5.3.1.3 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas

This section describes the results of Waste Management Alternative 3. It includes analysis of long-term groundwater impacts from sources within the IDF-East, IDF-West, and RPPDF Barriers. Impacts of sources remaining within the tank farm barriers are discussed in Section 5.1, which deals with tank closure impacts. Impacts of sources remaining within the FFTF Barrier are discussed in Section 5.2.

Waste Management Alternative 3 is designed to show the impacts of waste disposal at IDFs in the 200-East and 200-West Areas. Summaries of the actions and timelines for Waste Management Alternative 3 are provided in Chapter 2, Section 2.5. There are three disposal facilities:

- Two IDFs, one in the south-central part of the 200-East Area, which would receive tank wastes, and the other in the northern part of the 200-West Area, which would receive FFTF decommissioning waste, onsite-generated non-CERCLA waste, and offsite-generated LLW and MLLW. The LLW and MLLW inventories for trenches 31 and 34 are also included with the IDF inventory in this analysis.

- The RPPDF, located in the Core Zone between the 200-East and 200-West Areas, which would receive lightly contaminated equipment and soils resulting from tank farm closure activities.

Three disposal groups are analyzed. Each has a different configuration and timeline for the IDF and RPPDF facilities. The three disposal groups are discussed in detail in the following subsections.

5.3.1.3.1 Disposal Group 1

Disposal Group 1 is characterized by an operational completion date of CY 2050 for IDF-East, IDF-West, and the RPPDF. In Disposal Group 1, IDF-West has a large capacity (90,000 cubic meters [117,720 cubic yards]), IDF-East a larger capacity (1,300,000 cubic meters [1,700,400 cubic yards]), and the RPPDF a capacity of 1,080,000 cubic meters (1,412,640 cubic yards). These capacities are designed to meet the waste generation volumes associated with Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, 6C; FFTF Decommissioning Alternative 2 or 3; and onsite- and offsite-generated waste.

5.3.1.3.1.1 Disposal Group 1, Subgroup 1-A

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, includes Tank Closure Alternative 2B, FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste. Tank Closure waste would be converted to IHLW and ILAW glass. For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009 and the RPPDF in CY 2022 and continues for all three through CY 2050 when the disposal facilities will be operationally closed. During the disposal period, the materials in these permitted, operational facilities are not available for release to the environment.

- The post-disposal period starts in CY 2051 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 3, Disposal Group, Subgroup 1-A, were selected by evaluating the risk or hazard associated with all 28 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A.

The COPC drivers discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, and nitrate) are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. The other COPCs analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, (IDF-East, IDF-West, and the RPPDF), in terms of the total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Integrated Disposal Facility

IDF-East has four subtotals plotted representing releases from ILAW glass, ETF-generated secondary waste, retired melters, and tank closure secondary waste.

Figure 5–703 shows the release to the vadose zone for the radiological risk drivers and Figure 5–704, the chemical hazard drivers. For all four sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 and chromium is tank closure secondary waste. For iodine-129 and nitrate, ETF-generated secondary waste is the predominant source. Boron and fluoride do not exist at IDF-East.

