)	2.9E-06	4.1E-07	1.4E-08	2.3E-09
Postretrieval Hanford Barrier (1f)	2.9E-06	4.1E-07	1.4E-08	2.3E-09
Nominal Losses/Soil Grouting (1g)	8.9E-06	1.1E-06	3.3E-08	5.4E-09
Large Losses/Soil Grouting (1h)	1.1E-05	1.3E-06	4.0E-08	6.7E-09
Baseline Retrieval/Unrestricted Land Use (2)	7.5E-08	3.3E-08	1.0E-09	1.7E-10
Nominal Losses/Excavate Soil (2a)	7.6E-08	3.3E-08	1.0E-09	1.7E-10
Past Leak/In Situ Soil Treatment (2b)	1.2E-06	1.6E-07	4.7E-09	7.8E-10
Nominal Losses/In Situ Soil Treatment (2c)	3.0E-05	3.4E-06	9.8E-08	1.6E-08
No Soil Treatment (2d)	1.8E-06	3.2E-07	9.9E-09	1.6E-09
No Action (3)	1.0E-04	1.7E-05	5.2E-07	8.5E-08
	Maximum HI			
Baseline Retrieval/Restricted Land Use (1)	3.6E+00	4.4E-01	7.1E-03	2.7E-04
Nominal Retrieval Losses (1a)	4.5E+00	5.5E-01	9.5E-03	3.3E-04
Large Retrieval Losses (1b)	7.7E+00	9.6E-01	1.9E-02	5.4E-04
Optimal Residual Volume (1c)	2.4E+00	3.0E-01	8.3E-03	1.5E-04
Suboptimal Residual Volume (1d)	7.0E+00	8.6E-01	1.1E-02	5.3E-04
Temporary Operations Barrier (1e)	4.5E+00	5.5E-01	9.6E-03	3.3E-04
Postretrieval Hanford Barrier (1f)	4.5E+00	5.5E-01	9.6E-03	3.3E-04
Nominal Losses/Soil Grouting (1g)	8.0E+00	9.8E-01	2.0E-02	5.5E-04
Large Losses/Soil Grouting (1h)	9.3E+00	1.2E+00	2.4E-02	6.4E-04
Baseline Retrieval/Unrestricted Land Use (2)	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nominal Losses/Excavate Soil (2a)	3.5E-05	4.3E-06	1.1E-07	2.3E-09
Past Leak/In Situ Soil Treatment (2b)	7.4E-03	1.4E-03	1.1E-06	1.6E-07
Nominal Losses/In Situ Soil Treatment (2c)	1.7E+01	2.1E+00	5.0E-02	1.1E-03
No Soil Treatment (2d)	8.3E-01	1.0E-01	2.5E-03	5.4E-05
No Action (3)	1.4E+01	1.9E+00	1.7E-02	9.9E-04

Table 5.3.3. Summary of ILCRs and HIs from Composite Source Terms (cont'd)

Strategies/Options	7,600 Yr from 1963 Maximum ILCRs			
	Native American	Residential Farmer	Industrial Worker	Recreational Shoreline
Baseline Retrieval/Restricted Land Use (1)	3.8E-06	7.8E-07	4.6E-08	7.2E-09
Nominal Retrieval Losses (1a)	6.7E-06	1.3E-06	7.3E-08	1.1E-08
Large Retrieval Losses (1b)	2.1E-05	4.4E-06	2.1E-07	3.3E-08
Optimal Residual Volume (1c)	5.8E-06	1.1E-06	6.3E-08	9.9E-09
Suboptimal Residual Volume (1d)	1.4E-05	2.6E-06	1.1E-07	1.8E-08
Temporary Operations Barrier (1e)	6.1E-06	1.3E-06	6.3E-08	1.0E-08
Postretrieval Hanford Barrier (1f)	6.0E-06	1.2E-06	6.3E-08	1.0E-08
Nominal Losses/Soil Grouting (1g)	6.6E-06	1.1E-06	5.2E-08	8.4E-09
Large Losses/Soil Grouting (1h)	8.8E-06	1.4E-06	6.9E-08	1.1E-08
Baseline Retrieval/Unrestricted Land Use (2)	3.3E-08	1.4E-08	5.1E-10	8.4E-11
Nominal Losses/Excavate Soil (2a)	3.3E-08	1.4E-08	5.1E-10	8.5E-11
Past Leak/In Situ Soil Treatment (2b)	8.9E-07	2.1E-07	8.0E-09	1.3E-09
Nominal Losses/In Situ Soil Treatment (2c)	1.9E-05	2.2E-06	6.6E-08	1.1E-08
No Soil Treatment (2d)	3.8E-06	8.8E-07	5.8E-08	8.9E-09
No Action (3)	1.1E-04	1.6E-05	6.1E-07	9.9E-08
	Maximum HI			
Baseline Retrieval/Restricted Land Use (1)	3.6E+00	4.4E-01	7.1E-03	2.7E-04
Nominal Retrieval Losses (1a)	4.5E+00	5.5E-01	9.5E-03	3.3E-04
Large Retrieval Losses (1b)	7.7E+00	9.6E-01	1.9E-02	5.4E-04
Optimal Residual Volume (1c)	2.2E+00	2.7E-01	8.1E-03	1.3E-04
Suboptimal Residual Volume (1d)	7.0E+00	8.6E-01	1.1E-02	5.3E-04
Temporary Operations Barrier (1e)	4.5E+00	5.5E-01	9.6E-03	3.3E-04
Postretrieval Hanford Barrier (1f)	4.5E+00	5.5E-01	9.6E-03	3.3E-04
Nominal Losses/Soil Grouting (1g)	5.4E+00	6.6E-01	1.2E-02	3.8E-04
Large Losses/Soil Grouting (1h)	6.2E+00	7.6E-01	1.5E-02	4.4E-04
Baseline Retrieval/Unrestricted Land Use (2)	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nominal Losses/Excavate Soil (2a)	3.5E-05	4.3E-06	1.1E-07	2.3E-09
Past Leak/In Situ Soil Treatment (2b)	3.2E-03	5.9E-04	4.8E-07	6.6E-08
Nominal Losses/In Situ Soil Treatment (2c)	1.0E+01	1.3E+00	3.1E-02	6.7E-04
No Soil Treatment (2d)	0.0E+00	0.0E+00	0.0E+00	0.0E+00
No Action (3)	1.3E+01	1.8E+00	1.2E-02	9.3E-04

Table 5.3.3. Summary of ILCRs and HIs from Composite Source Terms (cont'd)

Strategies/Options	10,000 Yr from 1963 Maximum ILCRs			
	Native American	Residential Farmer	Industrial Worker	Recreational Shoreline
Baseline Retrieval/Restricted Land Use (1)	3.7E-06	6.3E-07	4.5E-08	7.0E-09
Nominal Retrieval Losses (1a)	8.0E-06	1.2E-06	9.5E-08	1.5E-08
Large Retrieval Losses (1b)	2.9E-05	4.9E-06	3.3E-07	5.0E-08
Optimal Residual Volume (1c)	7.1E-06	1.0E-06	8.4E-08	1.3E-08
Suboptimal Residual Volume (1d)	1.8E-05	3.3E-06	1.8E-07	2.8E-08
Temporary Operations Barrier (1e)	8.0E-06	1.3E-06	9.4E-08	1.4E-08
Postretrieval Hanford Barrier (1f)	8.2E-06	1.3E-06	9.8E-08	1.5E-08
Nominal Losses/Soil Grouting (1g)	7.1E-06	1.0E-06	7.5E-08	1.2E-08
Large Losses/Soil Grouting (1h)	1.2E-05	1.4E-06	1.4E-07	2.1E-08
Baseline Retrieval/Unrestricted Land Use (2)	8.2E-09	3.5E-09	1.4E-10	2.3E-11
Nominal Losses/Excavate Soil (2a)	8.5E-09	3.6E-09	1.5E-10	2.4E-11
Past Leak/In Situ Soil Treatment (2b)	1.2E-06	2.6E-07	1.4E-08	2.2E-09
Nominal Losses/In Situ Soil Treatment (2c)	7.1E-06	9.6E-07	3.7E-08	5.9E-09
No Soil Treatment (2d)	6.3E-06	8.4E-07	9.6E-08	1.4E-08
No Action (3)	9.6E-05	1.2E-05	5.2E-07	8.3E-08
	Maximum HI			
Baseline Retrieval/Restricted Land Use (1)	3.6E+00	4.4E-01	7.0E-03	2.7E-04
Nominal Retrieval Losses (1a)	4.5E+00	5.5E-01	9.5E-03	3.3E-04
Large Retrieval Losses (1b)	7.7E+00	9.5E-01	1.9E-02	5.4E-04
Optimal Residual Volume (1c)	2.1E+00	2.7E-01	8.0E-03	1.3E-04
Suboptimal Residual Volume (1d)	7.0E+00	8.6E-01	1.1E-02	5.3E-04
Temporary Operations Barrier (1e)	4.5E+00	5.5E-01	9.5E-03	3.3E-04
Postretrieval Hanford Barrier (1f)	4.5E+00	5.5E-01	9.6E-03	3.3E-04
Nominal Losses/Soil Grouting (1g)	4.7E+00	5.8E-01	1.0E-02	3.4E-04
Large Losses/Soil Grouting (1h)	5.2E+00	6.4E-01	1.2E-02	3.7E-04
Baseline Retrieval/Unrestricted Land Use (2)	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nominal Losses/Excavate Soil (2a)	3.5E-05	4.3E-06	1.1E-07	2.3E-09
Past Leak/In Situ Soil Treatment (2b)	3.2E-03	5.9E-04	4.8E-07	6.6E-08
Nominal Losses/In Situ Soil Treatment (2c)	3.3E+00	4.1E-01	9.8E-03	2.1E-04
No Soil Treatment (2d)	0.0E+00	0.0E+00	0.0E+00	0.0E+00
No Action (3)	1.3E+01	1.8E+00	1.2E-02	9.4E-04

Table 5.3.4. Peak ILCRs from Composite Source Terms

Strategies/Options	Native American		Residential Farmer		Industrial Worker		Recreational Shoreline User	
	Peak Risk (ILCR)	Time (Yr from 1963)	Peak Risk (ILCR)	Time (Yr from 1963)	Peak Risk (ILCR)	Time (Yr from 1963)	Peak Risk (ILCR)	Time (Yr from 1963)
Baseline Retrieval/Restricted Land Use (1)	1.1E-04	150	1.2E-05	150	3.3E-07	150	5.5E-08	150
Nominal Retrieval Losses (1a)	1.2E-04	2,600	1.4E-05	2,600	5.5E-07	2,600	9.2E-08	2,600
Large Retrieval Losses (1b)	3.4E-04	1200	3.8E-05	1200	1.2E-06	2,600	2.0E-07	2,600
Optimal Residual Volume (1c)	1.1E-04	150	1.2E-05	150	3.4E-07	150	5.6E-08	150
Suboptimal Residual Volume (1d)	4.9E-04	2,600	5.8E-05	2,600	2.0E-06	2,600	3.3E-07	2,600
Temporary Operations Barrier (1e)	1.5E-04	2,600	1.8E-05	2,600	6.5E-07	2,600	1.1E-07	2,600
Postretrieval Hanford Barrier (1f)	1.6E-04	2,600	1.8E-05	2,600	6.3E-07	2,600	1.1E-07	2,600
Nominal Losses/Soil Grouting (1g)	6.6E-05	2,600	8.2E-06	2,600	3.5E-07	2,600	5.8E-08	2,600
Large Losses/Soil Grouting (1h)	7.5E-05	2,600	9.3E-06	2,600	3.8E-07	2,600	6.3E-08	2,600
Baseline Retrieval/Unrestricted Land Use (2)	7.6E-05	150	8.5E-06	150	2.4E-07	150	4.0E-08	150
Nominal Losses/Excavate Soil (2a)	7.6E-05	150	8.5E-06	150	2.4E-07	150	4.0E-08	150
Past Leak/In Situ Soil Treatment (2b)	5.3E-05	150	5.9E-06	150	1.7E-07	150	2.8E-08	150
Nominal Losses/In Situ Soil Treatment (2c)	5.5E-05	150	6.1E-06	150	1.7E-07	150	2.9E-08	150
No Soil Treatment (2d)	1.1E-04	150	1.2E-05	150	3.4E-07	150	5.6E-08	150
No Action (3)	1.4E-03	2,600	1.6E-04	2,600	4.3E-06	2,600	7.1E-07	2,600

Notes:

Peak risks shown are peaks that would occur after institutional controls end at 150 yr (from 1963).

Potential risks for the Native American scenario would remain above 1.0E-04 for at least 150 yr and be above 1.0E-06 through the 10,000-yr time period. Potential risks for the residential farmer scenario would remain above 1.0E-05 for at least 150 yr and be above 1.0E-06 through the 2,600-yr-time period. The ILCR for the industrial worker scenario and the recreational shoreline user scenario would be below 1.0E-06 for all time periods. The HI would exceed 1.0 only for the Native American scenario at 2,600, 5,000, 7,600, and 10,000 yr. indicating that toxic effects would be expected at these time periods.

5.3.1.2 Nominal Retrieval Losses (Option 1a)

The ILCR for each scenario would peak at 2,600 yr. At 2,600 yr the ILCR would exceed 1.0E-04 for the Native American scenario, 1.0E-05 for the residential farmer scenario, 1.0E-07 for the industrial worker scenario, and 1.0E-08 for the recreational shoreline user scenario.

Potential risks for the Native American scenario would exceed 1.0E-06 at all time periods and be above 1.0E-04 at 150 and 2,600 yr. The HI for the Native American would exceed 1.0 at all time periods, indicating that toxic effects would be expected. Potential risks for the residential farmer scenario would exceed 1.0E-05 for at least 150 yr and be above 1.0E-06 for all but the 5,000-yr time period. The HI for the residential farmer would exceed 1.0 at 1,200 and 2,600 yr indicating that toxic effects would be expected. The ILCR for the industrial worker and recreational shoreline user scenarios would be below 1.0E-06 for all time periods. The HI would be less than 1.0 for the industrial worker and recreational shoreline user scenarios, indicating that no toxic effects would occur.

Contour maps depicting the risk to the residential farmer from radionuclides in the composite source term for the Nominal Retrieval Losses option (Option 1a) are presented in Figures 5.3.11 through 5.3.16.

5.3.1.3 Large Retrieval Losses (Option 1b)

The ILCR would peak at 1,200 yr for the Native American and residential farmer scenarios and at 2,600 yr for the industrial worker and recreational shoreline user scenarios. At 1,200 yr the ILCR would exceed 1.0E-04 for the Native American scenario and 1.0E-05 for the residential farmer scenario. At 2,600 yr the ILCR would exceed 1.0E-06 for the industrial worker scenario and 1.0E-07 for the recreational shoreline user scenario.

Potential risks for the Native American scenario would exceed 1.0E-06 at all time periods and be above 1.0E-04 at 150, 200, 1,200, and 2,600 yr. The HI for the Native American would be greater than 1.0 for all time periods, indicating that toxic effects would be expected. Potential risks for the residential farmer scenario would be near or above 1.0E-05 for at least 2,600 yr and be above 1.0E-06 through the 10,000-yr time period. The HI for the residential farmer would approach or exceed 1.0 for all time periods. Potential risks for the industrial worker scenario would exceed 1.0E-06 at 1,200 and 2,600 yr but would be below this level at all other time periods. The ILCR for the recreational shoreline user scenario would be below 1.0E-06 for all time periods. The HI would be less than 1.0 for the industrial worker and recreational shoreline user through the entire 10,000-yr time period.

Figure 5.3.11. Nominal Retrieval Losses Option, Residential Farmer Scenario, ILCR from Composite Source Term at 150 Yr (1a)

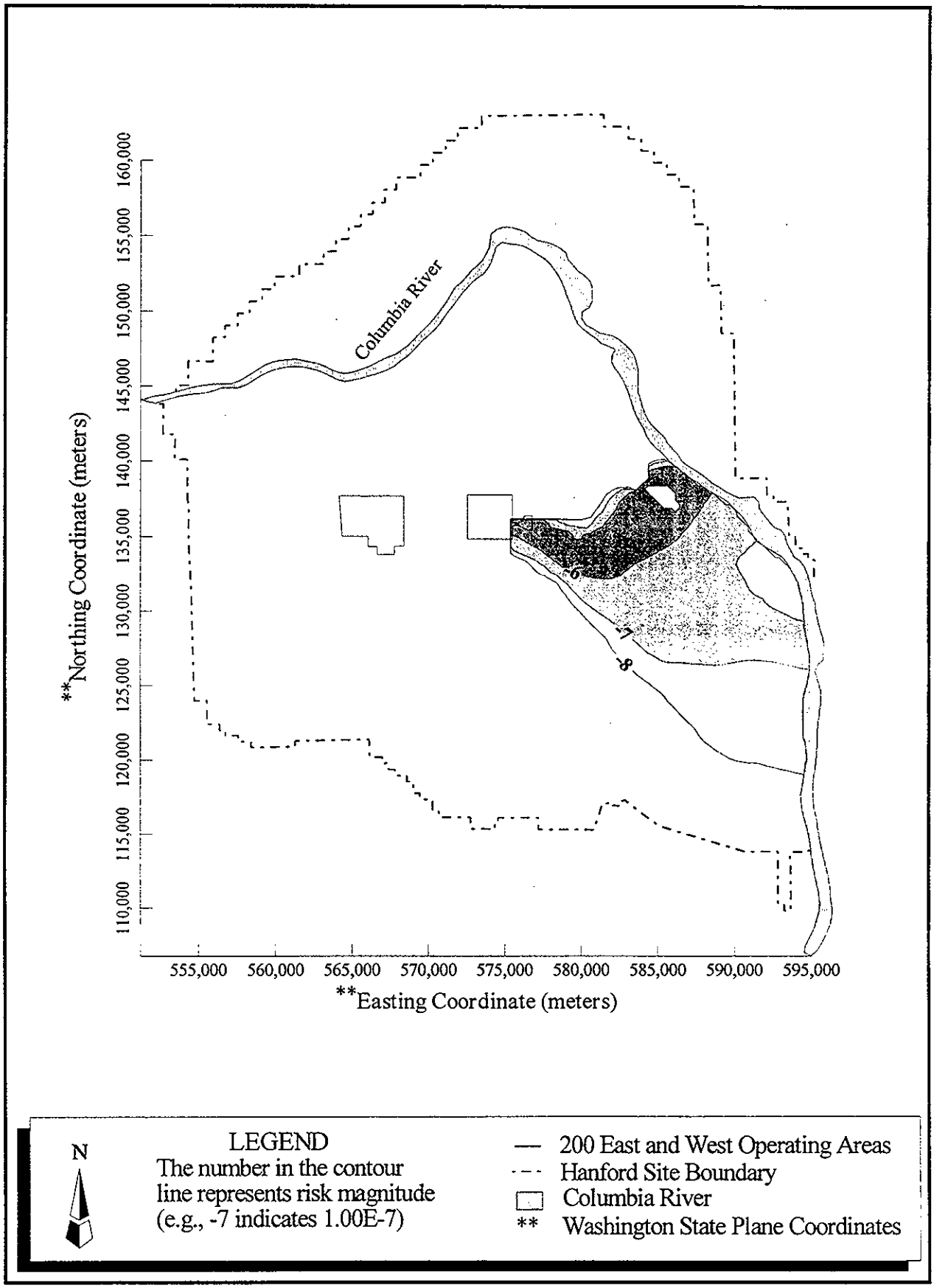
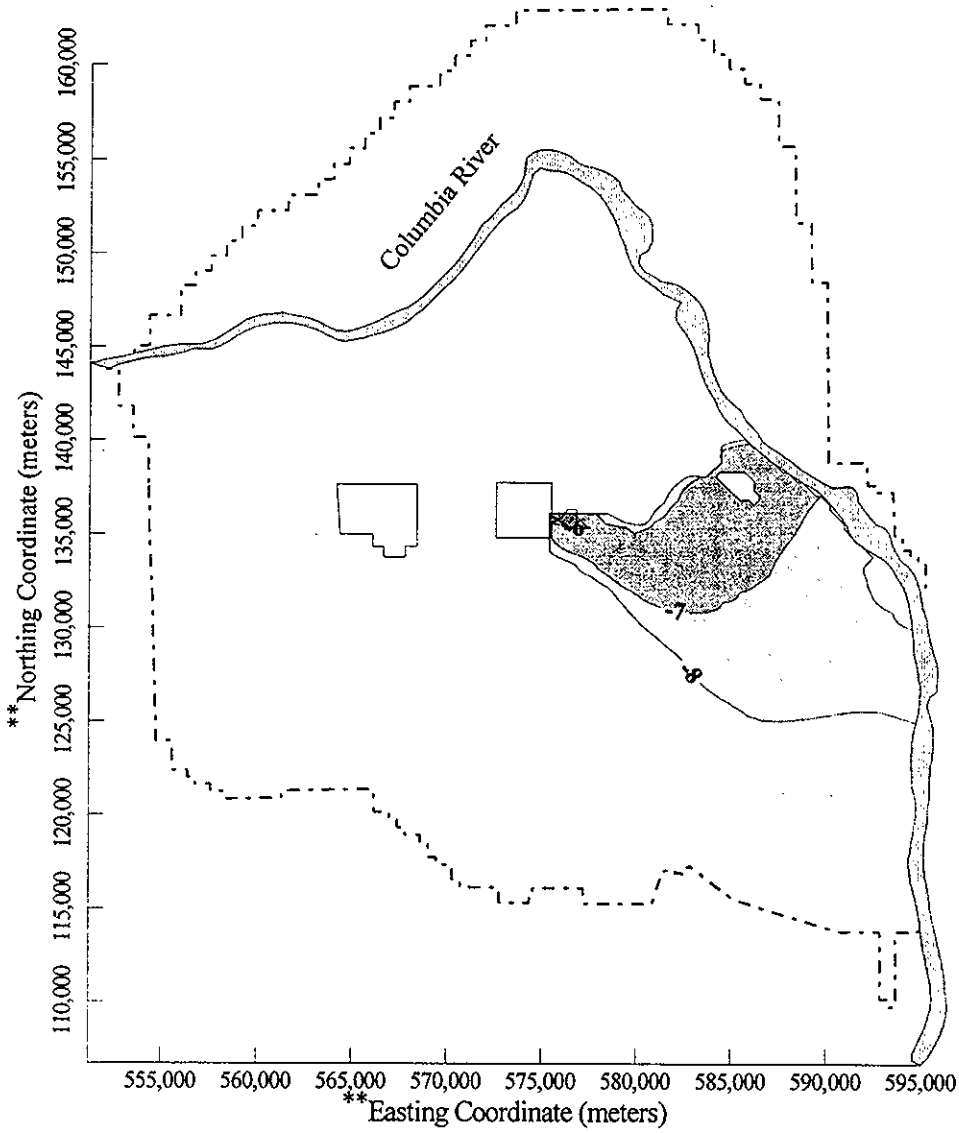


Figure 5.3.12. Nominal Retrieval Losses Option, Residential Farmer Scenario, ILCR from Composite Source Term at 600 Yr (1a)



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The number in the contour line represents risk magnitude (e.g., -7 indicates 1.00E-7)

— 200 East and West Operating Areas

- - - Hanford Site Boundary

Columbia River

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Figure 5.3.13. Nominal Retrieval Losses Option, Residential Farmer Scenario, ILCR from Composite Source Term at 1,200 Yr (1a)

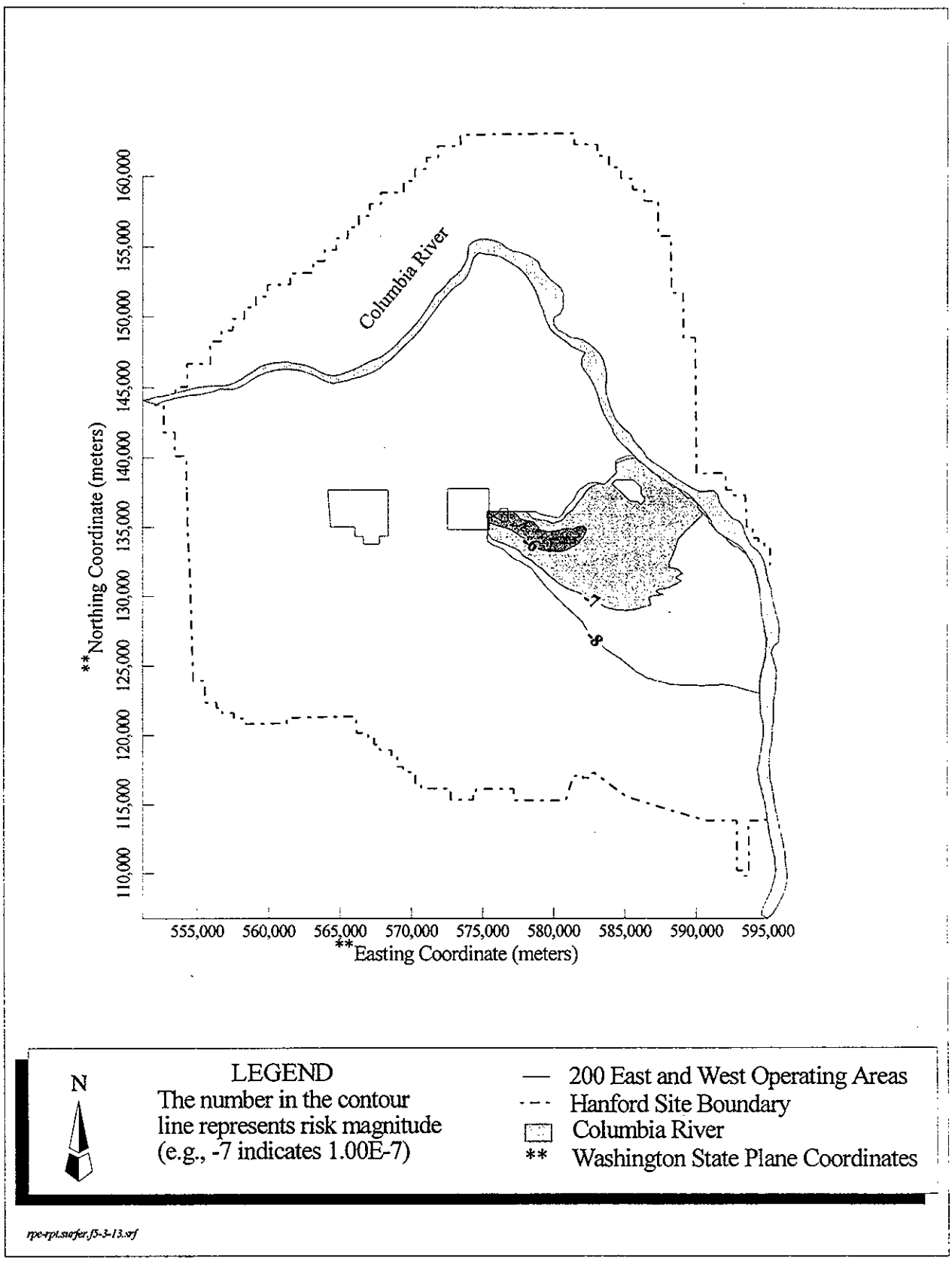
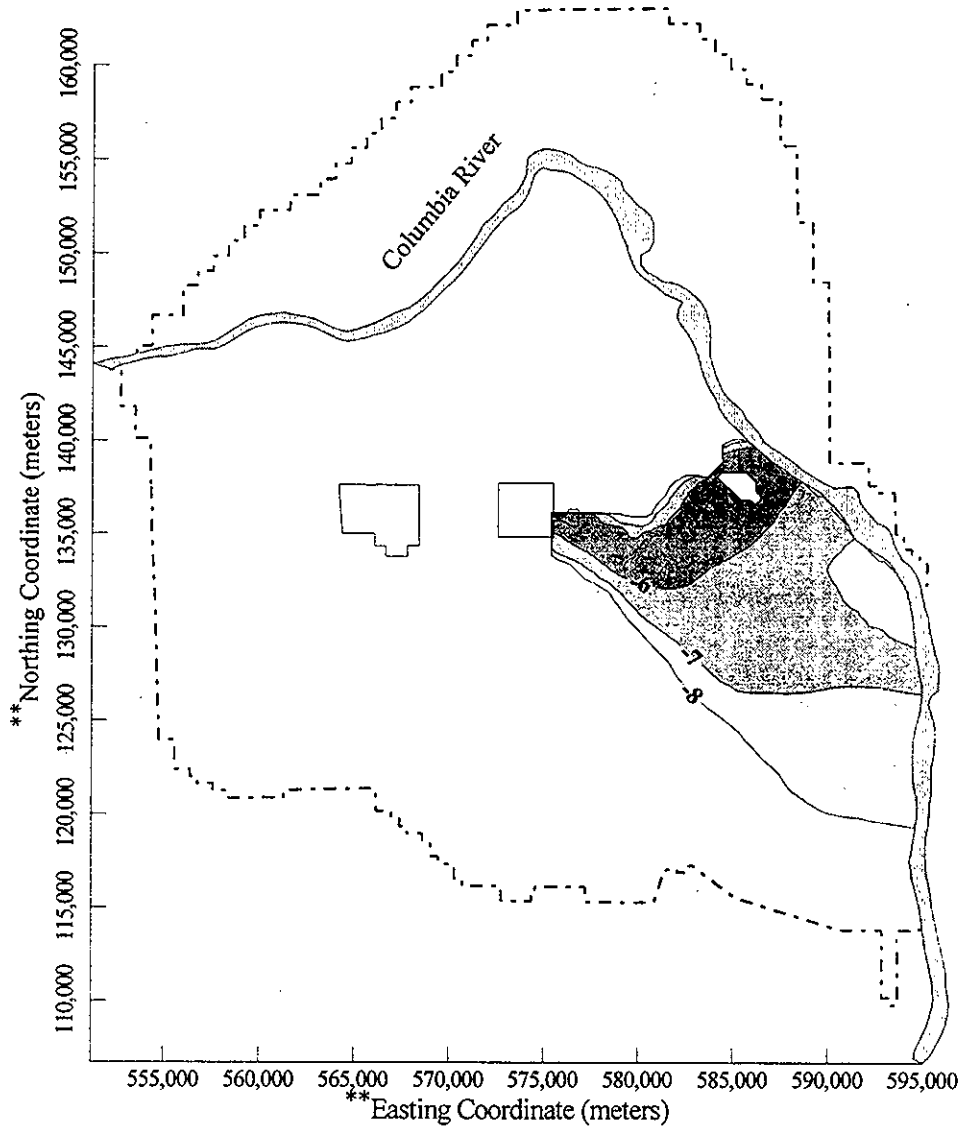


Figure 5.3.14. Nominal Retrieval Losses Option, Residential Farmer Scenario, ILCR from Composite Source Term at 2,600 Yr (1a)



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— 200 East and West Operating Areas

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Columbia River

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Figure 5.3.15. Nominal Retrieval Losses Option, Residential Farmer Scenario, ILCR from Composite Source Term at 5,000 Yr (1a)

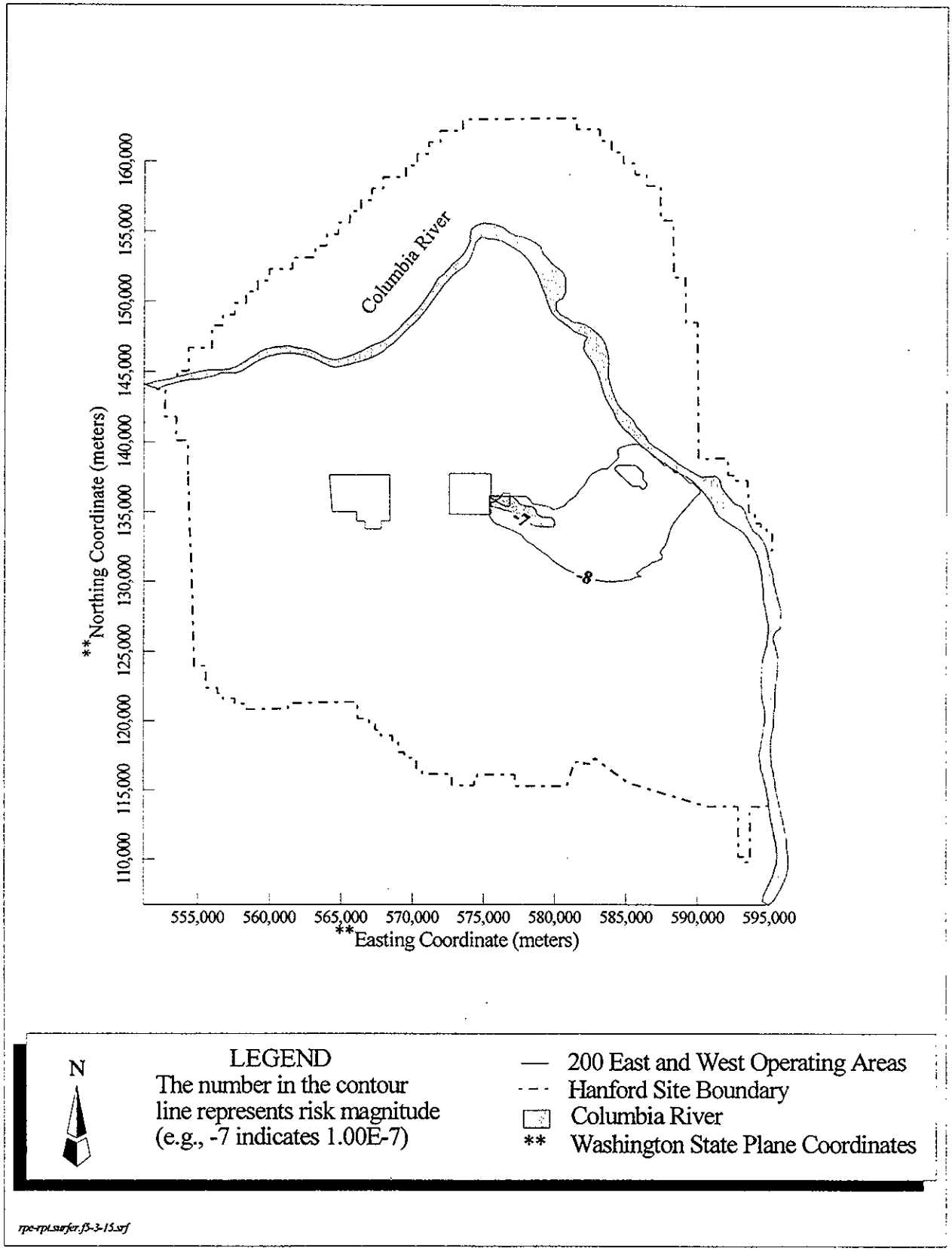
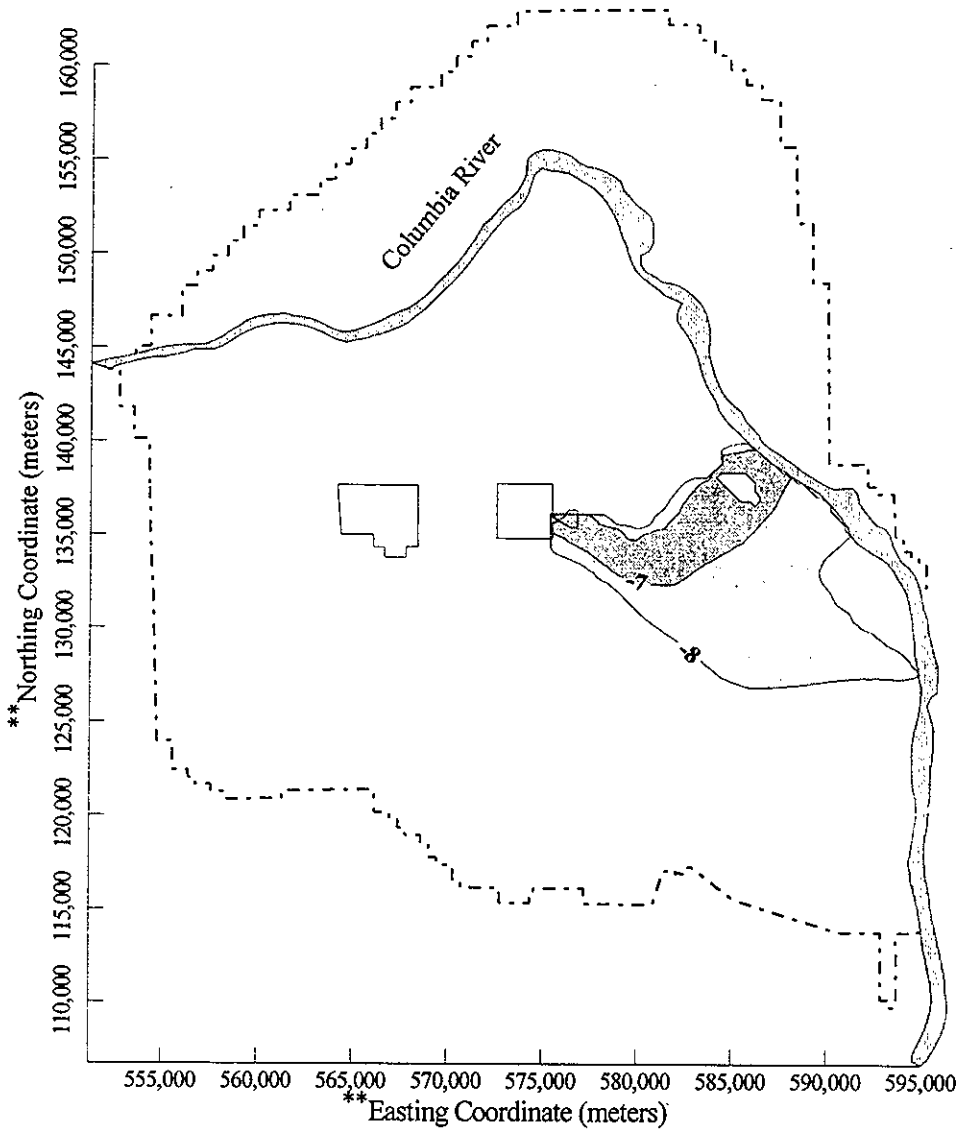


Figure 5.3.16. Nominal Retrieval Losses Option, Residential Farmer Scenario, ILCR from Composite Source Term at 10,000 Yr (1a)



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— 200 East and West Operating Areas

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5.3.1.4 Optimal Residual Volume (Option 1c)

The ILCR for each scenario would peak within 150 yr. At 150 yr the ILCR would exceed 1.0E-04 for the Native American scenario, 1.0E-05 for the residential farmer scenario, 1.0E-07 for the industrial worker scenario, and 1.0E-08 for the recreational shoreline user scenario.

Potential risks for the Native American scenario would exceed 1.0E-06 at all time periods and be above 1.0E-04 at 150 yr. The HI for the Native American would be greater than 1.0 at all time periods, indicating that toxic effects would occur. Potential risks for the residential farmer scenario would exceed 1.0E-05 for at least 150 yr and be above 1.0E-06 for all but the 5,000-yr time period. The HI for the residential farmer would exceed 1.0 only at 1,200 and 2,600 yr. The ILCR for the industrial worker and recreational shoreline user scenarios would be below 1.0E-06 for all time periods. The HI would be below 1.0 for the industrial worker and recreational shoreline user, indicating no toxic effects would be expected.

5.3.1.5 Suboptimal Residual Volume (Option 1d)

The ILCR for each scenario would peak at 2,600 yr. At 2,600 yr the ILCR would exceed 1.0E-04 for the Native American scenario, 1.0E-05 for the residential farmer scenario, 1.0E-06 for the industrial worker scenario, and 1.0E-07 for the recreational shoreline user scenario.

Potential risks for the Native American scenario would exceed 1.0E-06 at all time periods and be above 1.0E-04 at 150 and 2,600 yr. The HI for the Native American would be greater than 1.0 for all time periods, indicating that toxic effects would be expected. Potential risks for the residential farmer scenario would exceed 1.0E-06 at all time periods and be above 1.0E-05 at 150 and 2,600 yr. The HI for the residential farmer would exceed 1.0 only at 1,200 and 2,600 yr. The ILCR for the industrial worker scenario would exceed 1.0E-06 only at 2,600 yr. The ILCR for the recreational shoreline user scenario would be below 1.0E-06 for all time periods. The HI would be below 1.0 for the entire 10,000-yr period for the industrial worker and recreational shoreline user, indicating no toxic effects would be expected.

5.3.1.6 Temporary Operations Barrier (Option 1e)

The ILCR for each scenario would peak within 2,600 yr. At 2,600 yr the ILCR would exceed 1.0E-04 for the Native American scenario, 1.0E-05 for the residential farmer scenario, and 1.0E-07 for the industrial worker and recreational shoreline user scenarios.

Potential risks for the Native American scenario would exceed 1.0E-06 at all time periods and be above 1.0E-04 at 2,600 yr. The HI for the Native American would be greater than 1.0 for all time periods, indicating that toxic effects would be expected. Potential risks for the residential farmer scenario would exceed 1.0E-05 at 2,600 yr and be above 1.0E-06 for all but the 5,000-yr time period. At 2,600 yr, the HI for the residential farmer would exceed 1.0. The ILCR for the industrial worker and recreational shoreline user scenarios would be below 1.0E-06 for all time periods. The HI would be below 1.0 for the entire 10,000-yr period for the industrial worker and recreational shoreline user, indicating no toxic effects would be expected.

5.3.1.7 Postretrieval Hanford Barrier (Option 1f)

The ILCR for each scenario would peak within 2,600 yr. At 2,600 yr the ILCR would exceed 1.0E-04 for the Native American scenario, 1.0E-05 for the residential farmer scenario, and 1.0E-07 for the industrial worker and recreational shoreline user scenarios.

Potential risks for the Native American scenario would exceed 1.0E-06 at all time periods and be above 1.0E-04 at 150 and 2,600 yr. The HI for the Native American would be greater than 1.0 at all time periods, indicating that toxic effects would be expected. Potential risks for the residential farmer scenario would exceed 1.0E-05 at 150 and 2,600 yr and be above 1.0E-06 for all but the 5,000-yr time period. At 2,600 yr, the HI for the residential farmer would exceed 1.0. The ILCR for the industrial worker and recreational shoreline user scenarios would be below 1.0E-06 for all time periods. The HI would not exceed 1.0 at any time period for the industrial worker and recreational shoreline user, indicating that no toxic effects would be expected.

5.3.1.8 Nominal Losses/Soil Grouting (Option 1g)

The ILCR for each scenario would peak at 2,600 yr. At 2,600 yr the ILCR would 1.0E-05 for the Native American scenario, 1.0E-06 for the residential farmer scenario, 1.0E-07 for the industrial worker scenario, and 1.0E-08 for the recreational shoreline user scenario.

Potential risks for the Native American scenario would exceed 1.0E-05 for at least 2,600 yr and be above 1.0E-06 through the entire 10,000-yr period. The hazard index for the Native American would exceed 1.0 at 2,600, 5,000, 7,600, and 10,000 yr, indicating that toxic effects would be expected. Potential risks for the residential farmer scenario would be above 1.0E-06 for the entire 10,000-yr period but the HI would be below 1.0, indicating that no toxic effects would be expected. The ILCR for the industrial worker and recreational shoreline user scenarios would be below 1.0E-06 for all time periods and the hazard indices for these scenarios would be less than 1.0.

It should be noted that contaminant fate and transport modeling for the options involving grouted vadose zone soil (Options 1g, 1h, 2b, 2c) was not conducted in the same manner as for the other options primarily because of the inability to adequately simulate the performance of the grouted soil mass. Adjustments to the modeling approach were necessary to overcome large numerical errors that occurred when contaminant transport was simulated with the grouted material properties. Groundwater impacts for these options were approximated by conducting limited simulations combined with results from other analogous options. For these reasons, the long-term human health risk results for Options 1g, 1h, 2b, and 2c carry a higher degree of uncertainty than the results for the other options. The results for the grouted soil options are considered commensurate with the current understanding of these options and their associated implementability issues. Contaminant fate and transport modeling for the Nominal Losses/Soil Grouting option (Option 1g) is discussed in Section 5.2.8.

5.3.1.9 Large Losses/Soil Grouting (Option 1h)

The ILCR for each scenario would peak at 2,600 yr at levels slightly greater than for the Nominal Losses/Soil Grouting option (Option 1g). At 2,600 yr the ILCR would 1.0E-05 for the Native American scenario, 1.0E-06 for the residential farmer scenario, 1.0E-07 for the industrial worker scenario, and 1.0E-08 for the recreational shoreline user scenario.

Potential risks and hazards associated with this option would be similar to but slightly greater than for the Nominal Losses/Soil Grouting option (Option 1g). The ILCR for the Native American and residential farmer scenarios would be near or above 1.0E-05 and 1.0E-06, respectively, for the entire 10,000-yr period. The ILCR for the industrial worker and recreational shoreline user scenarios would be below 1.0E-06 for all time periods.