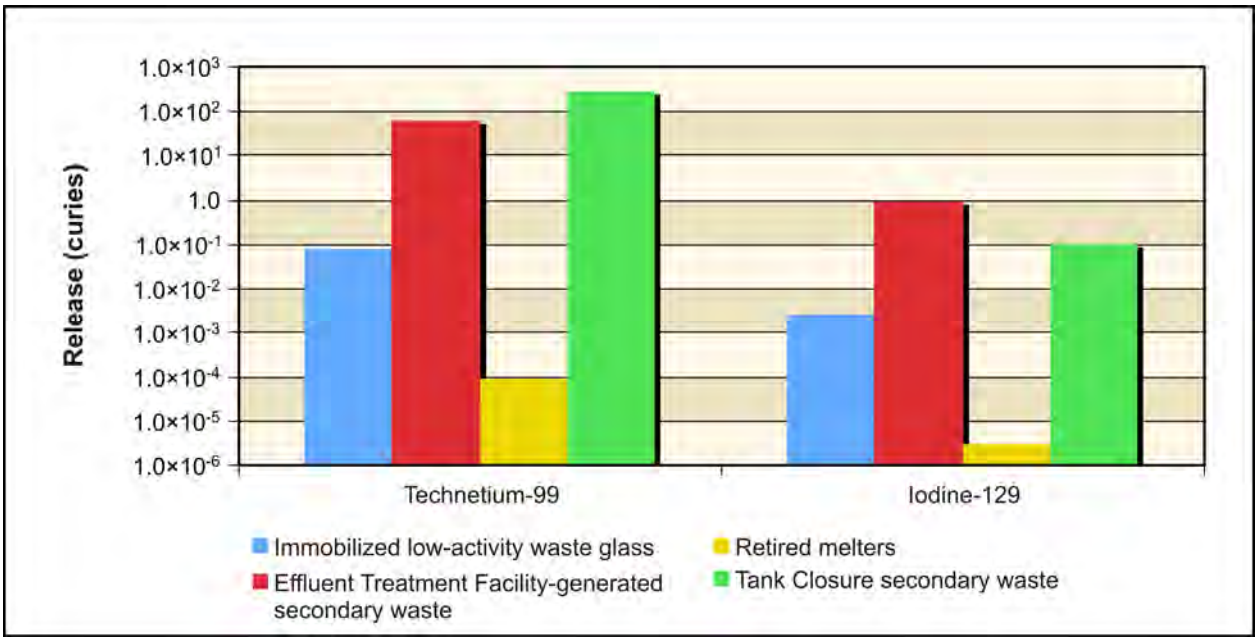


Figure 5–703. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

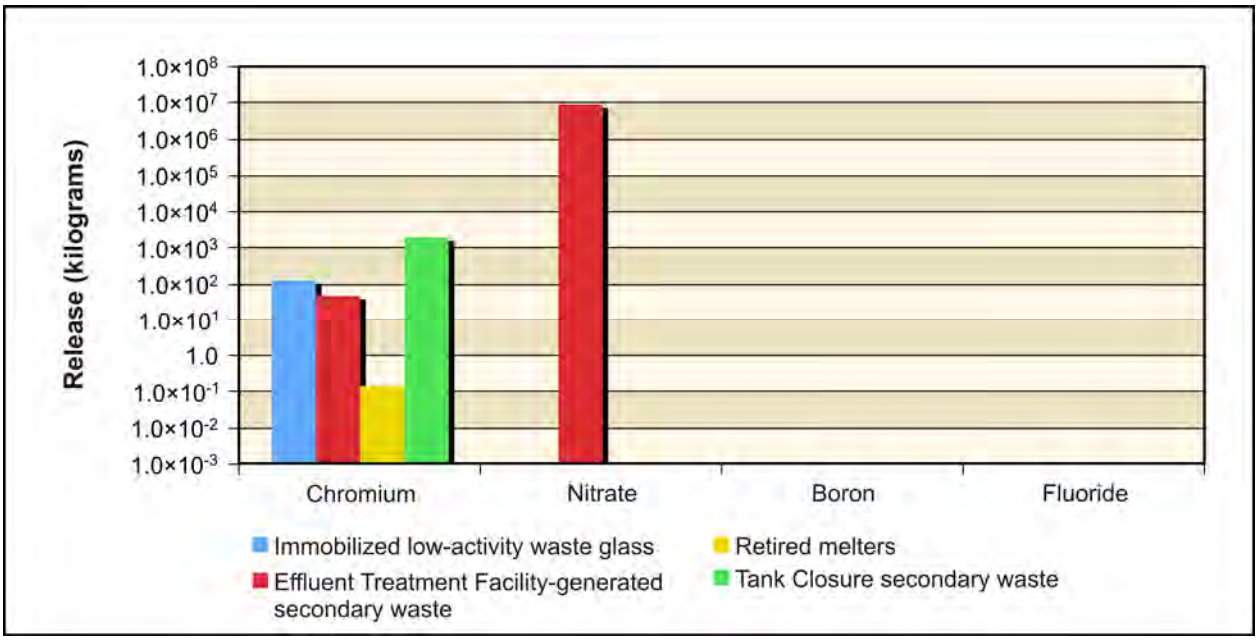


Figure 5–704. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–705 shows the release to groundwater for the radiological risk drivers and Figure 5–706, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. This means that there is less than one order of magnitude difference. Overall, about 60 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reaches groundwater; approximately 100 percent of the chemical quantity (kilograms) reaches groundwater.