As discussed in Section 5.3.1.8, contaminant fate and transport modeling for the options involving grouted vadose zone soil (Options 1g, 1h, 2b, 2c) was not conducted in the same manner as for the other options, resulting in the long-term human health risk results for these options carrying a higher degree of uncertainty than the results for the other options. The results for the grouted soil options are considered commensurate with the current understanding of these options and their associated implementability issues. Contaminant fate and transport modeling for the Large Losses/Soil Grouting option (Option 1h) is discussed in Section 5.2.9.

5.3.1.10 Baseline Retrieval/Unrestricted Land Use (Strategy 2)

The ILCR for each scenario would peak within 150 yr. At 150 yr the ILCR would exceed 1.0E-05 for the Native American scenario, 1.0E-06 for the residential farmer scenario, 1.0E-07 for the industrial worker scenario, and 1.0E-08 for the recreational shoreline user scenario.

Potential risks for the Native American scenario would exceed 1.0E-05 for at least 600 yr and be above 1.0E-06 through the 1,200-yr time period. The HI for the Native American would not exceed 1.0, indicating that no toxic effects would be expected. Potential risks for the residential farmer scenario would be near or above 1.0E-06 through the 1,200-yr time period. The ILCR for the industrial worker and recreational shoreline user scenarios would be below 1.0E-06 for all time periods. The HI would be less than 1.0 for all time periods for the residential farmer, industrial worker, and recreational shoreline user scenarios, indicating that no toxic effects would be expected.

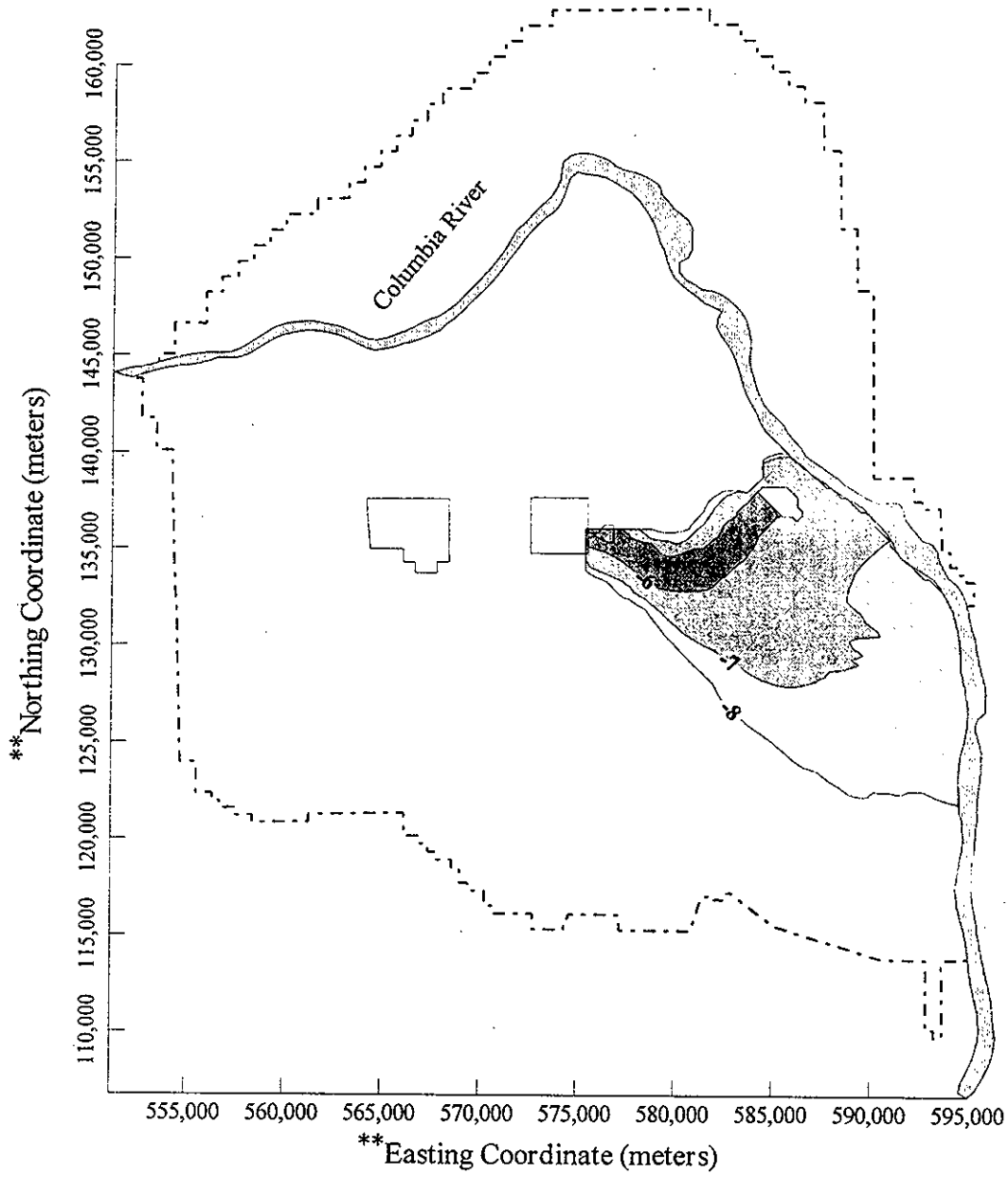
5.3.1.11 Nominal Losses/Excavate Soil (Option 2a)

The ILCR for each scenario would peak within 150 yr. At 150 yr the ILCR would exceed 1.0E-05 for the Native American scenario, 1.0E-06 for the residential farmer scenario, 1.0E-07 for the industrial worker scenario, and 1.0E-08 for the recreational shoreline user scenario.

The risks and hazards associated with this option would be nearly identical to the Baseline Retrieval/Unrestricted Land Use strategy (Strategy 2). The ILCR for the Native American scenario would exceed 1.0E-06 through the 1,200-yr period. The ILCR for the residential farmer scenario would approach or exceed 1.0E-06 through the 1,200-yr period. The ILCR for the industrial worker and recreational shoreline user scenarios would be below 1.0E-06 for all time periods.

Contour maps depicting the risk to the residential farmer from radionuclides in the composite source term for the Nominal Losses/Excavate Soil option (Option 2a) are presented in Figures 5.3.17 through 5.3.22.

Figure 5.3.17. Nominal Losses/Excavate Soil Option, Residential Farmer Scenario, ILCR from Composite Source Term at 150 Yr (2a)



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The number in the contour line represents risk magnitude (e.g., -7 indicates 1.00E-7)

— 200 East and West Operating Areas

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Columbia River

** Washington State Plane Coordinates

Figure 5.3.18. Nominal Losses/Excavate Soil Option, Residential Farmer Scenario, ILCR from Composite Source Term at 600 Yr (2a)

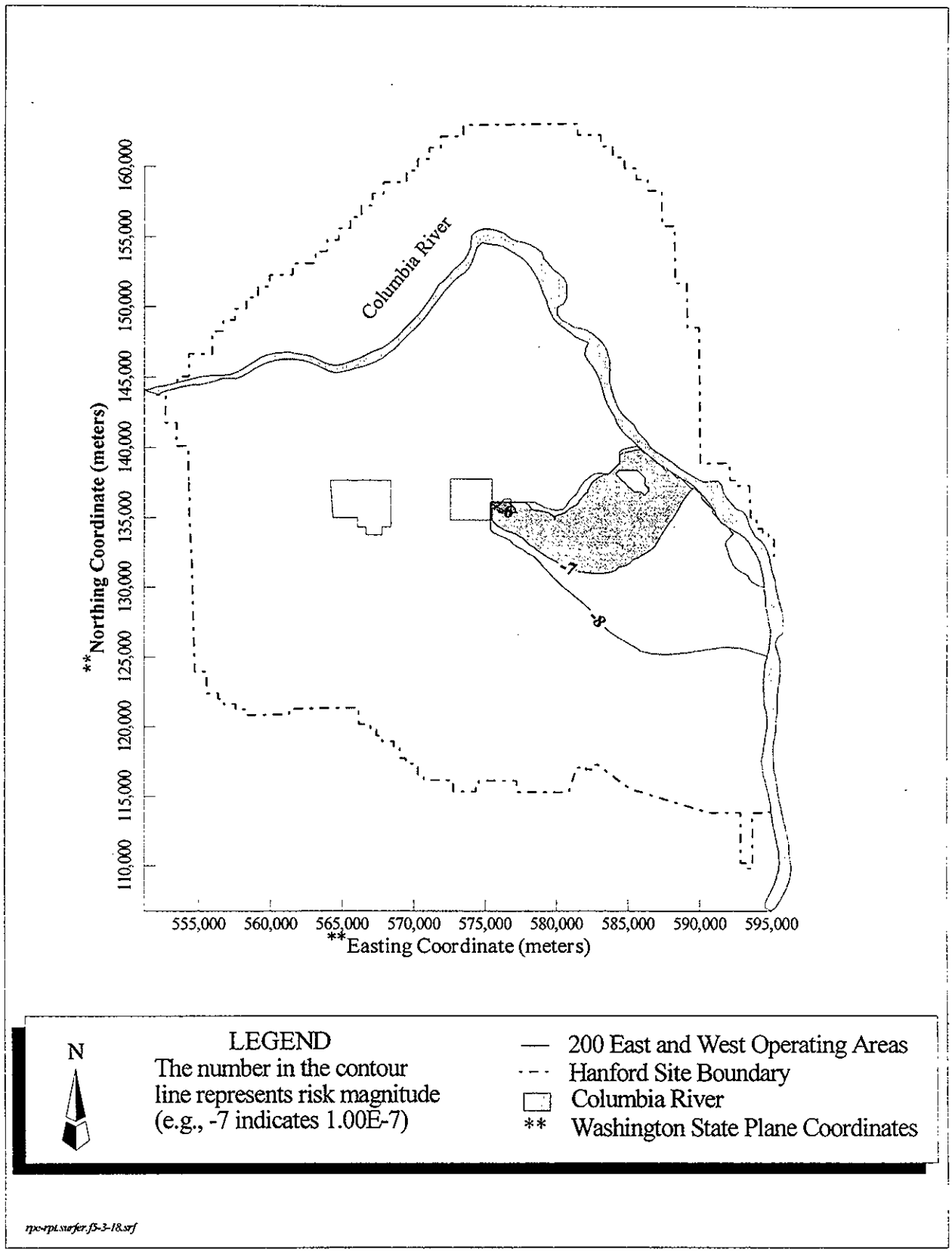

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Figure 5.3.19. Nominal Losses/Excavate Soil Option, Residential Farmer Scenario, ILCR from Composite Source Term at 1,200 Yr (2a)

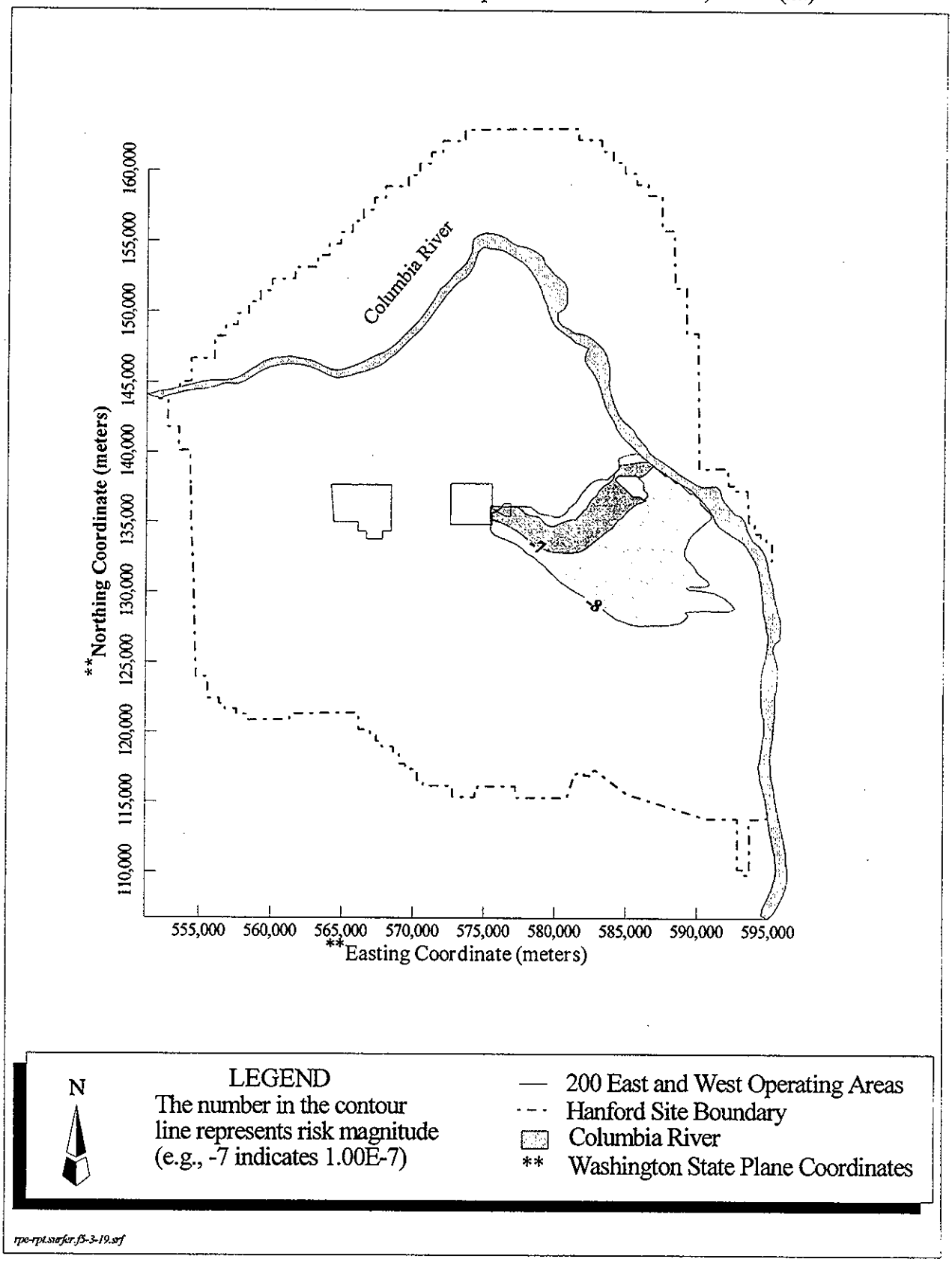

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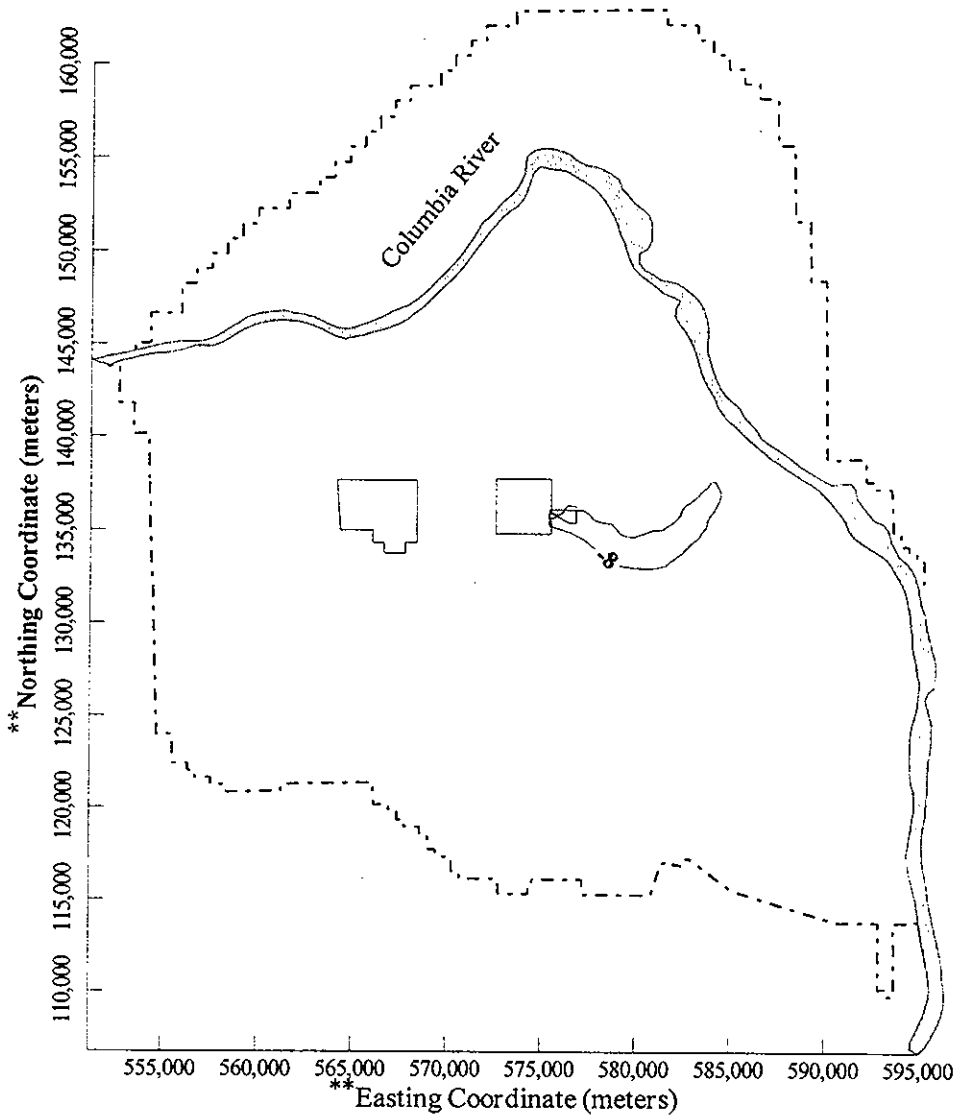
Figure 5.3.20. Nominal Losses/Excavate Soil Option, Residential Farmer Scenario, ILCR from Composite Source Term at 2,600 Yr (2a)



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— 200 East and West Operating Areas

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Columbia River

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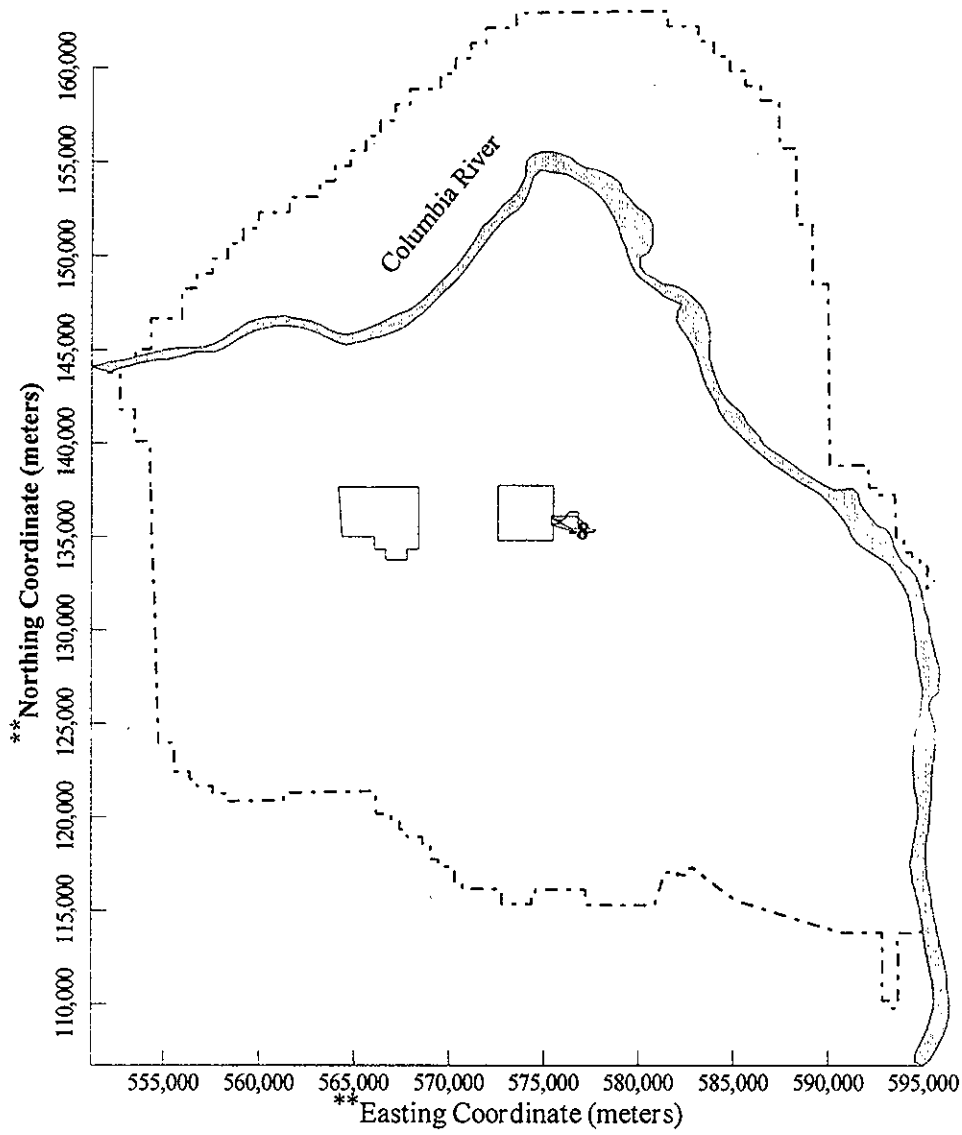
Figure 5.3.21. Nominal Losses/Excavate Soil Option, Residential Farmer Scenario, ILCR from Composite Source Term at 5,000 Yr (2a)



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The number in the contour line represents risk magnitude (e.g., -7 indicates 1.00E-7)

— 200 East and West Operating Areas
- - - Hanford Site Boundary
Columbia River
** Washington State Plane Coordinates

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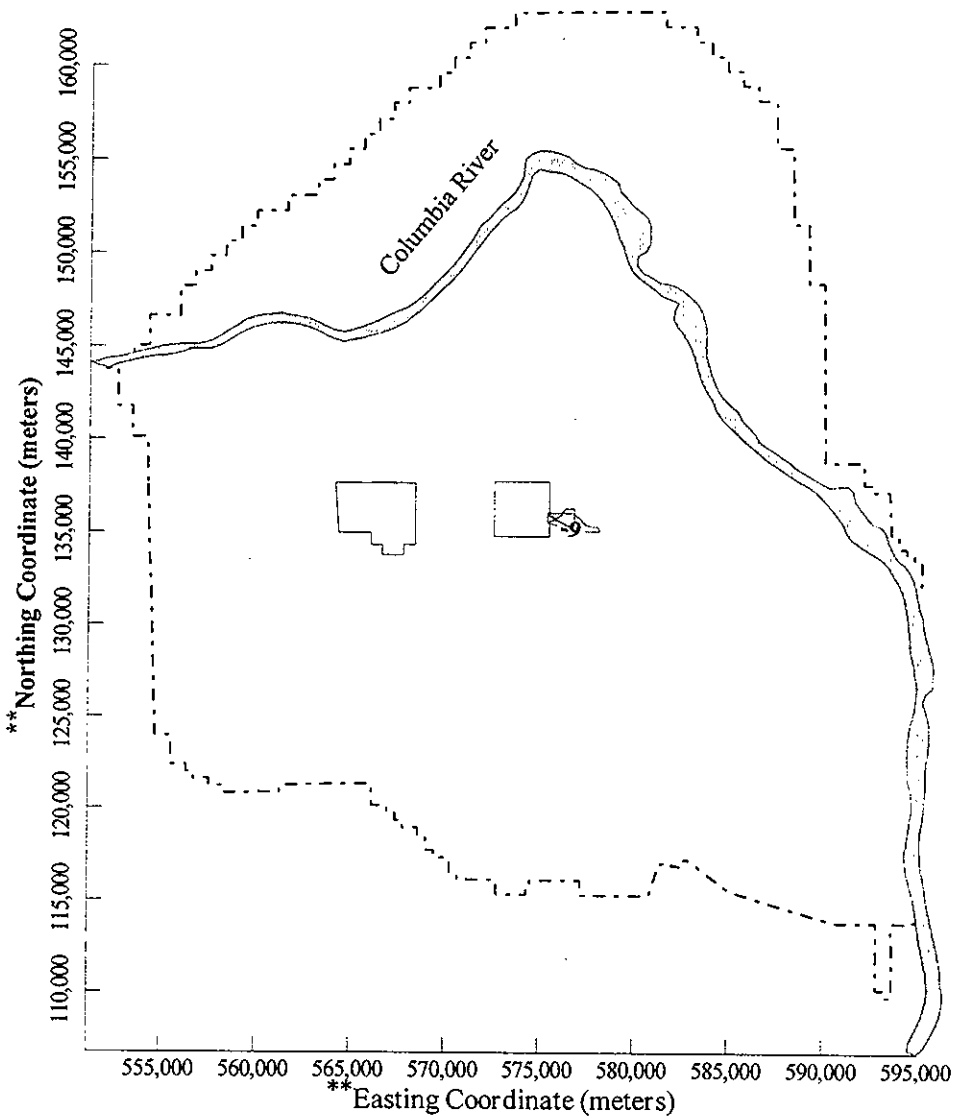
Figure 5.3.22. Nominal Losses/Excavate Soil Option, Residential Farmer Scenario, ILCR from Composite Source Term at 10,000 Yr (2a)



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The number in the contour line represents risk magnitude (e.g., -7 indicates 1.00E-7)

— 200 East and West Operating Areas

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5.3.1.12 Past Leak/In Situ Soil Treatment (Option 2b)

The ILCR for each scenario would peak within 150 yr. At 150 yr the ILCR would exceed 1.0E-05 for the Native American scenario, 1.0E-06 for the residential farmer scenario, 1.0E-07 for the industrial worker scenario, and 1.0E-08 for the recreational shoreline user scenario.

Potential risks for the Native American scenario would be near or above 1.0E-06 for the entire 10,000-yr period and be above 1.0E-05 at 150, 200, 400, 600, and 1,200 yr. The HI for the Native American would not exceed 1.0, indicating that no toxic effects would be expected. Potential risks for the residential farmer scenario would fall below 1.0E-06 at 1,200 yr and remain below this level through the 10,000-yr period. The ILCR for the industrial worker and recreational shoreline user scenarios would not exceed 1.0E-06 at any time period. The HI would be less than 1.0 for all time periods for the residential farmer, industrial worker, and recreational shoreline user scenarios, indicating that no toxic effects would be expected.

As discussed in Section 5.3.1.8, contaminant fate and transport modeling for the options involving grouted vadose zone soil (Options 1g, 1h, 2b, 2c) was not conducted in the same manner as for the other options, resulting in the long-term human health risk results for these options carrying a higher degree of uncertainty than the results for the other options. The results for the grouted soil options are considered commensurate with the current understanding of these options and their associated implementability issues. Contaminant fate and transport modeling for the Past Leak/In Situ Soil Treatment option (Option 2b) is discussed in Section 5.2.12.

5.3.1.13 Nominal Losses/In Situ Soil Treatment (Option 2c)

The ILCR for each scenario would peak within 150 yr. At 150 yr the ILCR would exceed 1.0E-05 for the Native American scenario, 1.0E-06 for the residential farmer scenario, 1.0E-07 for the industrial worker scenario, and 1.0E-08 for the recreational shoreline user scenario.

Potential risks for the Native American scenario would exceed 1.0E-06 at all time periods and exceed 1.0E-05 through at least the 7,600-yr period. The HI for the Native American would be greater than 1.0 at all time periods, indicating that toxic effects would be expected. Potential risks for the residential farmer scenario would be near or above 1.0E-06 for the entire 10,000-yr period and the HI would be near or above 1.0 at 2,600, 5,000, and 7,600 yr, indicating that toxic effects would be expected at these time periods. The ILCR for the industrial worker and recreational shoreline user scenarios would not exceed 1.0E-06 at any time period. The HI would be less than 1.0 for all time periods for the industrial worker and recreational shoreline user scenarios, indicating that no toxic effects would be expected.

As discussed in Section 5.3.1.8, contaminant fate and transport modeling for the options involving grouted vadose zone soil (Options 1g, 1h, 2b, 2c) was not conducted in the same manner as for the other options, resulting in the long-term human health risk results for these options carrying a higher degree of uncertainty than the results for the other options. The results for the grouted soil options are considered commensurate with the current understanding of these options and their associated implementability issues. Contaminant fate and transport modeling for the Nominal Losses/In Situ Soil Treatment option (Option 2c) is discussed in Section 5.2.13.

5.3.1.14 No Soil Treatment (Option 2d)

The ILCR for each scenario would peak within 150 yr. At 150 yr the ILCR would exceed 1.0E-04 for the Native American scenario, 1.0E-05 for the residential farmer scenario, 1.0E-07 for the industrial worker scenario, and 1.0E-08 for the recreational shoreline user scenario.

Potential risks for the Native American scenario would exceed 1.0E-06 at all time periods and would be above 1.0E-04 for at least 150 yr. The HI for the Native American would be greater than 1.0 for at least 2,600 yr, indicating that toxic effects would be expected. Potential risks for the residential farmer scenario would remain above 1.0E-06 through the 2,600-yr period and would be above 1.0E-05 for at least 150 yr. The HI for the residential farmer would exceed 1.0 only at 1,200 and 2,600 yr. The ILCR for the industrial worker and recreational shoreline user scenarios would not exceed 1.0E-06 at any time period. The HI would be less than 1.0 for all time periods for the industrial worker and recreational shoreline user scenarios, indicating that no toxic effects would be expected.

5.3.1.15 No Action Strategy (Strategy 3)

The ILCR for each exposure scenario would peak at 2,600 yr. At 2,600 yr, the ILCR would exceed 1.0E-03 for the Native American scenario, 1.0E-04 for the residential farmer scenario, 1.0E-06 for the industrial worker scenario, and 1.0E-07 for the recreational shoreline user scenario.

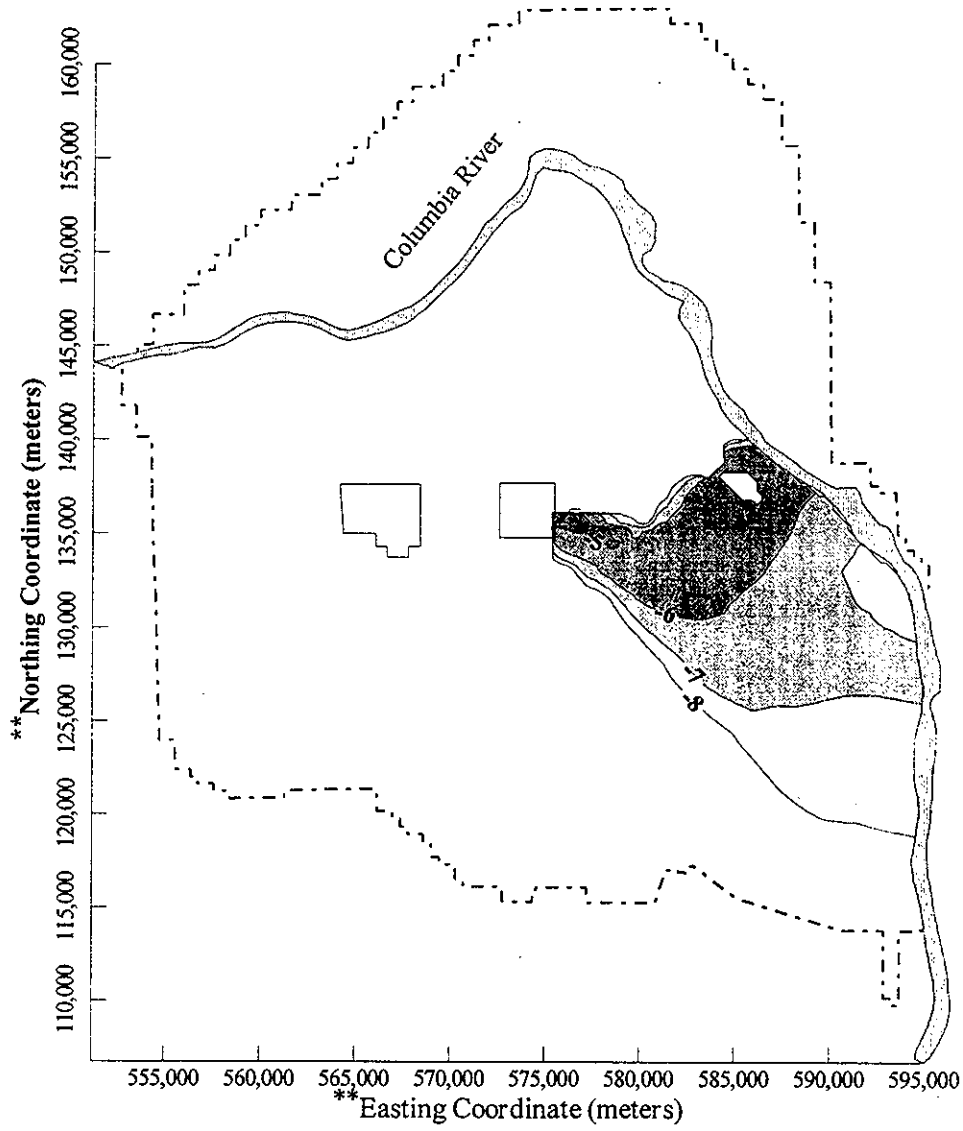
Potential risks for the Native American scenario would be near or above 1.0E-04 at all time periods and be above 1.0E-03 at 2,600 yr. The HI for the Native American would be greater than 1.0 at all time periods, indicating that toxic effects would be expected. Potential risks for the residential farmer scenario would be above 1.0E-05 for all time periods and above 1.0E-04 at 2,600 yr. The HI for the residential farmer would approach or exceed 1.0 at all time periods. The ILCR for the industrial worker scenario would exceed 1.0E-06 at 1,200 and 2,600 yr. The ILCR for the recreational shoreline user scenario would be below 1.0E-06 for all time periods. The HI would be less than 1.0 for the industrial worker and recreational shoreline user scenarios, indicating that no toxic effects would be expected.

Contour maps depicting the risk to the residential farmer from radionuclides in the composite source term for the No Action strategy are presented in Figures 5.3.23 through 5.3.28.

5.3.2 Long-Term Human Health Risk Results by Source Term

The composite source term risks presented above were a summation of the risks from three potential source term components: past tank leaks and spills, retrieval leakage loss, and residual waste in tanks and ancillary equipment. This section describes the relative contributions to long-term human health risks from each of these source terms. The residential farmer exposure scenario is used for this discussion. As previously presented, the risks for the other exposure scenarios can be related to the residential farmer risk with a scaling factor. Native American risks are higher than residential farmer risks by approximately 1 order of magnitude. Industrial worker and recreational shoreline user risks are lower than residential farmer risks by approximately 1 and 2 orders of magnitude, respectively.

Figure 5.3.23. No Action Strategy, Residential Farmer Scenario, ILCR from Composite Source Term at 150 Years (3)



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SOURCE: Jacobs

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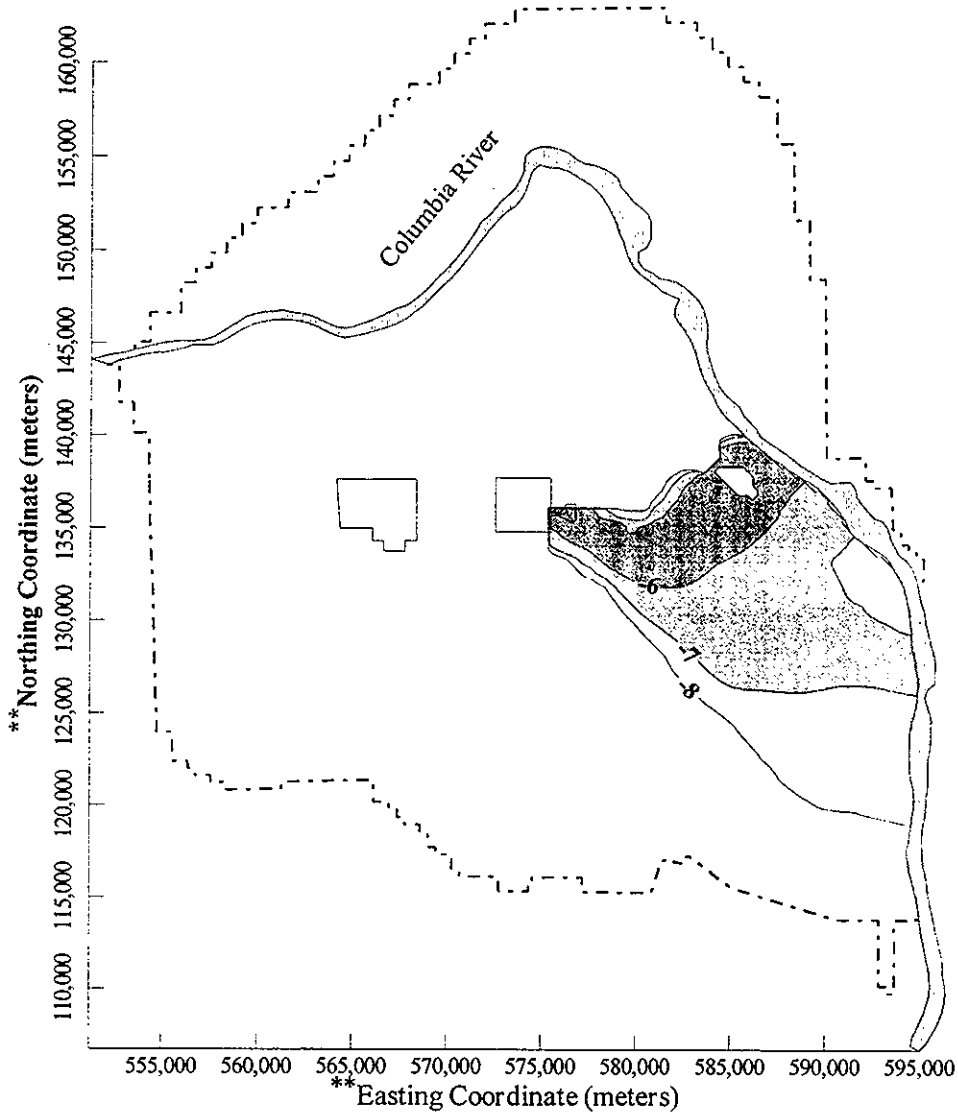
Figure 5.3.24. No Action Strategy, Residential Farmer Scenario, ILCR from Composite Source Term at 600 Yr (3)



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The number in the contour line represents risk magnitude (e.g., -7 indicates 1.00E-7)

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** Washington State Plane Coordinates

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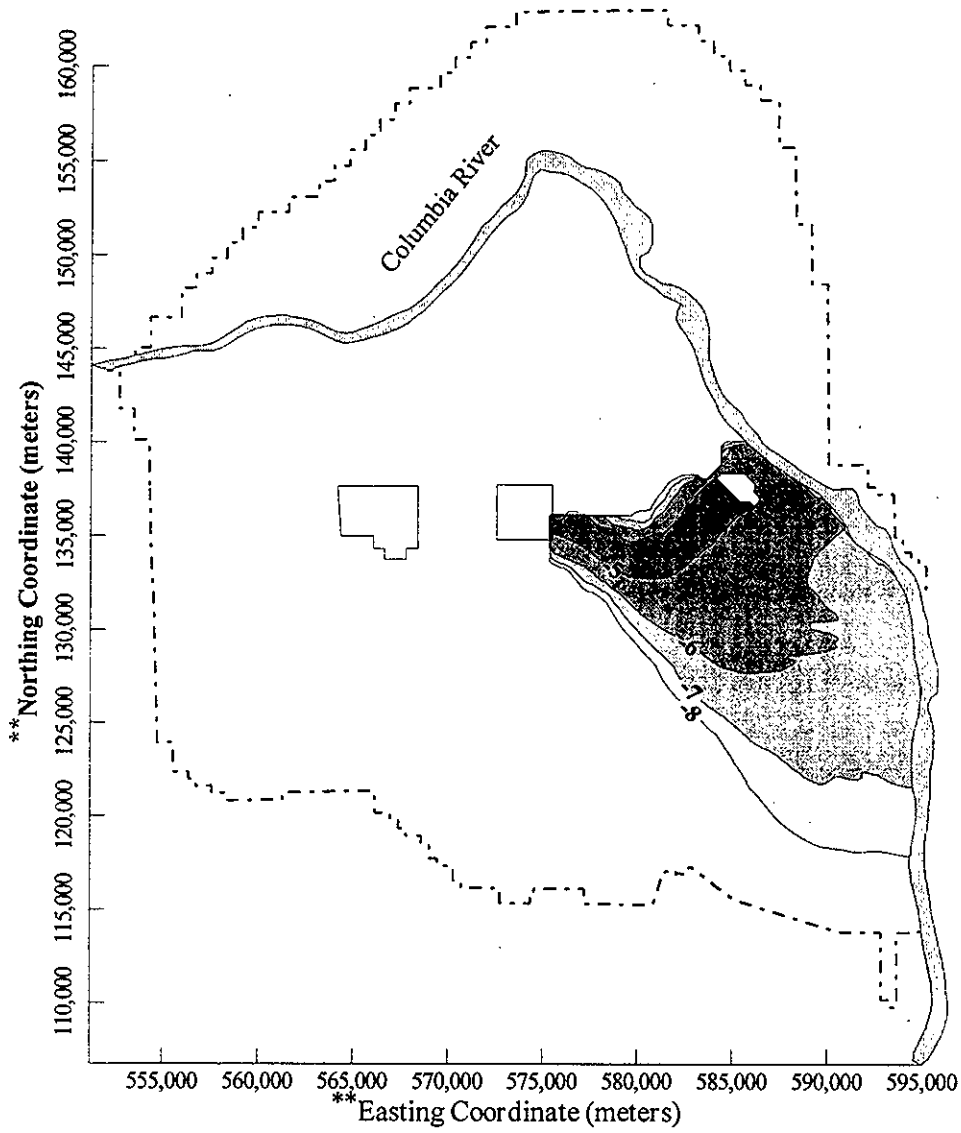
Figure 5.3.25. No Action Strategy, Residential Farmer Scenario, ILCR from Composite Source Term at 1,200 Yr (3)



N

LEGEND

The number in the contour line represents risk magnitude (e.g., -7 indicates 1.00E-7)

— 200 East and West Operating Areas

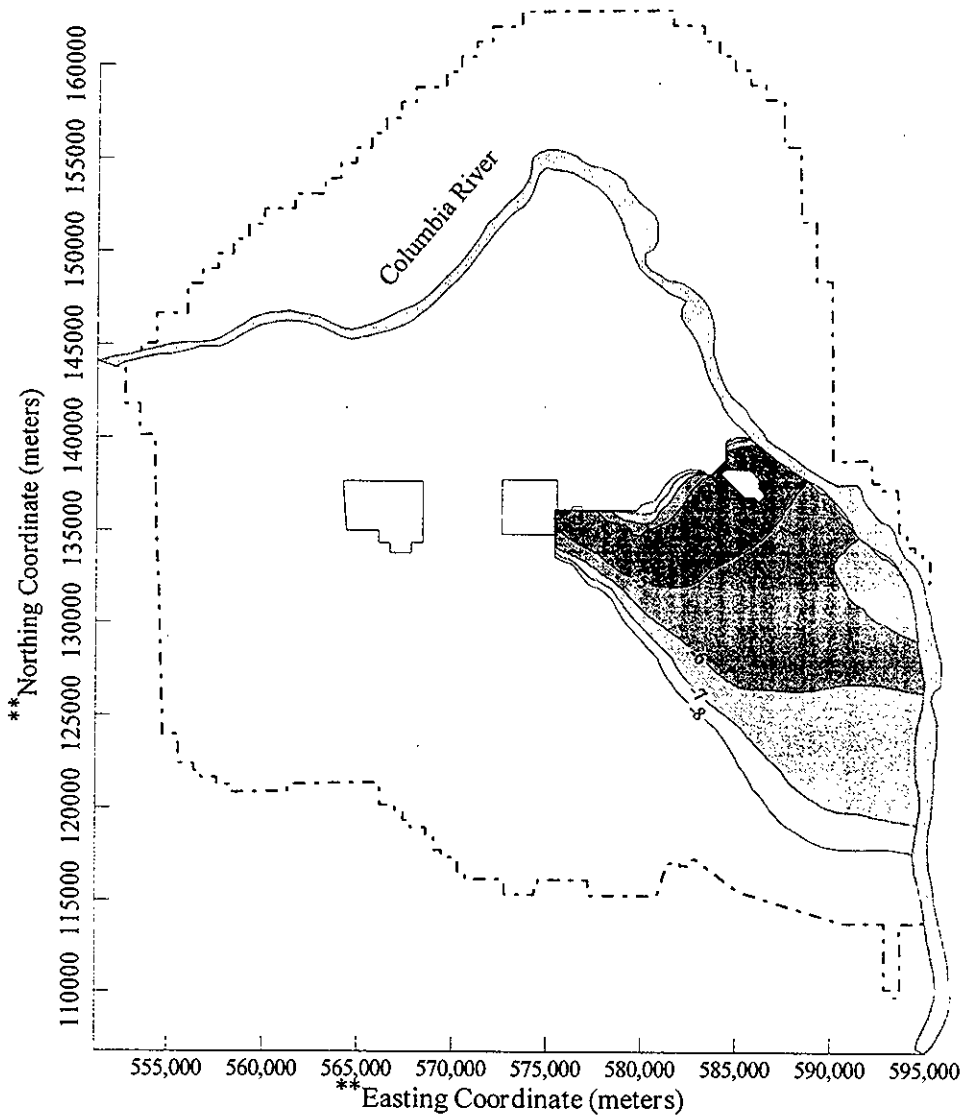
- - - Hanford Site Boundary

Columbia River

** Washington State Plane Coordinates

rpe-rpt.surfer.f5-3-25.srf

Figure 5.3.26. No Action Strategy, Residential Farmer Scenario, ILCR from Composite Source Term at 2,600 Yr (3)



N

LEGEND

The number in the contour line represents risk magnitude (e.g., -7 indicates 1.00E-7)

— 200 East and West Operating Areas

- - - Hanford Site Boundary

Columbia River

** Washington State Plane Coordinates

rpe-rpt.surfer.f5-3-26.srf

Figure 5.3.27. No Action Strategy, Residential Farmer Scenario, ILCR from Composite Source Term at 5,000 Yr (3)

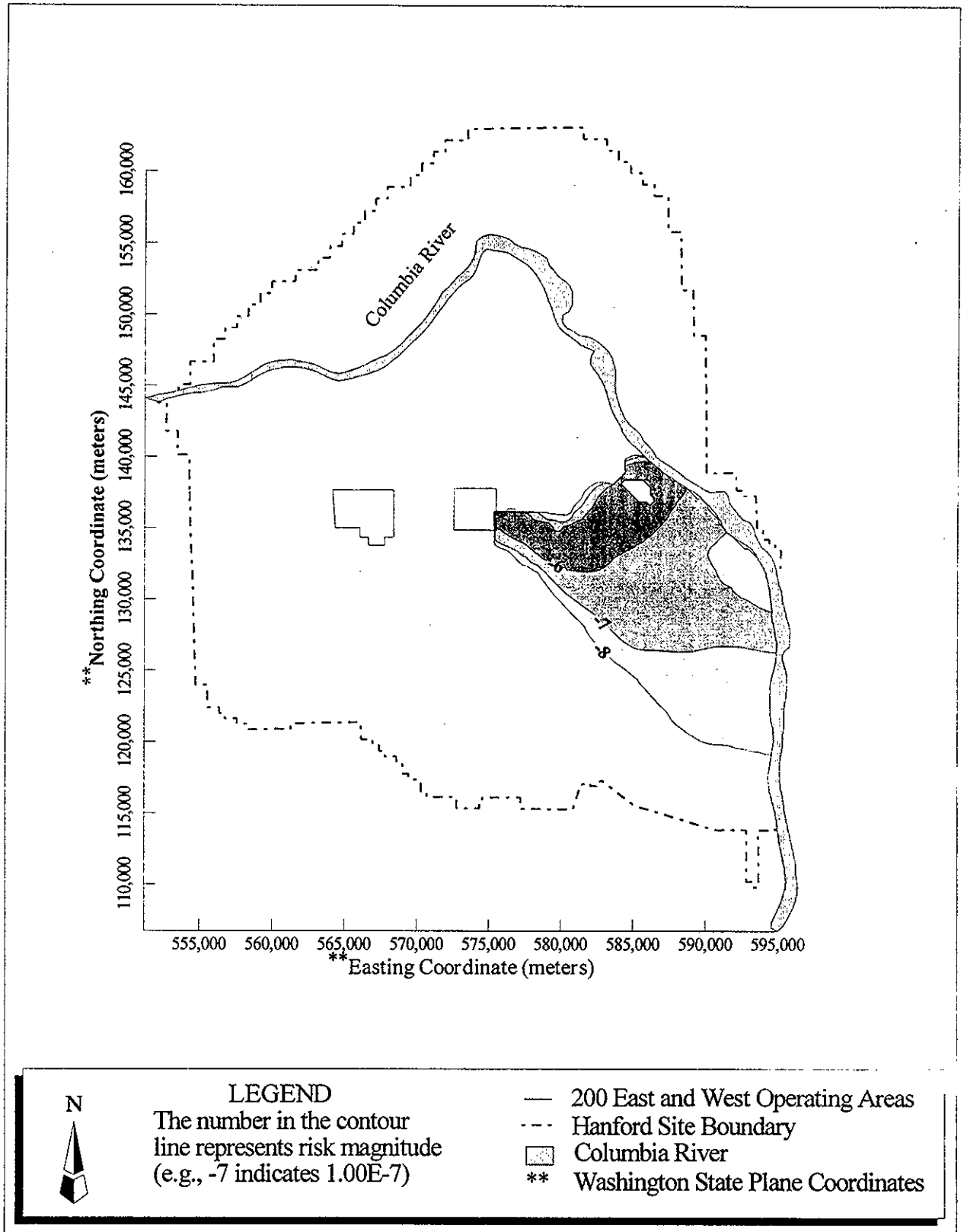


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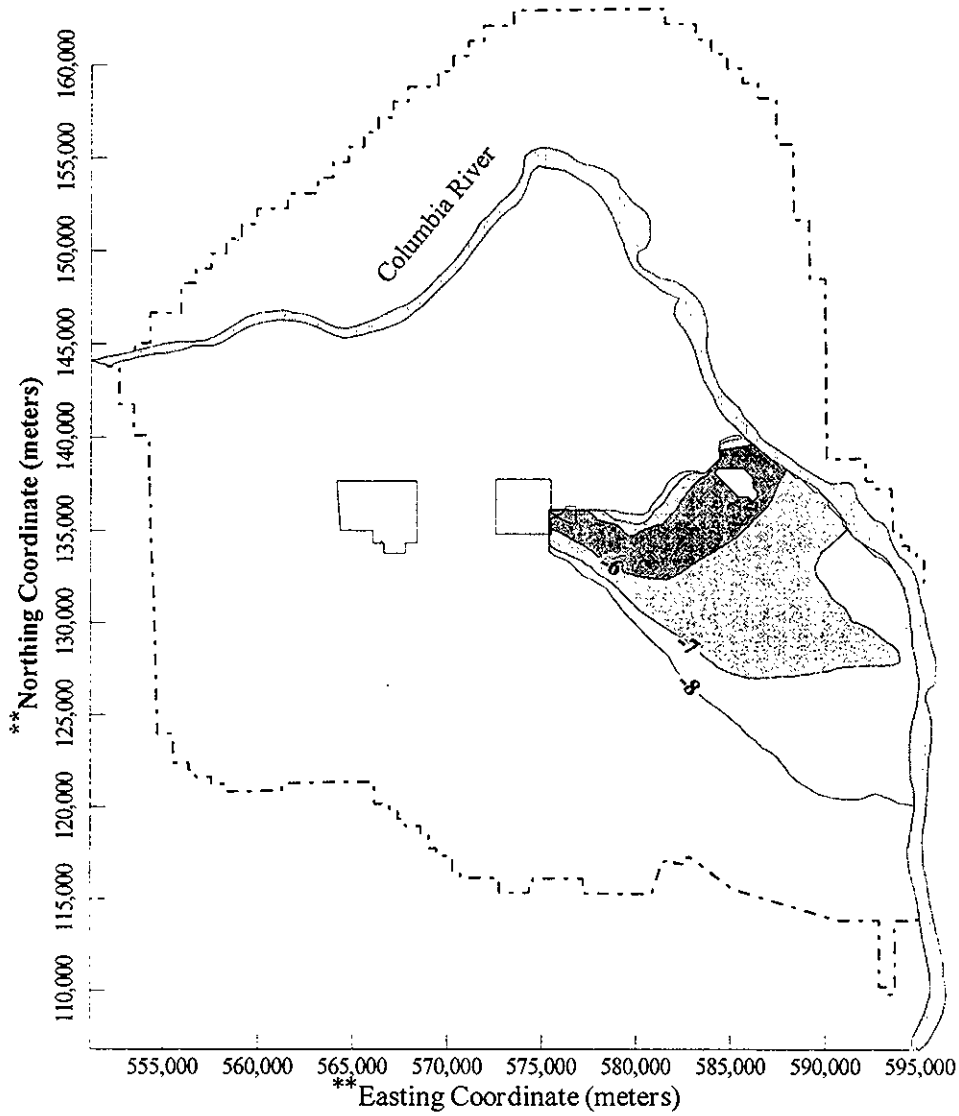
Figure 5.3.28. No Action Strategy, Residential Farmer Scenario, ILCR from Composite Source Term at 10,000 Yr (3)



N

LEGEND

The number in the contour line represents risk magnitude (e.g., -7 indicates 1.00E-7)

— 200 East and West Operating Areas

- - - Hanford Site Boundary

Columbia River

** Washington State Plane Coordinates

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As shown in Table 5.3.5, not every source term would contribute to the risk for every waste retrieval and tank farm closure option. Some options would involve contributions from one or two source terms (e.g., past leaks and residual waste), while other options would involve all three source terms. Also note that individual source term contributions were not evaluated in every case. This is because source term contributions would be similar between a number of the options. Only those source terms contributions considered likely to facilitate comparison among the options were evaluated. Table 5.3.5 identifies the source terms for each waste retrieval and tank farm closure option and the cases evaluated. Table 5.3.6 shows the maximum calculated potential ILCR for the residential farmer scenario for the cases evaluated for each source term. The ILCR data shown in Table 5.3.6 are plotted graphically in Figures 5.3.29 through 5.3.31 for past tank leaks and spills, retrieval leakage loss, and residual waste.

Table 5.3.5. Source Term Components Evaluated for Long-Term Human Health Risk

Option	Source Term Cases Evaluated		
	Past Tank Leaks and Spills	Retrieval Leakage Loss	Residual Waste
Baseline Retrieval/Restricted Land Use (1)	Evaluated	N/A	Evaluated
Nominal Retrieval Losses (1a)	1	Evaluated	1
Large Retrieval Losses (1b)	1	Evaluated	Evaluated
Optimal Residual Volume (1c)	1	1	Evaluated
Suboptimal Residual Volume (1d)	1	1	Evaluated
Temporary Operations Barrier (1e)	Evaluated	Evaluated	1
Postretrieval Hanford Barrier (1f)	Evaluated	Evaluated	1
Nominal Losses/Soil Grouting (1g)	1	1	1
Large Losses/Soil Grouting (1h)	1	1	1
Baseline Retrieval/Unrestricted Land Use (2)	1	N/A	N/A
Nominal Losses/Excavate Soil (2a)	1	1	N/A
Past Leak/In Situ Soil Treatment (2b)	1	N/A	N/A
Nominal Losses/In Situ Soil Treatment (2c)	1	1	N/A
No Soil Treatment (2d)	1	1	N/A
No Action (3)	1	N/A	Evaluated

Notes:

N/A= Not applicable, component would make no contribution to long-term human health risk

1= Component would make a contribution to long-term human health risk but contribution was not specifically evaluated.

Table 5.3.6. Maximum ILCR for Residential Farmer Scenario from Source Term Components by Time

Source Term Component	Case(s) Evaluated	Time (Yr from 1963)								
		150	200	400	600	1,200	2,600	5,000	7,600	10,000
Past Tank Leaks and Spills	Baseline Retrieval/Restricted Land Use (1)	1.2E-05	8.1E-06	3.5E-06	2.6E-06	3.5E-06	7.9E-08	2.4E-07	5.1E-07	3.6E-07
	Temporary Operations Barrier (1e)	5.5E-06	4.2E-06	2.5E-06	2.1E-06	5.6E-06	6.8E-07	1.5E-07	5.1E-07	4.0E-07
	Postretrieval Hanford Barrier (1f)	1.1E-05	7.9E-06	3.5E-06	2.5E-06	1.1E-06	5.8E-07	1.6E-07	4.9E-07	3.9E-07
Retrieval Leakage Loss	Nominal Retrieval Losses (1a)	3.7E-07	3.7E-07	3.7E-07	3.7E-07	2.9E-06	8.2E-06	1.7E-07	5.7E-07	6.0E-07
	Large Retrieval Losses (1b)	1.2E-05	1.2E-05	6.1E-06	6.3E-06	3.5E-05	3.1E-05	8.3E-07	3.1E-06	3.1E-06
	Temporary Operations Barrier (1e)	2.4E-07	2.5E-07	2.4E-07	2.5E-07	2.5E-07	1.1E-05	1.7E-07	5.3E-07	6.0E-07
	Postretrieval Hanford Barrier (1f)	2.5E-07	2.6E-07	2.5E-07	2.6E-07	2.6E-07	1.1E-05	1.7E-07	5.2E-07	6.2E-07
Residual Waste (tanks and ancillary equipment)	Baseline Retrieval/Restricted Land Use (1)	1.1E-07	1.1E-07	1.1E-07	1.1E-07	1.1E-07	6.1E-06	8.3E-08	2.7E-07	2.7E-07
	Large Retrieval Losses (1b)	9.7E-08	9.7E-08	9.6E-08	9.5E-08	9.3E-08	3.9E-06	6.9E-08	7.7E-07	1.5E-06
	Optimal Residual Volume (1c)	2.1E-08	2.1E-08	2.1E-08	2.1E-08	2.1E-08	1.1E-06	1.6E-08	5.2E-08	5.4E-08
	Suboptimal Residual Volume (1d)	9.1E-07	9.3E-07	9.1E-07	9.3E-07	9.2E-07	4.9E-05	8.0E-07	1.5E-06	2.3E-06
	No Action (3)	1.2E-05	1.2E-05	1.2E-05	1.1E-05	9.0E-05	1.6E-04	1.6E-05	1.6E-05	1.2E-05

Figure 5.3.29. Residential Farmer Scenario, Maximum ILCR from Past Tank Leaks

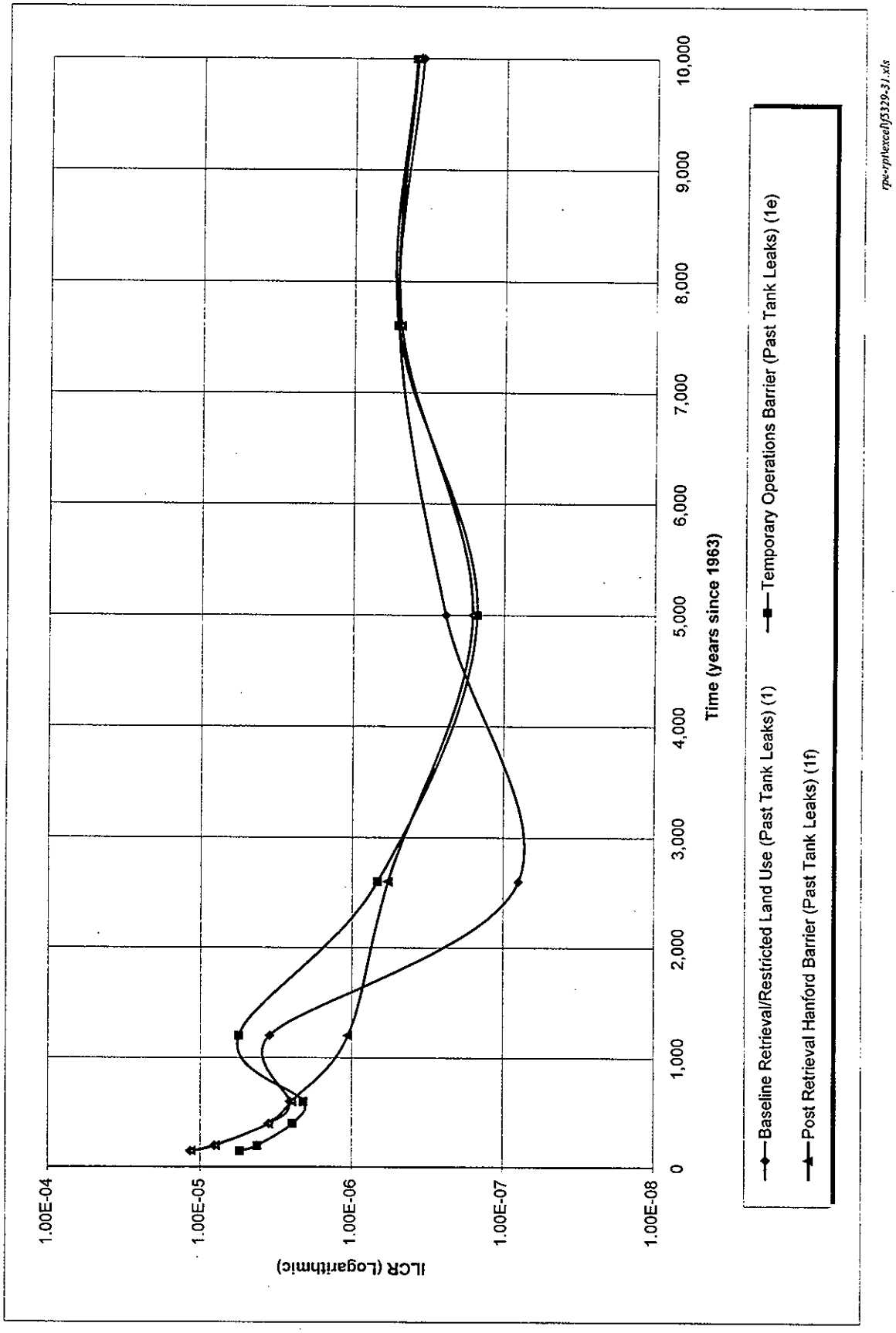

Figure 5.3.30. Residential Farmer Scenario, Maximum ILCR from Retrieval Leakage Loss

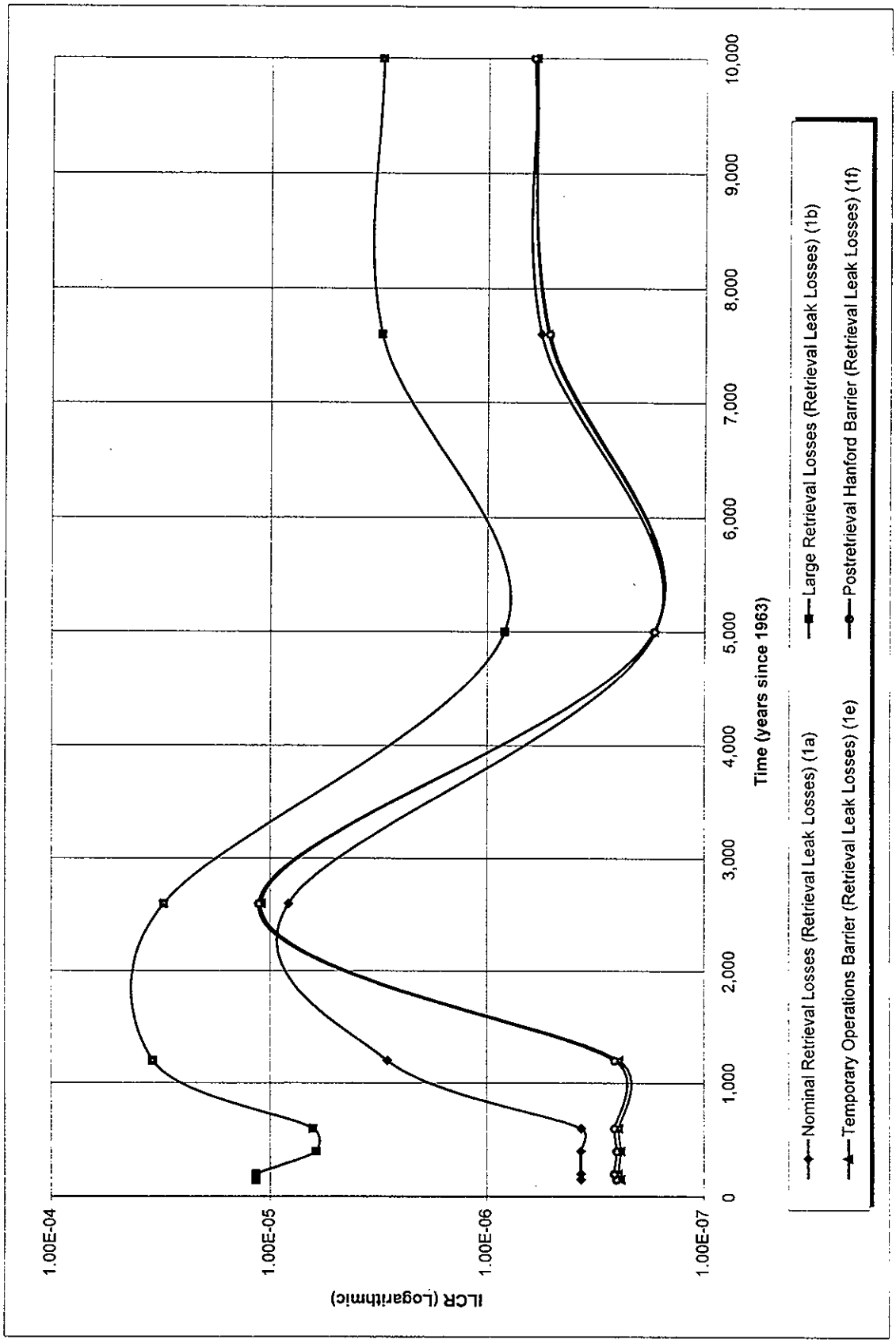

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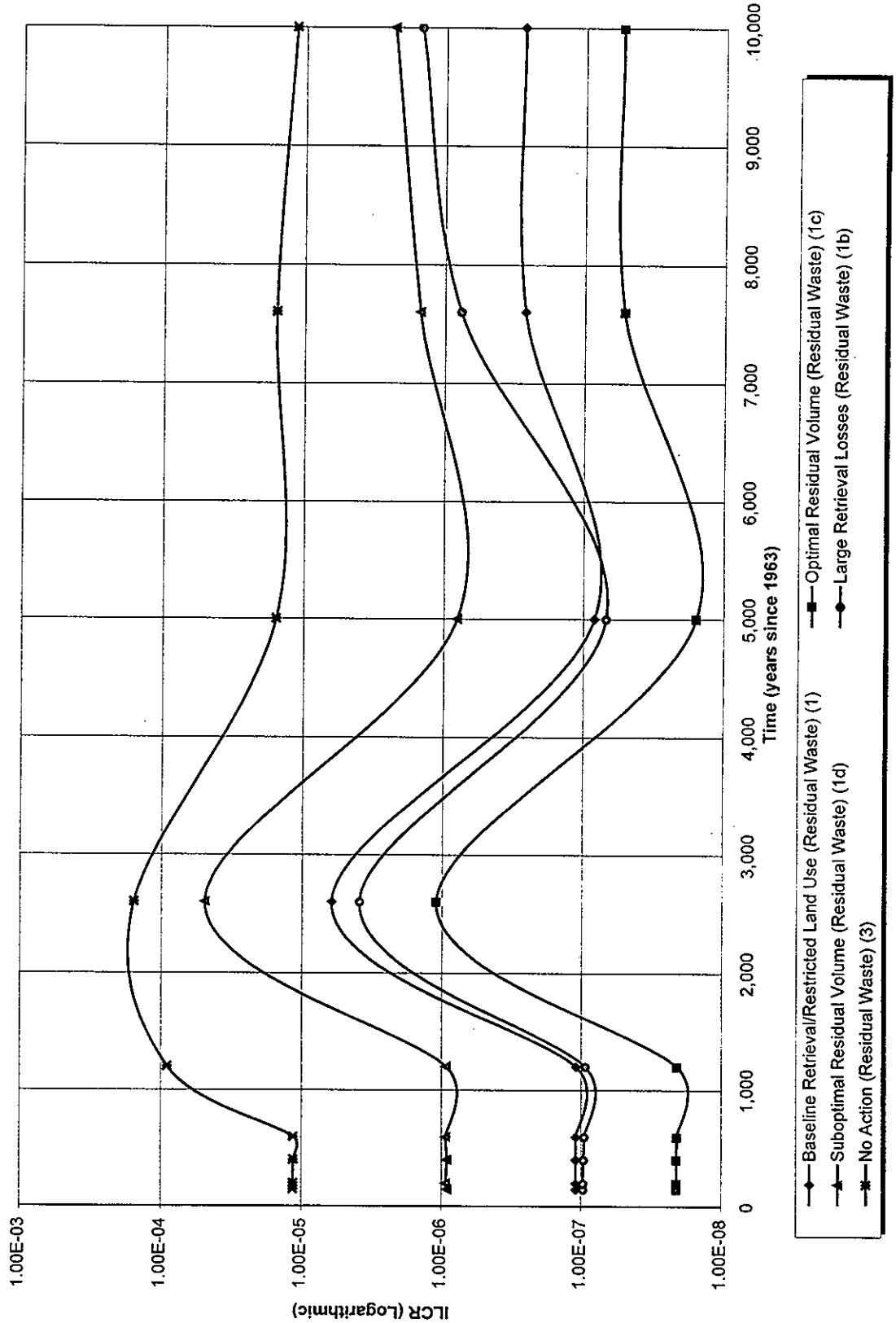
Figure 5.3.31. Residential Farmer Scenario, Maximum ILCR from Residual Waste



rpe-rpt\excel\f5329-31.xls

5.3.2.1 Past Tank Leaks and Spills

Although the same past tank leak and spill release scenario was used for all waste retrieval and tank farm closure options, it is possible that the risk contribution from past leaks and spills would be affected by the type of surface barrier used. To test for the effects of variations in surface barriers, three separate options were evaluated:

- Past tank leaks with an enhanced RCRA Subtitle C barrier, represented by the Baseline Retrieval/Restricted Land Use strategy (Strategy 1).
- Past tank leaks with temporary and enhanced RCRA Subtitle C barriers, represented by the Temporary Operations Barrier option (Option 1e).
- Past tank leaks with a Hanford Barrier, represented by the Postretrieval Hanford Barrier option (Option 1f).

The ILCR for the residential farmer scenario from Strategy 1 past tank leaks would peak within 150 yr. The ILCR would exceed 1.0E-05 at 150 yr and remain above 1.0E-06 through the 1,200-yr time period (Figure 5.3.29).

The ILCR for the residential farmer scenario from Option 1e past tank leaks would peak at 1,200 at a lower level than either Strategy 1 or Option 1f. The ILCR would exceed 1.0E-06 at 150 yr and remain above this level through the 1,200-yr time period (Figure 5.3.29).

The ILCR for the residential farmer scenario from Option 1f past tank leaks would peak within 150 yr at the same level as Strategy 1 and remain at similar levels to Strategy 1 through the 600-yr time period. The ILCR would exceed 1.0E-05 at 150 yr and remain above 1.0E-06 through the 1,200-yr time period (Figure 5.3.29).

A past leaks sensitivity case study was also performed to evaluate risk impacts from past leaks that are more representative of condensate leaks (as opposed to the more conservative tank liquor leaks used for this analysis). Results of the sensitivity case study are presented in Appendix F.

5.3.2.2 Retrieval Leakage Loss

The risk contributions from retrieval leakage loss were evaluated for four separate options:

1. Nominal 30 m^3 (8,000 gal.) retrieval leakage loss with an enhanced RCRA Subtitle C barrier; Nominal Retrieval Leakage Losses (Option 1a)
2. Large 151 m^3 (40,000 gal.) retrieval leakage loss with an enhanced RCRA Subtitle C barrier; Large Retrieval Leakage Losses (Option 1b)
3. Nominal 30 m^3 (8,000 gal.) retrieval leakage loss with temporary and enhanced RCRA Subtitle C barriers; Temporary Operations Barrier (Option 1e)
4. Nominal 30 m^3 (8,000 gal.) retrieval leakage loss with a Hanford barrier; Postretrieval Hanford Barrier (Option 1f).

The ILCR for the residential farmer scenario from Option 1a retrieval leakage loss would peak at 2,600 yr. The ILCR would exceed 1.0E-06 at 1,200 and 2,600 yr but would be below this level for all other time periods (Figure 5.3.30).

The ILCR for the residential farmer scenario from Option 1b retrieval leakage loss would peak at 1,200 yr. The ILCR would exceed 1.0E-06 for all but the 5,000-yr time period and would exceed 1.0E-05 at 150, 200, 1,200, and 2,600 yr (Figure 5.3.30).

The ILCR for the residential farmer scenario from both Option 1e and Option 1f retrieval leakage loss would peak at 2,600 yr. The ILCR would exceed 1.0E-05 at 2,600 yr but would be below 1.0E-06 for all other time periods (Figure 5.3.30).

A retrieval leakage sensitivity case study was also performed to evaluate risk impacts from a 30-m^3 (8,000-gal.) retrieval leak loss that has one-half the initial contaminant concentrations used for Option 1a. Results of the sensitivity case study are presented in Appendix F.

5.3.2.3 Residual Waste

The risk contributions from residual waste were evaluated for five separate options:

1. Retrieval to a waste residual volume of 10 m^3 (360 ft^3) (1 percent residual), represented by Baseline Retrieval/Restricted Land Use (Strategy 1)

2. Retrieval to a waste residual volume of 10 m^3 (360 ft^3) (1 percent residual) with a vadose zone wetted by large (40,000 gal.) retrieval leakage loss, represented by the Large Retrieval Leakage Losses (Option 1b)

3. Retrieval to a waste residual volume of 1 m^3 (36 ft^3) (0.1 percent residual), represented by Optimal Residual Volume (Option 1c)

4. Retrieval to a waste residual volume of 100 m^3 (3,600 ft^3) (10 percent residual), represented by Suboptimal Residual Volume (Option 1d)

5. No waste retrieval (100 percent residual), represented by No Action (Strategy 3).

The ILCR for the residential farmer scenario from Strategy 1 residual waste volumes would peak at 2,600 yr. The ILCR would exceed 1.0E-06 at 2,600 yr, but would be below this level for all other time periods (Figure 5.3.31).

The ILCR for the residential farmer scenario from Option 1e residual waste volumes would peak at 2,600 yr at a slightly lower level than Strategy 1 and would remain at similar levels to Strategy 1 through the 5,000-yr time period. The ILCR would approach or exceed 1.0E-06 at 2,600, 7,600, and 10,000 yr (Figure 5.3.31).

The ILCR for the residential farmer scenario from Option 1c residual waste volumes would peak at 2,600 yr at a lower level than Strategy 1. The ILCR would exceed 1.0E-05 at 2,600 yr and would be near or slightly above 1.0E-06 for all other time periods (Figure 5.3.31).

The ILCR for the residential farmer scenario from Option 1d residual waste volumes would peak at 2,600 yr at a higher level than Strategy 1 and Options 1e and 1c. The ILCR would exceed 1.0E-05 at 2,600 yr and would be near or slightly above 1.0E-06 for all other time periods (Figure 5.3.31).

The ILCR for the residential farmer scenario from Strategy 3 residual waste volumes would peak at 2,600 yr and at all time periods would have the highest level of the five options evaluated. The ILCR would approach or exceed 1.0E-04 at 1,200 and 2,600 yr and exceed 1.0E-05 for all other time periods (Figure 5.3.31).

A residual waste sensitivity case study was also performed to evaluate risk impacts from residual waste after application of a getter agent that would limit the mobility of some CoCs. Results of the sensitivity case study are presented in Appendix F.

5.3.3 Inadvertent Human Intruder

This section presents the results for the inadvertent human intruder based on DOE and NRC methodologies described in Section 3.6.4. The results of the DOE inadvertent human intruder is based on a well driller and postdriller resident scenario, whereas the NRC scenario is based on the tank waste meeting the concentration limits established for Class C LLW for the inadvertent human intruder.

5.3.3.1 DOE Intruder Scenario

The purpose of this analysis is to estimate the human health risk from inadvertent human intrusion into the postclosure contamination sources for each of the strategies and options. The scenarios used in this analysis are based on the Hanford LLW PA intrusion model (Wood et al. 1995) and include a well driller scenario and a postdriller resident scenario. The human health risk for the two intruder scenarios is calculated as the carcinogenic effect resulting from exposure to the radionuclides contained in the waste exhumed during well drilling and is expressed in terms of LCFs. The methodology used for the analysis is discussed in Section 3.6.4. The human health dose and risk to the well driller and postdriller resident for each strategy and option are presented in Table 5.3.7.

Table 5.3.7. Driller and Postdriller Resident Annual Dose and LCF Risk

Strategy/Option	Driller		Postdriller Resident	
	Dose (mrem/incident)	LCF Risk/Incident	Dose (mrem/yr)	LCF Risk/yr
Strategy 1	7.8E+01	3.1E-05	1.8E+02	9.0E-05
Option 1a	9.7E+01	3.9E-05	2.3E+02	1.2E-04
Option 1b	1.7E+02	6.9E-05	4.3E+02	2.2E-04
Option 1c	2.7E+01	1.1E-05	6.9E+01	3.4E-05
Option 1d	1.1E+02	4.4E-05	6.0E+02	3.0E-04
Option 1e	9.7E+01	3.9E-05	2.3E+02	1.2E-04
Option 1f	9.7E+01	3.9E-05	2.3E+02	1.2E-04
Option 1g	9.7E+01	3.9E-05	2.3E+02	1.2E-04

Table 5.3.7. Driller and Postdriller Resident Annual Dose and LCF Risk (cont'd)

Strategy/Option	Driller		Postdriller Resident	
	Dose (mrem/incident)	LCF Risk/Incident	Dose (mrem/yr)	LCF Risk/yr
Option 1h	1.7E+02	6.9E-05	4.3E+02	2.2E-04
Strategy 2	NAD	NAR	NAD	NAR
Option 2a	NAD	NAR	NAD	NAR
Option 2b	NAD	NAR	NAD	NAR
Option 2c	1.9E+01	7.6E-06	5.1E+01	2.6E-05
Option 2d	1.9E+01	7.6E-06	5.1E+01	2.6E-05
Strategy 3	2.4E+02	9.8E-05	6.3E+02	3.1E-04

Notes:
NAD = No appreciable dose
NAR = No appreciable risk

The source or the total activity in curies of each constituent exhumed and made available at the surface for the Baseline Retrieval/Restricted Land Use strategy (Strategy 1) includes waste from the 1 percent residual waste in tank AX-102. The radiological activity in the 1 percent residual waste was obtained from the AX Tank Farm Inventory Study for the Hanford Tanks Initiative Project (NHC 1997).

The source for the Nominal Retrieval Losses option (Option 1a), Temporary Operations Barrier option (Option 1e), Postretrieval Hanford Barrier option (Option 1f), and the Nominal Losses/Soil Grouting option (Option 1g) includes the 1 percent residual waste in tank AX-102 and contaminated soil from a 30-m^3 (8,000-gal.) retrieval leakage loss. The radiological activity in the 30-m^3 (8,000-gal.) retrieval leakage loss was obtained from NHC (1997).

The source for the Large Retrieval Losses option (Option 1b) and the Large Losses/Soil Grouting option (Option 1h) includes waste from the 1 percent residual waste in tank AX-102 and contaminated soil from a 151-m^3 (40,000-gal.) retrieval leakage loss. The radiological activity in the 151-m^3 (40,000-gal.) retrieval leakage loss was obtained from NHC (1997).

The source for the Optimal Residual Volume option (Option 1c) includes waste from the 0.1 percent residual waste in tank AX-102 and contaminated soil from a 30-m^3 (8,000-gal.) retrieval leakage loss. The radiological activity in the 0.1 percent residual waste was obtained from NHC (1997).

The source for the Suboptimal Residual Volume option (Option 1d) includes waste from the 10 percent residual waste in tank AX-102 and contaminated soil from a 30-m^3 (8,000-gal.) retrieval leakage loss. The radiological activity in the 10 percent residual waste was obtained from NHC (1997).

There would not be an appreciable source for the Baseline Retrieval/Unrestricted Land Use strategy (Strategy 2), the Nominal Losses/Excavate Soil option (Option 2a), or the Past Leak/In Situ Soil Treatment option (Option 2b). The tanks would be removed and there would be no retrieval leakage loss for the Baseline Retrieval/Unrestricted Land Use strategy (Strategy 2) or

the Past Leak/In Situ Soil Treatment option (Option 2b). The tanks would be removed and the contaminated soil plume from a 30-m^3 (8,000-gal.) retrieval leakage loss would be removed for Nominal Losses/Excavate Soil option (Option 2a).

The source for the Nominal Losses/In Situ Soil Treatment option (Option 2c) and the No Soil Treatment option (Option 2d) includes waste from the contaminated soil from a 30-m^3 (8,000-gal.) retrieval leakage loss.

The source for the No Action strategy (Strategy 3) includes waste from the 100 percent residual waste in tank AX-102. The radiological activity in the 100 percent residual waste was obtained from NHC (1997).

5.3.3.2 NRC Requirements

The NRC uses the Class C concentration upper limits for individual radionuclides to determine waste classification and meet the requirements for protecting the inadvertent human intruder. Table 5.3.8 shows the Class C concentration upper limits.

These concentration limits were compared to the 10-m^3 (360-ft^3) residual waste in all four SSTs in the AX Tank Farm to determine if they complied with the regulatory requirements. Based on the mathematical model and the parameters used in deriving Class C limits, Cochran and Shyr (1998a) determined that none of the SST residual waste concentrations in the AX Tank Farm would meet regulatory requirements based on the sum of the fractions for long-lived radionuclides and short-lived radionuclides. Based on the Class C upper limits for individual radionuclides, the NRC requires the following process to determine waste classification (10 CFR 61). If radioactive waste does not contain any of the radionuclides listed in Table 5.3.8, it is Class A waste. Otherwise, long-lived radionuclides should be assessed first to classify waste. For multiple radionuclides, the sum of fractions for individual radionuclides needs to be used. If the concentration does not exceed 0.1 times the limit in Table 5.3.8, the waste will be Class A. If the concentration exceeds 0.1 times the limit but is less than the limit, the waste is Class C, unless the short-lived radionuclides in the waste exceed the Class C upper limits. If either the short-lived or long-lived radionuclides exceed Class C upper limits, the waste will be classified as GTCC. If only short-lived radionuclides exist, waste will be classified as Class C if concentrations exceed the upper limits for Class B but are less than the Class C limits listed in Table 5.3.8.

Based on the case of tank 20 at the Savannah River Site, Cochran and Shyr (1998a) examined using in-tank grout as one of the options for stabilizing any unretrievable residual waste that may remain after retrievable operations. For grouted waste the concentration of the combined residual waste and sludge may be taken into account in estimating the solidified waste concentration. Using this principle, Cochran and Shyr (1998a) analyzed the amount of grout required for the AX Tank Farm SSTs to meet Class C limits based on an average residual volume of 10 m^3 (360 ft^3) of residual waste. If the grout-averaging concept is approved by the NRC for tank 20 at the Savannah River Site and waste residuals are 10 m^3 (360 ft^3) or less, the AX Tank Farm SSTs would meet Class C limits and protect the inadvertent human intruder. The basis for the grout averaging requires the residual waste to be uniformly mixed with the grout. Table 5.3.9, which is taken from Cochran and Shyr (1998a), shows the minimum amount

Table 5.3.8. Class C Concentration Upper Limits

Long-lived Radionuclides	Class C Upper Limits	Short-lived Radionuclides	Class C Upper Limits
C-14	8 Ci/m^3	Ni-63	700 Ci/m^3
C-14 in activated metal	80 Ci/m^3	Ni-63 in activated metal	7,000 Ci/m^3
Ni-59 in activated metal	220 Ci/m^3	Sr-90	7,000 Ci/m^3
Nb-94 in activated metal	0.2 Ci/m^3	Cs-137	4,600 Ci/m^3
Tc-99	3 Ci/m^3		
I-129	0.08 Ci/m^3		
Alpha emitting TRU with $t_{1/2}$ > 5 yr	100 nCi/g		
Pu-241	3,500 nCi/g		
Cm-242	20,000 nCi/g		

Notes:
Source: 10 CFR 61

of grout required to meet Class C limits for the AX Tank Farm SSTs with residual waste of 10 m^3 (360 ft^3). The estimate of the inches of grout required in a tank depends on the number of inches of residual waste in a tank and the concentration of the residual waste. Based on analysis provided by Cochran and Shyr (1998a), as shown in Table 5.3.9, the constituent concentrations for each tank in the AX Tank Farm were calculated assuming the tanks were filled with grout that is uniformly mixed with the residual waste. Cochran and Shyr (1998a) indicate the amount of uniformly mixed grout required to meet Class C LLW limits. For tank AX-101, 241 cm (95 in.) of uniformly mixed grout with the residual waste would be required. Tank AX-102 would require 775 cm (305 in.) of uniformly mixed grout with the residual waste. Tank AX-103 would require 130 cm (51 in.) of uniformly mixed grout with the residual waste. Tank AX-104 would require 170 cm (67 in.) of uniformly mixed grout with the residual waste. Table 5.3.10 provides concentrations compared to the Class C LLW limits for the 10.2 m^3 (360 ft^3) of residual waste resulting from filling the SSTs with grout.

The concentration values for 100 m^3 (3600 ft^3) of residual waste (Option 1d) and filling the tanks with grout also was calculated. The results are presented in Table 5.3.11. For tank AX-102 the concentration exceeds the Class C limit for TRU waste for the maximum amount of uniformly mixed grout needed to fill the tank.

Table 5.3.9. AX Tank Farm Residual Waste (10 m^3 [360 ft^3]) and Grout Mix Required to Meet the NRC Class C Limit

Strategy/Options	Tank AX-101 Concentration	Tank AX-102 Concentration	Tank AX-103 Concentration	Tank AX-104 Concentration	Class C Limits
Long-lived radionuclides (Ci/m^3)					
C-14	2.00E-06	4.00E-06	0.00E+00	4.30E-05	8 Ci/m^3
Tc-99	3.60E-05	7.00E-05	0.00E+00	8.10E-04	3 Ci/m^3
I-129	2.60E-05	5.10E-06	0.00E+00	5.90E-05	0.08 Ci/m^3
Alpha emitting TRU (nCi/g)					
Np-237	1.46E-06	2.70E-06	2.30E-05	2.10E-05	
Pu-238, 239, 240, 242	8.50E-01	3.00E-01	9.90E-01	7.60E-01	
Am-241, 243	1.40E-01	6.40E-01	7.50E-06	2.20E-01	
Cm-243 to 247	3.76E.04[1]	4.40E-03	5.40E-04	4.90E-04	
Total	9.90E-01	9.44E-01	9.91E-01	9.81E-01	100 nCi/g
Pu-241 (nCi/g)	9.10E-03	5.80E-02	1.20E-02	1.10E-02	3500 nCi/g
Cm-242 (nCi/g)	5.70E-07	4.20E-06	1.10E-06	1.00E-06	20000 nCi/g
Short-lived radionuclides (Ci/m3)					
Ni-63	2.00E-04	2.30E-05	0.00E+00	2.40E-04	700 Ci/m^3
Sr-90	1.01E-01	2.70E-03	1.40E-01	1.10E-01	7000 Ci/m^3
Cs-137	3.10E-03	5.60E-04	4.30E-03	3.30E-03	4600 Ci/m^3
Grout in inches in tank to meet Class C limits	95	305	51.5	67	

Notes:
Source: Cochran and Shyr 1998a.

Table 5.3.10. AX Tank Farm Residual Waste (10 m^3 [360 ft^3]) and Grout Mix Under Strategy 1 and all Options with 10 m^3 (360 ft^3) Residual Waste

Radionuclides	Tank AX-101 Concentration	Tank AX-102 Concentration	Tank AX-103 Concentration	Tank AX-104 Concentration	Class C Limits
Long-lived radionuclides (Ci/m^3)					
C-14	4.87E-07	3.13E-06	0.00E+00	7.39E-06	8 Ci/m^3
Tc-99	8.77E-06	5.47E-05	0.00E+00	1.39E-04	3 Ci/m^3
I-129	6.33E-06	3.99E-06	0.00E+00	1.01E-05	0.08 Ci/m^3
Alpha emitting TRU (nCi/g)					
Np-237	3.56E-07	2.11E-06	3.04E-06	3.61E-06	
Pu-238, 239, 240, 242	2.07E-01	2.35E-01	1.31E-01	1.31E-01	
Am-241, 243	3.41E-02	5.01E-01	9.90E-07	3.78E-02	
Cm-243 to 247	9.17E.05[1]	3.44E-03	7.13E-05	8.42E-05	
Total	2.41E-01	7.39E-01	1.31E-01	1.68E-01	100 nCi/g
Pu-241 (nCi/g)	2.22E-03	4.54E-02	1.58E-03	1.89E-03	3500 nCi/g
Cm-242 (nCi/g)	1.39E-07	3.28E-06	1.45E-07	1.72E-07	20000 nCi/g
Short-lived radionuclides (Ci/m^3)					
Ni-63	4.87E-05	1.80E-05	0.00E+00	4.12E-05	700 Ci/m^3
Sr-90	2.46E-02	2.11E-03	1.85E-02	1.89E-02	7000 Ci/m^3
Cs-137	7.55E-04	4.38E-04	5.68E-04	5.67E-04	4600 Ci/m^3
Grout in inches in tank	390	390	390	390	

Table 5.3.11. Suboptimal Residual Volume (Option 1d) Waste and Grout Mix Comparison to NRC Class C Limits

Strategy/Options	Tank AX-101 Concentration	Tank AX-102 Concentration	Tank AX-103 Concentration	Tank AX-104 Concentration	Class C Limits
Long-lived radionuclides (Ci/m^3)					
C-14	5.01E-06	3.05E-04	NR	4.53E-04	8 Ci/m^3
Tc-99	8.95E-05	5.34E-03	NR	8.55E-03	3 Ci/m^3
I-129	6.52E-05	3.90E-04	NR	6.21E-04	0.08 Ci/m^3
Alpha emitting TRU (nCi/g)					
Np-237	3.67E-06	2.07E-04	2.86E-04	2.22E-04	
Pu-238, 239, 240, 242	2.11E+00	1.45E+01	1.11E+01	8.07E+00	
Am-241, 243	3.55E-01	3.10E+01	9.90E-05	2.32E+00	
Cm-243 to 247	1.29E.01[1]	2.13E-01	5.98E-03	5.17E-03	
Total	7.16E+01	2.09E+02	4.75E+01	4.13E+01	100 nCi/g
Pu-241 (nCi/g)	2.31E-02	2.80E+00	1.32E-01	1.16E-01	3500 nCi/g
Cm-242 (nCi/g)	1.42E-06	2.03E-04	1.22E-05	1.06E-05	20000 nCi/g
Short-lived radionuclides (Ci/m^3)					
Ni-63	1.41E-03	1.20E-03	NR	2.53E-03	700 Ci/m^3
Sr-90	2.58E-01	1.36E-01	1.55E+00	1.58E+00	7000 Ci/m^3
Cs-137	3.49E-02	3.63E-02	4.85E-02	3.49E-02	4600 Ci/m^3
Grout in inches in Tank	390	390	390	390	

Notes:
NR = Not reported
[1] Calculated value based on residual content for 1 percent Class C LLW limits provided from Cochran and Shyr 1998a, b.