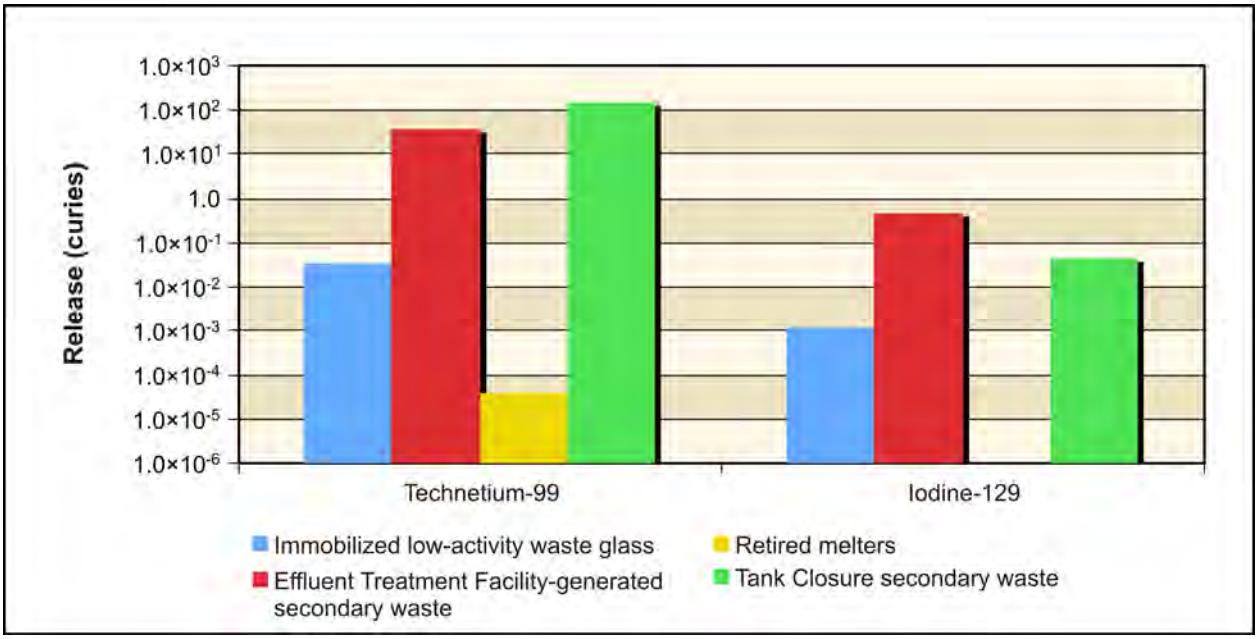


Figure 5–705. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

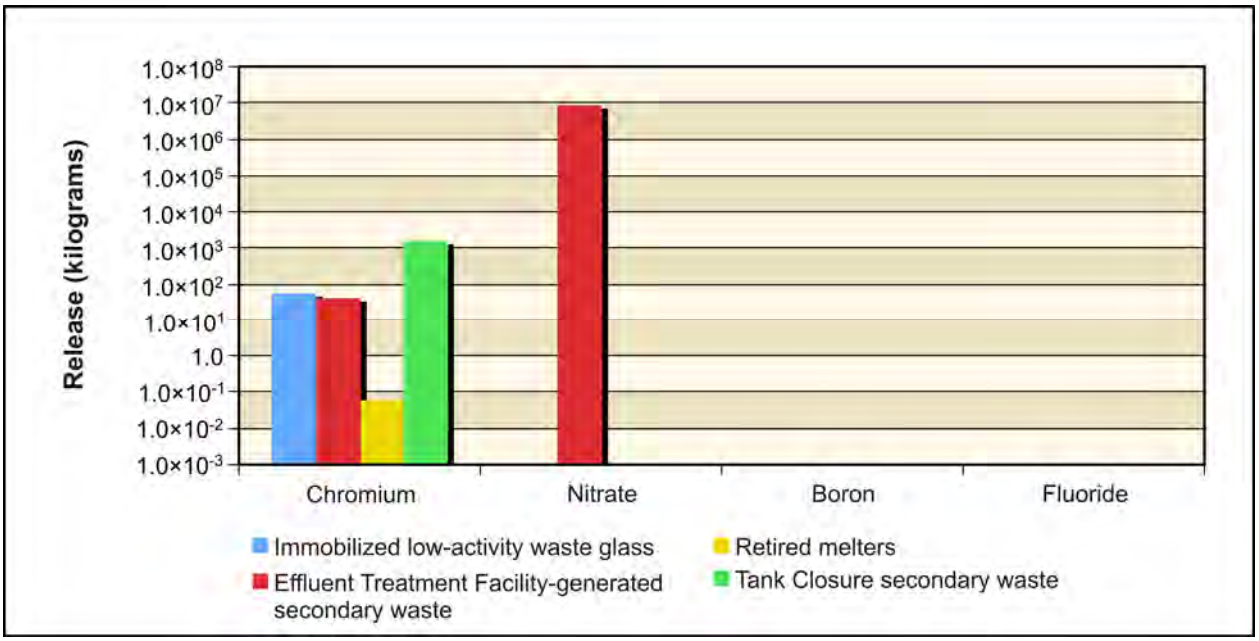


Figure 5–706. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–707 shows the release to the Columbia River for the radiological risk drivers and Figure 5–708, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For iodine-129, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. The exception is waste from retired melters for technetium-99. In this case, releases to groundwater did not reach the Columbia River. About 90 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reaches the river; approximately 99 percent of the chemical quantity (kilograms) reaches the river.