5.4 UNCERTAINTY AND SENSITIVITY ANALYSIS

The uncertainty analysis conducted was based on methodology described in Section 3.7 and applied to one specific strategy. This section presents results of the uncertainty and sensitivity analysis. Conclusions, retrieval performance measures, and data needs are described in Sections 6.1, 6.2, and 6.3, respectively.

The need to conduct an uncertainty and sensitivity analysis was identified early in the planning process as a method to better define how the assumptions and data uncertainties affect the overall uncertainty in long-term human health risk predictions. The uncertainty analysis also was identified as a means to evaluate the compounding effect of conservative point-estimate model input values and the potential for overestimating the potential long-term human health risk. The sensitivity analysis was identified as a means to better understand what components of the system were drivers in terms of long-term human health risk, which then could be targeted for additional data collection to reduce the overall uncertainty.

The National Research Council identified the potential for conservative upper-bound model input values to produce conservative estimates that may not reflect meaningful values (National Research Council 1996: The Hanford Tanks Environmental Impacts and Policy Choices). Evaluating the long-term human health risk uncertainty based on the uncertainty associated with model inputs allows for evaluating the degree of conservatism in the deterministic risk results.

This approach also is consistent with the requirements identified in the CRCIA (DOE 1998a). One of the principles (specified as a requirement for CRCIA, Part II) was borrowed from other industries that routinely use limited resources to deal with large, complex problems. The principle involves using sensitivity analyses and parametric analyses during the planning process to identify and sort the factors that have the greatest influence from those that are less influential on a given performance measure. This process allows for evaluating the biggest contributors under varying levels of technical analysis.

As stated in the methodology section (Section 3.7), the uncertainty analysis methodology was developed to evaluate uncertainties in the long-term human health risk that result from uncertainty and variability in the model inputs for source term, transport, and exposure parameters. The long-term human health risk CoCs were selected based on current understanding of their mobility and behavior in the environmental setting described for the conceptual model. The uncertainty analysis is not intended to evaluate conceptual model uncertainty or uncertainty in future site environmental conditions.

Conceptual model uncertainty evaluation would be expected to result in increasing the uncertainty range in long-term risk calculations. James and Oldenburg (1997) evaluated both parameter uncertainty and conceptual model uncertainty and found that both sources of uncertainty could result in large uncertainties in calculated contaminant concentrations in groundwater.

The MEPAS computer code was used for calculating the human health impacts as the measuring indicator for variations in model input parameters used for the source, transport, and exposure (presented in Section 3.7). The analysis of parameter distribution selection and evaluation are

discussed in this section. Summary tables for each module (source, vadose zone, saturated zone, and exposure) are presented in this section. The resultant risk value and corresponding parameter variables generated by the MEPAS code, which uses the LHS simulation, are analyzed using the Number Crunching Statistical System software. The probability density functions for model output were performed using the Excel® spreadsheet software.

5.4.1 Retrieval Strategy Considered

The Baseline Retrieval/Restricted Land Use strategy, Nominal Retrieval Leakage Losses (Option 1a) was selected for evaluation in the uncertainty analysis. This option includes waste retrieval down to 10 m^3 (360 ft^3), stabilization of the tanks and ancillary equipment, and construction of a surface barrier. Based on variations in the potential retrieval leakage loss and residual waste inventory, the parameter uncertainty ranges include the point-estimate values for several of the restricted land use options. Source terms influencing long-term human health risk include past leaks, potential retrieval leakage loss, and residual waste remaining in the tanks following retrieval. The uncertainty analysis treats these source terms, the vadose zone, groundwater pathway, and the exposure scenario as variables.

5.4.2 Uncertainty Analysis Input Parameters

The uncertainty analysis methodology involved identifying model input parameters, developing a rationale for which parameters would be treated as independent variables, and defining a range and distribution for the independent variables. A total of 131 parameters were treated as independent variables in the uncertainty analysis. A number of model inputs for the source term, transport, and exposure were identified as independent variables. Ranges and distributions for the independent variables were developed using existing data where available and supplemented with engineering judgement where necessary. The input parameters used in the uncertainty analysis along with the uncertainty ranges and distributions are presented in Appendix C.

5.4.3 Analysis Results

This section presents the results of the uncertainty analysis based on the approach identified in Section 3.7 and the model input parameter values described in Appendix C. A point-estimate analysis was completed using the MEPAS model and best-estimate parameter values for model inputs. The uncertainty analysis is based on performing multiple model evaluations to determine the uncertainty in the model predictions and to identify the independent variables that have the greatest influence on the uncertainty. Each uncertainty run included a total of 250 iterations or realizations. Within each uncertainty run the model randomly selected a set of input values for the independent variables and calculated the receptor risk. For each of the 250 model realizations, a random value from each independent parameter (total of 69 variable parameters) was selected and the maximum risk, along with the risk at several preselected time periods from the release date, were calculated. The selected time periods were 700, 1400, 2100, 2900, 3600, 4300, 5000, 5700, 6400, 7100, 7900, 8600, 9300, 10,000 yr from the initial release time (1970). The initial time period and the incremental times were based on dividing the 10,000-yr period into manageable time steps. The time increment corresponds to approximately 10 generations. Risks from each radionuclide were evaluated at each of the time periods, in addition to the maximum risk time period for the purpose of calculating the cumulative risk. The maximum risk

for different radionuclides occurs at different times, therefore, the total risk from all the radionuclides evaluated cannot be calculated by adding the maximum risk values.

5.4.3.1 Point-Estimate Risk Results

Point-estimate risk results at peak time periods are presented in Table 5.4.1. These risk values are based on using the MEPAS model with the independent variables fixed at best-estimate values. Table 5.4.1 also includes a breakdown on the exposure pathways that contribute to the constituent specific risk. For example, the peak point-estimate risk for Tc-99 occurred 700 yr after initial release and resulted almost entirely from ingestion of contaminated milk and drinking water. Because of the differences between the PORFLOW numerical transport model (Analytic & Computational Research 1996) developed for the RPE and the MEPAS model developed for the uncertainty analysis, a separate point-estimate analysis was conducted with the MEPAS model using best-estimate input parameter values. Best-estimate parameter values were generally taken as the mean or median value from the parameter uncertainty distributions. However, there were parameters where the best-estimate parameter value was taken at the conservative end of the uncertainty distribution. Best-estimate parameter values for each module (source, partially saturated and saturated zone, and exposure) are presented in previous sections along with the parameter uncertainty data.

Table 5.4.1. Deterministic Risk for Different Time Periods and CoCs

Exposure pathway	CoCs				
	C-14	Se-79	Tc-99	I-129	U-238
Maximum risk	1.7E-04	9.9E-09	3.8E-04	1.2E-04	4.20E-07
Time to peak (Years following initial release)	2,900	700	700	2,900	2,900
Risk Contribution by Exposure Pathway, Percent					
Drinking water	4	0	36	35	75
Shower dermal	0	100	0	0	12
Shower	0	0	0	0	0
Leafy vegetables	22	0	3	1	3
Other vegetables	7	0	2	1	2
Meat	58	0	4	2	0
Milk	8	0	56	60	8
Shower inhalation	0	0	0	0	0

The composite point-estimate risk values calculated for selected times are presented in Table 5.4.2. These risks are based on using the MEPAS model developed for the uncertainty analysis with the independent variables fixed at best-estimate values. The risk from each individual CoC is added together at each time period to obtain the composite deterministic risk.

Table 5.4.2. Composite Point-Estimate Risk for Different Time Periods

Time Period (Years Following Initial Release)	Risk, ILCR
700	3.9E-04
1,400	8.3E-05
2,100	2.6E-04
2,900	2.9E-04
3,600	2.2E-04
4,300	1.3E-04
5,000	7.4E-05
5,700	4.3E-05
6,400	2.9E-05
7,100	2.3E-05
7,900	2.1E-05
8,600	1.9E-05
9,300	1.8E-05
10,000	1.5E-05

Differences between the contaminant transport module in MEPAS and PORFLOW are such that the results obtained using PORFLOW are not directly comparable to the results obtained using MEPAS. Even though both models are designed to simulate contaminant transport, and for the RPE are based on the same conceptual model, they have not been benchmarked against each other. MEPAS is based on a one-dimensional transient transport code for the vadose zone and a one-dimensional advective three-dimensional dispersive transport code based on a homogeneous aquifer. The PORFLOW model is based on a two-dimensional finite difference model for the vadose and saturated zones. A comparison of the uncertainty analysis results with the deterministic results calculated using PORFLOW is presented in Section 5.4.3.7.

5.4.3.2 Uncertainty Analysis Results

The uncertainty analysis was conducted by defining the uncertainty for each independent variable individually, and then using the uncertainty ranges for each variable to calculate the total human health risk uncertainty. In this discussion, total risk is used to characterize the summation of risk from each of the constituents considered in the uncertainty analysis. Constituents evaluated in the uncertainty analysis make up most (greater than 99 percent) but not all of the long-term human health risks from the scenario being evaluated. Consistency in sampling values from independent variables that were common to all contaminants was ensured by using the same seed value in the LHS module. Because the human health risks changed over time, the range and distribution of the uncertainty analysis results also changed over time. It is important to note that the risk predictions calculated by the model represent the uncertainty and variability in the model input parameters.

The composite human health risk uncertainty analysis results are shown in Figure 5.4.1 and are summarized in Figure 5.4.2. Figure 5.4.1 shows a scatter plot of the risk results versus time. The dots in each vertical bar represent 250 model realizations. Figure 5.4.2 is a box and whisker

plot that shows the risk uncertainty at various time periods over the 10,000-yr period of interest. The horizontal line within the box represents the median risk value meaning that half of the results fell below this value and half above this value. The bottom and top of the box represent the 25th and 75th percentile meaning that 50 percent of all results fell within the box (i.e., the interquartile range). The ends of the whiskers represent upper and lower adjacent values. The upper adjacent value is the largest observation this is less than or equal to the 75th percentile plus 1.5 times the interquartile range. The lower adjacent value is the smallest observation that is greater than or equal to the 25th percentile minus 1.5 times the interquartile range. Results that fell out of the range are shown on the figure as dots. The human health risk values represent the total risk from all constituents evaluated in the uncertainty analysis. The minimum and maximum values shown in the figure represent the extreme highest and lowest values obtained from the 250 model realizations and would have a low probability of occurrence. Examples of the input variable of the sampling results are shown in Figure 5.4.3. These histograms illustrate the values obtained from sampling the individual parameter uncertainties defined in Appendix C. To understand how often (frequency) and how probable (cumulative probability) specific risk values could occur the cumulative probability and frequency distribution must be considered. These plots provide a convenient way to graphically summarize the large volume of output generated by the model.

Uncertainty analysis results for the total risk approximately 700 yr after the initial release (or at approximately year 2670) are shown in Figure 5.4.4. The results are presented in the form of a cumulative probability versus risk and the frequency distribution (density function). This figure shows the frequency and cumulative probability of risk uncertainty for a snapshot in time. The frequency number shown on the left axis indicates the number of times out of 250 that the predicted risk fell into a range between the value shown on the horizontal axis and the next lower risk value. For example, 700 yr following the time of first release the calculated risk fell between 3.2E-05 and 1.0E-05 approximately 45 out of 250 times. The cumulative probability shown on the right axis indicates the probability of occurrence for the predicted risk values. For example, 700 yr following the time of first release 80 percent of the realizations fell at or below a risk of 3.2E-05. The cumulative probability function is useful in developing confidence levels. Confidence levels provide an indication of how frequently the outcome would exceed a specific value. For example, the 95 percent confidence level for the total risk 700 yr following the initial release falls between 1.0E-03 and 3.2E-03, indicating that only 5 percent of the realizations exceed this value. The 5 percent confidence interval for the total risk 700 yr following the initial release is approximately 3.2E-07, so the risk range between 5 and 95 percent confidence limits spans four order of magnitude.

The uncertainty analysis results for times corresponding to approximately 5,000 and 9,300 yr following initial release are shown in Figures 5.4.5 and 5.4.6, respectively. These figures show how the uncertainty range increases with time and the most frequently occurring risk value decreases with time. At the 10,000 yr time period this risk range between 5 and 95 percent confidence limits spans six order of magnitude.

Figure 5.4.1. Uncertainty Analysis Results (1,100 m from AX Tank Farm)

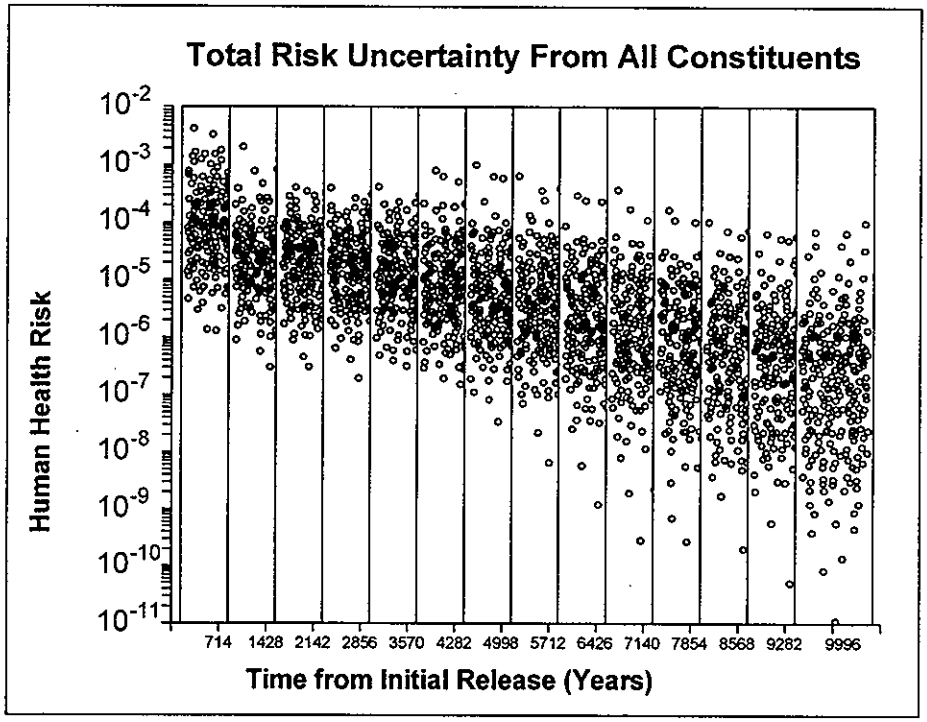


Figure 5.4.2. Uncertainty Analysis Results Total Human Health Risk (1,100 m from AX Tank Farm) (with Variable Exposure Parameters)

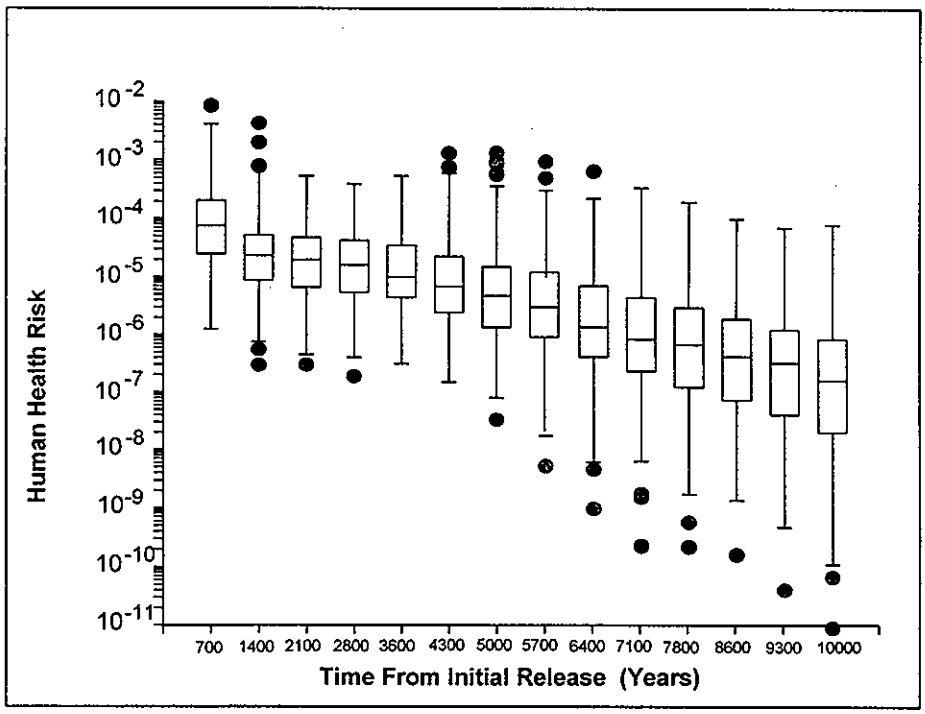
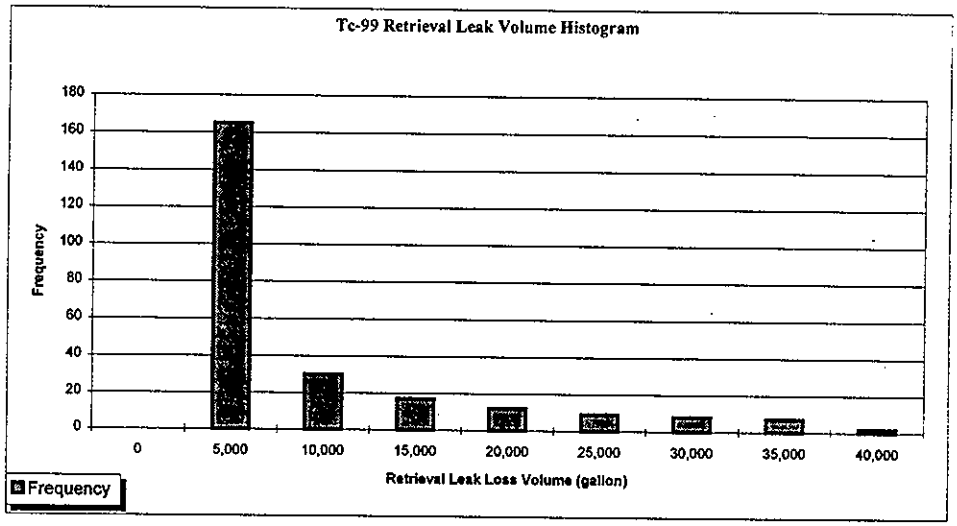
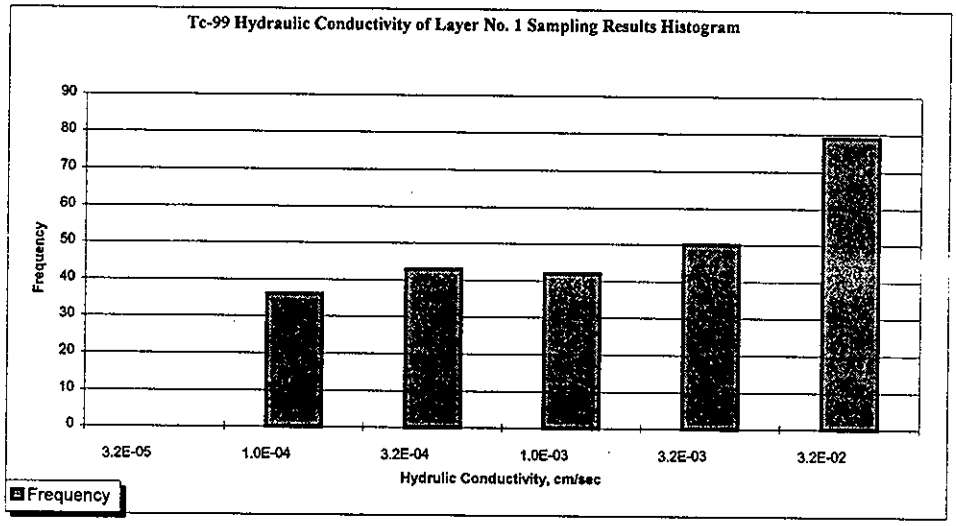


Figure 5.4.3. Input Parameter Sampling Results





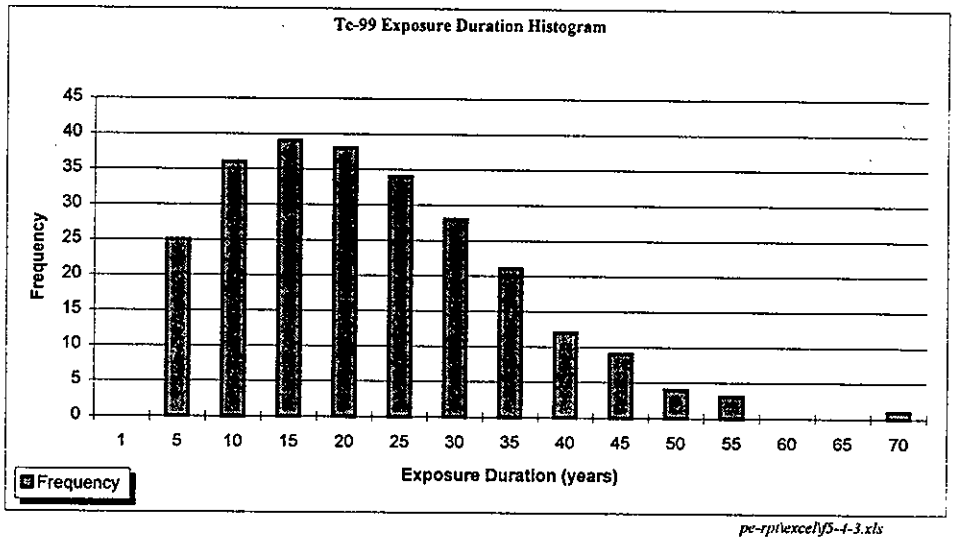


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Figure 5.4.4. Uncertainty Analysis Results 700 Yr Following Release (1,100 m from AX Tank Farm)

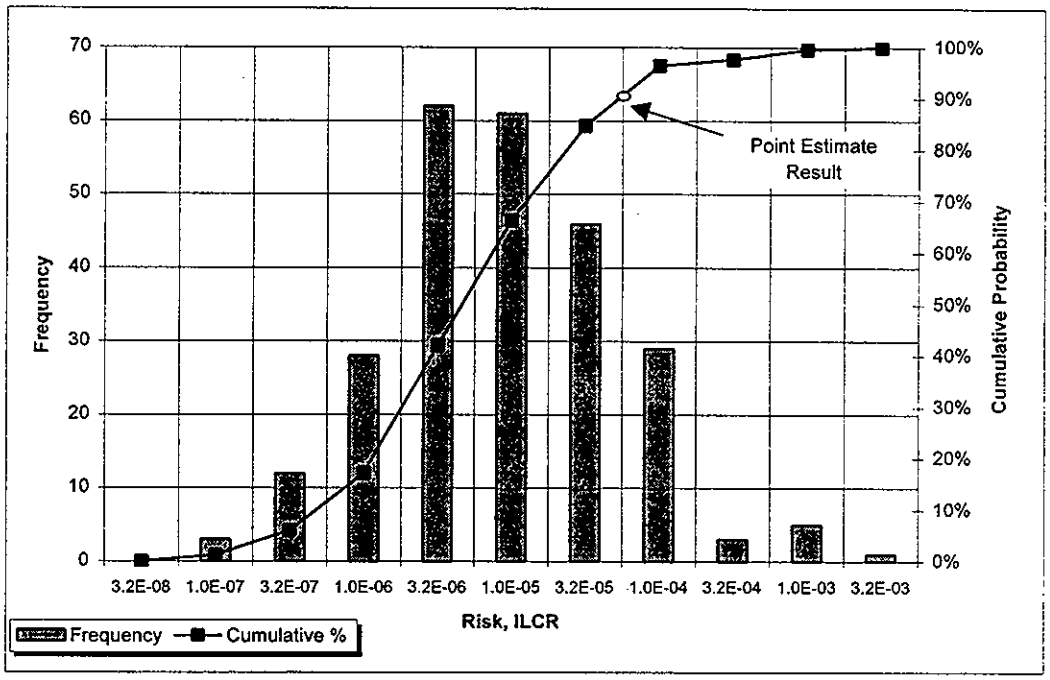

Figure 5.4.5. Uncertainty Analysis Results 5,000 Yr Following Release (1,100 m from AX Tank Farm)

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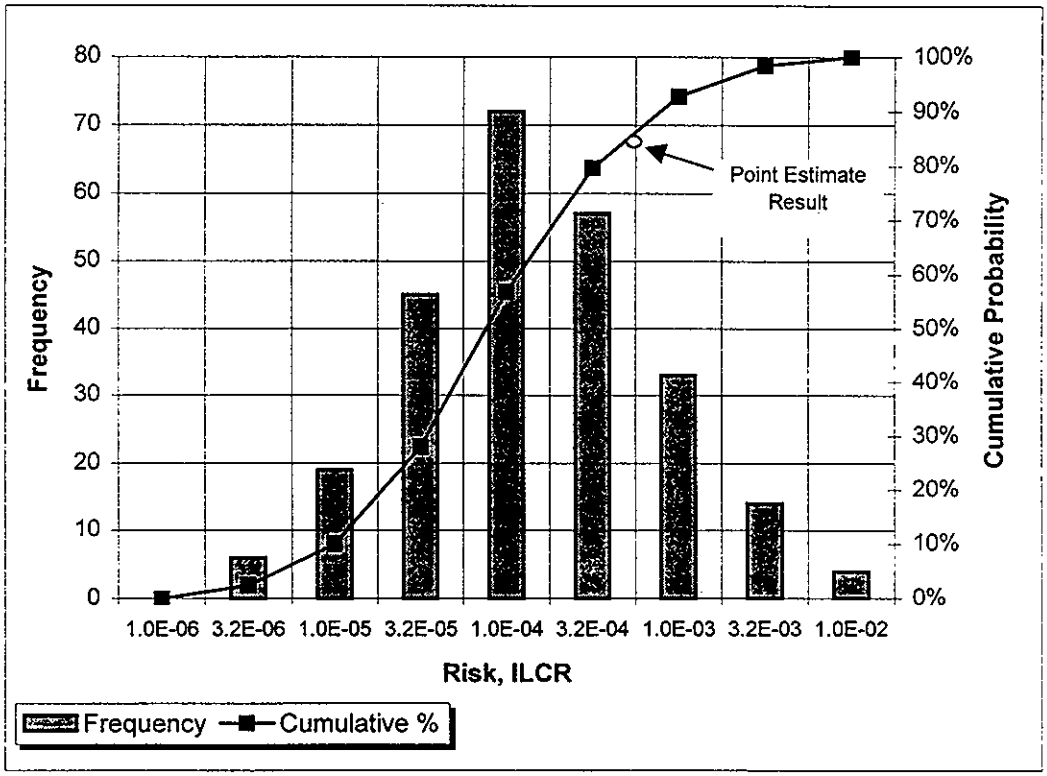

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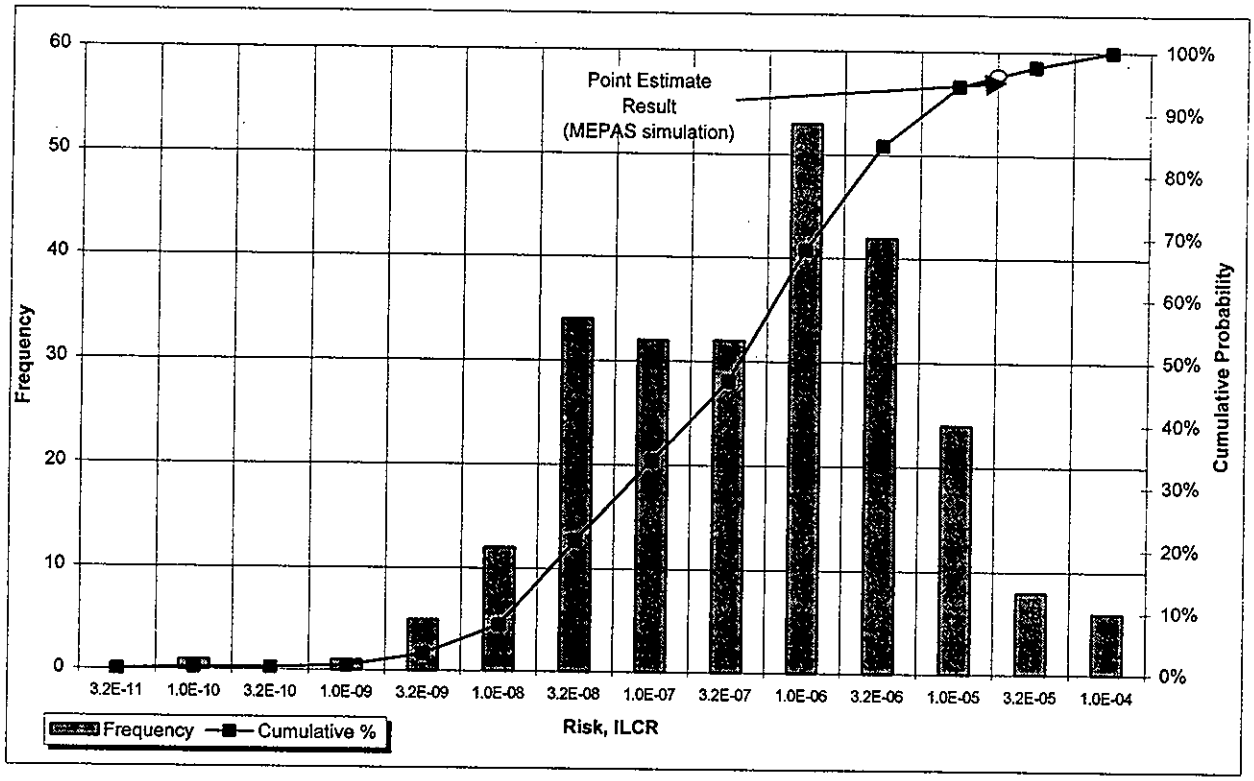
Figure 5.4.6. Uncertainty Analysis Results 9,300 Yr Following Release (1,100 m from AX Tank Farm)



5.4.3.3 Uncertainty Analysis Results by Constituent

This section presents the uncertainty analysis results for the time period corresponding to the maximum deterministic risk for each constituent evaluated in the uncertainty analysis. Results of the analysis are presented graphically and include histograms showing risk values, frequency of occurrence, and the cumulative probability. The best-estimate risk (deterministic risk) value is also shown on the graph by a date crossing the risk axes at the deterministic risk value.

The deterministic risk value illustrates the relationship between the risk calculated using best-estimate parameter values and risk values calculated when the parameter uncertainties are considered. The uncertainty analysis results for C-14, Se-79, Tc-99, I-129, and U-238 are presented in Figures 5.4.7, 5.4.8, 5.4.9, 5.4.10, and 5.4.11, respectively. For each constituent these figures show the uncertainty analysis results corresponding to the peak risk time period for that constituent.

Figure 5.4.12 presents the uncertainty analysis results as a function of time for U-238. This figure illustrates how the uncertainty or range in calculated human health risk values changes over time. The increasing range observed for the later time periods follows an expected trend for the evaluation of this type of system. Similar trends are observed for other CoCs (i.e., C-14, Se-79, Te-99, and I-129) at the later time periods.

Figure 5.4.7. Uncertainty Analysis Results for C-14 2,900 Yr Following Initial Release (1,100 m from AX Tank Farm)

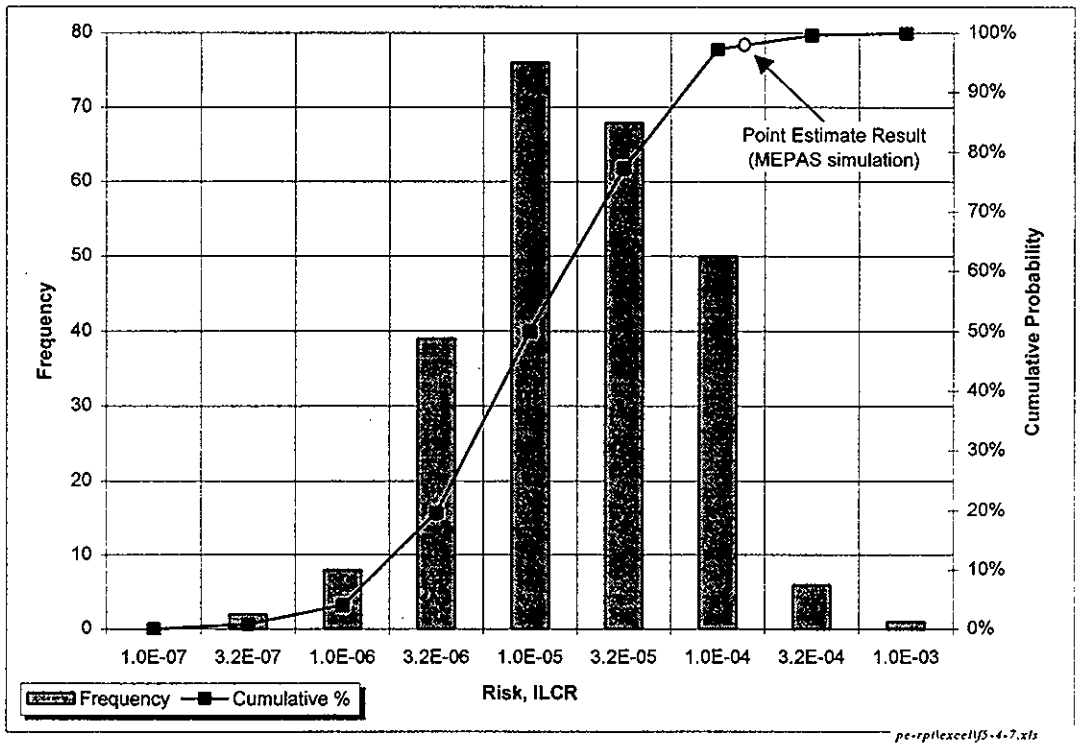


Figure 5.4.8. Uncertainty Analysis Results for Se-79 700 Yr Following Initial Release (1,100 m from AX Tank Farm)

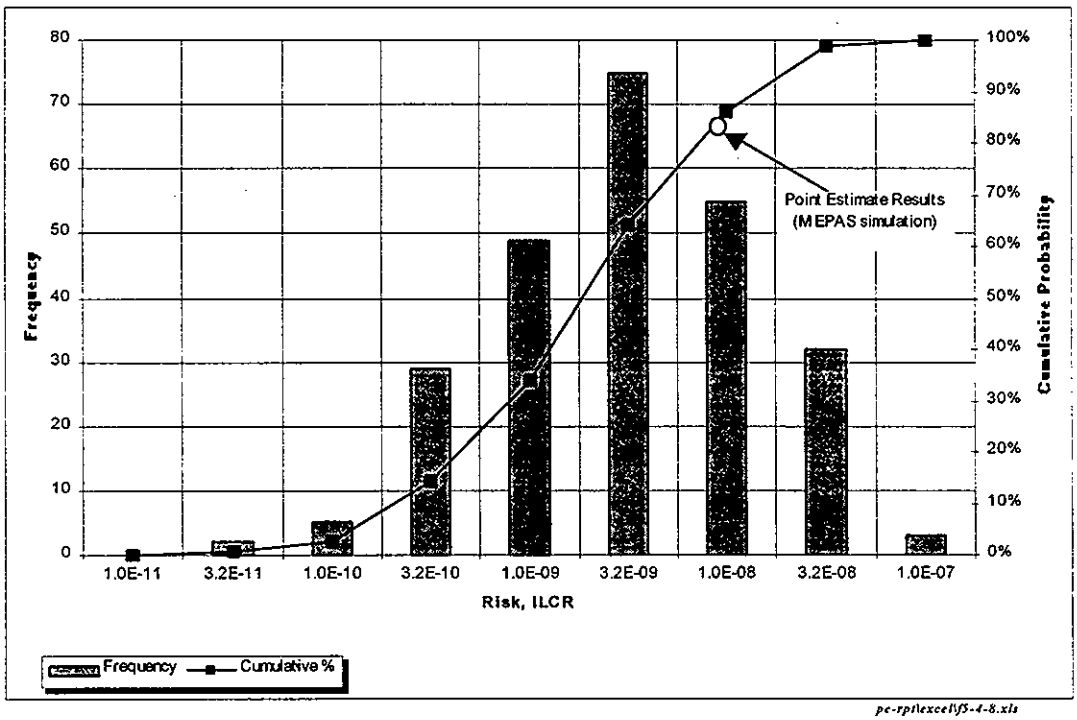


Figure 5.4.9. Uncertainty Analysis Results for Tc-99 700 Yr Following Initial Release (1,100 m from AX Tank Farm)

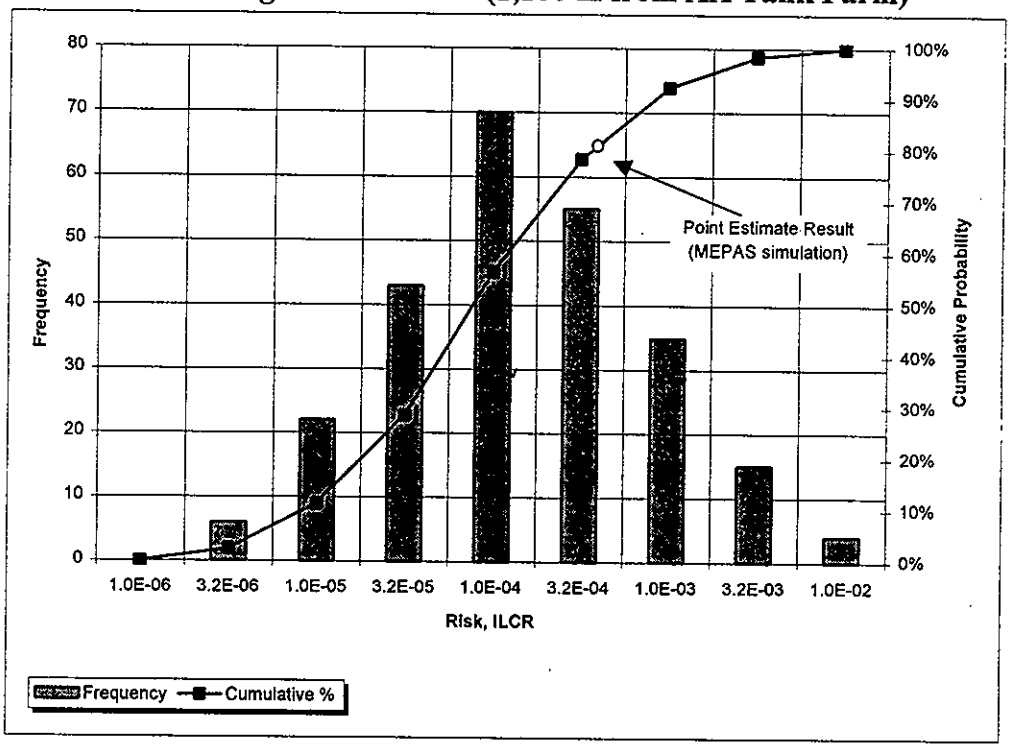


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Figure 5.4.10. Uncertainty Analysis Results for I-129 2,900 Yr Following Initial Release (1,100 m from AX Tank Farm)

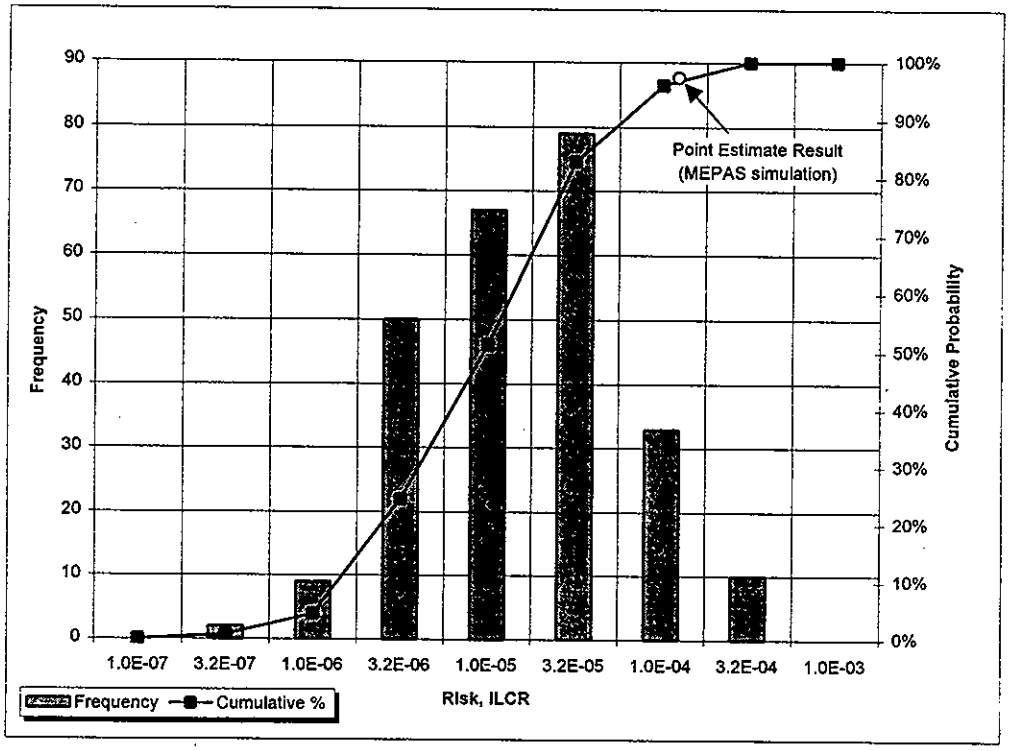

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Figure 5.4.11. Uncertainty Analysis Results for U-238 2,900 Yr Following Initial Release (1,100 m from AX Tank Farm)

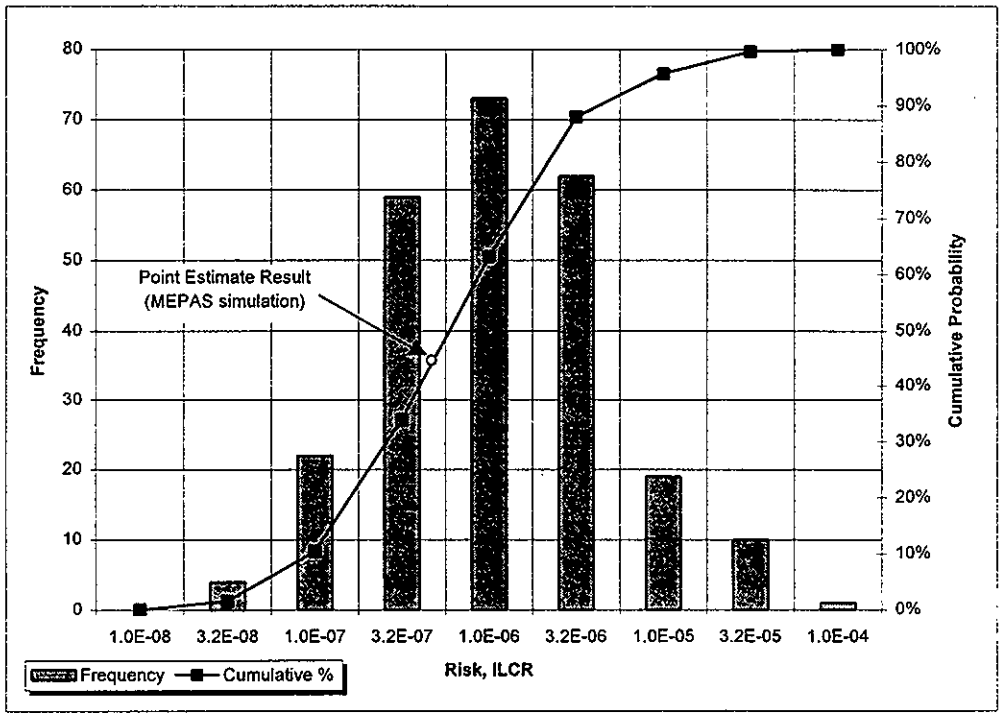

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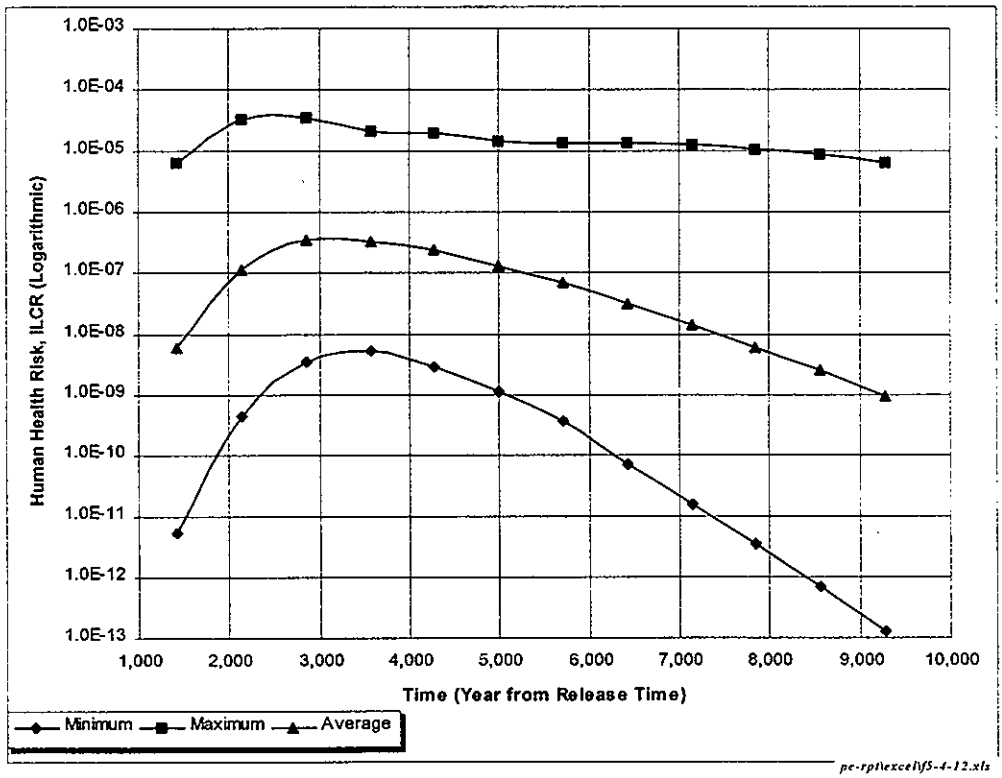
Figure 5.4.12. Uncertainty Analysis Results for U-238 as a Function of Time (1,100 m from AX Tank Farm)



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5.4.3.4 Uncertainty Analysis Results by Source Term

To evaluate source term issues relative to the uncertainty analysis, the results were examined to identify potential relationships or trends between the risk results and source term values obtained from sampling the uncertainty distribution. Areas of interest included identifying threshold values for potential retrieval leakage loss and residual waste inventories that would result in specific levels of risk. A scatter plot of the retrieval leakage inventory (curies of Tc-99), which is the product of the leakage volume and concentration is shown in Figure 5.4.13. This plot illustrates a high degree of randomness and the lack of strong relationship between the leakage source term and the risk. A scatter plot of residual waste inventory (curies of Tc-99), which is the product of the residual waste volume and concentration is shown in Figure 5.4.14. This plot illustrates the relationship between the residual waste inventory and the maximum long-term risk.

5.4.3.5 Uncertainty Analysis Results with Fixed Exposure Parameters

The uncertainty and variability described for the exposure parameters reflect parameter values describing lifestyles and characteristic of future receptors. The uncertainty and variability in these parameters describe normally occurring differences among individual members of the population (e.g., height, weight, food consumption rates). There is little in the way of data that can be collected to substantially reduce the uncertainties associated with exposure parameters for a given exposure scenario. To evaluate the effects of exposure parameter uncertainties on long-term risk the uncertainty analysis was conducted with fixed exposure parameter values.

The results of the uncertainty analysis with fixed exposure parameter values are shown in Figure 5.4.15. A composite risk histogram with fixed exposure parameters at the 700-yr time period is shown in Figure 5.4.16. These results show that fixing the exposure parameters reduces the overall uncertainty range by reducing the peak risk value by one-half to one order of magnitude. Little change is observed in the minimum risk values. The uncertainty analysis results with fixed exposure parameters for Tc-99 is shown in Figure 5.4.17. These figures show a general reduction in long-term human health risk results when the exposure parameters are fixed.

5.4.3.6 Uncertainty Analysis Results with Fixed Transport Parameters

To investigate how the overall system uncertainty would change if the vadose zone and saturated zone transport parameters were held fixed a separate uncertainty analysis was conducted. This analysis was conducted in an identical manner to the uncertainty analysis previously described for the overall system except the vadose zone and saturated zone transport parameters were fixed at best-estimate values.

The results of the uncertainty analysis with fixed transport parameters were similar to the results presented in Section 5.4.3.2 for the overall system. Fixing the vadose zone and saturated zone parameters tended to reduce the mean ILCR value and the variance up through the 5,000-yr time period and increase the mean ILCR value and variance at the 9,300-yr time period. Descriptive statistics for the model output for both cases are presented in Table 5.4.3.

Figure 5.4.13. Scatter Plot of Maximum Risk Variation Versus Retrieval Leakage Loss Inventory for Tc-99 (1,100 m from AX Tank Farm)

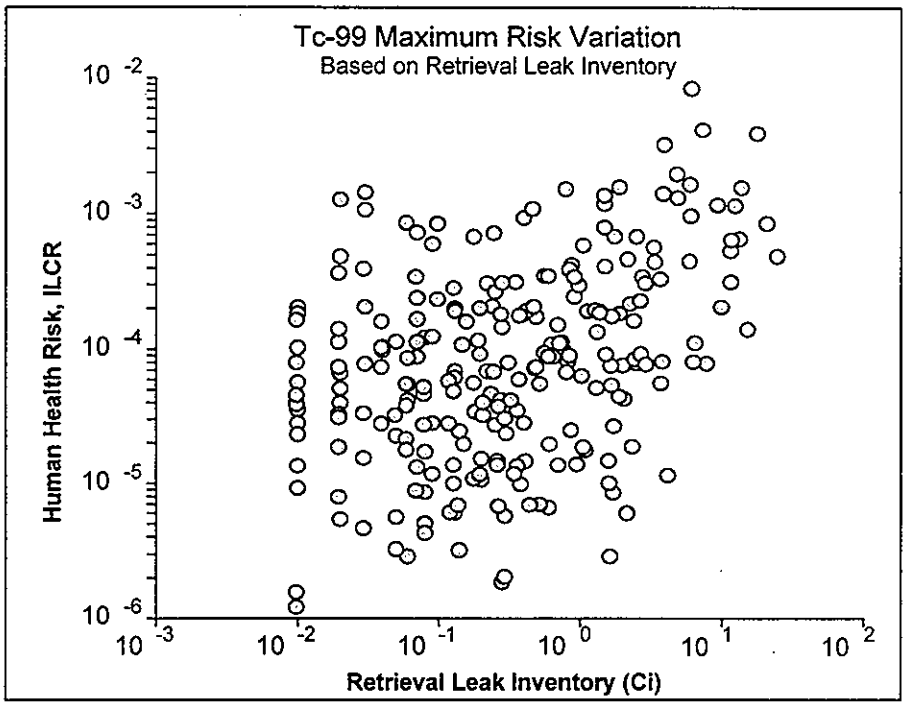

Figure 5.4.14. Scatter Plot of Maximum Risk Variation Versus Residual Waste Inventory for Tc-99 (1,100 m from AX Tank Farm)

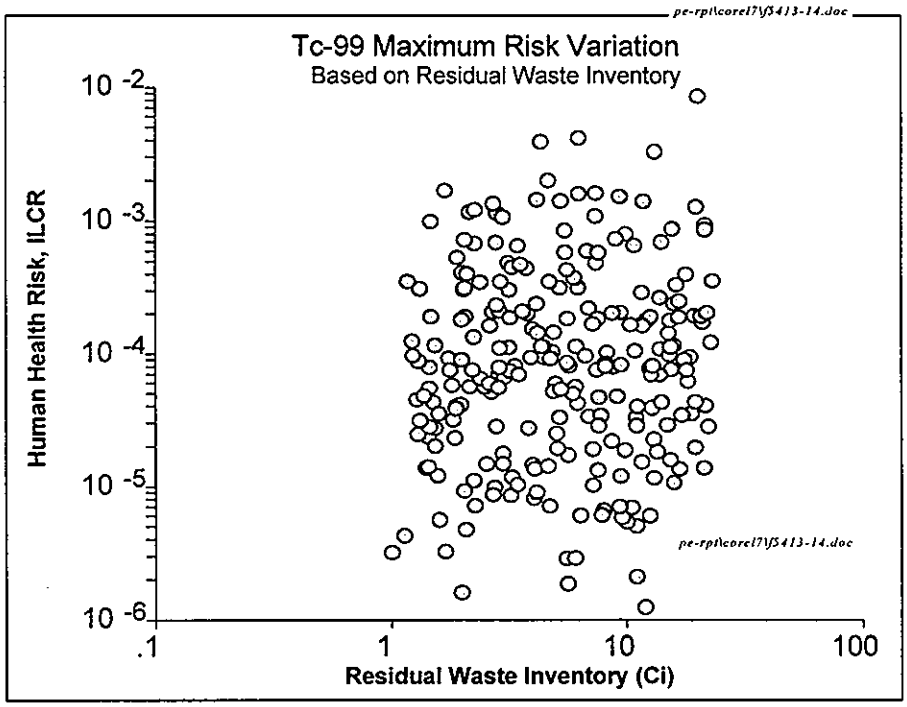

Figure 5.4.15. Uncertainty Analysis Results, Total Human Health Risk as a Function of Time with Fixed Exposure Parameters (1,100 m from AX Tank Farm)

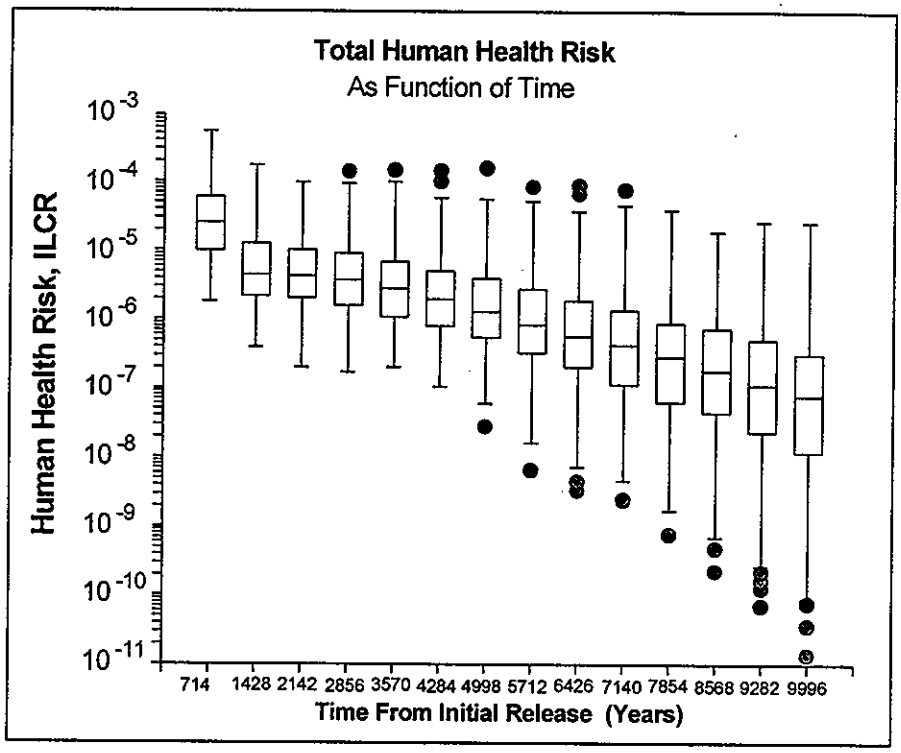

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Figure 5.4.16. Uncertainty Analysis Results 700 Yr Following Initial Release with Fixed Exposure Parameters (1,100 m from AX Tank Farm)

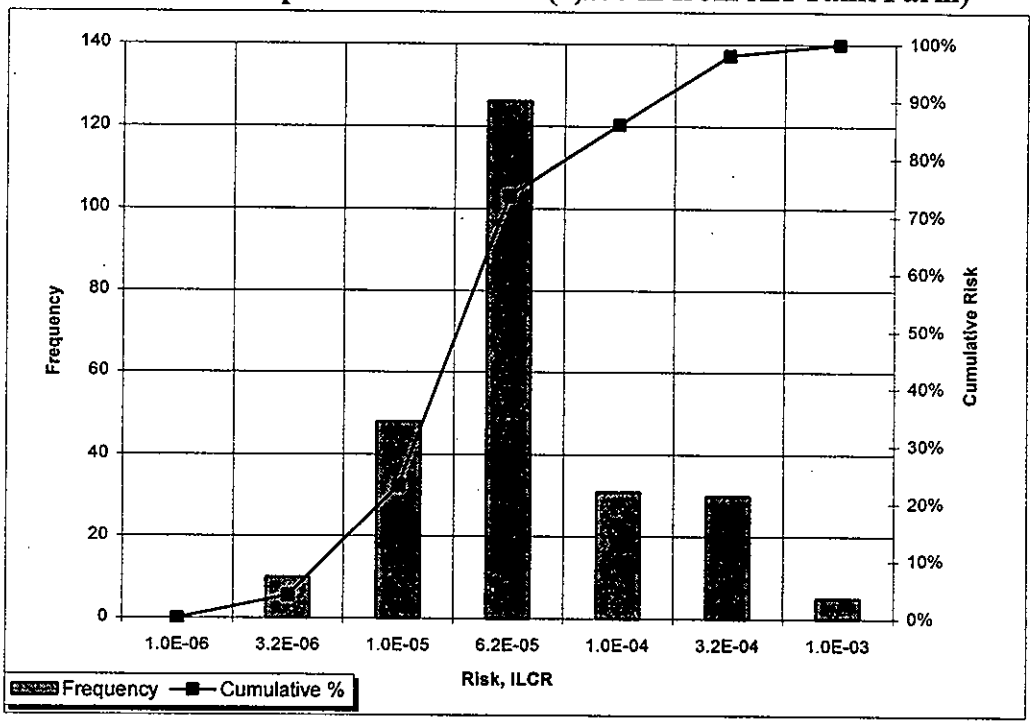

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Figure 5.4.17. Uncertainty Analysis Results for Tc-99 with Fixed Exposure Parameters (1,100 m from AX Tank Farm)

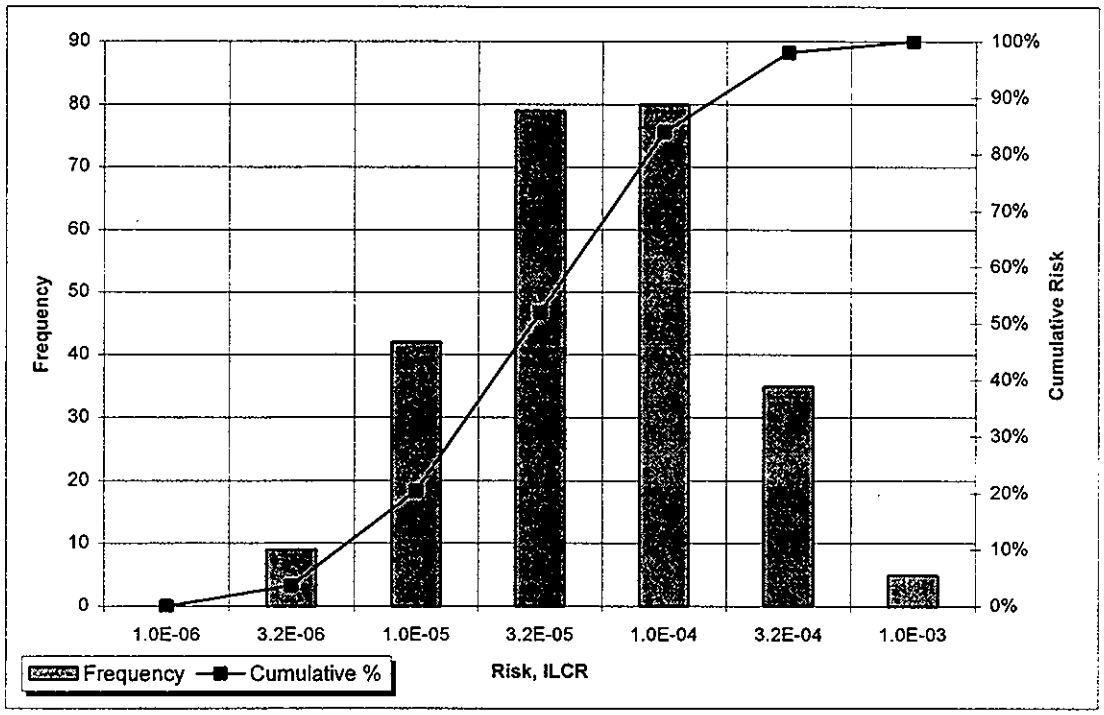

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Table 5.4.3. Descriptive Statistics for Uncertainty Analysis Results with Fixed Transport Parameters

Statistic	Time Period		Time Period		Time Period	
	700 yr following release		5,000 yr following release		9,300 yr following release	
	Variable source, transport, and exposure	Variable source, fixed transport, and variable exposure	Variable source, transport, and exposure	Variable source, fixed transport, and variable exposure	Variable source, transport, and exposure	Variable source, fixed transport, and variable exposure
Mean ILCR value	2.9E-04	2.1E-04	3.3E-05	1.5E-05	3.0E-06	1.4E-05
Standard deviation	7.4E-04	3.9E-04	1.3E-04	2.0E-05	9.9E-06	4.3E-05
Minimum ILCR value	1.3E-06	1.1E-06	3.4E-08	9.6E-08	5.0E-11	5.4E-09
Maximum ILCR value	8.6E-03	4.8E-03	1.4E-03	1.5E-04	8.8E-05	3.4E-04

5.4.3.7 Uncertainty Analysis with Fixed Source Term and Transport Parameters

To investigate the uncertainty in long-term human health risk resulting from variations in exposure parameters a separate analysis was conducted. This analysis was conducted in an identical manner to the uncertainty analysis previously described for the overall system except

the source term and transport parameters were held fixed at best-estimate values. The exposure parameters identified in Appendix C were treated as independent variables with the same ranges and distributions.

The results of the uncertainty analysis with fixed source term and transport parameters are presented in Table 5.4.4. For the 700- and 5,000-yr time periods the mean ILCR value is slightly higher and the range and variance is smaller for the fixed source, fixed transport, and variable exposure case compared to the variable source, transport, and exposure case. The results of this uncertainty analysis case illustrate that when exposure parameters are considered in the uncertainty analysis by themselves they are responsible for risk uncertainties that range between two and three orders of magnitude.

Table 5.4.4 Descriptive Statistics for Uncertainty Analysis with Fixed Source Term and Transport Parameters

Statistic	Time Period		Time Period		Time Period	
	700 yr following release		5,000 yr following release		9,300 yr following release	
	Variable source, transport, and exposure	Fixed source, fixed transport, and variable exposure	Variable source, transport, and exposure	Fixed source, fixed transport, and variable exposure	Variable source, transport, and exposure	Fixed source, fixed transport, and variable exposure
Mean ILCR value	2.9E-04	5.1E-04	3.3E-05	6.0E-05	3.0E-06	2.0E-05
Standard deviation	7.4E-04	6.5E-04	1.3E-04	7.3E-05	9.9E-06	2.7E-05
Minimum ILCR value	1.3E-06	1.5E-05	3.4E-08	1.7E-06	5.0E-11	5.4E-07
Maximum ILCR value	8.6E-03	5.3E-03	1.4E-03	6.1E-04	8.8E-05	2.3E-04

5.4.3.8 Sensitivity Results

This section presents the results of the sensitivity analysis conducted using the methodology presented in Section 3.7. A stepwise regression analysis was conducted separately for each constituent using the uncertainty analysis results described in the previous section.

The concepts of uncertainty analysis and sensitivity analysis are related in the sense that a uncertainty analysis deals with examining the entire set of possible outputs from a process, while sensitivity analysis attempts to determine which input variables have the most impact on the outputs.

The two sensitivity analysis techniques that can be used are both essentially linear techniques. The two techniques are: 1) compute partial derivatives of the output with respect to the input at a point or points in the input space (using this approach one can explain the local sensitivity of the outputs to changes in the inputs); 2) fit a linear surface between the inputs and outputs of the model. Neither of these approaches is completely satisfactory when the model is highly nonlinear. The derivatives are a local measure of sensitivity, and can change dramatically as one moves through the input space. Attempting to fit a linear surface to a highly nonlinear model

reduces the level of confidence that can be drawn in attempting to use the linear surface to explain anything about the underlying relationship between model input and output.

In this sensitivity analysis, a linear surface was fit to the input and output. This method was selected based on incorporating all variables over the entire range of inputs and outputs in an attempt to identify the most influential contributors to human health risk.

The model multiple correlation coefficient referred to as R^2 provides a measure of how well the linear approximation used in the regression model represents the MEPAS model. If the model R^2 is sufficiently large, then the linear approximation gives an adequate representation of the function, and the partial regression coefficients are estimates of the average partial derivative over the range of the input variables (Doctor 1990). A model R^2 value of one would indicate that the linear model completely represented the risk model over the input parameter range.

Because the risk model used in this analysis is not a linear system model, R^2 values less than one would be expected. Another statistical measure of the importance of the variables is the coefficients of partial determination (partial r^2), which give the amount of variation attributable to a particular variable. Results of the regression analysis are ranked based on coefficients of partial determination (r^2).

The sensitivity of each model input parameter is measured on the basis of its influence on the risk value. The order of sensitive parameters is constituent dependent. A parameter that is very sensitive to the risk from C-14 may not have the same degree of influence on another constituent such as U-238 or Se-79.

Sensitivity analysis results are provided in Table 5.4.5 for each of the constituents evaluated in the uncertainty analysis.

Results of this sensitivity analysis indicate that uncertainty in long-term human health risks is influenced to the greatest extent by exposure parameters involving consumption of food products and source term parameters associated with past leaks and potential retrieval leakage loss. The vadose zone and saturated zone parameters in general did not show a strong influence on the long-term human health risk measure. This assessment is consistent with the uncertainty analysis presented in Sections 5.4.3.5 to 5.4.3.7. Sections 5.4.3.5, 5.4.3.6, and 5.4.3.7 present detail or supporting analysis resulting from the above conclusions.

The exposure duration or length of time that the receptor is assumed to reside at the Hanford Site is also a parameter that influences the long-term human health risk. Because of the uncertainties associated with past leaks and retrieval leakage loss source terms there is a relatively wide range used to characterize the uncertainty in the liquid volume and contaminant concentration for past leaks and retrieval leakage loss.

A separate sensitivity analysis was conducted to evaluate the fixed-exposure parameter uncertainty analysis described in Section 5.4.3.5. This analysis applied the methodology described in the previous section to the uncertainty analysis conducted varying the source term, vadose zone and saturated zone parameters, and using fixed exposure parameters.

The sensitivity of each model input parameter is measured on the basis of its influence on the risk value. The order of sensitive parameters is constituent dependent and the ranking of parameters may vary from constituent to constituent. The results of the sensitivity analysis for the fixed-exposure parameter case are provided in Table 5.4.6 for each of the constituents evaluated in the uncertainty analysis.

The resultant model R^2 for this sensitivity analysis ranged from 0.4 to 0.8 (Tables 5.4.5 and 5.4.6). When the model R^2 values are less than 0.5, the fit of the linear model is poor. There are several methods that can be used to further evaluate the sensitivity analysis.

- Limit the entire sensitivity examination to a small number of the set of possible inputs. Even highly nonlinear models are often approximately linear in a small enough region. This approach is not very satisfactory if reasonable values for the input values can vary over wide ranges. However, it can provide some sensitivity information if there is a "preferred" set of inputs. This approach is not applicable to this sensitivity analysis based on its limitation of selecting a "preferred" set of input, not the entire ranges of inputs and outputs.

- Attempt to improve the fit of the linear surface. An approach typically taken is to use the relative numerical rankings of the input variables when fitting the linear surface rather than the actual input values. Sometimes this approach improves the fit of the surface (explains more of the variability), but one then has to explain the sensitivity in terms of ranks, rather than in terms of input data values.

- The third method that can be used for this analysis is to run a complete uncertainty analysis set and then select the set of output results above a given threshold for further analysis. One then attempts to determine what values or combinations of inputs caused the result to exceed the threshold. This approach sometimes yields valuable insight on the underlying process, but sometimes it is of no practical use. This approach was conducted for C-14, Tc-99, and I-129. The output risk for each of these constituents and their associated variables were sorted by the risk value and divided to three ranges of high, medium, and low. The inputs and outputs for the 250 model realizations were sorted and the sensitivity analysis was rerun on groups of output based on the risk level. The results of this analysis are presented in Table 5.4.7. Table 5.4.8 presents the order of sensitive parameters for each of the categories in Table 5.4.7. The order of the parameters from case to case changes, but the same parameters as identified in the overall analysis are presented for each case.

Table 5.4.5. Sensitivity Analysis Results

Constituent	Variable	Partial R^2
C-14	Other vegetable consumption	0.2803
	Concentration in past leaks	0.1295
	Exposure duration	0.1207
	Retrieval leak volume	0.0243
	Retrieval leak concentration	0.0242
	Leafy vegetable consumption	0.0163
	Darcy velocity in the groundwater	0.0118
	Hydraulic conductivity in vadose zone Layer No. 5	0.0068
	Hydraulic conductivity in vadose zone Layer No. 3	0.0070
	Model R^2	0.6209
Tc-99	Milk consumption	0.1553
	Retrieval leak volume	0.0901
	Exposure duration	0.0486
	Retrieval leak concentration	0.0274
	Darcy velocity in the groundwater	0.0281
	Past leak concentration	0.0260
	Groundwater thickness	0.0122
	Concentration of Tc-99 in residual waste	0.0112
	Model R^2	0.3988
I-129	Milk consumption	0.2169
	Past leak volume	0.1195
	Exposure duration	0.1352
	Retrieval leak volume	0.0446
	Retrieval leak concentration	0.0323
	Retrieval leak liquid flux (volume/area)	0.0159
	Leafy vegetable consumption	0.0158
	Hydraulic conductivity in vadose zone layer #6	0.0101
	Model R^2	0.5902

Table 5.4.5. Sensitivity Analysis Results (cont'd)

Constituent	Variable	Partial R^2
U-238	Retrieval leak water volume	0.2300
	Retrieval leak concentration	0.0682
	Exposure duration	0.0658
	Leafy vegetable consumption	0.0201
	Retrieval leak liquid flux (volume/area)	0.0164
	Meat consumption	0.0152
	Past leak volume	0.0141
	Infiltration rate following surface barrier degradation (>500 years)	0.0131
	Total porosity in vadose zone Layer #5	0.0103
	Hydraulic conductivity in vadose zone Layer #5	0.0110
	Field capacity in vadose zone Layer #5 (see Note 2)	0.0099
	Field capacity in vadose zone Layer #8 (see Note 2)	0.0085
	Model R^2	0.4825

Notes:
[1] Se-79 regression data were not included because of poor regression model fit (low R^2 value) indicating that variability in the parameter input was not well correlated with the model output.

Table 5.4.6. Sensitivity Analysis Results with Fixed-Exposure Parameters

Constituent	Variable	Partial R^2
C-14	Concentration in past leaks	0.6023
	Retrieval leak volume	0.1036
	Darcy velocity in the groundwater	0.0496
	Saturated zone thickness	0.0080
	Retrieval leak concentration	0.0188
	Past leak water volume	0.0040
	K_d in layer 7	0.0037
	Hydraulic conductivity in vadose zone Layer No. 8	0.0035
	Model R^2	0.8114

Table 5.4.6. Sensitivity Analysis Results with Fixed-Exposure Parameters (cont'd)

Constituent	Variable	Partial R^2
Tc-99	Retrieval leak volume	0.2228
	Darcy velocity in groundwater	0.0823
	Past leak concentration	0.0733
	Retrieval leak concentration	0.0762
	Groundwater thickness	0.0338
	Past leak infiltration rate (volume/area)	0.0213
	Total porosity in saturated zone	0.0082
	Past leak volume	0.0085
	Model R^2	0.5263
I-129	Past leak concentration	0.6088
	Retrieval leak volume	0.1139
	Retrieval leak concentration	0.0204
	Darcy velocity in groundwater	0.0223
	Groundwater thickness	0.0094
	Past leak volume	0.0074
	K_d in layer 3	0.0050
	K_d in layer 7	0.0036
	Model R^2	0.7908
U-238	Retrieval leak volume	0.3799
	Retrieval leak concentration	0.0654
	Past leak concentration	0.0244
	Total porosity in saturated zone	0.0188
	Groundwater thickness	0.0152
	K_d in layer 3	0.0141
	Residual waste solubility	0.0098
	Model R^2	0.5276
Se-79	(See Note 1)	

Notes:
[1] Se-79 regression data were not included because of poor regression model fit (low R^2 value) indicating that variability in the parameter input was not well correlated with the model output.

Table 5.4.7. Linear Model Fit for Segmented Output Ranges

Parameter Constituent	High Risks			Medium Risks			Low Risks			All Risks		
	RR	R^2	NI	RR	R^2	NI	RR	R^2	NI	RR	R^2	NI
C-14	1.0E-6	0.793	98	--	--	--	1.0E-7	0.835	152	1.0E-6-1.0E-7	0.829	250
Tc-99	1.0E-4	0.981	40	1.0E-5	0.450	159	1.0E-6	0.544	51	1.0E-4-1.0E-6	0.567	250
I-129	1.0E-5	0.965	33	1.0E-6	0.787	171	1.0E-7	0.976	46	1.0E-5-1.0E-7	0.807	250

Notes:
RR = Risk Range
NI = Number of Iteration

Table 5.4.8. Influential Parameters for Segmented and Overall Output (Human Health Risk) Ranges

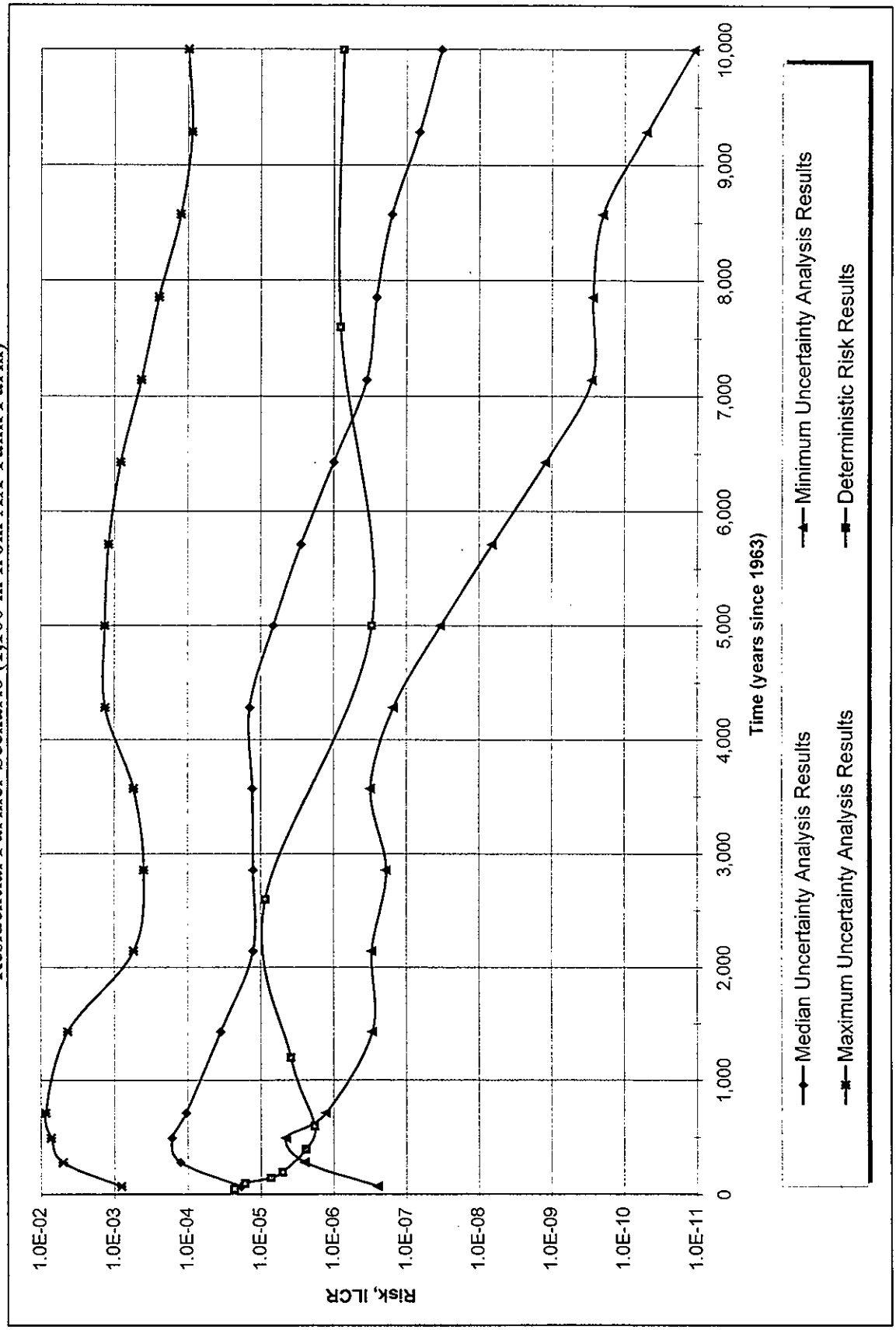
Constituents	RR	Order of parameters from most influential to less influential					
C-14	1.0E-06	Past Leak Water Concentration	Retrieval Water Volume	Contaminant Velocity (SZ)	Retrieval Loss Water Concentration	Past Leak Water Volume	Thickness of SZ
	1.0E-07	Past Leak Water Concentration	Contaminant Velocity (SZ)	Darcy infiltration rates (time #3)	Total porosity of SZ in %	Saturated hydraulic conductivity of PSZ (Layer #8)	Subsurface adsorption coefficients (Layer #7)
	1.0E-06-1.0E-07	Past Leak Water Concentration	Retrieval Water Volume	Contaminant Velocity (SZ)	Retrieval Loss Water Concentration	Thickness of SZ	Past Leak Water Volume
Tc-99	1.0E-04	Retrieval Water Volume	Retrieval Loss Water Concentration	Contaminant Velocity (SZ)	Subsurface adsorption coefficients (Layer #8)	Residual Water Content (Layer #2)	Saturated Hydraulic Conductivity of PSZ (Layer #2)
	1.0E-05	Past Leak Water Concentration	Darcy infiltration rates (time #3)	Contaminant Velocity (SZ)	Darcy infiltration rates (time #2)	Thickness of SZ	Retrieval Loss Water Concentration
	1.0E-06	Contaminant Velocity (SZ)	Past Leak Water Concentration	Subsurface adsorption coefficients (Layer #4)	Total porosity of PSZ (Layer #6)	Past Leak Water Volume	Saturated hydraulic conductivity of PSZ (Layer #1)
	1.0E-04-1.0E-06	Retrieval Water Volume	Contaminant Velocity	Past Leak Water Concentration	Retrieval Loss Water Concentration	Thickness of SZ	Darcy infiltration rates (time #2)
I-129	1.0E-05	Saturated hydraulic conductivity of PSZ (Layer #8)	Retrieval Loss Water Concentration	Darcy infiltration rates (time #2)	Darcy infiltration rates (time #1)	Saturated hydraulic conductivity of PSZ (Layer #7)	Residual Water Concentration
	1.0E-06	Past Leak Water Concentration	Darcy infiltration rates (time #3)	Contaminant Velocity (SZ)	Subsurface adsorption coefficients (Layer #7)	Past Leak Water Volume	Retrieval Loss Water Concentration
	1.0E-07	Past Leak Water Concentration	Contaminant Velocity (SZ)	Saturated hydraulic conductivity of PSZ (Layer #6)	Total porosity of SZ in %	Thickness of SZ	Past Leak Water Volume
	1.0E-5-1.2E-07	Past Leak Water Concentration	Retrieval Water Volume	Retrieval Loss Water Concentration	Contaminant Velocity (SZ)	Thickness of SZ	Past Leak Water Volume

Notes:
SZ = Saturated Zone
Time #1, #2, and #3 represent the time duration for past leak, retrieval leak, and residual leak infiltration rate.

5.4.3.9 Comparison of Probabilistic and Deterministic Risk Results

Figure 5.4.18 compares the uncertainty analysis results in terms of the minimum, median, and maximum risk values versus time to the deterministic analysis results obtained using PORFLOW. This figure shows that in general the deterministic risk results fall within the risk uncertainty range close to the median risk values from the uncertainty analysis results. Differences between the two methods in the early time periods are believed to result from differences in contaminant transport associated with past leaks. The two-dimensional PORFLOW vadose zone model includes preferential flow paths and tank geometry features that enhance the transport of contaminants under current tank farm conditions (see Section 3.5 and 5.2). These differences would be expected to shift the timing associated with peak concentrations from past leaks.

Figure 5.4.18. Probabilistic Versus Deterministic Risk Comparison, Residential Farmer Scenario (1,100 m from AX Tank Farm)



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5.5 REGULATORY COMPLIANCE

This section describes the regulatory compliance for the results presented in Sections 5.1 to 5.3 as the analysis results relate to the various strategies and options. A discussion of the methodology, relevant regulations and requirements, and the baseline waste retrieval and tank farm closure approach is presented in Section 3.8 and Appendix D. This section describes regulatory compliance issues for the CoCs, point-of-compliance, treatment of residual waste remaining following retrieval activities, disposal design as it complies with regulatory standards, corrective measures for retrieval leakage loss, and the technical practicability of leaving various amounts of residual waste in the tanks, and compliance with DOE and NRC requirements, and postclosure requirements for Dangerous Waste Regulations (WAC 173-303). Because all regulatory issues were not directly addressed (i.e., air), certain components were used to address other components. Regulatory compliance issues related to short-term human health risk were used for both the MEI for the public and worker exposure. For long-term human health risk, the maximum groundwater concentration for each analyte for each time period was used, as well as the ILCR based on the sum of the maximum risks for nine radionuclide CoCs for a Native American, residential farmer, industrial worker, and recreational shoreline user scenarios. The HI for four chemicals also was evaluated for long-term human health risks.

The AX Tank Farm point-of-compliance for RCRA groundwater monitoring of the A-AX WMA is approximately 10 m (33 ft) beyond the tank farm fence line. For this report the points-of-compliance examined were 1) 0 m (0 ft), corresponding to below the AX Tank Farms; 2) 250 m (820 ft), corresponding to AX Tank Farm boundary; 3) 1,000 m (3,300 ft), corresponding to the boundary of the 200 Area WMA; and 4) 2,000 m (6,600 ft), corresponding to the buffer zone around the 200 Area plateau. These points-of-compliance were evaluated using the maximum groundwater concentration value for the composite source term of Tc-99 for the Baseline Retrieval/Restricted Land Use strategy Nominal Retrieval Losses option (Option 1a), the Baseline Retrieval/Unrestricted Land Use strategy Nominal Retrieval Losses option (Option 2a), and No Action strategy. The time periods chosen were based on the end of institutional controls at 150 yr from 1963, barrier and inadvertent human intruder scenarios at 500 yr, and DOE Order 435.1 at 1,000 yr. Since the time periods for modeling were chosen at 150 yr, 600 yr, and 1,200 yr, these time periods were used to correlate to the regulatory requirement time periods.

The following subsections discuss the analysis results as it relates to regulatory compliance for short-term human health risk, long-term human health risk, groundwater transport, corrective action, point-of-compliance for the three strategies, treatment of residual waste for Baseline Retrieval/Restricted Land Use strategy, and regulatory issues related to tank farm closure.

5.5.1 Short-Term Human Health Risk

5.5.1.1 Routine Construction and Operations

For short-term human health risk the MEI at the Site boundary is below the State regulatory requirements of 25 mrem/yr, based on an inhalation dose, to the general public during routine construction and operations activities. For the Baseline Retrieval/Restricted Land Use strategy and options, the MEI for the general public was 0.003 mrem/yr. For the Baseline Retrieval/Unrestricted Land Use strategy and options, the MEI for the general public was

0.014 mrem/yr. For the No Action strategy, the MEI for the general public was 3.5E-09 mrem/yr. For a description of these strategies, see Section 4.0. Results of the short-term risk impact analysis are presented in Section 5.1.

The MEI worker exposure for short-term human health risk, which includes removing the tanks, tank ancillary equipment, and soils, has a maximum whole-body dose exposure of 1,500 mrem/yr with the exception of the Nominal Losses/Excavate Soil option (Option 2a), which would have a dose of 136,500 mrem/yr (COGEMA 1998) (SESC 1997) (Norman 1999). An exposure level of 1,500 mrem/yr will require written approval from the contractor senior site manager (WHC 1996c). The 1,500 mrem/yr exposure represents an individual LCF risk component of 6.0E-03. However, a maximum whole body dose of 1,500 mrem/yr was adopted as the exposure limit criterion based on the administrative control levels listed in Table H2-1 of the HSRCM (1994) and discussions with Hanford radiological engineering personnel. This limit has been used for remedial activities at 100-K Basins, which is the closest actual analog to the work reviewed in this study. It is unlikely that tank removal would qualify for consideration under any of the exceptional situations identified in the HSRCM (1994) (i.e., for emergency exposures or planned special exposures) for which DOE might authorize higher limits. The current routine worker exposure dose rates are 100 mrem/yr, with acute worker exposure dose rates of 500 mrem/yr (WHC 1996c).

Worker dose will be carefully monitored to ensure levels do not exceed recommended standards. The functional requirement or "standard of practicality" in this instance is to demonstrate with worker dose estimates that tanks can be demolished and all debris can be loaded and removed from the site with appropriate time, distance, and shielding provisions in a manner that maintains worker doses within acceptable limits. The regulatory requirement for worker exposure based on annual whole body dose is 5,000 mrem/yr (10 CFR 20 and DOE Order 5480.11). Table 5.5.1 provides information about routine worker exposure to radiation.

Even with worker exposure limits raised to 1,500 mrem/yr, retrieving the contaminated vadose zone soil under the Nominal Losses/Excavate Soil option (Option 2a) potentially could result in worker exposures as high as 136,500 mrem/yr, which would exceed the regulatory requirements of 5,000 mrem/yr (Norman 1999). Grouting the ancillary equipment, which is common to the restricted land use strategy and options, would result in worker exposures as high as 125,000 mrem/yr, which also would exceed the regulatory requirements (COGEMA 1998).

Based on the increased worker exposure dose rate, the soils and tank bases contain several elevated radionuclide potential exposures. As solid waste, the tank base rubble would be categorized as remote-handled TRU. No existing waste package design is suitable for transporting material with activity levels as high as anticipated. A new container would have to be developed for onsite transport of base slab debris to the processing facility as proposed in the RPE report. However, a design for this container is presented in Section 4.0 and COGEMA (1999). This increases uncertainty about whether the soil and tank rubble can be disposed at ERDF as proposed in the engineering study reports (SESC 1997).

Short-term chemical health impacts from normal operations would be below the regulatory standard for noncarcinogenic for all strategies and options. For carcinogenic risks from exposure, the ILCR for the noninvolved worker and public would be below the regulatory

Table 5.5.1. Regulatory Performance Measures for Routine Worker Exposure to Radiological Dose

Regulation	Requirement	Performance Measure	Individual Risk[1]	Point-of-Compliance	Notes
10 CFR 20 and DOE Order 5480.11	Annual whole body dose limit (rem)	5	2.0E-03	Workplace exposure.	OSHA and DOE standards
Site Administrative Controls	Annual whole body dose limit (rem) not to be exceeded without prior approval	0.5	2.0E-04		Written approval required from Level 3 line manager and Radiological Control Manager
		1	4.0E-04		Written approval required from Level 2 line manager and Radiological Control Manager
		1.5	6.0E-04		Written approval required from the Contractor Senior Site Manager
WHC 1996c		2	8.0E-04		Written approval required from the DOE Program Secretarial Officer

Notes:

[1]Individual risk = Calculation of the equivalent risk to an individual based on the concentration or level of exposure permitted under the regulation (performance measure) times the unit dose to risk factor.

standard of 1.0E-06. The involved worker ILCR would be below the Washington State standard of 1.0E-05 for multiple constituents and below the Federal standard of 1.0E-04 based on available data and assumptions documented in this report.