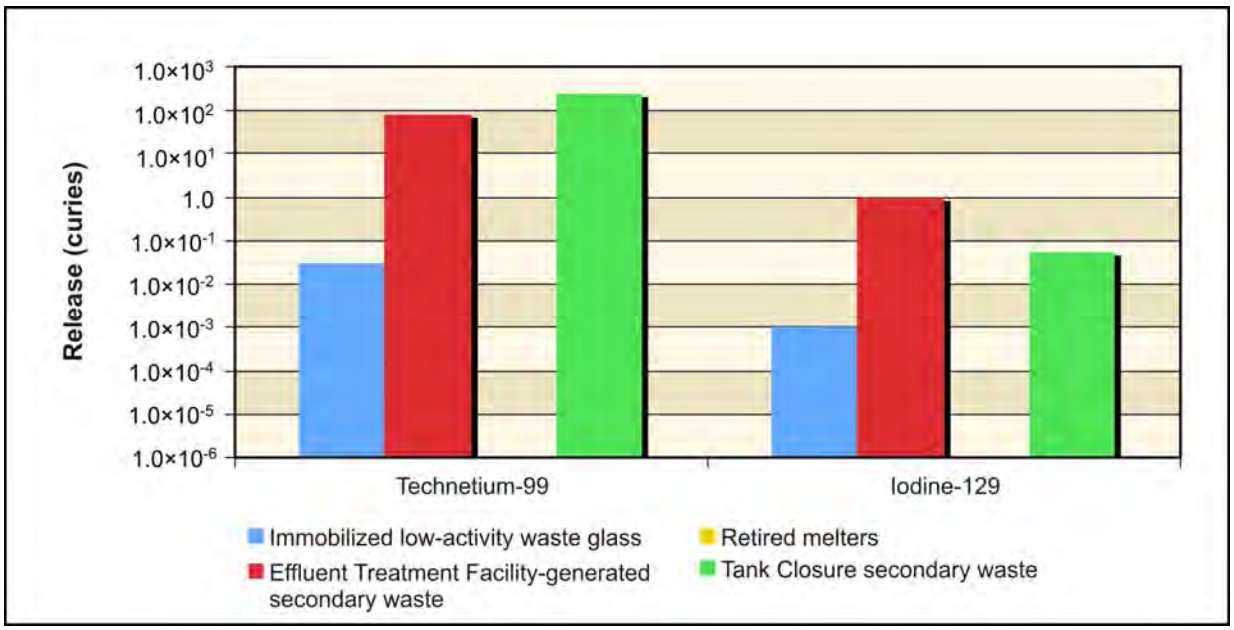


Figure 5–707. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

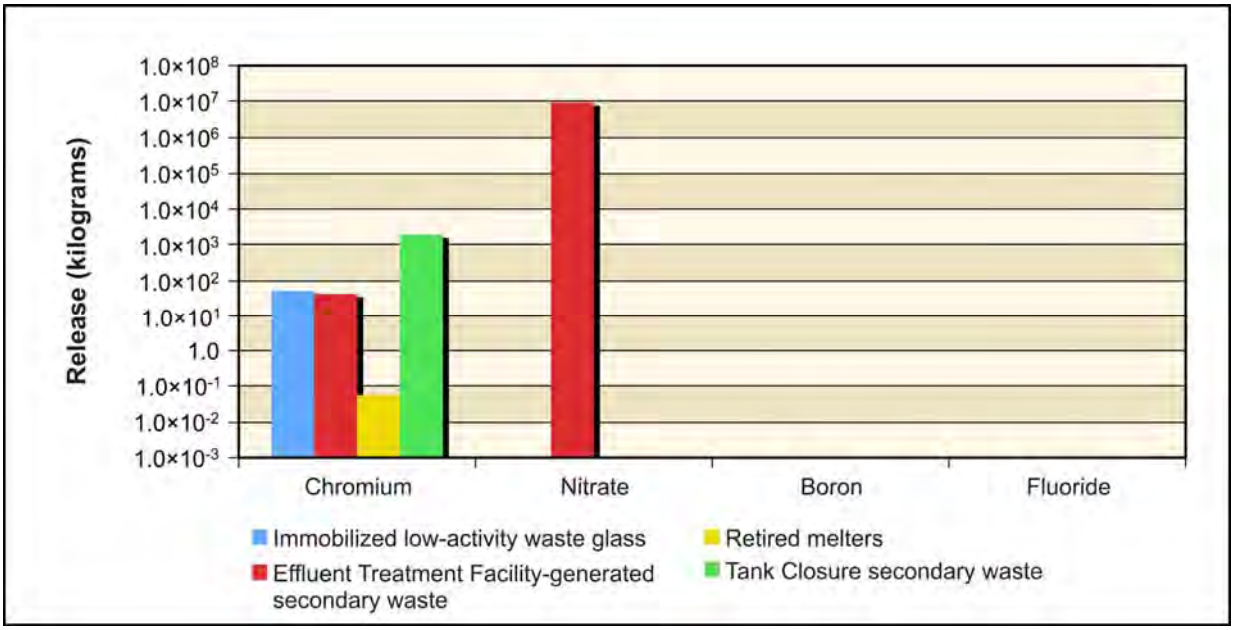


Figure 5–708. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases: FFTF Decommissioning Alternative 3 waste, waste management and onsite-generated waste, and offsite-generated waste.

Figure 5–709 shows the release to the vadose zone for the radiological risk drivers and Figure 5–710, the chemical hazard drivers. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 and iodine-129 is offsite-generated waste. For chromium, nitrate, boron, and fluoride, the predominant source is waste management secondary waste and onsite-generated waste.