The radiological LCF risk from normal operations would result in 1 LCF under the Baseline Retrieval/Restricted Land Use strategy (Strategy 1) and its options and the Nominal Losses/Excavate Soil option under the Baseline Retrieval/Unrestricted Land Use strategy (Strategy 2) for the involved worker population.

Sensitivity Case

The sensitivity case as discussed in Appendix F indicates the radiological LCF risk from normal operations would not result in a LCF (0.7) under the Baseline Retrieval/Restricted Land Use strategy (Strategy 1) and its options and the Nominal Losses/Excavate Soil option (Option 2a) under the Baseline Retrieval/Unrestricted Land Use strategy for the involved worker population. However, the involved worker MEI would exceed regulatory requirements for the task of grouting pipes for ancillary equipment.

5.5.1.2 Risks From Accidents

Table 5.5.2 shows the regulatory performance measures for routine worker and public exposure from accident conditions during routine construction and operations.

Accidents presented in Section 5.1 would result in a chemical and radiological exposure and some accidents would result in a lethal radiological dose for the involved worker MEI for all strategies and options. Under the accident scenarios the noninvolved worker MEI would exceed

ERPG-3 threshold values for all strategies and options. Table 5.5.3 lists the radiological and chemical accidents that could result in doses or exposures exceeding regulatory limits.

Table 5.5.2. Worker And Public Exposure From Accident Conditions During Routine Operations and Construction

Site Administrative Controls	Requirements	Performance Measures (mrem)	Point-of-Compliance	Notes
Accidents During Operations and Construction -- Radiological Exposures (Site Administrative Controls) **Source: WHC 1996c**	Worker risk for anticipated accident ($>10^{-2}$ to $<10^{-0}$ annual frequency)	500	Onsite receptor exposure	Requirement risk range is based on the probability of an accident occurring and not a health effect risk.
	Public risk for anticipated accident ($>10^{-2}$ to $<10^{-0}$ annual frequency)	100	Offsite receptor exposure	
	Worker risk for unlikely accident ($>10^{-4}$ to $<10^{-2}$ annual frequency)	5,000	Onsite receptor exposure	
	Public risk for unlikely accident ($>10^{-4}$ to $<10^{-2}$ annual frequency)	500	Offsite receptor exposure	
	Worker risk for extremely unlikely accident ($>10^{-6}$ to $<10^{-4}$ annual frequency)	10,000	Onsite receptor exposure	
	Public risk for extremely unlikely accident ($>10^{-6}$ to $<10^{-4}$ annual frequency)	4,000	Offsite receptor exposure	

Table 5.5.2. Worker And Public Exposure From Accident Conditions During Routine Operations and Construction (cont'd)

Site Administrative Controls	Requirements	Performance Measures (mrem)	Point-of-Compliance	Notes
Accidents During Operations and Construction – Chemical Exposures (Site Administrative Controls) **Source: WHC 1996c**	Worker risk for anticipated accident ($>10^{-2}$ to $<10^{-0}$)	<ERPG-1	Onsite receptor exposure	**ERPG 1:** Chemical exposure for more than 1 hr resulting in mild transient adverse health effects or perceiving a clearly defined objectionable odor.
	Public risk for anticipated accident ($>10^{-2}$ to $<10^{-0}$)	<PEL-TWA	Offsite receptor exposure.	
	Worker risk for unlikely accident ($>10^{-4}$ to $<10^{-2}$)	<ERPG2	Onsite receptor exposure.	**ERPG 2:** Chemical exposure for more than 1 hr resulting in irreversible or other serious health effects, or symptoms that could impair ability to take protective action.
	Public risk for unlikely accident ($>10^{-4}$ to $<10^{-2}$)	<ERPG-1	Offsite receptor exposure.	
	Worker risk for extremely unlikely accident ($>10^{-6}$ to $<10^{-4}$)	<ERPG-3	Onsite receptor exposure.	**ERPG 3:** Chemical exposure for more than 1 hr resulting in irreversible or life-threatening health effects.
	Public risk for extremely unlikely accident ($>10^{-6}$ to $<10^{-4}$)	<ERPG-2	Offsite receptor exposure.	

Table 5.5.3. Accident Exposures Exceeding Regulatory Limits for Involved Worker, Noninvolved Worker, and General Public (MEI)

Accident	Involved Worker Dose (mrem)	Noninvolved Worker Dose (mrem)	General Public Dose (mrem)	Regulatory Standard (mrem)
Radiological Dose From Postulated Accidents (mrem)				
Soil excavation accident for an 8,000 gal. retrieval leakage loss (Option 2a)	Exceeds fatal dose of 500,000	Exceeds fatal dose of 500,000	Does not exceed regulatory standard (1,100)	Involved worker = 10,000 Noninvolved worker = 10,000 General public = 4,000
Tank removal accident (Strategy 2 and all Strategy 2 options)	Exceeds fatal dose of 500,000	Does not exceed regulatory standard (328,000)	Does not exceed regulatory standard (300)	Involved worker = 5,000 Noninvolved worker = 10,000 General public = 4,000

Table 5.5.3. Accident Exposures Exceeding Regulatory Limits for Involved Worker, Noninvolved Worker, and General Public (MEI) (cont'd)

Accident	Involved Worker Dose (mrem)	Noninvolved Worker Dose (mrem)	General Public Dose (mrem)	Regulatory Standard (mrem)
Tank waste retrieval accident (all strategies and options except No Action)	Exceeds fatal dose of 500,000	Does not exceed regulatory standard (21,000)	Does not exceed regulatory standard (92)	Involved worker = 10,000 Noninvolved worker = 10,000 General public = 4,000
Ancillary equipment removal accident (Strategy 2 and all Strategy 2 options)	Does not exceed regulatory standard (200,000)	Does not exceed regulatory standard (79)	Does not exceed regulatory standard (0.05)	Involved worker = 5,000 Noninvolved worker = 10,000 General public = 4,000
Ancillary equipment grouting accident (Strategy 1 and all Strategy 1 options)	Does not exceed regulatory standard (100,000)	Does not exceed regulatory standard (0.07)	Does not exceed regulatory standard (6.5E-05)	Involved worker = 5,000 Noninvolved worker = 10,000 General public = 4,000
No Action for earthquake accident (Strategy 3)	Exceeds fatal dose of 500,000	Exceeds fatal dose of 500,000	4,680	Involved worker = 10,000 Noninvolved worker = 10,000 General public = 4,000
Chemical Exposure From Postulated Accidents				
Soil excavation accident for an 8,000 gal. retrieval leakage loss (Option 2a)	Worker would receive a lethal radiological dose as shown for radiological dose.	Noninvolved worker MEI would receive a lethal radiological dose as shown above for radiological dose.	Does not exceed regulatory standard (1.5E-11 of ERPG-1)	Involved worker = ERPG-1 Noninvolved worker = ERPG-1 General public = ERPG-2
Tank waste retrieval accident (all strategies and options except No Action)	Worker would receive a lethal radiological dose as shown for radiological dose.	Noninvolved worker MEI would receive a lethal radiological dose as shown above for radiological dose.	Does not exceed regulatory standard (1.1E-01 of ERPG-1)	Involved worker = ERPG-3 Noninvolved worker = ERPG-3 General public = ERPG-2
Tank removal accident (Strategy 2 and all Strategy 2 options)	Worker would receive a lethal radiological dose as shown for radiological dose.	Does not exceed regulatory standard (1.3E-01 of ERPG-1)	Does not exceed regulatory standard (7.0E-07 of ERPG-1)	Involved worker = ERPG-1 Noninvolved worker = ERPG-1 General public = ERPG-2

For the Nominal Losses/Excavate Soil option (Option 2a) of the Baseline Retrieval/Unrestricted Land Use strategy (Table 5.5.3) an accident while removing contaminated soil from past leaks and retrieval leakage loss was assumed to be an extremely unlikely event. The radiological dose for the involved and noninvolved workers would exceed the standard of 5 rem and 10 rem, respectively. The general public would not receive a dose exceeding the standard of 4 rem. The next most severe accident would occur during tank removal for Strategy 2 (Baseline Retrieval/Unrestricted Land Use) and its options. The radiological dose for the involved and

noninvolved worker would exceed the regulatory limit, and the dose to the general public would be within regulatory limits (Table 5.5.3).

The bounding accident for the Baseline Retrieval/Restricted Land Use strategy and its options is the retrieval accident. This same accident would apply to all of the strategies and options except for No Action (Strategy 3). For the retrieval accident, the involved worker and noninvolved worker dose would exceed regulatory limits, while the dose to the general public would be below the limits (Table 5.5.3).

Sensitivity Case

The sensitivity case as discussed in Appendix F, indicates the radiological LCF risk from normal operations would not result in a LCF (0.7) under the Baseline Retrieval/Restricted Land Use strategy (Strategy 1) and its options and the Nominal Losses/Excavate Soil option (Option 2a) under the Baseline Retrieval/Unrestricted Land Use strategy for the involved worker population.

5.5.2 Groundwater Contamination

Groundwater quality requirements are detailed in Section 3.8 and include compliance with the EPA's MCLs, DOE's derived concentration guide (DCG), and concentration limits under Washington State Dangerous Waste Regulations (WAC 173-303-645). The CoC with the highest concentration level in the groundwater was Tc-99 (Section 5.2). The highest constituent for the chemicals was nitrate-nitrite as nitrogen (Jacobs 1998b).

Tc-99 is used as an indicator constituent as a result of its mobility in the environment (K_d of 0) and its long half-life. Tc-99 does not exceed the EPA regulatory MCL (900 pCi/L) for any of the strategies including the No Action strategy. All other CoCs are below EPA MCLs, the DOE DCGs, and State concentration limits for all strategies and options. The groundwater MCLs and the DOE 4-mrem EDE standard are presented in Section 5.2.

Appendix A.8.1 provides the best basis inventory for the No Action AX Tank inventories. Based on this inventory, the Tc-99 inventory was compared to the Tc-99 inventory used in the RPE and a ratio was established. This ratio was multiplied by the maximum concentration value (600 pCi/L) of Tc-99 for the time periods modeled (150 yr from 1963 to 10,000 from 1963) and a new calculated maximum concentration value for Tc-99 (927 pCi/L) was derived.
The maximum concentration value would exceed the EPA maximum contaminant level of 900 pCi/L was derived.

5.5.3 Long-Term Human Health Risk

Long-term human health risk was evaluated based on the maximum groundwater concentration and the level of risk (i.e., ILCR) as expressed in human health exposure to nine radiological constituents (Tc-99, Se-79, I-129, C-14, U-233, -234, -235, -236, and -238) and four chemical constituents (nitrate, nitrite, cyanide, and EDTA). These constituents were chosen to evaluate long-term risks. A discussion is provided in Sections 3.3, 3.5, 3.6, 5.2, and 5.3.

For human health risks related to ILCR, the level of protection provided by regulatory agencies is consistent among the regulations, whether they apply to dangerous contaminants or radiological contaminants. The level of protection provided under the regulations ranges from

1 in 10,000 (1.0E-04) and 1 in 1,000,000 (1.0E-06). Washington State requires ILCR not to be higher than 1.0E-06 for individual contaminants and 1.0E-05 for cumulative contaminants, while the EPA requires the ILCR not to be higher than 1.0E-04. For noncarcinogenic contaminants an HI equal to or greater than 1 would exceed State and Federal standards.

Regulatory exceedance may occur for long-term human health risk and not for drinking water standards as a result of water being used for bathing, washing food, irrigation, as well as drinking for the human health standard; while the drinking water standard only assumes consumption.

Table 5.5.4 summarizes the range of ILCRs and HIs calculated for the various strategies and their options for the two exposure scenarios based on State cleanup requirements (residential farmer and industrial worker). Peak ILCRs and HIs for each option are provided in Section 5.3 (Table 5.3.4).

Table 5.5.4 Long-Term Human Risks (ILCR and HI)

Strategy/ Option	Residential Farmer Scenario				Industrial Worker Scenario			
	ILCR Range [1]	ILCR Regulatory Limits	HI Range [1]	HI Regulatory Limits	ILCR Range [1]	ILCR Regulatory Limits	HI Range [1]	HI Regulatory Limits
Strategy 1 and Options	5.8E-05 to 3.3E-07	1.0E-04 (Federal) and 1.0E-05 (State)	2.2E+01 to 6.0E-02	1.0 (Federal and State)	2.0E-06 to 1.2E-08	1.0E-04 (Federal) and 1.0E-05 (State)	5.3E-01 to 4.5E-04	1.0 (Federal and State)
Strategy 2 and Options	1.2E-05 to 3.6E-09	1.0E-04 (Federal) and 1.0E-05 (State)	4.7E+00 to 0.00E+00	1.0 (Federal and State)	3.4E-07 to 1.4E-10	1.0E-04 (Federal) and 1.0E-05 (State)	1.1E-01 to 0.00E+00	1.0 (Federal and State)
Strategy 3	1.6E-04 to 1.2E-05	1.0E-04 (Federal) and 1.0E-05 (State)	1.2E+01 to 8.1E-01	1.0 (Federal and State)	4.3E-06 to 4.9E-07	1.0E-04 (Federal) and 1.0E-05 (State)	2.6E-02 to 2.4E-03	1.0 (Federal and State)

Notes:
[1] The range represents the lowest and highest peak risk among the strategies and options for any time period from the end of institutional control through 10,000 yr from 1963.

From the end of institutional control until 10,000 yr from 1963, long-term human health risks would exceed the State regulatory standards of 1.0E-05 for ILCRs and 1.0 for the HI for the residential farmer scenario under the following strategies and options based on available data and assumptions documented in the RPE Report.

- Baseline Retrieval/Restricted Land Use (Strategy 1) would slightly exceed the ILCR standard (1.1E-05) for 150 yr from 1963 but would not exceed the HI regulatory limit. Options 1a, 1d, and 1f would exceed the ILCR at 150 yr and 2,600 yr from 1963. These same options would exceed the HI regulatory limit at either 1,200 yr and/or 2,600 yr from 1963. Option 1c would slightly exceed the ILCR standard (1.1E-05) for 150 yr from 1963 and the HI regulatory limit for 1,200 yr and 2,600 yr from 1963. Option 1e would exceed the ILCR and HI regulatory standards at 2,600 yr from 1963. Option 1b would exceed the ILCR standard for four time periods and the HI standard for five time periods. Options 1g and 1h would not exceed the ILCR standard for any of the time periods.

However, Option 1h would slightly exceed the HI regulatory limit (with values of 1.6 and 1.1) at 2,600 yr and 5,000 yr from 1963, respectively.

- Baseline Retrieval/Unrestricted Land Use (Strategy 2) and its options would not exceed the ILCR or HI regulatory limits, except for Option 2d. Option 2d would slightly exceed the ILCR standard (1.2E-05) at 150 yr from 1963 and the HI regulatory limit at 1,200 yr and 2,600 yr from 1963.

- The No Action strategy (Strategy 3) would exceed the ILCR standard for all time periods. No Action would exceed the HI regulatory standard at 1,200 yr to 10,000 yr from 1963.

None of the strategies or options would exceed the ILCR or HI regulatory limits for the industrial worker scenario.

Sensitivity Case

The sensitivity cases for long-term human health risk were conducted for past leaks (Appendix F.3) and retrieval leakage loss limits (Appendix F.4). The regulatory conclusions for these two sensitivity cases are presented in Appendix F and Section 6.1.6. For the sensitivity case involving past leaks (Appendix F.3), long-term human health risk based on ILCR for the residential farmer scenario indicates for this past leak sensitivity case, ILCR would not exceed the State regulatory human health-based requirements of 1.0E-05 in the early time periods (150 yr from 1963 to 1,200 yr from 1963).

For the retrieval leakage loss sensitivity case (Appendix F.4), long-term human health risk based on ILCR for the residential farmer scenario indicates the ILCR would exceed the State regulatory human health-based requirements of 1.0E-05 in the early time period (150 yr from 1963) and would meet the requirement when retrieval leakage loss source term is the predominant source term (2,600 yr from 1963). The ILCR value at 150 yr from 1963 is 1.2E-05. The ILCR value at 2,600 yr from 1963 is 1.0E-05.

Inadvertent Human Intruder

Section 5.3.3 presents the inadvertent human intruder analysis results. Both the NRC and DOE inadvertent human intruder scenario were analyzed. Sections 3.6.3 and 5.5.3 present the methodology and results, respectively.

The DOE inadvertent human intruder scenario was analyzed. DOE regulations require exposure to the hypothetical inadvertent intruder to be 100 mrem in a year from chronic exposure and 500 mrem for a single event (Frei 1996). Based on these values, the postdriller resident scenario provides the bounding analysis for chronic exposure, while the well driller scenario provides the bounding analysis for the acute exposure.

The analysis was conducted based on a cumulative dose from various components.
The components examined for the intruder scenario included drilling through SST AX-102 containing 0.1 percent residual waste, 1 percent residual waste, 10 percent residual waste, and 100 percent residual waste. Under the scenario, the well driller scenario drills through SST AX-102 until the borehole reaches groundwater. The 30 m^3 (8,000 gal.) retrieval leakage loss

and the 151 m^3 (40,000 gal.) retrieval leakage loss were examined. These contributions were added together based on the various strategies and options. The results are provided in Table 5.3.6 of Section 5.3.3.

For the well driller scenario, no exceedance of the DOE regulatory standard (500 mrem/yr) occurs 100 yr after closure. The postdriller scenario indicates exceedance of 100 mrem/yr for chronic exposure would occur for Strategy 1 and Options 1a, 1b, 1d, 1e, 1f, 1g, 1h, and Strategy 3 at 100 yr after closure.

Based on component contributions, the postdriller scenario exceeds the DOE regulatory requirements for 1 percent, 10 percent, and 100 percent of the residual waste from SST AX-102 and the 151 m^3 (40,000 gal.) retrieval leakage loss.

Based on the analysis of the postdriller resident scenario for specific constituent concentrations in SST AX-102, the results indicate that Cs-137 and Sr-90 for the 10 percent residual waste exceed 100 mrem/yr. Sr-90 nearly exceeds for the 1 percent residual case (95 mrem/yr). For retrieval leakage loss components, the constituents of Sr-90 and Cs-137 exceed the DOE regulatory requirement of 100 mrem/yr for the 151 m^3 (40,000 gal.) retrieval leakage loss.

The NRC standard for upper concentration limits for Class C LLW disposal would be exceeded for 10 m^3 (360 ft^3) of residual waste in the SSTs if no additional actions were implemented. However, stabilization of the residual waste with grout and assuming a uniform mixing of the grout and the residual waste ranging from 1.3 m (4.5 ft) for tank AX-103 to 7.7 m (25 ft) for tank AX-102 would result in contaminant concentrations that would meet upper concentration limits for Class C LLW disposal. However, the technological feasibility to uniformly mix this much grout with the residual waste is uncertain. For 100 m^3 (3,600 ft^3) of residual waste, NRC requirements for Class C LLW disposal would be exceeded.

5.5.4 Regulatory Issues

5.5.4.1 Point-of-Compliance

Under WAC 173-303-645(6), the point-of-compliance is defined as:

> A vertical surface located at the hydraulically down gradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units. Alternatively, the point-of-compliance may be any closer point identified by the department at the time the permit is issued, considering the risk of the facility, the wastes and constituents managed that, the potential for waste constituents to have already migrated past the alternate compliance point and the potential threats to ground and surface water.
>
> The waste management area is the limit projected in the horizontal plane of the area on which waste will be placed during the active life of a regulated unit. The waste management area includes horizontal space taken up by any liner, dike, or other barrier designed to contain waste in a regulated unit. If the facility contains more than one regulated unit, the waste management area is described by an imaginary line circumscribing the several regulated units.

Under WAC 173-303-645(8)(b), which addresses general groundwater monitoring requirements, the point-of-compliance location is clarified by the following statement.

> If a facility contains more than one regulated unit, separate groundwater monitoring systems are not required for each regulated unit, provided that provisions for sampling the ground water in the uppermost aquifer will enable detection and measurement at the compliance point of dangerous constituents from the regulated units that have entered the groundwater in the uppermost aquifer.

Currently, the AX Tank Farm point-of-compliance is combined with A Tank Farm and the closest downgradient well (299-E24-19) is approximately 10 m (33 ft) to the west of A-AX SST WMA (PNNL 1998).

Based on recent comments to the *Performance Objectives for the Hanford Immobilized Low-Activity Waste (ILAW Performance Assessment* (HNF-EP-0826, Rev. 2B), Ecology cites numerous times that the point of compliance is at the fence line of the facility for a RCRA disposal facility. One comment indicated that the point-of-compliance listed in the document and referenced to Kincaid et al. (1998) is liberal in accurate interpretation of the DOE Order 5400.5, which states the fence line of the facility and not the boundary of the 200 Areas. The comment further states that Ecology does not agree with the 200 Areas boundary point of compliance interpretation (Ecology 1999).

A point-of-compliance for groundwater impacts and/or human health risk assessments is a regulatory issue that has not been determined for the AX Tank Farm for the closure plan requirements. However, options, under State and Federal regulations include 1) beneath the tank farm at the vadose zone/groundwater interface; 2) the AX Tank Farm boundary; and 3) the boundary of the 200 Areas. Additionally, the CA assessed compliance with the DOE 100 mrem/yr for all pathway exposures standard at the boundary of the 200 Area buffer zone (Kincaid et al. 1998), and ER has proposed evaluation at the interface of the groundwater and Columbia River during the institutional control period to assess potential impacts to the Columbia River (DOE 1998b). This section evaluates groundwater contaminant concentration values (concentration limits) as defined in WAC 173-303-645(5) and human health risk impacts at these various distances downgradient from the AX Tank Farm.

For groundwater maximum concentrations, distances of 0 m (0 ft), 250 m (800 ft), 1,000 m (3,300 ft), and 2,000 m (6,600 ft) were selected for analysis. The distance to the point-of-compliance for the DOE PA requirements is 100 m (328 ft) downgradient of the disposal facility. The 250 m (800 ft) represents the distance at the AX SST Farm boundary. The distance of 1,000 m (3,300 ft) is based on distance of the AX Tank Farm from the 200 Area WMA boundary. The 2,000 m (6,600 ft) distance represents the proposed buffer zone at the 200 Area Plateau used in the CA as a point-of-compliance (Kincaid et al. 1998). Groundwater concentrations for Tc-99 under the Baseline Retrieval/Restricted Land Use strategy Nominal Retrieval Losses (Option 1a), Baseline Retrieval/Restricted Land Use strategy Nominal Losses/Excavate Soil (Option 2a), and No Action strategy were used in the analysis.

Figures 5.5.1 through 5.5.3 provide Tc-99 concentrations at the alternative points-of-compliance for the three strategies for 1) 150 yr after 1963, which represents the end of institutional control; 2) 600 yr after 1963, which represents the decay of the enhanced RCRA Subtitle C barrier; and 3) 1,200 yr, which represents the DOE compliance period requirement for Performance Assessments.

At 150 yr, the end of institutional control at the AX Tank Farm, Tc-99 ranges between 93 to 32 pCi/L. The highest concentration is for the No Action strategy while the lowest concentration value is associated with Option 2a. For the distance 250 m (800 ft) downgradient of the AX Tank Farm, Tc-99 ranges from 85 to 29 pCi/L. For the distance 1,000 m (3,300 ft), southeast of the AX Tank Farm, the Tc-99 concentration ranges from 54 to 28. For the distance of 2,000 m (6,600 ft), southeast of the AX SST farm, the Tc-99 concentration ranges from 32 to 11 pCi/L. The contaminant concentrations for Tc-99 would not exceed MCLs, DCGs, or State concentration limits at any of the alternative points-of-compliance.

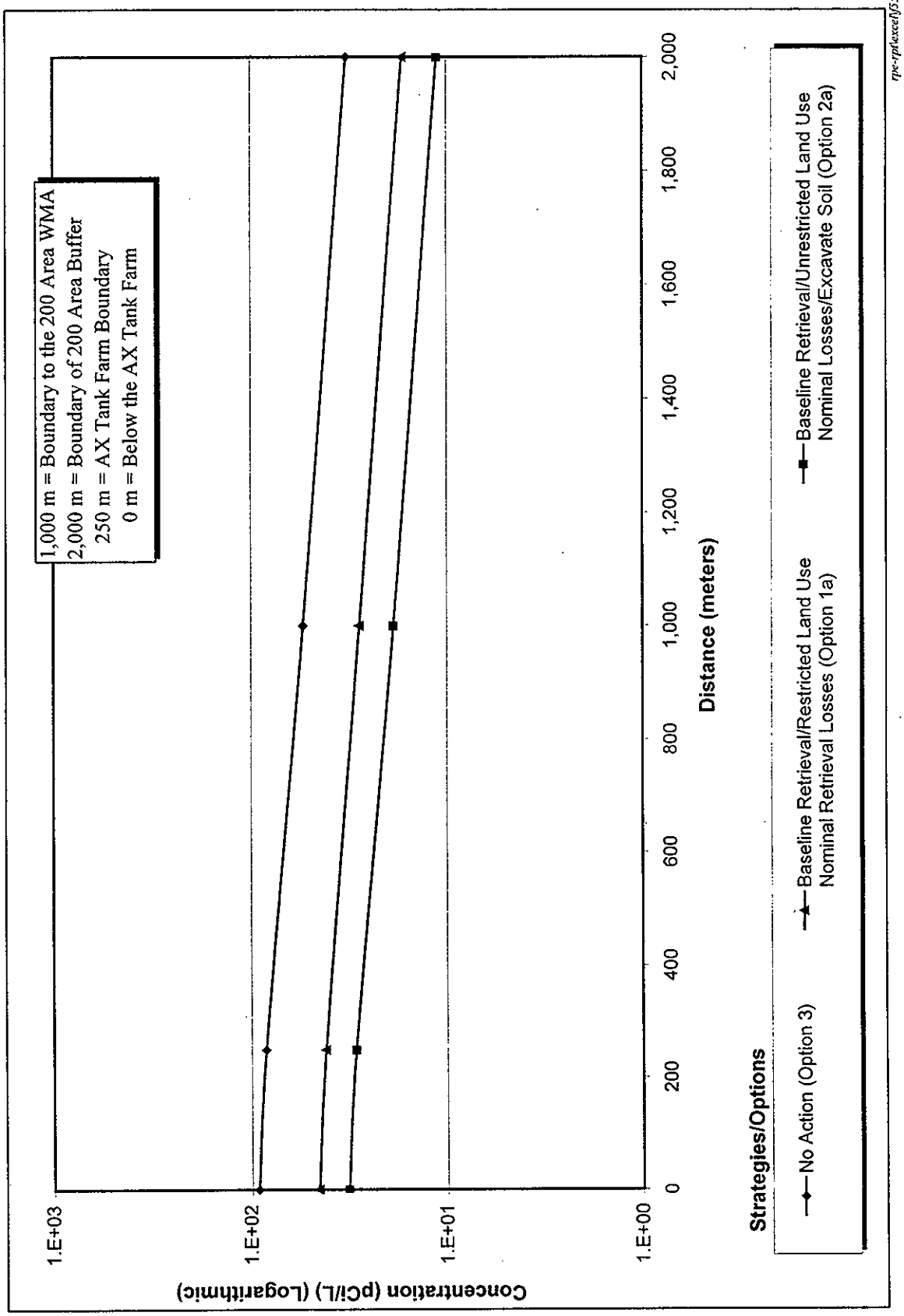
At 600 yr, the end of barrier performance, Tc-99 ranges between 64 to 11 pCi/L for the entire distance for all options. The highest concentration is for the No Action strategy while the lowest concentration value is associated with Option 2a. Contaminant concentration standards would not be exceeded at any of the points-of-compliance based on available data and assumptions provided in this report.

At 1,200 yr, Tc-99 ranges between 308 to 1.2 pCi/L for the entire distance for all options. The highest concentration is for the No Action strategy while the lowest concentration value is associated with Option 2a. Contaminant concentrations limits would not be exceeded based on available data and assumptions documented in this report.

Based on the Draft 200 Areas Remedial Investigation/Feasibility Study Implementation Plan (DOE 1998b), an evaluation was conducted for the potential contaminated media of groundwater and surface water using their conceptual exposure model. For contaminated groundwater, the potential exposure routes will be through dermal contact and external radiation only to the current and future worker. For contaminated surface water the potential exposure routes from the Columbia River will be through dermal contact and external radiation to the current and future worker and ingestion to the occasional user for humans. The points-of-compliance are the 200 Area for the current and future worker and a point along the Columbia River, where the highest groundwater concentration is to be expected based on the long-term human health risk data presented in Section 5.3.

The maximum groundwater concentration levels are for 1) 150 yr after 1963, which represents the end of institutional control; 2) 1,200 yr, which represents the DOE requirements for CAs; and 3) 5,000 yr and 10,000 yr which represent the NRC requirements for the time span of LLW disposal analysis. The EPA MCLs for Tc-99, I-129, nitrate-nitrite, and U-238 were used to compare the EPA maximum groundwater concentration levels during these time periods for the No Action strategy, the Baseline Retrieval/Restricted Land Use–Nominal Retrieval Losses option (Option 1a), and the Baseline Retrieval/Unrestricted Land Use–Nominal Losses/Excavate Soil option (Option 2a). Table 5.5.5 presents the results of this analysis. Section 6.1.6 discusses the implications of these findings and how they compare to other points-of-compliance.

Figure 5.5.1. Tc-99 Composite Source Concentrations at Alternative Points-of-Compliance at 150 Yr from 1963



rpe-rpt\excel\5511-3.xls

Figure 5.5.2. Tc-99 Composite Source Concentrations at Alternative Points-of-Compliance at 600 Yr from 1963

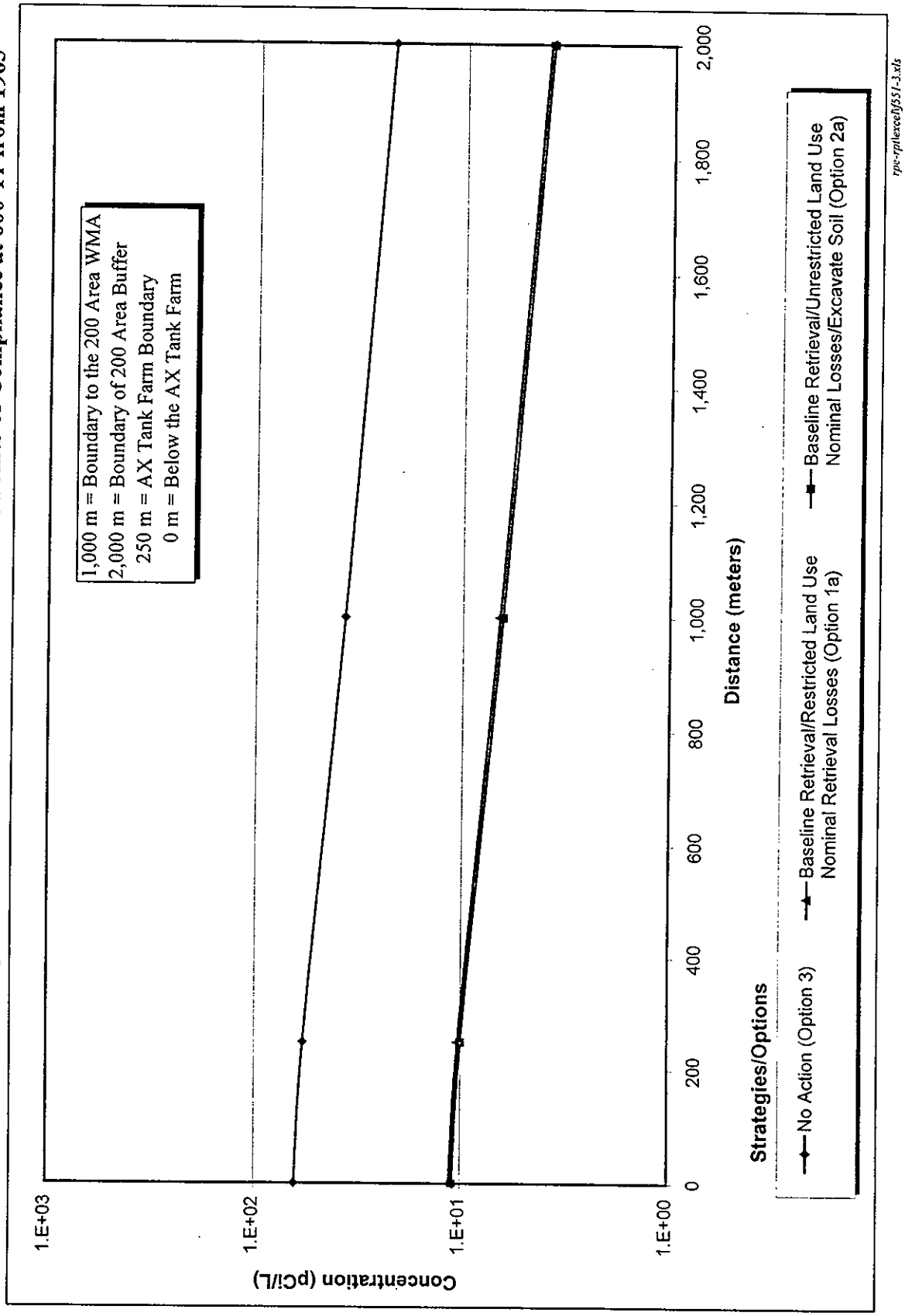


Figure 5.5.3. Tc-99 Composite Source Concentrations at Alternative Points-of-Compliance at 1,200 Yr from 1963

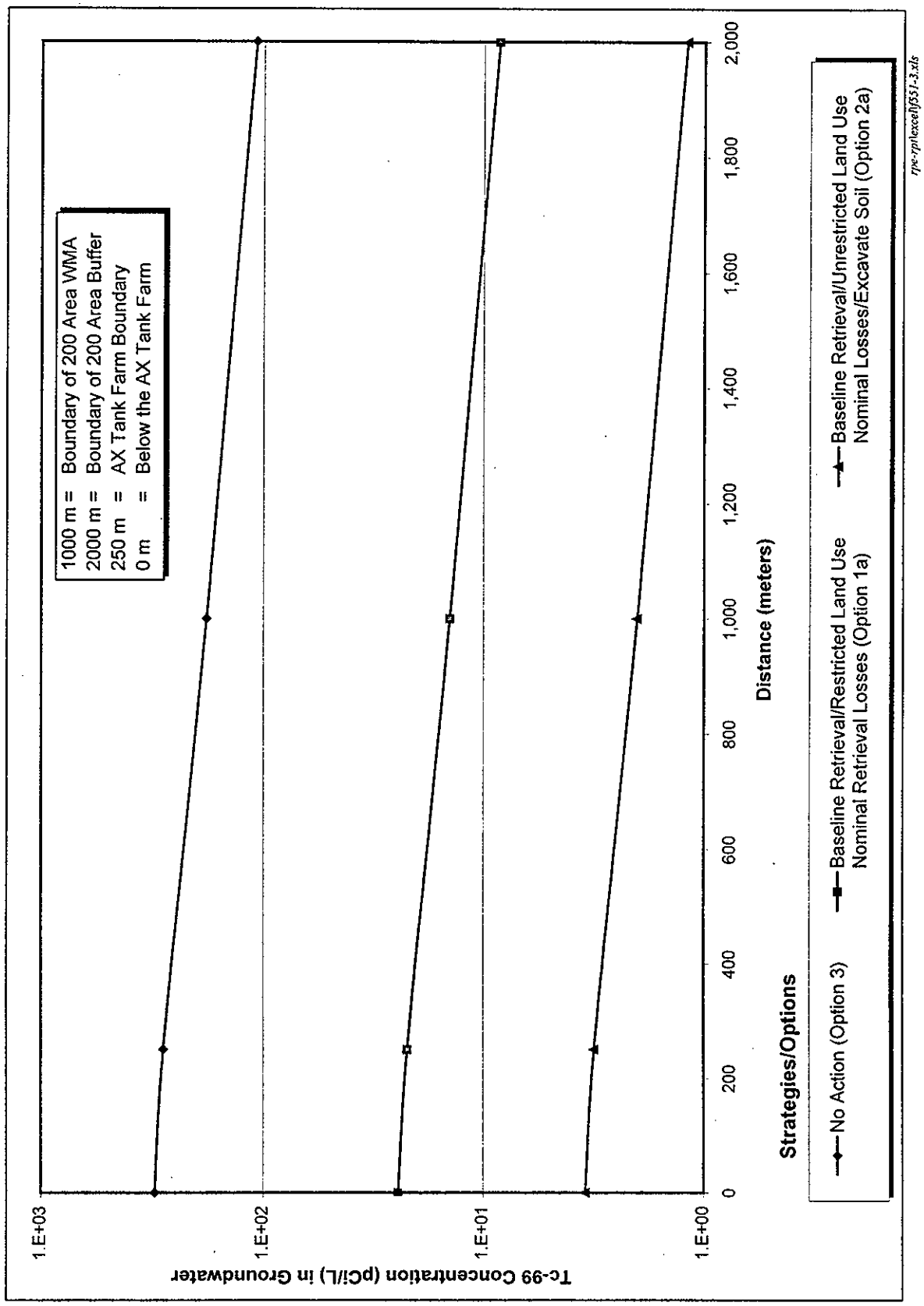


Table 5.5.5. 200 Areas Implementation Plan Point-of-Compliance at Various Times for Maximum Groundwater Concentrations at AX Tank Farm and the Shoreline

Constituents (Concentration)	Options	150 Yr from 1963		1,200 Yr from 1963		5,000 Yr from 1963		10,000 Yr from 1963		Regulatory EPA MCL[1]
		Industrial user AX Tank Farm	Residential farmer at shoreline	Industrial user AX Tank Farm	Residential farmer at shoreline	Industrial user AX Tank Farm	Residential farmer at shoreline	Industrial user AX Tank Farm	Residential farmer at shoreline	
NO_3-NO_2 (mg/L)	1a	2.40E-02	2.42E-03	3.39E-02	1.94E-03	5.52E-03	1.22E-04	9.30E-71	6.10E-71	10
	2a	1.25E-02	1.25E-03	6.03E-14	6.14E-15	8.82E-13	8.98E-14	9.01E-146	0.00E+00	
	3	9.35E-03	9.36E-03	4.63E-01	4.71E-02	4.72E-02	4.81E-03	7.46E-90	0.00E+00	
Tc-99 (pCi/L)	1a	4.56E+01	5.85E+00	1.07E+00	2.47E+00	2.40E-01	1.09E-01	1.20E-67	5.35E-68	900
	2a	3.21E+01	3.23E+00	3.43E+00	3.64E-01	2.06E-38	0.00E+00	7.02E-143	0.00E+00	
	3	9.26E+01	1.03E+01	3.08E+02	3.14E+01	2.65E+01	2.70E+00	2.37E-83	0.00E+00	
I-129 (pCi/L)	1a	5.66E-04	5.39E-05	5.66E-04	5.77E-05	5.08E-03	4.23E-04	2.62E-02	2.68E-03	1
	2a	6.03E-05	5.66E-06	6.03E-05	6.14E-06	8.82E-04	8.98E-05	1.38E-04	1.40E-05	
	3	5.60E-03	5.31E-04	5.60E-03	5.70E-04	1.50E-01	1.50E-01	1.22E-01	1.26E-02	
U-238 (pCi/L)	1a	2.13E-04	2.03E+05	2.13E-04	2.17E-05	2.13E-04	2.17E-05	3.11E-02	3.13E-03	0.02 mg/L (total)
	2a	1.41E-07	1.34E-08	1.41E-07	1.43E-08	2.49E-06	2.57E-07	1.84E-07	1.88E-08	
	3	4.26E-03	4.05E-04	4.26E-03	4.34E-04	6.35E-02	6.44E-03	2.13E-01	2.17E-02	

Notes:

Industrial = Based on industrial use scenario for the 200 Area exclusive use WMA.

Shoreline = Based on residential farmer scenario for the point of highest long-term risk at or near the Columbia River.

[1] MCLs only apply for 1,000 yr, other time increments are presented for informational purposes.

Table 5.5.6 presents the long-term human health risks for 1) the industrial worker in the 200 Areas at the AX Tank Farm at various time periods; and 2) the residential farmer at the maximum risk exposure point at the shoreline of the Columbia River for the same time periods. As indicated in Table 5.5.4, neither scenario would exceed the Washington State Model Toxic Control Act (MTCA) level of 1.0E-05 for cumulative exposure at any time period (WAC 173-340). Maximum risks would be experienced by the residential farmer under the No Action strategy (with a peak risk of 9.3E-06 at 1,200 yr from 1963) and by the industrial worker under the same strategy (with a peak risk of 3.3E-06 at 1,200 yr from 1963). For the residential farmer, ILCR generally would be less than one-third to three-fourth order of magnitude higher at the shoreline of the Columbia River than at the peak risk location (below the AX Tank Farm) for the industrial worker scenario for the same time periods.

Table 5.5.6. ILCR for the Industrial User at the AX Tank Farm and for the Residential Farmer at the Shoreline of the Columbia River

Strategy or Option	150 Yr from 1963		1,200 Yr from 1963		5,000 Yr from 1963		10,000 Yr from 1963	
	Industrial User AX Tank Farm	Residential Farmer at Shoreline	Industrial User AX Tank Farm	Residential Farmer at Shoreline	Industrial User AX Tank Farm	Residential Farmer at Shoreline	Industrial User AX Tank Farm	Residential Farmer at Shoreline
Nominal Retrieval Losses (Option 1a)	3.4E-07	1.6E-06	1.86E-07	6.7E-07	1.7E-08	4.8E-08	9.5E-8	1.3E-07
Nominal Losses/Excavate Soil (Option 2a)	2.4E-07	8.6E-07	2.6E-08	1.0E-07	1.0E-09	3.4E-09	1.5E-10	3.7E-10
No Action (Strategy 3)	7.0E-07	2.8E-06	3.3E-06	9.3E-06	5.2E-07	1.6E-06	5.2E-07	1.2E-06

5.5.4.2 Tank Farm Closure of Hazardous Constituents

Tank farm closure requirements are relevant to this analysis. The end state of the tank farms, as defined under closure regulations, will in part determine retrieval criteria associated with the amount of waste that must be retrieved from the tanks, waste losses during retrieval actions, and disposition of contamination in the soils surrounding the tanks resulting from tank waste retrieval leakage loss and past tank waste leaks.

The SSTs are classified as RCRA facilities that contain hazardous waste (i.e., dangerous waste) as defined by either the characteristics of the waste (e.g., toxicity, corrosivity) or as designated hazardous through listing. In either case, because the SSTs contain dangerous waste, these units are managed as RCRA Subtitle C TSD units in accordance with the Washington State HWMA. Under the Tri-Party Agreement, both SSTs and DSTs are RCRA hazardous SWMUs that eventually will be closed under Washington State Dangerous Waste Regulations (WAC 173-303). Closure will require the submittal to and approval of closure and postclosure plans by Ecology (Milestone 45-06) (Ecology et al. 1996). A draft SST closure work plan (DOE 1996d) has been submitted in conformance with the Tri-Party Agreement.

The Tri-Party Agreement lists the Dangerous Waste Regulations (WAC 173-303) and the MTCA (WAC 173-340) as the key state statutes and regulations from which the cleanup requirements for nonradiological hazards for the Hanford Site waste units will be developed. Furthermore, the agreement states that all TSD units that undergo closure, irrespective of permit status, shall be

closed pursuant to the authorized Washington State Dangerous Waste Program in accordance with regulations that pertain to permitted units (WAC 173-303-610).

The Tri-Party Agreement (M-45-00) states that:

> For the purposes of this agreement all units located within the boundary of each tank farm will be closed in accordance with WAC 173-303-610. This includes contaminated soil and ancillary equipment that were previously designated as RCRA past-practice units. . . . . In evaluating closure options for SSTs, contaminated soil, and ancillary equipment, Ecology and EPA will consider cost, technical practicability, and potential exposure to radiation. Closure of all units within the boundary of a given tank farm will be addressed in a closure plan for the SSTs.

5.5.4.2.1 Clean Closure

The Tri-Party Agreement establishes a two-phased process for tank remediation. The first phase is tank waste retrieval, during which waste must be removed to at least an equivalent of 99 percent of the waste volume or the limit of waste retrieval technology achieved, whichever is less. Thereafter, closure of the tanks in accordance with the Dangerous Waste Regulations for interim status facilities is implemented. The Tri-Party Agreement also allows for consideration of cost, technical practicability, and potential exposure to radiation when considering closure options (Ecology et. al 1996). These considerations are not provided for in the Dangerous Waste Regulations. The clean closure standard for the tank system components may be based on applying the Hazardous Debris Rule, or alternative performance standards for a Hazardous Debris Rule defined technology, or an alternative decontamination method approved by Ecology.

Strategies and options that potentially represent clean closure are Baseline Retrieval/ Unrestricted Land Use (Strategy 2), Nominal Losses/Soil Excavate (Option 2a), Past Leaks/In Situ Soil Treatment (Option 2b) and Nominal Losses/In Situ Soil Treatment (Option 2c).

5.5.4.2.2 Modified Closure

The Hanford Site RCRA Permit allows a modified closure of TSD units. A modified closure involves alternative cleanup levels for soil and groundwater based upon MTCA Method C (industrial use scenario), and postclosure care requirements (Rosenthal 1997). According to the permit, it appears that the modified closure standards are available only in the instance of clean closure for the structures and ancillary equipment of the TSD unit itself (Rosenthal 1997, Ecology et al. 1996). The modified closure allows for less stringent cleanup levels for soil and groundwater than would otherwise be available in a clean closure and appears to allow less stringent postclosure requirements than would otherwise be available under closure as a landfill.

MTCA Method C cleanup levels must be at least as stringent as 1) concentrations established under applicable State and Federal laws; 2) concentrations of 100 times the Method B groundwater cleanup level; and 3) defined health risk-based levels. MTCA Method B also defines cleanup levels using items 1 and 2, but item 3 differs somewhat. The Method C health risk levels are based on an ILCR of 1.0E-05 for individual carcinogens and for multiple carcinogens or pathways. Method B uses 1.0E-06 for individual carcinogens and 1.0E-05 for

multiple carcinogens (WAC 173-340). Method C equations use frequency of contact and rates of ingestion that are one-half of the values used under MTCA Method B (Rosenthal 1997).

Strategies and options that potentially represent modified closure are Baseline Retrieval/ Unrestricted Land Use (Strategy 2), Nominal Losses/Soil Excavate (Option 2a), Past Leaks/In Situ Soil Treatment (Option 2b), Nominal Losses/In Situ Soil Treatment (Option 2c) and No Soil Treatment Option (Option 2d).

5.5.4.2.3 Landfill Closure

In addition to the general Federal closure standard and other requirements found at 40 CFR 264.111 through 264.115, closure requirements unique to a landfill include a final cover that minimizes migration of liquids, requires minimum maintenance, promotes drainage, accommodates settling, and has a permeability less than the bottom liner or subsoils (40 CFR 264.310). Thus, the closure requirements applicable to a landfill are narrative and provide little, if any, guidance regarding the amount of waste that may remain in the tanks and soil.

If the tanks are closed as landfills, then the postclosure requirements are applicable. Postclosure requirements generally apply for a period of 30 yr, but the postclosure period may be decreased or increased by the regulatory agency.

The Washington State closure and postclosure requirements are similar to the Federal requirements (WAC 173-303-610). However, a significant difference is that the State regulations provide for numerical concentration levels for environmental media for clean closure. Ecology requires postclosure care (i.e., closure as a landfill) when dangerous waste or waste residues are left in place at concentrations above numeric cleanup levels determined using residential exposure assumptions under MTCA Methods A or B (Ecology 1994a). The general performance standards that apply to landfill closure require the unit to be closed in a manner that:

- Minimizes the need for further maintenance
- Controls, minimizes, or eliminates to the extent necessary to protect human health and the environment, postclosure escape of dangerous waste, dangerous constituents, leachate, contaminated run-off, and dangerous waste decomposition products to the ground, surface water, groundwater, and atmosphere
- Returns the land to the appearance and use of surrounding land areas to the degree possible given the nature of the previous dangerous waste activity.

The specific requirements for closure as a landfill are defined in WAC 173-303-665(6). Closure requirements for a landfill include cover of the landfill with a final cover designed and constructed to:

- Provide long-term minimization of migration of liquids through the closed landfill
- Function with minimum maintenance

- Promote drainage and minimize erosion or abrasion of the cover
- Accommodate settling and subsidence so the cover's integrity is maintained
- Have permeability less than or equal to the permeability of any bottom liner system or natural subsoil present.

The owner must comply with the postclosure requirements contained in WAC 173-303-610(7)(8)(9) and (10) which include 1) continuing postclosure care for 30 yr (which can be decreased or increased by Ecology); 2) maintaining a postclosure plan to address activities which will be carried out to monitor and maintain the integrity of the landfill; 3) notifying local land authorities of the location of the landfill; and 4) providing a notice in the deed to the property that restricts land usage and includes the type, location, and quantity of dangerous waste disposed in the landfill. Additionally, the owner and operator must "maintain and monitor the groundwater monitoring system and comply with all other applicable requirements of WAC 173-303-645" that regulates releases from regulated units and requires implementation of corrective actions if releases exceed levels established in the closure permit. WAC 173-303-645 may require DOE to install vadose zone monitoring for some or all of the TSD units where past tank leaks have contaminated surrounding soils that would not be remediated to background levels.

The only exemptions from requirements for postclosure vadose zone and groundwater monitoring are if: 1) the unit has been clean closed and if monitoring during unit operations has shown no migration beyond the treatment zone during facility operations; or 2) "there is no potential for migration of liquid" from the unit to the uppermost aquifer during the closure and postclosure care period based on analysis that provides an "adequate margin of safety" by using predictions based on "assumptions that maximize the rate of liquid migration" (WAC 173-303-645(b)(iii-iv).

Strategies and options that represent potential landfill closure are Baseline Retrieval/Restricted Land Use (Strategy 1), and all of Strategy 1 options (Options 1a, 1b, 1c, 1d, 1e, 1f, 1g, and 1h) and No Soil Treatment option (Option 2d) from Strategy 2.

5.5.4.3 Tank Farm Closure of Radioactive Constituents

Much of the waste in the SSTs came from the reprocessing of spent nuclear fuel and therefore the residual waste may be classified as HLW. On the other hand, some of the waste was derived from non-HLW sources such as the phosphate/sulfate wash. All of this waste has been mixed to the point that the accurate classification is unknown. The Hanford Site tanks contain HLW, TRU waste, and mixed waste. In the current storage mode they are managed as HLW and are listed as HLW in the Integrated Database Inventory. One of the key issues impacting closure of the tank farms will be the classification of any residual waste remaining in the tanks and ancillary equipment following completion of retrieval of the waste to the extent practicable under the Tri-Party Agreement. For the Hanford Site SST residual wastes, the three potential waste classifications are LLW, incidental waste, and HLW.

Determination of the classification of radioactive waste involves two considerations. First, consideration must be given to the concentration of long-lived radionuclides whose

potential hazard will persist long after such precautions such as institutional controls, waste form, and engineered disposal technologies have ceased to be effective. Second, consideration must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effective.

5.5.4.3.1 Low-Level Waste

The performance objectives for 10 CFR 61 include protecting the general population from released radioactivity, protecting individuals from inadvertent intrusion, protecting individuals during operations, and maintaining stability of the disposal site after closure. In 10 CFR 61, NRC classified LLW into three categories for near-surface disposal. These three categories are Class A, Class B, and Class C. Class C having the most stringent disposal requirements for shallow land burial. GTCC needs special disposal methods and requires NRC's approval on waste form and disposal configuration. As stated in 10 CFR 61, waste classification is a mechanism to ensure that the overall performance objectives for near-surface disposal will be met through implementation of the technical requirements and controls established for various waste categories. Technical requirements for various waste classes were established for site characterization, design and operation, waste form and packaging, and institutional control.

NRC derived the Class C waste concentration limits based on calculated doses to the inadvertent intruders, assuming intrusion occurred at 500 yr after waste disposal. The intruder is assumed to contact the disposed waste while performing typical activities such as putting in a basements, growing and eating vegetables and so forth. Two scenarios were considered: intruder-construction scenario and intruder-agriculture scenario. For the intruder-construction scenario, the inadvertent intruder would build a house on top of an unrecognizable waste site by digging a deep foundation hole for a basement. During the construction phase, inadvertent intruders would be exposed to external irradiation and contaminated airborne dust. Following the construction of a house, the excavated mixture of soil and waste would be used as backfill around the house and also would be used in the gardening bed. Inadvertent intruders living in the house would be exposed to external irradiation, airborne radionuclides, and radionuclides in food grown in the garden. This is considered to be the intruder-agriculture scenario. Class C limits are the waste concentrations that would deliver either 500 mrem radiation dose to the whole body or the bone or 1,500 mrem to other organs under the intruder-construction or intruder-agriculture scenario (Cochran and Shyr 1998a).

Table 5.5.7 lists the Class C limits for various radionuclides as defined in 10 CFR 61. The mathematical model and the parameters used in deriving Class C limits are described in Cochran and Shyr (1998a).

Given the Class C upper limits for individual radionuclides, the NRC requires using the following process to determine waste classification (10 CFR 61). If radioactive waste does not contain the radionuclides listed in Table 5.5.7, it is Class A waste. Otherwise, long-lived radionuclides should be assessed first to classify waste. For multiple radionuclides, the sum-of-fractions for individual radionuclides needs to be used. If the concentration does not exceed 0.1 times the limit in Table 5.5.7, the waste will be Class A. If the concentration exceeds 0.1 times the limit but is less than the limit, the waste is Class C, unless the short-lived radionuclides in the waste exceed the Class C upper limits. If either the short-lived or long-lived

Table 5.5.7. Class C Concentration Upper Limits

Long-lived Radionuclides	Class C Upper Limits	Short-lived Radionuclides	Class C Upper Limits
C-14	8 Ci/m^3	Ni-63	700 Ci/m^3
C-14 in activated metal	80 Ci/m^3	Ni-63 in activated metal	7,000 Ci/m^3
Ni-59 in activated metal	220 Ci/m^3	Sr-90	7,000 Ci/m^3
Nb-94 in activated metal	0.2 Ci/m^3	Cs-137	4,600 Ci/m^3
Tc-99	3 Ci/m^3		
I-129	0.08 Ci/m^3		
Alpha emitting TRU with $t_{1/2} > 5$ yr	100 nCi/g		
Pu-241	3,500 nCi/g		
Cm-242	20,000 nCi/g		

Notes:
Source: 10 CFR 61

radionuclides exceeded Class C upper limits, the waste will be classified as GTCC. If only short-lived radionuclides exist, waste will be Class C if concentrations exceed the upper limits for Class B, but are less than the Class C limits listed in Table 5.5.7.

For the AX Tank Farm, the inches of grout required for solidified waste to meet Class C limits based on 10 m^3 (360 ft^3) of residual waste would be 2.4 m (7.4 ft) for Tank 241-AX-101, 7.7 m (25 ft) for Tank 241-AX-102, 1.3 m (4.3 ft) for Tank 241-AX-103, and 1.7 m (5.6 ft) for Tank 241-AX-104 (Cochran and Shyr 1998a). These estimates of grout are based on current projected inventory data using process knowledge based models and/or very limited past samples (Cochran and Shyr 1998a). For tank AX-102, the concentration almost exceeds the Class C limit for TRU waste for the maximum amount of uniformly mixed grout needed to fill the tanks (10.1 m [32.5 ft]). For the AX Tank Farm, solidified 10 percent residual waste concentrations exceed the Class C limit for TRU constituents.

For the ancillary equipment, a total of 36 percent of the equipment would meet NRC Class C limits (Cochran and Shyr 1998b). After grouting the ancillary equipment approximately 81 percent would meet the NRC Class C limits (Cochran and Shyr 1998b). For the type of equipment, 58 percent of the transfer line, 67 percent of the sluice line, 67 percent of the ventilation header, and 94 percent of the riser meets NRC Class C limits after grouting (Cochran and Shyr 1998b). Nineteen percent of the equipment would have contaminant concentrations higher than the NRC Class C limits following grouting.

5.5.4.3.2 High-Level Waste

Because the Hanford SSTs are less than a quarter mile from an underground source of drinking water, the current version of 40 CFR 191 is not applicable to in-place disposal of tank residual waste if they are classified as HLW. Also, 40 CFR 191 is not applicable to sites being characterized under the authority of the Nuclear Waste Policy Act (NWPA). If the tank farms were under the authority of the NWPA, then the current version of 40 CFR 191 would not be applicable to disposal of the SST residual waste. If the NWPA does not govern the disposal of

the SST residual waste, then the current version of 40 CFR 191 may be applicable (Cochran and Shyr 1998a,b).

Protection of the general population is provided by the Containment Requirement defined in 40 CFR 191.13. The Containment Requirement does not set a dose-based limit, rather the Containment Requirement sets probabilistic limits on the fluxes of certain radionuclides through the controlled area boundary. Demonstrating compliance with the flux limits provides protection of the general population. The Containment Requirement sets a low flux limit for likely releases and a higher flux limit for unlikely releases.

The allowable flux limits through the controlled area boundary are calculated using the EPA sum. The EPA sum is the ratio of the calculated releases (the calculated curies that move through the controlled area boundary) divided by the number of curies set by the release limit.

The release limit is taken from a table in the back of 40 CFR 191. For example, if a disposal system contained the HLW from 1,000 metric tons of heavy metal reactor fuel, the Tc-99 release limit would be 10,000 Ci, and if a disposal system contained 10 times as much HLW, the Tc-99 release limit would be 10 times higher or 100,000 Ci. The Individual Protection Requirements and the Groundwater Protection Requirements of 40 CFR 191 do not change with the disposal inventory.

The Containment Requirement also requires the assessment of all significant processes and events that may affect the disposal system for 10,000 yr. No other environmental standard requires such an explicit consideration of future events and processes.

The EPA's 40 CFR 191 does not protect the inadvertent human intruder (58 FR 66399). There are three quantitative sets of requirements in 40 CFR 191, both the Groundwater Protection Requirements and the Individual Protection Requirements are, by regulation, to be assessed under the assumption that the disposal system has not been disturbed by human intrusion. The third quantitative requirement, the Containment Requirement, does require consideration of inadvertent human intrusion, but the standard is not dose-based, therefore, doses to the hypothetical intruder are not relevant in demonstrating compliance with 40 CFR 191.

In 10 CFR 60 the NRC established licensing criteria for disposal of HLW in geologic repository. The regulation also addresses performance objectives, land ownership, siting criteria, design criteria, and license applications. 10 CFR 60 is written specifically for the licensing of DOE to receive spent nuclear fuel and HLW at a geologic repository "constructed or operated in accordance with the Nuclear Waste Policy Act." Therefore, the NCR's licensing criteria for disposal of HLW only applies to sites authorized by the NWPA.

Because the Hanford tank waste is DOE titled and located on a DOE facility, DOE Order 5820.2A, Chapter I also governs the disposal of HLW. The DOE order does not set standards for disposal, rather the order requires compliance with the existing regulations for disposal of new and readily retrievable HLW. It should be noted that the DOE order states that HLW, which is not new and readily retrievable, may be assessed for in-place stabilization and disposal (Cochran and Shyr 1998a). A comparison of LLW disposal requirements under DOE

Order 5820.2A and Frei 1996 and HLW requirements under 40 CFR 191 are provided in Table 5.5.8.

Table 5.5.8. Comparison of Major LLW (DOE Order 5820.2A and Frei 1996) and HLW (40 CFR 191) Disposal Requirements

Requirement	LLW	HLW
Compliance timeframe	1,000 yr	10,000 yr
Institutional control assumption	100 yr	100 yr
Dose to member of public	25 mrem/yr (10 mrem/yr via air; 25 mrem/yr all pathways)	15 mrem/yr
Point-of-compliance for member of public	Land Use Boundary; Groundwater at 100 m (330 ft) downgradient of Site or applicable groundwater protection management program or plan	At land surface; Groundwater at 5 km (3 mi) radius of Site
Dose to inadvertent intruder	100 mrem/yr all pathways; 500 mrem chronic	Not required
Groundwater protection standard	40 CFR 141	40 CFR 141

The NRC initially defined the boundary between HLW and incidental waste as the result of concerns raised about the amount of radioactivity that would be disposed onsite in near-surface grout vaults at the Hanford Site. DOE planned to treat liquid HLW from the tanks, vitrify the high-level fraction for eventual disposal in a geologic repository, and treat the incidental waste fractions by mixing them with a cement-like grout, and disposing of the mixture in near-surface vaults (DOE 1987 and Cochran and Shyr 1998a).

A petition by Washington, Oregon, and the Yakama Indian Nation asked the NRC to change the definition of HLW so that NRC would regulate the Hanford Site tank waste destined for the grout vaults. The states and Tribe petitioned because of their concern that DOE was not doing all it could to separate HLW radionuclides from the waste prior to onsite disposal. The petition was specific to the treatment facility and the wastestream proposed for the vaults.

In the petition, the NRC was asked to adopt a rule classifying all waste in the tanks as HLW unless the NRC determines on a case-by-case basis that DOE has eliminated as much radioactivity from the material to be grouted as "technically feasible," and the NRC would oversee the pretreatment process.

In response to the petition, the NRC defined a set of three tests to determine if a wastestream is incidental waste. In this report, these three tests are identified as the Incidental Waste Criteria. These same criteria were presented in a letter from R. Bernero, NRC to J. Lytle, DOE dated March 2, 1993 (NRC 1993).

Importantly, "there was no fundamental challenge to the concept of incidental wastes" (58 FR 12344). Therefore, if a waste can be demonstrated to be incidental, the waste is not HLW and not subject to NRC licensing. The Incidental Waste Criteria was originally developed for evaluating a wastestream from a processing plant, however, application of these same criteria to the SST residual waste is a viable closure option. Each of the Incidental Waste Criteria are discussed in the following sections, with respect to application to the SST residual waste.

Technically and Economically Practical

In 1996, DOE petitioned the NRC for a determination that a certain wastestream from a treatment plant is incidental waste, and therefore not subject to NRC licensing (DOE 1996b). In the technical basis for the petition, the criteria for technically and economically practical is "determined by the total life-cycle cost per curie removed" and the economically practical limit is "the point where additional removal costs increase significantly." Further, an economic assessment is not provided if a technology option is "not technically practical" (WHC 1996b). In reviewing these definitions, the NRC staff agreed that DOE had satisfied the "technically and economically practical" criteria (NRC 1997).

Not to Exceed Class C Limits

This test compares the concentrations of radionuclides in the wastestream to the 10 CFR 61 Class C limits. Initially the test was applied in 1993 to the wastestream destined for the Hanford Site grout facility (i.e., waste combined with grout). The same test may not apply to SST residual waste. However, if grout were mixed with the residual waste prior to final closure, the test may be applicable to the combination of grout and residual waste (Cochran and Shyr 1998a,b). This is the approach that was recently employed by Savannah River for closure of tank 20.

Performance Objectives Comparable to 10 CFR 61

10 CFR 61 is the standard for disposal of NRC-regulated LLW. 10 CFR 61 is not applicable to disposal of DOE-titled LLW, therefore the NRC could not require DOE to comply with NRC regulations for disposal of LLW. The NRC asked DOE to provide comparable protection of human health (NRC 1997). The NRC has agreed that DOE Order 5820.2A, Chapter III is comparable to 10 CFR 61 (NRC 1997).

On three occasions, the NRC has provisionally agreed that the LAW fraction, from a treatment facility for Hanford Site tank waste is not HLW, meets the criteria for incidental waste, and is not subject to NRC licensing (NRC 1989, 1993, and 1997). The first occasion was shortly after the completion of the DOE EIS, Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes (DOE 1987), when DOE and NRC staff met to discuss the preferred alternative proposed in the EIS. That preferred alternative was to treat the wastes from the DST and dispose the LAW fraction from the treatment facility as grout in near-surface vaults. The NRC provisionally agreed that the LAW fraction from the treatment facility would not be HLW subject to NRC licensing (NRC 1989). The NRC further suggested that if DOE could demonstrate that at least 90 percent (the largest practical amount) of first cycle solvent extraction waste had been removed, the NRC would concur that the LAW would not be subject to NRC licensing and could be disposed in the near-surface vaults.

Subsequently, DOE made three major changes to the strategy for managing tank waste. First, concerns about the stability of grout resulted in the decision to vitrify the LAW fraction (instead of making grout), second, DOE treatment facilities will be privatized, and third, waste from the SSTs will be combined with the waste from the DSTs prior to treatment (DOE 1996c). Reflecting these three changes in the strategy for managing the tank waste, the DOE requested NRC agreement that Hanford Site tank waste planned for removal from the SSTs and DSTs and disposal onsite as vitrified LAW would not be HLW, and therefore, not subject to NRC licensing (DOE 1996b). DOE based their November 7, 1996, request on the report titled Technical Basis

for Classification of Low Activity Waste Fraction from Hanford Tanks (WHC 1996b) and Hanford Low-Level Tank Waste Interim Performance Assessment (WHC 1996c). This DOE request addressed the three changes in management strategy that occurred subsequent to the NRC acceptance of the previous strategy defined at 58 FR 12344.

The NRC responded to the DOE request in a letter that addresses the LAW fraction from the treatment facility. There are several portions of the NRC response that are relevant to closure of the SST residual waste. These portions include the following.

- LAW meets the incidental waste classification criteria specified in the March 2, 1993 letter from R. Bernero, NRC, to J. Lytle, DOE (NRC 1997).

The March 2, 1993 letter to J. Lytle is included as an Appendix to Technical Basis Report (WHC 1996b). The criteria in the Lytle letter are identical to the criteria presented in 58 FR 12344. Therefore, the three criteria presented in 58 FR 12344 continues to be the criteria used to determining if a waste is incidental rather than high-level.

- The staff's preliminary finding is a provisional agreement that the LAW portion of the Hanford tank waste planned for removal from the tanks and disposed onsite is incidental waste and is, therefore, not subject to NRC licensing authority. Staff considers that the information presented is not sufficient to make an absolute determination at this time (NRC 1997).

The NRC agreement with the DOE proposal is provisional because much of the information presented to the NRC is draft or generic (e.g., DOE has not selected an onsite disposal configuration for the LAW). Also, the NRC accepts the format of the Technical Basis Report as a format for documentation of compliance with LLW requirements.

- Approximately 8.5 MCi of activity will remain in the LAW fraction, which corresponds to about 2 percent of the estimated 422 MCi generated at the Hanford Site (based on a December 31, 1999, decay date) (NRC 1997).

Early discussions of the criteria for incidental wastes were based, in part, on percentage removal (e.g., if 90 percent were removed, the remaining fraction might be incidental waste). Current criteria for incidental waste does not specifically set a limit on the percentage of curies that must be removed, however, as this statement reflects, percentage removal is still a secondary consideration.

- "The DOE PA was performed to the requirements of DOE Order 5820.2A, 'Radioactive Waste Management,' September 26, 1988. This Order is similar to the 10 CFR Part 61 performance objectives" (NRC 1997).

The NRC agreed that the requirements LLW of DOE Order 5820.2A, Chapter III are comparable to the LLW requirements in 10 CFR 61.

- "Please submit future PAs as supplements to the Technical Basis Report so that they can be reviewed to confirm the current analysis and resolve any outstanding issues" (NRC 1997).

The NRC also indicated that it plans to take an active role in reviewing the DOE LLW performance assessments for the onsite disposal of incidental waste.

5.5.4.4 Corrective Actions

As a result of groundwater contamination at certain SST farms, Ecology and the EPA have imposed corrective action on some of the SST farms. Therefore, the following sections describe the Federal and State regulations for corrective action under RCRA and the Tri-Party Agreement and how these corrective actions may influence tank waste retrieval and closure strategies.

5.5.4.4.1 Corrective Action Regulations

Washington State Requirements (WAC 173-303-645 and WAC 173-303-646)

Washington State also has programs for groundwater corrective action and corrective action for releases from facilities that manage solid or hazardous waste. On November 4, 1994, Ecology received authorization from EPA to implement corrective actions under the HSWA of 1984 for the Hanford Site (Ecology et al. 1996). In Washington State, the corrective action for releases from SWMUs can be one of two types: a conventional corrective action, which is conducted under Washington State Dangerous Waste Regulations, or an alternative corrective action, which is imposed using the State Superfund-like cleanup authority under MTCA. And, finally, it may consist of a hybrid of the two types of authorities (Rosenthal 1997). Washington State may compel corrective action by issuing State-only corrective action orders under MTCA to owners or operators of facilities required to have a dangerous waste permit. State-only corrective action orders generally are issued in advance of the permit or permit modification, but ultimately would be incorporated into the facility dangerous waste permit (Rosenthal 1997).

Some portions of the Washington State program are more stringent than the Federal corrective action program. The more stringent portions are not enforceable by EPA but are enforceable by the State (Rosenthal 1997). Some of the requirements that are more stringent include the following.

- The Washington State corrective action covers a broader range of constituents. In addition to the Federally defined hazardous wastes, Washington State's program covers releases of dangerous wastes and hazardous substances subject to MTCA (Ecology 1994b).

- The State corrective action program covers all releases including releases from regulated units that occurred prior to the effective date of RCRA, releases to the environment other than the uppermost aquifer, and releases from other sources in addition to regulated units and SWMUs.

- Cleanup levels are determined using the MTCA risk assessment process. The MTCA process is less flexible than EPA's process for determining cleanup levels.

Levels calculated using MTCA are, in many cases, more protective than those required by Federal guidelines (Ecology 1994b).

Ecology generally follows the Federal corrective action process. Ecology requires the performance of a RCRA facility assessment, including identifying SWMUs and releases or potential releases from them (Ecology 1994b). RCRA facility investigations also are required. Because the MTCA cleanup program does not use the concept of action levels, Ecology applies this concept on a case-by-case basis, generally using the MTCA Method A, B, and C table values as action levels (Ecology 1994b). A corrective measures study must use the MTCA preference for remedies (i.e., reuse or recycling, destruction or detoxification, reduction of the amount of the waste, containment, and disposal) (Ecology 1994b). Remedy selection criteria include the Federal criteria and also must provide for appropriate management of remedial-generated waste and consider public concerns (Ecology 1994b). After implementing the final remedy, periodic site reviews are required if residual contamination is present or if a point-of-compliance is established so that the entire site is not remediated (Ecology 1994b).

Currently, seven SST WMAs are monitored as TSD facilities. These SST WMAs are under RCRA TSD requirements in 40 CFR 265 and WAC 173-303-400 for groundwater monitoring as interim status TSD units (PNNL 1998). WMA A-AX SSTs, WMA C SST, and WMA U SST are in groundwater monitoring and are being evaluated for indicator parameters. Should indicator parameter evaluation monitoring TSD units detect concentrations of contaminants statistically above acceptable limits under RCRA interim status (Part A), then the TSD or RCRA past-practice unit would go under groundwater quality assessment monitoring.

WMA B-BX-BY SSTs, WMA S-SX SSTs, WMA T SST, and WMA TX-TY SSTs are in Groundwater Quality Monitoring, which is comparable to compliance monitoring under Final Status Groundwater Monitoring for TSD and RCRA past-practice units. Based on findings from WMA B-BX-BY SSTs, WMA S-SX SSTs, WMA T SST, and WMA TX-TY SSTs, these units will proceed into corrective action groundwater monitoring (Johnson and Chou 1998, Hodges 1998, Narbutovskih 1998).

If a TSD unit or RCRA past-practice unit requires groundwater remediation, this is conducted as a RCRA corrective action. As an example, currently 200-PO-1, a Groundwater Operable Unit located in 200 East Area, is a RCRA past-practice unit receiving contaminant monitoring. In addition, 100-NR-2, 100-HR-3, and 200-UP-1 are in assessment monitoring for the pump-and-treat contaminant project (PNNL 1998). According to the Tri-Party Agreement, "Ecology reserves the right to enforce timely cleanup of TSD associated groundwater contamination as provided in Article XLVI" (Reservation of Rights) (Ecology et al. 1994).

Corrective Actions under the Tri-Party Agreement

Milestones are incorporated into Appendix D of the Tri-Party Agreement addressing submittals of various RCRA corrective action work plans through RCRA facility investigations and corrective measures studies. According to the Tri-Party Agreement, DOE will investigate the contamination at the operable unit and study strategies for cleaning up the problem. Following a public comment period, Ecology will select the remedy for RCRA corrective actions.

A work plan will be developed for each operable unit that will address all activities from the start of field investigations through the proposed selection of a remedy for cleanup. Both the work plan and the documentation of the selected remedy will be made available for public comment (from Part 3, Article XIV, Work) (Ecology et. al 1996).

A recent draft Federal Facility Agreement and Consent Order Change Control Form number M-45-98-03 was issued on January 7, 1999, which will modify the Tri-Party Agreement. Modification includes 1) integration of groundwater and vadose zone activities related to corrective actions at DOE's SST WMAs, 2) interim measures identified to-date as initial response actions to SST leaks, and 3) commitments between the parties regarding the use of HWMA and RCRA corrective action processes. Ecology and DOE agree that work under this M-45-98-03 change will be managed through one unified schedule incorporating Agreement milestones, DOE (internal agency) milestones, and DOE contractor baseline. This change will incorporate Site-specific RFI/CMS workplans for characterization of the nature and extent of contamination into one overall RFI/CMS workplan when completed. Figure 5.5.4 illustrates the new Tri-Party Agreement Milestones related to corrective action for SST WMAs B-BX-BY, S-SX, T, and TX-TY.

5.5.4.4.2 Past Leaks

A groundwater detection monitoring system for the SST farms has been installed and is monitoring groundwater quality beneath the tank farms (PNNL 1996 and BHI 1996). Based on evaluations of groundwater samples from beneath four of the seven SST WMAs, RCRA groundwater quality assessment monitoring programs have been initiated. RCRA facility assessments are underway for the T, TX-TY, B-BX-BY, C, and S-SX WMAs. The assessments are being conducted under Washington State requirements for interim status facilities (WAC 173-303-400), which incorporate by reference EPA interim status standards (40 CFR 265) (WHC 1996b).

Washington State regulations also incorporate by reference the EPA corrective action program (WAC 173-303-646). The groundwater quality assessment is the first step in a corrective action process (WAC 173-303-645). The assessments have determined that the tank farms have impacted groundwater quality; therefore, a study of potential corrective measures will be conducted to support decisions on the implementation of corrective actions to mitigate further impacts to the groundwater from the tank farms and to remediate groundwater (Johnson and Chou 1998, Hodges 1998, Narbutovskih 1998).

Besides impacts to groundwater, soil concentrations from past AX Tank Farm leaks and spills (based on the assumption that the source term consisted of tank liquors and not header leak loss concentrations) would exceed regulatory limits for concentration levels for Cs-137 in soils (Norman 1999). These calculations are based on soil volume adjacent and above the tanks as estimated from engineering studies developed for the RPE (COGEMA 1998, Norman 1999, SESC 1997, Skelly 1999). Thus, a basis for remediation of soils contaminated by past leaks may exist under State corrective action regulations.

5.5.4.4.3 Retrieval Loss

Under the Tri-Party Agreement, both SSTs and DSTs are RCRA hazardous SWMUs managed under Washington State Dangerous Waste Regulations (WAC 173-303). Waste retrieval actions to support managing waste volume, resolving safety issues, and implementing treatment specified under the Tri-Party Agreement would be subject to requirements regarding intentional or accidental spills and discharges to the environment that threaten human health or the environment, regardless of the quantity of the waste (WAC 173-303-645). Therefore, if waste is released to the environment during tank farm operations associated with waste retrieval, DOE would be required to:

- Notify appropriate State and local agencies
- Take appropriate actions to protect human health and the environment through control or mitigation of the spill or release
- Perform complete or partial cleanup of all released wastes to ensure compliance with applicable laws and regulations and to the extent necessary based on the nature of the substance and human and environmental risks.

Tri-Party Agreement Milestone M-45-08 addresses the mitigation of tank leakage during waste retrieval operations. Under Milestone M-45-08-T02, DOE, in consultation with stakeholders and Tribal Nations, is to develop a process for establishing potential leakage volumes and acceptable LDMM necessary to permit retrieval operations. Based on the evaluation of the potential environmental and human health impacts of various waste retrieval leakage scenarios within the context of past tank leaks, tank waste residuals following completion of retrieval actions, and the end state of the tank farms and evaluation of LDMM measures, Ecology will determine potential leakage volumes and acceptable LDMM measures (DOE 1997). Analysis of leakage volumes during retrieval actions may influence the type of retrieval technologies that can be deployed on a tank-by-tank basis, the level of waste that can be practicably retrieved from any particular tank, and the ability of various closure options to comply with closure regulations. Although potential leakage volumes during retrieval operations are permitted through the Tri-Party Agreement, Ecology reserves the right to enforce mitigation measures and cleanup of these approved leaks based on Milestone M-45-08, "Establish full-scale capability for mitigation of waste tank leakage during retrieval sluicing operations" (Ecology et al. 1996). These potential leakage volumes may require corrective actions if failure of the acceptable leakage detection/monitoring mitigation measures or inappropriate monitoring occurs.

For the AX Tank Farm retrieval leakage loss as analyzed based on a zero retrieval leakage loss, a 30 m^3 (8,000 gal.), and a 151 m^3 (40,000 gal.) were evaluated. Both the 30 m^3 (8,000 gal.), and a 151 m^3 (40,000 gal.) retrieval leakage loss were evaluated based on soil contamination concentrations that may trigger corrective action requirements.

Soil waste concentration analysis results in Appendix B of Norman (1999) indicate the soil waste concentration levels would exceed waste acceptance criteria and Class C LLW limits for disposal of Category 1 and Category 3 waste and this indicates that soil contamination concentrations may trigger corrective action requirements for retrieval leakage losses of 30 m^3 (8,000 gal.) or greater. Further discussion is provided in Section 6.1.6.

5.5.4.5 Land Disposal Restrictions

This section describes land disposal restrictions (LDRs) and identifies issues regarding the applicability of the LDR to tank waste residuals and the tank farm system (e.g., tank structures, ancillary equipment, and contaminated soil).

The LDR regulations govern treatment and disposal methods, characterization and analysis, labeling and accumulation, documentation, training, record keeping, offsite shipments, and exemptions. This section focuses on the treatment standards and the storage prohibition.

5.5.4.5.1 Federal Treatment Standards and Storage Prohibition

Compliance with LDR treatment standards is required prior to land disposal, unless a treatment variance is granted or another exemption is applicable. Treatment standards include the following.

- All hazardous constituents in the waste or in the treatment residue must be at or below contaminant concentrations provided in the rule.
- Hazardous constituents in the extract of the waste or in the extract of the treatment residue must be at or below contaminant concentrations provided in the rule.
- The waste must be treated using a best-demonstrated available technology (BDAT) specified in the regulation.

The LDR treatment requirement for high-level mixed waste generated during the reprocessing of fuel rods is vitrification (for non-wastewaters only). EPA defines vitrification as occurring "in units in compliance with all applicable radioactive protection requirements under control of the [NRC]" (40 CFR 268.42 and WAC 173-303-140).

If the high-level mixed waste treatment standard via vitrification is inapplicable, then DOE will need to consider other potential LDR treatment standards for mixed waste, such as:

- Macroencapsulation for mixed waste containing elemental lead (e.g., reactor shielding)
- Amalgamation with zinc for mixed waste containing elemental mercury
- Incineration for radioactive mercury-contaminated oils (40 CFR 268.40).

Where there is no specific treatment standard for the high-level mixed waste in the tanks, the treatment standard for the hazardous waste constituent applies. Also, hazardous debris containing radioactive waste is subject to the treatment standards for debris.

Mixed radioactive/hazardous debris is prohibited from land disposal unless the debris meets the treatment standards for the contaminating constituents or meets the decontamination standards of the Hazardous Debris Rule (40 CFR 268.45), or an exemption applies (40 CFR 268.35). See Jacobs (1998c) for more information on the Hazardous Debris Rule.

Hazardous soil contaminated with wastes having treatment standards based on incineration, mercury retorting or vitrification, and soils contaminated with hazardous wastes listed in 40 CFR 268.10, 268.11, and 268.12 that are mixed radioactive/hazardous wastes, are prohibited from land disposal (40 CFR 268.35(e)(4)). Thus, soil contaminated with HLW can not be exhumed and disposed elsewhere, unless compliant with the LDRs or an exemption applies.

To prevent facilities from circumventing the treatment requirements, EPA also prohibited the storage of untreated LDR waste for any period longer than necessary to accumulate amounts necessary to facilitate proper recovery, treatment, or disposal. Storing mixed waste beyond 1 yr, even though no technology exists to treat it, is a violation of the LDR storage prohibition (40 CFR 268.50). EPA's position was upheld in the Washington, D.C. District Court of Appeals (Edison 1993). However, the FFCA allows for DOE facilities with mixed waste to continue storing mixed waste (Rosenthal 1997).

5.5.4.5.2 Washington State Land Disposal Restrictions

Washington State's Dangerous Waste Regulations incorporate the Federal LDRs by reference (WAC 173-303-140). However, not all of the LDRs have been delegated by EPA to the State. Thus, EPA implements any requirements under undelegated LDRs. Nevertheless, Washington State can impose its LDRs as a function of State law. If it is determined which LDRs are applicable to tank waste residuals; tanks or ancillary equipment, or contaminated soils, a review of the jurisdiction of the EPA and Ecology for each LDR should be completed (Rosenthal 1997).

The State LDRs prohibit the land disposal of State-only dangerous wastes, including extremely dangerous waste, liquid waste, solid acid waste, and organic/carbonaceous waste, except under specified circumstances (WAC 173-303-140). If the LDRs are deemed applicable to the tank residue, DOE will need to determine whether the tank residue contains any of these State-only dangerous wastes. Land disposal of extremely dangerous waste in Washington State is prohibited except in an approved facility at the Hanford Site. The Hanford Site extremely dangerous waste facility has not been constructed (Ecology Undated).

5.5.4.5.3 Land Disposal Restriction Exemptions

Exemptions for State-Only Dangerous Wastes

Exemptions from State-only dangerous waste land disposal prohibitions include exemptions for treatment residuals and an exemption based on economic hardship.

Treatability Variance

If LDRs are determined to be applicable to tank residual waste or contaminated soils and the waste cannot be treated to meet a total or extract concentration level or the treatment technology is not appropriate to the waste then "The petitioner must demonstrate that because the physical or chemical properties of the waste differs significantly from waste analyzed in developing the treatment standard, the waste cannot be treated to specified levels or by the specified methods" (40 CFR 268.44 and WAC 173-303-140).

EPA has established a presumption that until specific standards for soil are developed, current BDAT standards generally are considered to be inappropriate for contaminated soil for CERCLA response actions and RCRA corrective actions and closures. EPA presumes that because

contaminated soil differs substantially from the wastes evaluated in establishing the BDAT standards it qualifies for a treatability variance (EPA 1990). A treatability variance does not remove the requirement to treat contaminated soil. Rather, alternative treatment standards based on data from actual treatment of soil become the treatment standard that must be met (Rosenthal 1997). EPA has issued guidance providing appropriate levels or percentage reductions of hazardous wastes (EPA 1990).

No Migration Petition

A no migration petition allows for land disposal of hazardous waste, if it is adequately demonstrated that there would be no migration of hazardous waste from the disposal unit as long as the waste remains hazardous (40 CFR 268.6). A monitoring program to detect any releases is also required. A no migration petition would be site-specific, if not tank-specific.

Petitions must be submitted to the EPA. Under the RCRA program, typically no migration petitions are submitted for operating units (i.e., not for units undergoing closure). However, if DOE determines that most likely it can meet the technical requirements for a petition, it would first consult with EPA and Ecology about the possibility of submitting a no migration petition for tanks that are not clean-closed for the postclosure period.

5.5.4.6 Postclosure Care Requirements

Clean Closure Approach

For clean closure, no postclosure vadose zone and groundwater monitoring is required if the unit has been clean closed and if monitoring during unit operations has shown no migration beyond the treatment zone during facility operations. Clean closure of the AX Tank Farm could apply to Strategy 2 and Options 2a, 2b, and 2c.

Modified Closure Approach

For modified closure, no postclosure care of the vadose zone and groundwater monitoring system is required if there is no potential for migration of liquid from the unit to the uppermost aquifer during the closure and postclosure care period. This determination is based on analysis that provides an adequate margin of safety by using predictions based on assumptions that maximize the rate of liquid migration (WAC 173-303-645(b)(iii-iv)).

However, postclosure care would be required if dangerous waste or waste residuals are left in place at concentrations above numeric cleanup levels determined using residential exposure assumptions under MTCA Methods A or B (Ecology 1994a). Postclosure care requirements are described in the Hanford RCRA Permit under Condition II.K.3 (Ecology 1998). For the postclosure care requirements, DOE shall provide 1) institutional controls in accordance with WAC 173-340-440 which restricts access to the TSD unit for a minimum of 5 years following completion of closure, and; 2) periodic assessments of the TSD unit to determine the effectiveness of the closure. The periodic assessments shall include, at a minimum, a compliance monitoring plan in accordance with WAC 173-340-410 that will address the assessment requirements on a unit-by-unit basis. At least one assessment activity shall take place after a period of 5 years from the completion of closure, which will demonstrate whether the soils and groundwater have been maintained at or below the allowed concentrations as

specified in Parts III, V, and VI of the Hanford RCRA Permit. Should the required assessment activities identify contamination above the allowable limits as specified, the TSD unit must be further remediated or the requirements for landfill closure must be followed. Should the required assessment activities demonstrate that contamination has diminished or remained the same, DOE may request that Ecology reduce or eliminate the assessment activities and/or institutional controls, and shall specify the specific activities required by this condition in a post-closure permit application.

Modified closure of the AX Tank Farm could apply to Strategy 2 and Options 2a, 2b, 2c, and 2d.

Landfill Closure Approach

For landfill closure, the owner must comply with postclosure care requirements contained in WAC 173-303-610(7), (8), (9), and (10), which include 1) continuing postclosure care for 30 yr (which can be decreased or increased by Ecology); 2) maintaining a postclosure plan to address activities that will be carried out to monitor and maintain the integrity of the landfill; 3) notifying local land authorities of the location of the landfill; and 4) providing a notice in the deed to the property that restricts land usage and includes the type, location, and quantity of dangerous waste disposed of in the landfill. Additionally, the owner and operator must "maintain and monitor the groundwater system and comply with all other applicable requirements of WAC 173-303-645 that regulate releases from regulated units and require implementation of corrective actions if releases exceed levels established in the closure permit. WAC 173-303-645 may require DOE to install vadose zone monitoring for some or all of the TSD units where past tank leaks have contaminated surrounding soils that would not be remediated to background levels.

Landfill closure of the AX Tank Farm could apply to Strategy 1 and its options and the No Soil Treatment option (Option 2d).

5.6 STAKEHOLDER AND TRIBAL NATION VALUES

In early 1997 DOE and Ecology initiated consultations with stakeholders and Tribal Nations to receive input on RPE criteria. These consultations were scheduled to ensure that a wide range of stakeholders and all affected Tribal Nations were provided an opportunity to give DOE input and guidance on the analysis of retrieval and total system performance that should be addressed when evaluating retrieval performance criteria. The technical approach in Section 3.9 discusses the values identified by the stakeholders and Tribal Nations. The values that were identified include:

- Protect the environment
- Protect worker health and safety
- Protect public health and safety
- Get on with cleaning the waste
- Use a systems approach
- Protect the Columbia River
- Enable future site uses
- Protect the rights of Native Americans
- Ensure regulatory compliance
- Reduce cost
- Data quality and uncertainty.

5.6.1 Protect the Environment

Performance measures were identified in Section 3.9.3.1 that would support an evaluation of whether a waste retrieval and tank farm closure action would attain this value.

5.6.1.1 Number of Acres of Shrub Steppe or Other Habitat Disturbance

All strategies and options (except No Action) would require fill material from borrow sites. For this analysis it was assumed that the borrow sites would include the Vernita Quarry and McGee Ranch, which lie to the north and west of the AX Tank Farm, and Pit 30 borrow site, which is located between the 200 East and 200 West Areas. In addition to land disturbance at the borrow sites, Strategy 2 and all Strategy 2 options would require the disturbance of an additional 4.1 ha (10 ac) for the construction of a Preprocessing Facility including parking and setbacks. The number of additional acres disturbed at these borrow sites for each strategy and option, as well as the additional land disturbed from constructing the Preprocessing Facility for Strategy 2 and all Strategy 2 options, are presented in ascending order as follows:

• No Action (Strategy 3)	0 ha (0 ac)
• Baseline Retrieval/Restricted Land Use (Strategy 1)	1.2 ha (3.0 ac)
• Nominal Retrieval Losses (Option 1a)	1.2 ha (3.0 ac)
• Large Retrieval Losses (Option 1b)	1.2 ha (3.0 ac)
• Optimal Residual Volume (Option 1c)	1.2 ha (3.0 ac)
• Suboptimal Residual Volume (option 1d)	1.2 ha (3.0 ac)
• Nominal Losses/Soil Grouting (Option 1g)	1.2 ha (3.0 ac)
• Temporary Operations Barrier (Option 1e)	1.2 ha (3.0 ac)
• Large Losses/Soil Grouting (Option 1h)	1.2 ha (3.0 ac)

- Postretrieval Hanford Barrier (Option 1f) 3.1 ha (7.5 ac)
- Past Leak/In Situ Soil Treatment (Option 2b) 9.7 ha (24 ac)
- Nominal Losses/In Situ Soil Treatment (Option 2c) 9.7 ha (24 ac)
- No Soil Treatment (Option 2d) 10.5 ha (26 ac)
- Baseline Retrieval/Unrestricted Land Use (Strategy 2) 10.9 ha (27 ac)
- Nominal Losses/Excavate Soil (Option 2a) 13.0 ha (32 ac).