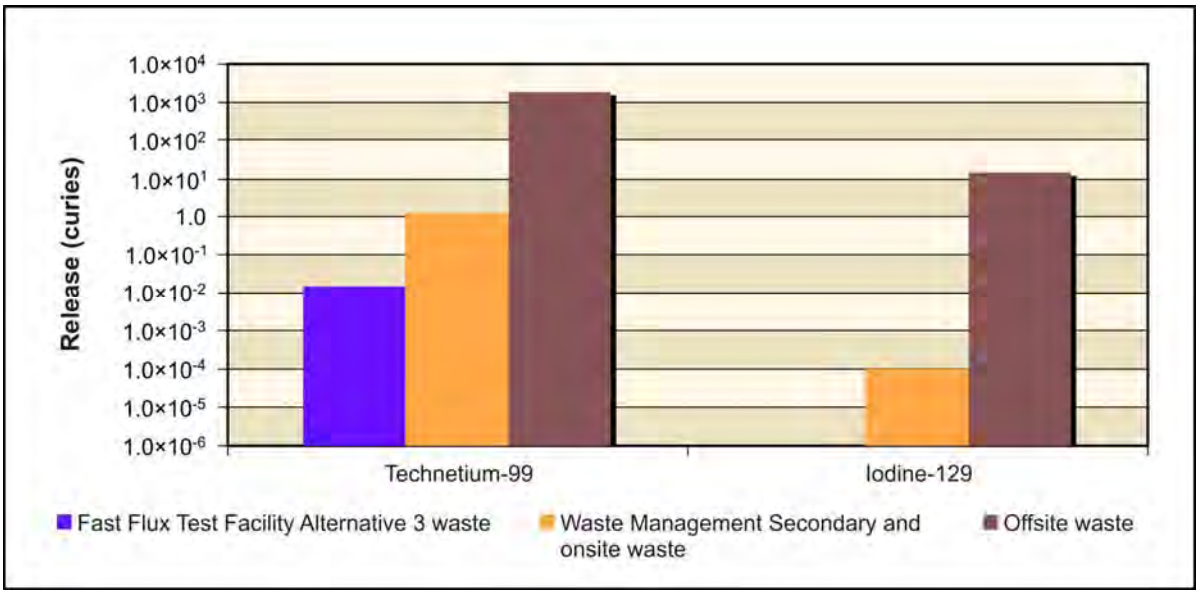


Figure 5–709. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

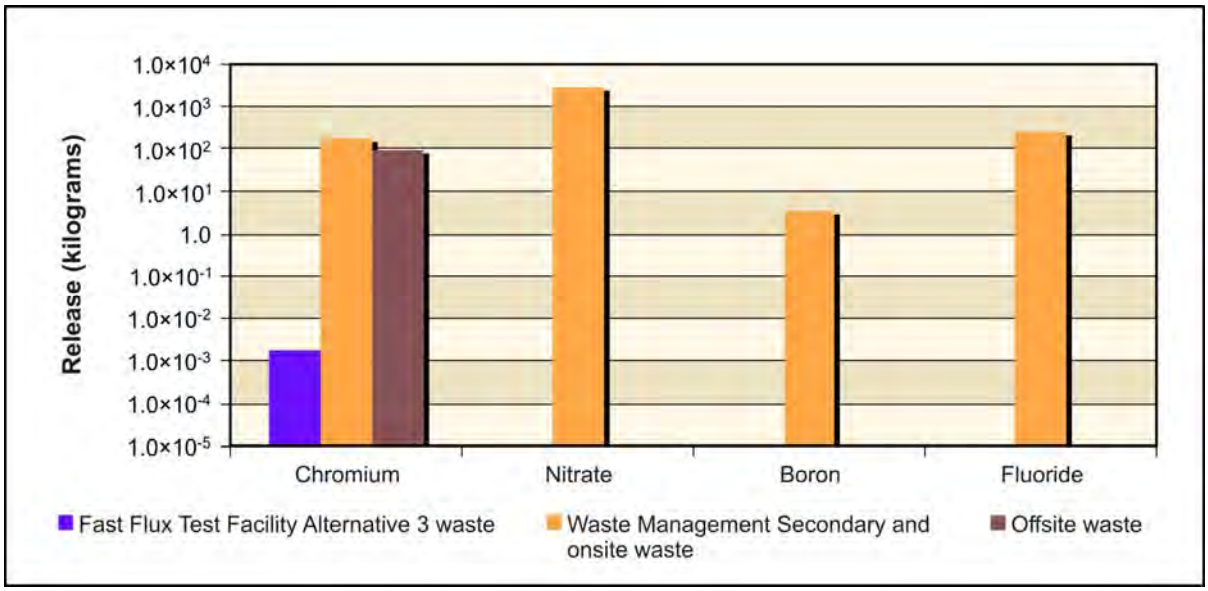


Figure 5–710. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–711 shows the release to groundwater for the radiological risk drivers and Figure 5–712, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, nitrate, boron, and fluoride, the amount released to groundwater is essentially equal to the amount released to the vadose zone. This means that there is less than one order of magnitude difference. Overall, about 98 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reaches groundwater; approximately 100 percent of the chemical quantity (kilograms) reaches groundwater.