It would require less fill material to grout the tanks and ancillary equipment and construct a surface barrier over the tank farm for the restricted land use options than it would to backfill the excavation pit resulting from removing the tanks and soil for the unrestricted land use options. The Postretrieval Hanford Barrier option would require more fill material than the other restricted land use options because of the increased size of the Hanford Barrier compared to the enhanced RCRA Subtitle C barrier used by the other options. The Nominal Losses/Excavate Soil option would require more fill material than the other unrestricted land use options because of the increased excavation requirements to remove the contaminated soil from the potential retrieval leakage loss.

5.6.1.2 Number of Acres Impacted by Soil Deposition

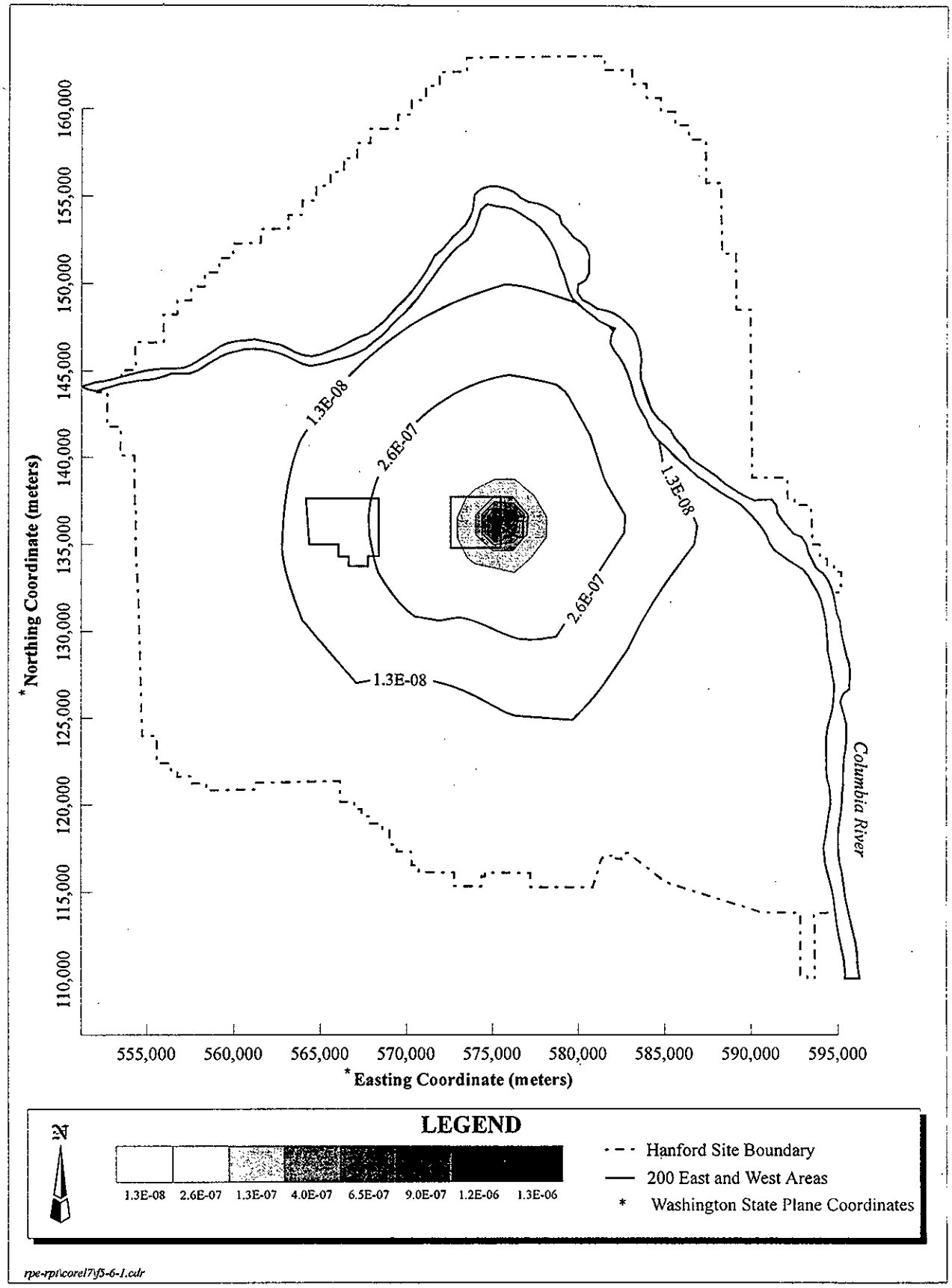
The health risk resulting from routine atmospheric releases of radiological constituents depositing on the ground during normal operations were plotted on contours using atmospheric dispersion coefficient (Chi/Q) isopleths, as shown in Figure 5.6.1. The contour plots were generated using the GXQ computer program. The LCF health risk was based on ingestion for a hypothetical receptor raising food in the contaminated soil and immediately following remediation. Retrieval would have the greatest impact and would be the same for all restricted and unrestricted land use strategies and options. Approximately 81 ha (200 ac) would be contaminated at levels that would result in air LCF risk to the receptor that would exceed 1.0E-06. The LCF risk to the receptor would be approximately 5.5E-06.

5.6.1.3 Number of Acres of Groundwater Impacted by Contamination

The health risk to the Native American land user resulting from past tank leaks and spills, retrieval leakage loss, and residual waste was evaluated and plotted on contours in Section 5.3.1. Contours were plotted for a Strategy 1 Option 1a (Nominal Retrieval Losses), Strategy 2 Option 2a (Nominal Losses/Excavate Soil), and Strategy 3 (No Action). The Nominal Retrieval Losses option would result in a peak contamination of approximately 13,500 ha (33,500 ac) of groundwater at levels that would exceed an ILCR of 1.0E-06 to the Native American land user at approximately 150 yr. The Nominal Losses/Excavate Soil option would result in a peak contamination of approximately 9,500 ha (23,500 ac) at approximately 200 yr. The No Action strategy would result in a peak contamination of approximately 22,100 ha (54,600 ac) at approximately 2600 yr. The strategies and options evaluated in Section 5.3.1 that would result in higher health risks could potentially result in a larger area of contaminated groundwater. Therefore, it is assumed that Large Retrieval Losses (Option 1b) and Suboptimal Residual Volume (Option 1d) options would result in an excess of 13,500 ha (33,500 ac).

Postretrieval Hanford Barrier (Option 1f), Nominal Losses/Soil Grouting (Option 1g), Large Losses/Soil Grouting (Option 1h), Temporary Operations Barrier (Option 1e), Optimal Residual

Figure 5.6.1. ILCR From Ingestion (Immediately Following Remediation)



Volume (Option 1c), and Baseline Retrieval/Restricted Land Use (Strategy 1) would result in less than 13,500 ha (33,500 ac). No Soil Treatment (Option 2d), Nominal Losses/In Situ Soil Treatment (Option 2c), and Past Leak/In Situ Soil Treatment (Option 2b) would result in an excess of 9,500 ha (23,500 ac). Baseline Retrieval/Unrestricted Land Use (Strategy 2) would result in less than 9,500 ha (23,500 ac).

5.6.1.4 Impacts to Threatened or Endangered Species

For Strategies 1 and 2 and all options under the two strategies, there would be a disturbance of 1.2 to 13.0 ha (3 to 32 ac) of previously undisturbed land depending on the strategy or option. The land disturbance could affect the habitat of threatened or endangered species. There would be no disturbance of previously undisturbed land for No Action. The radiological and chemical impacts on threatened or endangered species from emissions during normal operations will require further analysis at a future date.

5.6.1.5 Permanent Changes to Site Topography or Views from Vistas

Permanent changes to site topography or views from vistas would include changes in the terrain at the borrow sites and permanent barriers over the AX Tank Farm.

The disturbed acres of previously undisturbed land were addressed in the preceding text. A permanent barrier would be constructed over the AX Tank Farm after closure activities have been completed for the landfill closure options and the No Soil Treatment option (Option 2d).

An enhanced RCRA Subtitle C barrier would be used on these options with the exception of the Postretrieval Hanford Barrier option that would use a Hanford Barrier. The enhanced RCRA Subtitle C barrier and Hanford Barrier would have a footprint of 1.5 ha (3.7 ac). The enhanced RCRA Subtitle C barrier would be 1.7 m (5.6 ft) high and the Hanford Barrier would be 4.5 m (14.8 ft) high. The Baseline Retrieval/Unrestricted Land Use strategy and associated options except for No Soil Treatment (Option 2d) would not require a barrier.

5.6.2 Protect Worker Health and Safety

Performance measures were identified in Section 3.9.3.1 that would support an evaluation of whether a waste retrieval and tank farm closure action would attain this value. The results of a detailed evaluation of worker health and safety are presented in Section 5.1 for the various strategies and options.

5.6.2.1 Risk of Worker Illnesses, Injuries, and Fatalities During Routine Operations

Worker health risks were evaluated for worker exposures to radiological and chemical emissions during normal operations. Risk from radiological exposure was evaluated in terms of LCFs. Risk from chemical exposure was evaluated in terms of noncarcinogenic health hazards (e.g., toxic or corrosive health effects) and ILCRs from exposure to carcinogenic chemicals. Health risk to the workers included involved workers and noninvolved worker population risks as well as health risk to the MEIs. The short-term risks to the workers (involved and uninvolved) from normal operations as they apply to each strategy and option are summarized as follows.

- The noncarcinogenic HI would be 0.023 for all strategies and options except No Action (Strategy 3), which would have an HI of 0.0017.

- The ILCR would be 1.8E-06 for all strategies and options except No Action, which would have an ILCR of 1.6E-08.

- The LCF risk to the worker MEI would be 0.10 for all restricted land use options and 0.0018 for all unrestricted land use options except Nominal Losses/Excavate Soil (Option 2a), which would have an LCF risk of 0.11. The risk for restricted land use options would be driven by worker exposure while grouting ancillary equipment. The risk for unrestricted land use options (except Nominal Losses/Excavate Soil) would be driven by worker exposure during tank removal. The risk for the Nominal Losses/Excavate Soil option would be driven by worker exposure during removal of soil contaminated from potential retrieval leakage loss. The LCF risk to the MEI worker for No Action would be 0.006.

- The LCF risk to the worker population would be 1.0 to 1.2 for all restricted land use options and 0.67 for all unrestricted land use options except for Nominal Losses/Excavate Soil option. The restricted land use options LCF risk are driven by retrieval and grouting ancillary equipment, and the unrestricted land use options are driven by retrieval. The Nominal Losses/Excavate Soil option would have a 1.1 LCF risk as a result of removing the soil contaminated from potential retrieval leakage loss. The LCF risk to the worker population for No Action would be 0.00056.

5.6.2.2 Risk of Worker Illnesses, Injuries, and Fatalities Resulting from an Accident

Worker health risks were evaluated for accident conditions. Accidents are unplanned events or a sequence of events that would cause undesirable consequences. The analysis addressed occupational, transportation, radiological, and chemical accidents.

Occupational risks included the nonradiological/nontoxicological injuries, illnesses, and fatalities from construction and operations common to the workplace such as falls and cuts and operator-machine impacts. Transportation accidents included injuries and fatalities resulting from potential accidents while transporting materials to support construction and operation activities. Radiological and chemical risks were associated with accidents that could result in radiological and chemical emissions. Radiological risk resulting from an accident is expressed as a point-estimate LCF risk. Chemical risk was evaluated against ERPGs. The short-term risk to the workers (involved and uninvolved) from accidents as they apply to each strategy and option are summarized as follows.

- The bounding evaluated chemical accident for all strategies and options would result in a lethal radiological exposure to the MEI worker, therefore, a chemical risk was not evaluated.

- The point-estimate LCF risk to a MEI worker would be 8.1E-05 for all restricted land use options and 0.010 for all unrestricted land use options except Nominal Losses/Excavate Soil, which would be 0.011. The bounding accident for the restricted land use options was an ancillary grouting accident. The bounding accident for the unrestricted land use

option accident (except Nominal Losses/Excavate Soil) was a tank removal accident. The bounding accident for the Nominal Losses/Excavate Soil option was a soil removal accident. The point-estimate LCF risk to the MEI worker for No Action would be 0.014, which would result from an earthquake.

- The point-estimate LCF risk to the worker population would be 0.00057 for all restricted land use options and 0.00013 for all unrestricted land use options. The bounding accident for the restricted land use options was an ancillary grouting accident. The bounding accident for the unrestricted land use option accident was a retrieval accident. The point-estimate LCF risk to the worker population for No Action would be 0.16, which would result from an earthquake.

- Injuries and fatalities from occupational and transportation accidents for the strategies and options, listed in ascending order, are as follows:

  - No Action (Strategy 3) — 11 injuries
  - Suboptimal Residual Volume (Option 1d) — 30 injuries
  - Baseline Retrieval/Restricted Land Use (Strategy 1) — 41 injuries
  - Nominal Retrieval Losses (Option 1a) — 41 injuries
  - Large Retrieval Losses (Option 1b) — 41 injuries
  - Temporary Operations Barrier (Option 1e) — 41 injuries
  - Postretrieval Hanford Barrier (Option 1f) — 43 injuries
  - Optimal Residual Volume (Option 1c) — 44 injuries
  - Large Losses/Soil Grouting (Option 1h) — 45 injuries
  - Nominal Losses/Soil Grouting (Option 1g) — 47 injuries
  - Baseline Retrieval/Unrestricted Land Use (Strategy 2) — 321 injuries
  - No Soil Treatment (Option 2d) — 322 injuries
  - Nominal Losses/In Situ Soil Treatment (Option 2c) — 323 injuries
  - Past Leak/In Situ Soil Treatment (Option 2b) — 325 injuries
  - Nominal Losses/Excavate Soil (Option 2a) — 341 injuries.

5.6.3 Protect Public Health and Safety

Performance measures were identified in Section 3.9.3.1 that would support an evaluation of whether a waste retrieval and tank farm closure action would attain this value. The results of a detailed evaluation of public health and safety are presented in Section 5.1 for the various baseline strategies and options.

5.6.3.1 Risk of Public Illnesses, Injuries, and Fatalities During Routine Operations

Public health risk was evaluated for public exposures to radiological and chemical emissions during normal operations. Risk from radiological exposure was evaluated in terms of LCFs. Risk from chemical exposure was evaluated in terms of noncarcinogenic health hazards (e.g., toxic or corrosive health effects) and ILCRs from exposure to carcinogenic chemicals. Health risk to the public included a population risks as well as health risk to an MEI. The short-term risks to the general public from normal operations as they apply to each strategy and option are summarized as follows.

- The noncarcinogenic HI would be 5.3E-05 for all strategies and options except No Action, which would have an HI of 4.0E-07.

- The ILCR would be 2.4E-10 for all strategies and options except No Action, which would have an ILCR of 2.1E-12.

- The LCF risk to the general public MEI would be 1.5E-09 for all restricted land use options with the exception of Suboptimal Residual Volume (Option 1d). The Suboptimal Residual Volume would result in a slightly lower risk (1.4E-09) due to reduced emissions as a result of removing less residual waste. The risk would be 9.0E-09 for all unrestricted land use options. The risk for restricted land use options would be driven by emissions from retrieval operations. The risk for unrestricted land use options would be driven by emissions from retrieval and tank removal operations. The LCF risk to the general public MEI for No Action would be 5.2E-11.

- The LCF risk to the general public population would be approximately 3.0E-05 for all restricted land use options with the exception of Suboptimal Residual Volume. The Suboptimal Residual Volume would result in a slightly lower risk (2.8E-05) due to reduced emissions as a result of removing less residual waste. The risk would be 1.8E-04 for all unrestricted land use options. The restricted land use options would be driven by emissions from retrieval operations, and the unrestricted land use options would be driven by emissions from retrieval and tank removal operations. The LCF risk to the general public population for No Action would be 1.8E-06.

5.6.3.2 Risk of Public Illnesses, Injuries, and Fatalities Resulting from an Accident

Public health risk was evaluated for accident conditions. The analysis addressed transportation, radiological, and chemical accidents. Transportation accidents included injuries and fatalities resulting from potential accidents while transporting materials to support construction and operation activities. The transportation accidents were included in Section 5.6.2 with the risk to the workers. Radiological and chemical risks were associated with accidents that could result in radiological and chemical emissions. Radiological risk resulting from an accident was expressed as a point-estimate LCF risk. Chemical risks were evaluated against ERPGs. The short-term risks to the general public from accidents as they apply to each strategy and option are summarized as follows.

- The chemical hazard to a general public MEI from a bounding accident would not exceed ERPG-1 for all restricted and unrestricted land use strategies and options. For No Action the cumulative acute hazard ratio would be 1.8 for ERPG-2.

- The point-estimate LCF risk to a general public MEI resulting from a retrieval accident would be 5.8E-10 for all restricted land use options except for the Optimal Residual Volume (Option 1c) and Suboptimal Residual Volume (Option 1d). The Optimal Residual Volume option would result in a higher risk (8.3E-10) due to an increased accident probability as a result of the extended retrieval time to remove more of the residual waste. The Suboptimal Residual Volume option would result in a lower risk (2.2E-10) due to a decreased accident probability as a result of reducing the retrieval time

by removing less residual waste. The point-estimate LCF risk from a tank removal accident for the unrestricted land use options would be 9.3E-10 with the exception of Nominal Losses/Excavate Soil (Option 2a). The Nominal Losses/Excavate Soil option would result in a higher risk (7.1E-09) resulting from a contaminated soil removal accident from potential retrieval leakage loss. The point-estimate LCF to the MEI worker for No Action would be 3.3E-05, which would be the result of an earthquake.

- The point-estimate LCF risk to a general public population resulting from a retrieval accident would be 8.6E-07 for all restricted land use options except for Optimal Residual Volume and Suboptimal Residual Volume options. The Optimal Residual Volume option would result in a higher risk (1.2E-06) due to an increased accident probability as a result of the extended retrieval time to remove more of the residual waste. The Suboptimal Residual Volume option would result in a lower risk (3.3E-07) due to a decreased accident probability as a result of reducing the retrieval time by removing less residual waste. The point-estimate LCF risk from a tank removal accident for the unrestricted land use options would be 4.2E-06 with the exception of Nominal Losses/ Excavate Soil. The Nominal Losses/Excavate Soil option would result in a higher risk (3.2E-05) resulting from a contaminated soil removal accident from potential retrieval leakage loss. The point-estimate LCF to the MEI worker for No Action would be 2.9E-02, which would result from an earthquake.

5.6.4 Get On With Cleaning The Waste

Performance measures were identified in Section 3.9.3.1 that would support an evaluation of whether a waste retrieval or closure action would attain this value.

5.6.4.1 Date When DOE Completes Evaluation and Makes Final Cleanup Decision(s)

Under all strategies and options it was assumed that DOE would make a final cleanup decision by the year 2000 to facilitate AX Tank Farm retrieval system design, construction, and operations beginning in 2004.

5.6.4.2 Date When DOE Initiates Cleanup Action(s)

Cleanup actions would be initiated with waste retrieval for all strategies and options. Under current Tri-Party Agreement schedules AX Tank Farm waste retrieval is to begin by the year 2004. The exception would be the Temporary Operations Barrier option (Option 1e) that would begin with temporary barrier construction by the year 2000.

5.6.4.3 Date When DOE Initiates Closure of First SST Farm

AX Tank Farm closure would begin for all strategies and options by the year 2007.

5.6.4.4 Date When DOE Completes Cleanup Action(s)

Cleanup activities would be completed by the year 2009 for Baseline Retrieval/Restricted Land Use (Strategy 1) and all it associated options. The barrier for this strategy and options would be constructed by the year 2020. Cleanup for Baseline Retrieval/Unrestricted Land Use strategy (Strategy 2) and the Past Leak/In Situ Soil Treatment option (Option 2b) would take 15 yr and would be completed by the year 2019. Cleanup for the Nominal Losses/Excavate Soil option

(Option 2a) would take 20 yr and would be completed by the year 2024. Cleanup for the No Soil Treatment option (Option 2d) would take 13 yr and would be completed by the year 2017.

5.6.4.5 Availability of Existing Technologies

The Baseline Retrieval/Restricted Land Use strategy and options would use more existing technology (e.g., grouting tank residuals, capping) compared to the Baseline Retrieval/ Unrestricted Land Use strategy and options, which would tend to use more technologies (e.g., tank removal and soil excavation/grouting) that have not been demonstrated in a tank farm.

5.6.4.6 Availability and Likely Success of Implementing New Technologies

A detailed evaluation of the availability and likely success of implementing new technologies is presented in Section 6.2.6. In general the evaluation showed that restricted land use strategy and options would use more existing technology compared to the unrestricted land use options, which tend to use more technologies that have not been demonstrated in a tank farm.

5.6.5 Use a Systems Approach

Performance measures were identified in Section 3.9.3.1 that would support an evaluation of whether a waste retrieval and tank farm closure action would attain this value.

5.6.5.1 Data on Total System Source Term Including Residual Tank and Ancillary Equipment Waste, Waste Loss During Retrieval, and Past Leaks to the Vadose Zone

The evaluations in the RPE cover a range of strategies and options that includes residual tank waste (residual volumes of 1, 10, and 100 m^3 [36, 360, and 3,600 ft^3]) and ancillary equipment waste, waste losses during retrieval (no losses, 30 m^3 [8,000 gal.] and 151 m^3 [40,000 gal.] potential retrieval leakage loss), and past tank waste leaks and spills to the vadose zone.

5.6.5.2 Developing Alternatives that Include Various Options that Address the Total System (Residual Tank Waste and Waste in the Vadose Zone) for Restricted and Unrestricted Land Use

Restricted land use strategy and options developed for evaluation in the RPE include the following:

- Baseline Retrieval/Restricted Land Use (Strategy 1)
- Nominal Retrieval Losses (Option 1a)
- Large Retrieval Losses (Option 1b)
- Optimal Residual Volume (Option 1c)
- Suboptimal Residual Volume (Option 1d)
- Temporary Operations Barrier (Option 1e)
- Postretrieval Hanford Barrier (Option 1f)
- Nominal Losses/Soil Grouting (Option 1g)
- Large Losses/Soil Grouting (Option 1h).

Unrestricted land use strategy and options developed for evaluation in the RPE include the following:

- Baseline Retrieval/Unrestricted Land Use (Strategy 2)
- Nominal Losses/Excavate Soil (Option 2a)
- Past Leak/In Situ Soil Treatment (Option 2b)
- Nominal Losses/In Situ Soil Treatment (Option 2c)
- No Soil Treatment (Option 2d).

5.6.6 Protect the Columbia River

Performance measures were identified in Section 3.9.3.1 that would support an evaluation of whether a waste retrieval and tank farm closure action would attain this value.

5.6.6.1 Health Risk to Humans and Ecology from Contaminants in the River at the Hanford Site

The groundwater impact assessment does not address impacts once contaminated groundwater enters the Columbia River. The analysis will be required at a future date.

5.6.6.2 Health Risk to Future Populations of Humans Downriver from the Hanford Site

The groundwater impact assessment does not address impacts once contaminated groundwater enters the Columbia River. This analysis will be required at a future date.

5.6.6.3 Any Level of Release of Contaminants to the Columbia River

The groundwater impact assessment does not address impacts once contaminated groundwater enters the Columbia River. This analysis will be required at a future date.

5.6.7 Enable Future Site Uses

Performance measures were identified in Section 3.9.3.1 that would support an evaluation of whether a waste retrieval and tank farm closure action would attain this value.

5.6.7.1 Long-Term Human Health Risks from Future Land Use

The results of a detailed evaluation of long-term human health risks are presented in Section 5.3 for the various strategies and options. Long-term human health risks are defined as the potential risk to human health after the AX Tank Farm retrieval and closure actions are completed. Risk from chemical exposure was evaluated in terms of noncarcinogenic health hazards or toxic effects and ILCRs from exposure to carcinogenic chemicals and radiological constituents. Four exposure scenarios were evaluated: Native American, residential farmer, industrial worker, and recreational shoreline user. The potential risk for each of these future land uses was based on consumption and contact with contaminated groundwater or surface water contaminated by discharge of groundwater. The peak ILCR for each strategy and option and the year they would peak after the 100-yr institutional control period (150 yr from 1963) for the residential farmer are presented in ascending order. The ILCR to the Native American would be approximately one order of magnitude greater and the industrial worker and recreational shoreline user would be approximately one and two orders of magnitude less, respectively.

- Past Leak/In Situ Soil Treatment — 5.9E-06 ILCR at 150 yr
- Nominal Losses/In Situ Soil Treatment — 6.1E-06 ILCR at 150 yr
- Nominal Losses/Soil Grouting — 8.2E-06 ILCR at 2,600 yr
- Baseline Retrieval/Unrestricted Land Use — 8.5E-06 ILCR at 150 yr
- Nominal Losses/Excavate Soil — 8.5E-06 ILCR at 150 yr
- Large Losses/Soil Grouting — 9.3E-06 ILCR at 2,600 yr
- Baseline Retrieval/Restricted Land Use — 1.2E-05 ILCR at 150 yr
- Optimal Residual Volume — 1.2E-05 ILCR at 150 yr
- No Soil Treatment — 1.2E-05 ILCR at 150 yr
- Nominal Retrieval Losses — 1.4E-05 ILCR at 2,600 yr
- Temporary Operations Barrier — 1.8E-05 ILCR at 2,600 yr
- Postretrieval Hanford Barrier — 1.8E-05 ILCR at 2,600 yr
- Large Retrieval Losses — 3.8E-05 ILCR at 1,200 yr
- Suboptimal Residual Volume — 5.8E-05 ILCR at 2,600 yr
- No Action — 1.6E-04 ILCR at 2,600 yr.

In addition to the evaluation of the Native American, residential farmer, industrial worker, and recreational shoreline user scenarios the human health risk to an inadvertent intruder (driller and postdriller resident) also was evaluated in Section 5.3. The potential risk for the driller and postdriller resident was based on exposure to the radionuclides contained in the waste exhumed during well drilling and is expressed in terms of LCFs. The year of peak exposure would be immediately following the end of 100 yr of institutional controls. The LCF risk to the driller and postdriller are listed below in ascending order.

LCF Risk To Waste Site Driller

- Baseline Retrieval/Unrestricted Land Use — No appreciable LCF Risk/yr
- Nominal Losses/Excavate Soil — No appreciable LCF Risk/yr
- Past Leak/In Situ Soil Treatment — No appreciable LCF Risk/yr
- Nominal Losses/In Situ Soil Treatment — 7.6E-06 LCF Risk/yr
- No Soil Treatment — 7.6E-06 LCF Risk/yr
- Optimal Residual Volume — 1.1E-05 LCF Risk/yr
- Baseline Retrieval/Restricted Land Use — 3.1E-05 LCF Risk/yr
- Nominal Retrieval Losses — 3.9E-05 LCF Risk/yr
- Temporary Operations Barrier — 3.9E-05 LCF Risk/yr
- Postretrieval Hanford Barrier — 3.9E-05 LCF Risk/yr
- Nominal Losses/Soil Grouting — 3.9E-05 LCF Risk/yr
- Suboptimal Residual Volume — 4.4E-05 LCF Risk/yr
- Large Retrieval Losses — 6.9E-05 LCF Risk/yr
- Large Losses/Soil Grouting — 6.9E-05 LCF Risk/yr
- No Action — 9.8E-05 LCF Risk/yr.

LCF Risk to Post-Driller Resident

• Baseline Retrieval/Unrestricted Land Use	No appreciable LCF Risk/yr
• Nominal Losses/Excavate Soil	No appreciable LCF Risk/yr
• Past Leak/In Situ Soil Treatment	No appreciable LCF Risk/yr
• Nominal Losses/In Situ Soil Treatment	2.6E-05 LCF Risk/yr
• No Soil Treatment	2.6E-05 LCF Risk/yr
• Optimal Residual Volume	3.4E-05 LCF Risk/yr
• Baseline Retrieval/Restricted Land Use	9.0E-05 LCF Risk/yr
• Nominal Retrieval Losses	1.2E-04 LCF Risk/yr
• Temporary Operations Barrier	1.2E-04 LCF Risk/yr
• Postretrieval Hanford Barrier	1.2E-04 LCF Risk/yr
• Nominal Losses/Soil Grouting	1.2E-04 LCF Risk/yr
• Suboptimal Residual Volume	3.0E-04 LCF Risk/yr
• Large Retrieval Losses	2.2E-04 LCF Risk/yr
• Large Losses/Soil Grouting	2.2E-04 LCF Risk/yr
• No Action	3.1E-04 LCF Risk/yr.

5.6.7.2 Remediate TWRS to be Consistent with Other 200 Area Cleanup as Defined in the FSUWG and Draft Comprehensive Land Use Plan

The retrieval and closure strategies and options that are evaluated in the RPE are consistent with other 200 Area cleanup activities and support future site goals that include:

- Protecting the Columbia River from current and future contamination
- Dealing realistically and forcefully with groundwater contamination
- Keeping the contaminated waste from remediation centrally located at the Central Plateau
- Protecting human health and the environment during the cleanup
- Determining if waste retrieval and tank farm closure strategies and options can reasonably achieve unrestricted or restricted levels of cleanup
- Involving the pubic in decisions concerning cleanup.

5.6.7.3 Remediate TWRS to Ensure Contaminant Releases Beyond 200 Areas are at Acceptable Levels

The maximum groundwater concentrations for all strategies or options would not exceed EPA MCLs and DOE DCGs at the boundary of the 200 Areas.

5.6.8 Protect the Rights of Native Americans

Performance measures were identified in Section 3.9.3.1 that would support an evaluation of whether a waste retrieval and tank farm closure action would attain this value.

5.6.8.1 Number of acres of the Site that are Restricted to Future Land Use

The restricted land use strategy and options and the No Soil Treatment option would result in temporary and permanent land-use commitments. Unrestricted land use options would result in temporary land-use commitments. Temporary land-use commitments would not restrict future land use and include currently undisturbed areas used for constructing and operating the alternatives and construction activities associated with tank farm closure. Temporary land-use commitments would include facility footprints, parking lots, construction laydown areas, materials storage areas, facility assembly areas, and areas used at the three potential borrow sites. Permanent land-use commitments would include areas that would be permanently committed to waste disposal as a result of a closure option and would restrict future use of the land. The restricted land use strategy and options and the No Soil Treatment option would be permanently committed to waste disposal and would restrict future use of 1.5 ha (3.7 ac).

5.6.8.2 Risk of Native American User Fatality During Postremediation

The Native American land user scenario was evaluated as a future land user in Section 5.3. The scenario represented exposures to a Native American who engaged in both traditional lifestyle activities (e.g., hunting, fishing, and using a sweat lodge) and contemporary lifestyle activities (e.g., irrigated farming). Exposure pathways included those defined for the residential farmer scenario plus additional pathways unique to the Native American subsistence lifestyle (such as sweat lodge use). The exposures were assumed to be continuous for 365 days/yr over a 70-yr lifetime. The scenario used native food ingestion rates. By incorporating subsistence lifestyle activities and native food ingestion rates, this scenario resulted in exposures that would be approximately one order of magnitude higher than the exposures for the residential farmer scenario. The peak ILCR for each strategy and option and the year they would peak after the 100-yr institutional control period for the Native American are presented in ascending order.

- Past Leak/In Situ Soil Treatment — 5.3E-05 ILCR at 150 yr
- Nominal Losses/In Situ Soil Treatment — 5.5E-05 ILCR at 150 yr
- Nominal Losses/Soil Grouting — 6.6E-05 ILCR at 2,600 yr
- Large Losses/Soil Grouting — 7.5E-05 ILCR at 2,600 yr
- Baseline Retrieval/Unrestricted Land Use — 7.6E-05 ILCR at 150 yr
- Nominal Losses/Excavate Soil — 7.6E-05 ILCR at 150 yr
- Baseline Retrieval/Restricted Land Use — 1.1E-04 ILCR at 150 yr
- Optimal Residual Volume — 1.1E-04 ILCR at 150 yr
- No Soil Treatment — 1.1E-04 ILCR at 150 yr
- Nominal Retrieval Losses — 1.2E-04 ILCR at 2,600 yr
- Temporary Operations Barrier — 1.5E-04 ILCR at 2,600 yr
- Postretrieval Hanford Barrier — 1.6E-04 ILCR at 2,600 yr
- Large Retrieval Losses — 3.4E-04 ILCR at 1,200 yr
- Suboptimal Residual Volume — 4.9E-04 ILCR at 2,600 yr
- No Action — 1.4E-03 ILCR at 2,600 yr.

5.6.8.3 Impacts to Cultural and/or Historical Resources and New or Continuous Restrictions to Sacred Sites

The area of the Hanford Site near the Columbia River has been occupied by humans for over 10,000 yr, as reflected by the extensive archaeological deposits along the river. Inland areas with water resources also point to evidence of concentrated human activity. Recent surveys indicate extensive although dispersed use of semi-arid lowlands for hunting. However, surveys have recorded very few Native American sites or artifacts in and around the 200 Areas (Chatters and Cadoret 1990). Native American sites and artifacts have been identified at both McGee Ranch and the Vernita Quarry. These two sites are potential borrow sites to support AX Tank Farm closure activities. Therefore, the potential exists for further disturbance of cultural and historic resources at these two locations.

Native Americans have retained traditional secular and religious ties to the Hanford Site. No specific sites of religious significance have been identified at the AX Tank Farm. However, affected Tribal Nations indicate that there are culturally important biota, sacred sites such as Gable Mountain, and other culturally important properties within areas that might be impacted by TWRS activities (i.e., groundwater downgradient from TWRS sites, the Columbia River, and locations downwind of possible retrieval and closure air releases) (CTUIR 1996). The greater risk to the Native American land user when institutional controls are no longer in place would result from No Action rather than closure of the AX Tank Farm.

5.6.8.4 Number of Acres of Groundwater Contaminated by Tank Waste Releases

The results of the analysis for the number of acres of groundwater contaminated by tank waste releases is provided in Section 5.6.1.3.

5.6.8.5 Number of Acres Disturbed to Quarry Basalt or Other Materials Needed for Remediation

All strategies and options (except No Action) would require fill material from borrow sites. For this analysis it was assumed the borrow sites would include the Vernita Quarry and McGee Ranch, which lie to the north and west of the AX Tank Farm, and the Pit 30 borrow site, which is located between the 200 East and 200 West Areas. The borrow sites were identified to illustrate potential impacts and do not represent sites selected to meet project or site borrow material requirements. The number of additional acres disturbed at these borrow sites for each strategy and option are presented in ascending order as follows:

- No Action — 0 ha (0 ac)
- Baseline Retrieval/Restricted Land Use — 1.2 ha (3.0 ac)
- Nominal retrieval Losses — 1.2 ha (3.0 ac)
- Large Retrieval Losses — 1.2 ha (3.0 ac)
- Optimal Residual Volume — 1.2 ha (3.0 ac)
- Suboptimal Residual Volume — 1.2 ha (3.0 ac)
- Nominal Losses/Soil Grouting — 1.2 ha (3.0 ac)
- Temporary Operations Barrier — 1.2 ha (3.0 ac)
- Large Losses/Soil Grouting — 1.2 ha (3.0 ac)
- Postretrieval Hanford Barrier — 3.1 ha (7.5 ac)

- Past Leak/In Situ Soil Treatment 5.5 ha (14 ac)
- Nominal Losses/In Situ Soil Treatment 5.5 ha (14 ac)
- No Soil Treatment 6.4 ha (16 ac)
- Baseline Retrieval/Unrestricted Land Use 6.7 ha (17 ac)
- Nominal Losses/Excavate Soil 8.9 ha (22 ac).

It would require less fill for grouting the tanks and ancillary equipment and constructing a surface barrier over the tank farm for the restricted land use options than it would to replace the tanks and excavated soil for the unrestricted land use options. The Postretrieval Hanford Barrier option (Option 1f) would require more fill than the other restricted land use options because of the increased size of the Hanford Barrier compared to the enhanced RCRA Subtitle C barrier used by the other options. The Nominal Losses/Excavate Soil option (Option 2a) would require more fill than the other unrestricted land use options because of the increased excavation requirements to remove the contaminated soil from the potential retrieval leakage loss.

5.6.9 Ensure Regulatory Compliance

Performance measures were identified in Section 3.9.3.1 that would support an evaluation of whether a waste retrieval and tank farm closure action would attain this value.

5.6.9.1 The Degree to Which Remediation Meets the Requirements of the Tri-Party Agreement

The Tri-Party Agreement, signed by DOE, Ecology, and EPA on May 14, 1989, is an agreement to clean up radioactive and hazardous waste at the Hanford Site over a 30-yr period. The Tri-Party Agreement establishes an action plan for cleanup that addresses priority actions, methods for resolving problems, and milestones. The Tri-Party Agreement sets milestones to achieve coordinated cleanup of the Hanford Site and provides for the enforcement of these milestones to keep the program on schedule. In addition, the Tri-Party Agreement establishes the applicability of RCRA and CERCLA and their amendments to the Hanford Site.

The No Action Strategy would not be in compliance with the Tri-Party Agreement. For the Baseline Retrieval/Restricted Land Use Strategy and options and the Baseline Retrieval/ Unrestricted Land Use Strategy and options, Tri-Party Agreement compliance would be conditional. The Baseline Retrieval/Restricted Land Use Strategy and options would close the tanks as RCRA TSD units (landfill closure). Restricted Land Use options vary from no retrieval leakage loss to 151 m^3 (40,000 gal.) retrieval leakage loss, residual volumes range from 0.1 percent to 10 percent, surface barriers include a temporary barrier with a permanent enhanced RCRA Subtitle C barrier to the Hanford Barrier. Postclosure care will be required for Strategy 1 and its options. The Baseline Retrieval/Unrestricted Land Use Strategy includes removing the tanks, ancillary equipment, and the surrounding soils to 16 m (55 ft) for all options (clean closure). Unrestricted land use options vary from no retrieval leakage loss to 30 m^3 (8,000 gal.) retrieval leakage loss, no soil remediation to soil grouting or soil removal to 37 m (120 ft) below the tank bases, and no surface barrier to an enhanced RCRA Subtitle C barrier. These various strategies and options influence groundwater concentration values, human health risk, and worker exposure doses.

5.6.9.2 The Degree to Which Remediation Meets Other Laws and Regulations Including RCRA

Section 5.5 describes relevant Federal and State laws and regulations, permits, compliance agreements, and DOE orders that may be applicable to the retrieval and closure options. The degree to which waste retrieval and closure meets other laws and regulations are as follows.

- Groundwater compliance – The maximum groundwater concentrations for all strategies or options would not exceed State and Federal groundwater quality regulations.

- Public health protection – All options would comply with State and Federal regulations in protecting the public health (the general public) from emissions resulting from waste retrieval and tank farm closure activities.

- Worker health protection – The current Administrative Control Level of 500 mrem/yr would be exceeded by all strategies and options except No Action. The restricted land use strategy and options would exceed a proposed Administrative Control Level of 1,500 mrem/yr as well as the Federal level of 5,000 mrem/yr due to the high anticipated worker exposure during the ancillary groutfill operation. The Nominal Losses/Excavate Soil option (Option 2a) would also exceed 1,500 mrem/yr and 5,000 mrem/yr due to the high anticipated worker exposure during removal of soil contaminated from potential retrieval leakage loss.

  The dose consequences to the MEI involved and noninvolved worker resulting from 1) a soil excavation accident while excavating soil from a 30 m^3 (8,000 gal.) retrieval leakage loss (Option 2a); 2) an accident while removing a tank (Strategy 2 and all Strategy 2 options); and 3) an accident while retrieving residual waste from a tank (all strategies and options except No Action) would exceed the regulatory standards of 10 rem for accidents with a probability range of 1.0E-04 to 1.0E-06 and 5 rem for accidents with a probability range of 1.0E-02 to 1.0E-04. In addition to these accidents the dose consequences to the MEI involved worker resulting from an ancillary equipment removal accident (Strategy 2 and all Strategy 2 options) and ancillary equipment grouting accident (Strategy 1 and all Strategy 1 options) also would exceed the regulatory standard of 5 rem for accidents with a probability range of 1.0E-02 to 1.0E-04.

- Long-term health protection – The restricted land use and unrestricted land use strategies and options would not exceed Federal standard of 1.0E-04 ILCR for long-term health risks resulting from exposure to contaminants following the loss of institutional control (100 yr following the completion of waste retrieval and tank farm closure activities) through 10,000 yr in the future. No Action would exceed the Federal standards. All options except Past Leak/In Situ Soil Treatment, Nominal Losses/In Situ Soil Treatment, Nominal Losses/Soil Grouting, Baseline Retrieval/Unrestricted Land Use, Nominal Losses/Excavate Soil, and Large Losses/Soil Grouting would exceed the State standard of 1.0E-05 at one or more points during the period of interest.

- Intruder protection – For the DOE intruder scenario none of the strategies or options would exceed the Federal standard of 500 mrem/incident for the well driller. The Federal

standard of 100 mrem/yr for the postdriller resident would be exceeded by all strategies and options except for Optimal Residual Volume and all Strategy 2/Strategy 2 options. Optimal Residual Volume would have 0.1 percent tank residual waste and all Strategy 2 options would have the tanks removed.

For the NRC intruder scenario all strategies and options would comply with NRC standards after stabilizing the tank waste (filling the tanks with grout for Strategy 1 options and removing the tanks for Strategy 2 options) except for No Action and Suboptimal Residual Volume.

5.6.10 Reduce Cost

Performance measures were identified in Section 3.9.3.1 that would support an evaluation of whether a waste retrieval and tank farm closure action would attain this value.

5.6.10.1 Cost of Alternatives to the Action

The projected cost for restricted land use options were evaluated in Section 4.3 and Section 4.4 for unrestricted land use options. The projected cost for each strategy/options and No Action are presented in Appendix E for comparison with performance measures from other values. The cost per strategy or option in ascending order is as follows:

- Suboptional Residual Volume (Option 1d) $182 million
- Baseline Retrieval/Restricted Land Use (Strategy 1) $204 million
- Nominal Retrieval Losses (Option 1a) $204 million
- Large Retrieval Losses (Option 1b) $204 million
- Temporary Operations Barrier (Option 1e) $207 million
- Post Retrieval Hanford Barrier (Option 1f) $209 million
- Optimal Residual Volume (Option 1c) $218 million
- No Action (Strategy 3) $345 million
- Nominal Losses/Soil Grouting (Option 1g) $403 million
- Baseline Retrieval/Unrestricted Land Use (Strategy 2) $495 million
- Past Leak/In Situ Soil Treatment (Option 2b) $498 million
- Large Losses/Soil Grouting (Option 1h) $550 million
- No Soil Treatment (Option 2d) $600 million
- Nominal Losses/In Situ Soil Treatment (Option 2c) $639 million
- Nominal Losses/Excavate Soil (Option 2a) $791 million.

5.6.10.2 Cost for Postremediation Activities

The projected cost for postremediation would be approximately the same for the restricted land use and unrestricted land use strategies and options. Because they would all contain some level of contamination in the ground, test wells would be installed for routine monitoring and surveillance. Costs would be marginally higher for the Baseline Retrieval Restricted Land Use strategy and options and Option 2d to support monitoring and maintenance of the postretrieval barrier.

5.6.11 Data Quality and Uncertainty

Performance measures were identified in Section 3.9.3.1 that would support an evaluation of whether a waste retrieval or closure action would attain this value.

5.6.11.1 Identification of Data Gaps and Plans to Collect New Data

To address this performance measure Section 6.3, Recommendations for Additional Data, was included in this analysis. This section identifies the data gaps and quality of the data that was provided for the source term analysis, contaminant transport analysis, human health risk analysis, technical practicability writeup, cost evaluation, regulatory requirements evaluation, and stakeholder and Tribal Nation values evaluation.

5.6.11.2 Identification of Uncertainties with Technologies and Analysis of Potential Human Health, Environmental, and Cost Impacts of Various Options

Technologies. Because the engineering studies developed in support of the RPE are based on preconceptual design levels, all of the strategies or options would require further development before they could be implemented.

Human Health. An uncertainty and sensitivity analysis was conducted for the RPE to evaluate how variation and uncertainty in model input parameters translate into uncertainty in long-term human health risk predictions. The uncertainty analysis included evaluating the uncertainty associated with contaminant inventories and source terms, vadose zone properties, saturated zone properties, contaminant mobility, and exposure parameters. The results of the analysis shows that the uncertainty range spans approximately four orders of magnitude early in the period of analysis and up to six orders of magnitude late in the 10,000-yr period. The uncertainty range means that risks could range from between approximately 1.0E-02 to 1.0E-06 with the majority of the risks following into a smaller range (2.0E-05 to 2.0E-04). Because the risk uncertainty range spans across remediation action levels of 1.0E-06 to 1.0E-04, additional characterization and refinement of the analysis is warranted prior to decision making.

Cost. Additional cost estimating data would serve to improve the understanding and reduce the uncertainty of the total costs associated with implementing any of the retrieval and closure strategies. Additional cost data in the following areas would be required to develop more complete life-cycle cost estimates:

- In-tank characterization costs
- Improved vadose zone characterization requirements.

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