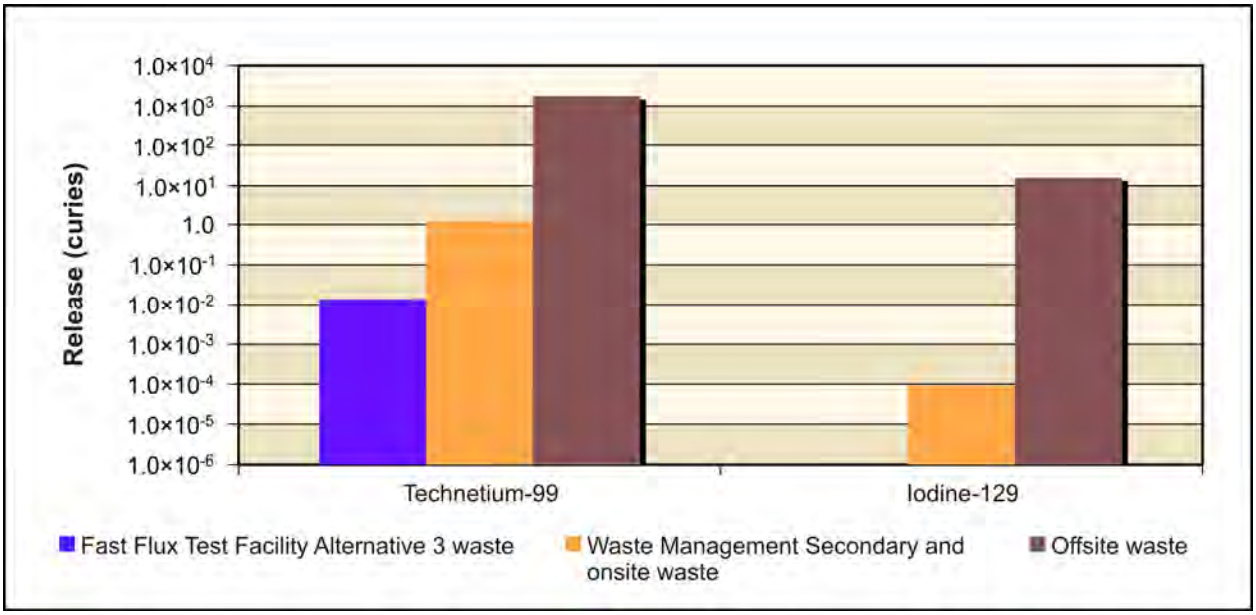


Figure 5–711. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

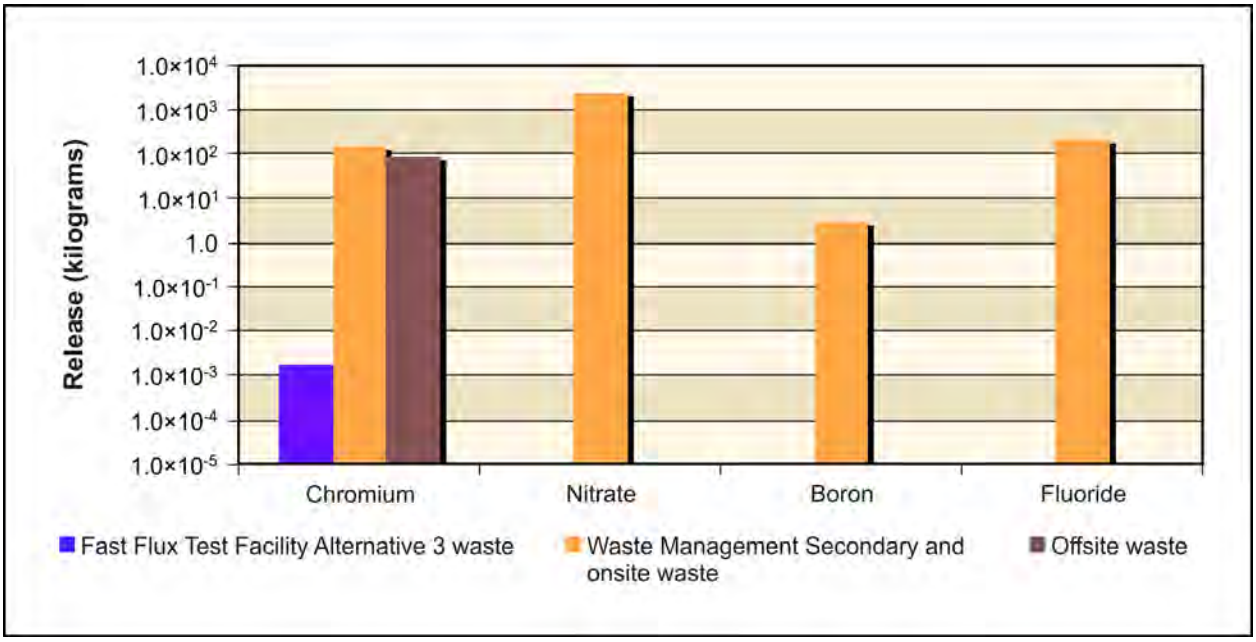


Figure 5–712. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–713 shows the release to the Columbia River for the radiological risk drivers and Figure 5–714, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For techetium-99, iodine-129, chromium, nitrate, boron, and fluoride, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 97 percent of the radionuclide amount (curies) released to groundwater during the period of analysis reaches the river; while approximately 98 percent of the chemical quantity (kilograms) reaches the river.

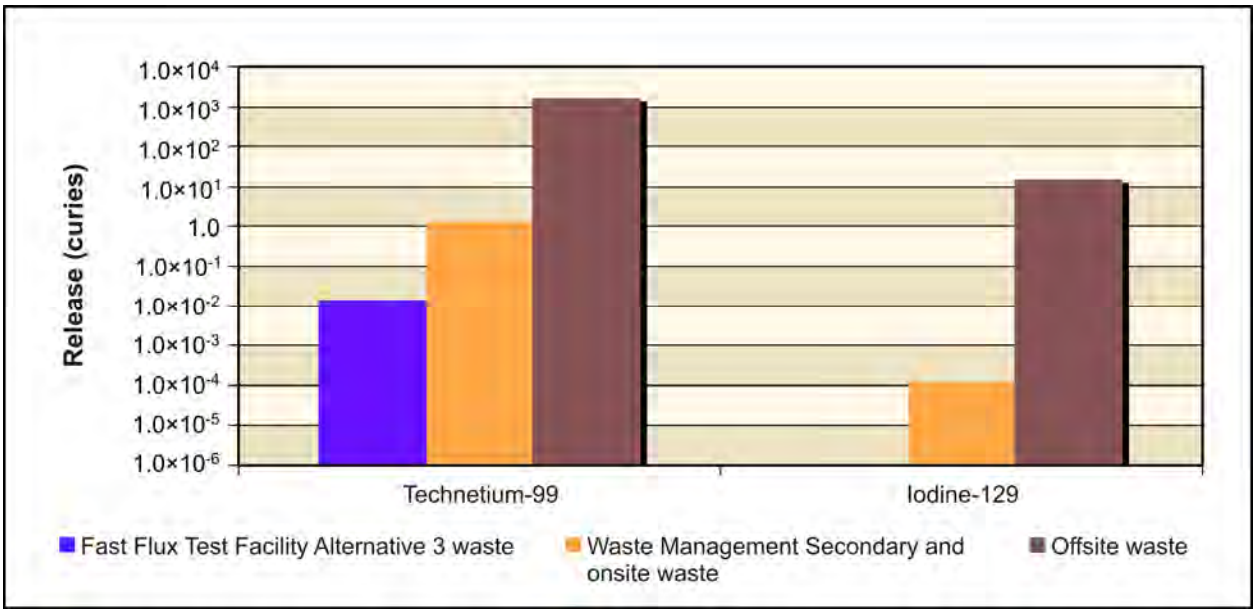


Figure 5–713. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

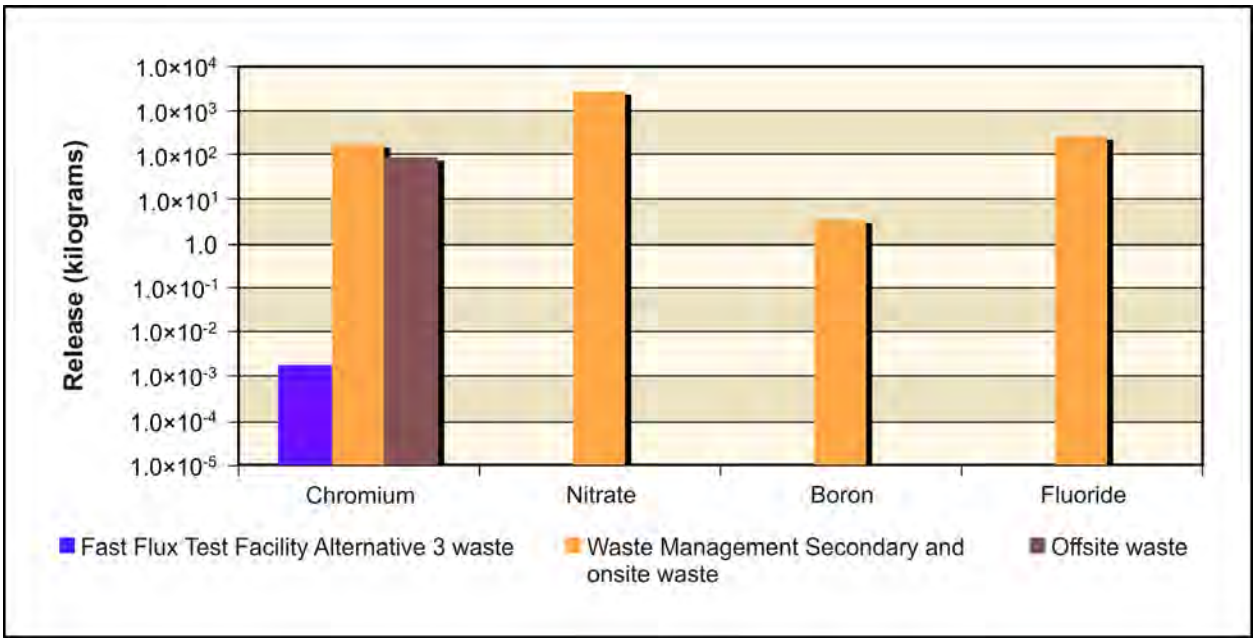


Figure 5–714. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–715 shows the release to the vadose zone for the radiological risk drivers and Figure 5–716, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The radiological releases to the vadose zone from the RPPDF include technetium-99 (largest) and iodine-129 (smallest). The chemical releases from the RPPDF include nitrate (largest) and chromium (smallest). Fluoride and boron do not exist at the RPPDF.

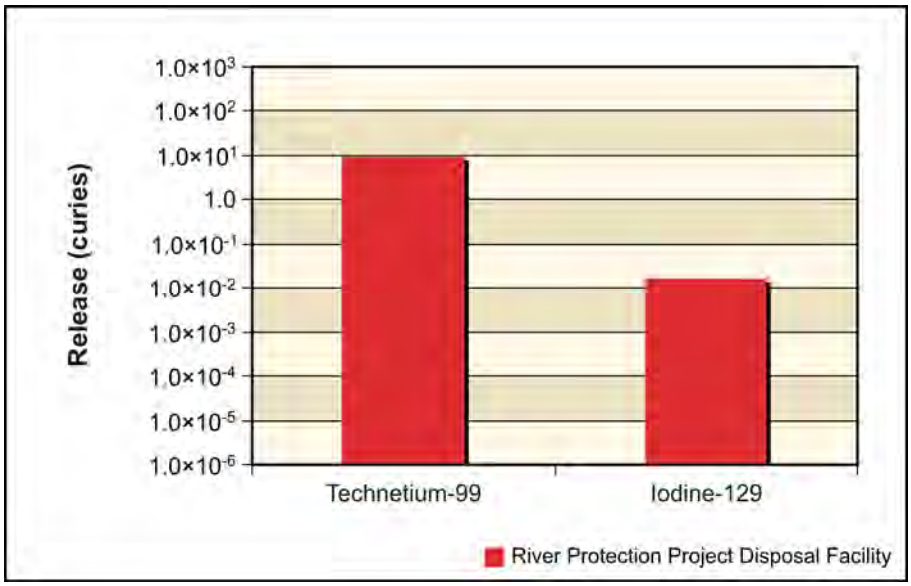


Figure 5–715. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

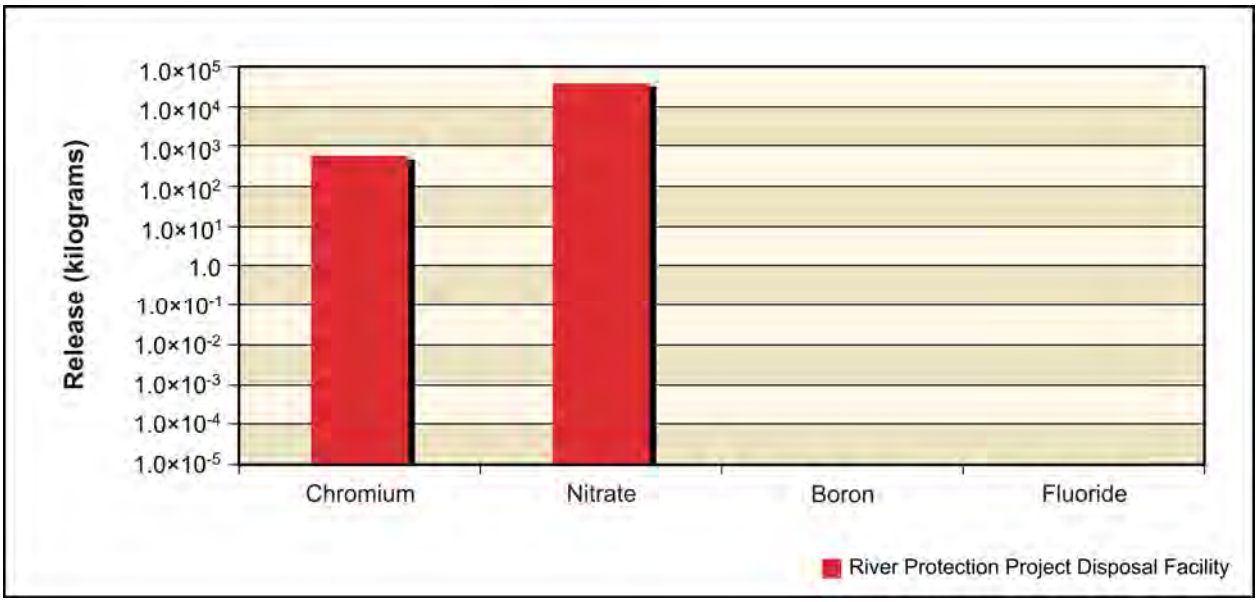


Figure 5–716. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–717 shows the release to groundwater for the radiological risk drivers and Figure 5–718, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. Overall, about 100 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reaches the groundwater; approximately 100 percent of the chemical quantity (kilograms) reaches the groundwater.

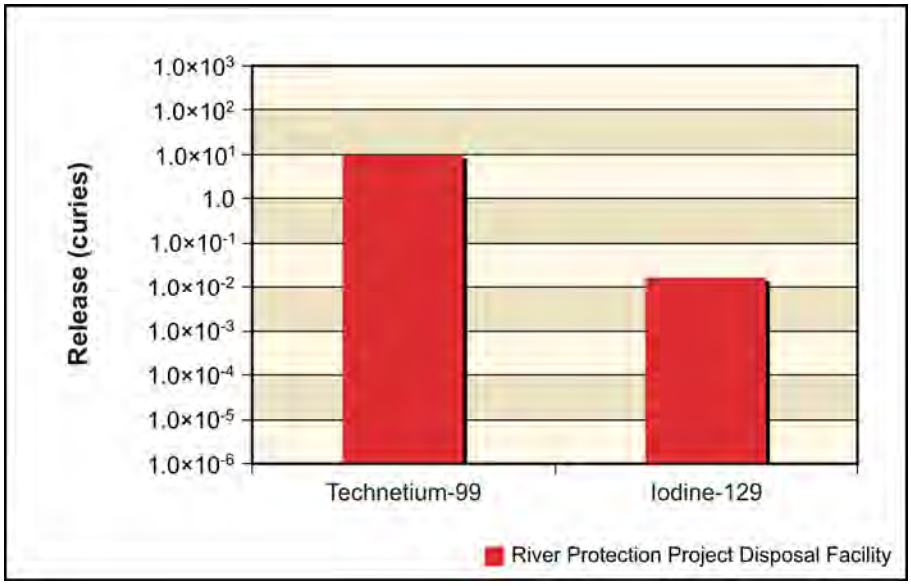


Figure 5–717. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at River Protection Project Disposal Facility to Groundwater

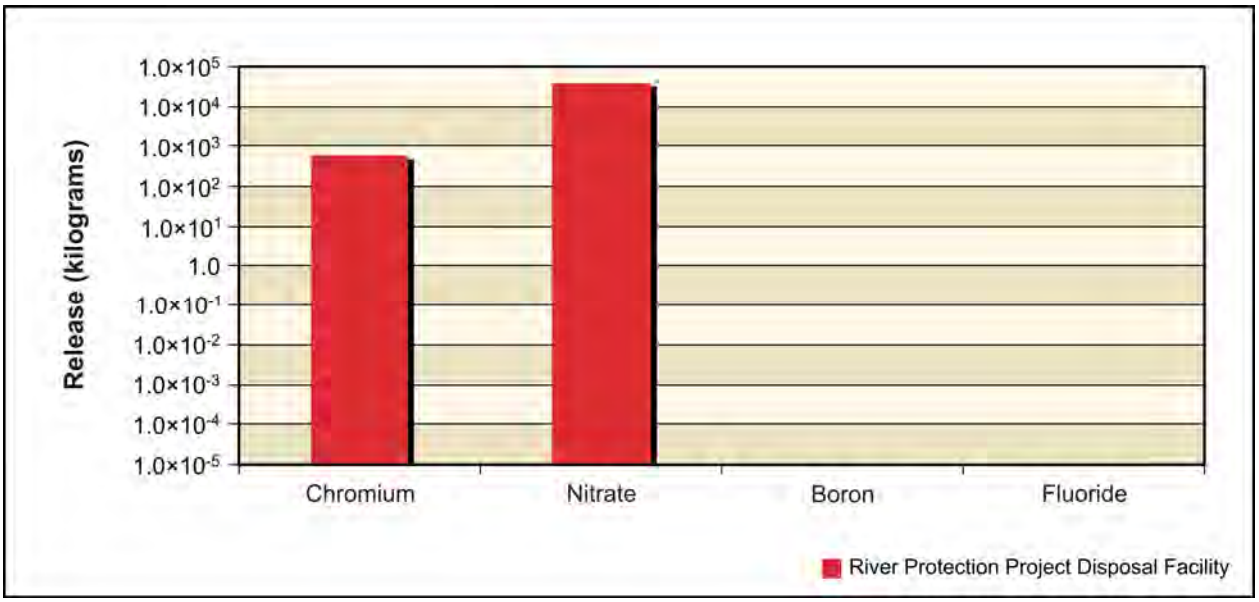


Figure 5–718. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–719 shows the release to the Columbia River for the radiological risk drivers and Figure 5–720, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For iodine-129, technetium-99, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. Overall, 96 percent of the radionuclide amount (curies) released to groundwater during the period of analysis reaches the river; 96 percent of the chemical quantity (kilograms) reaches the river.

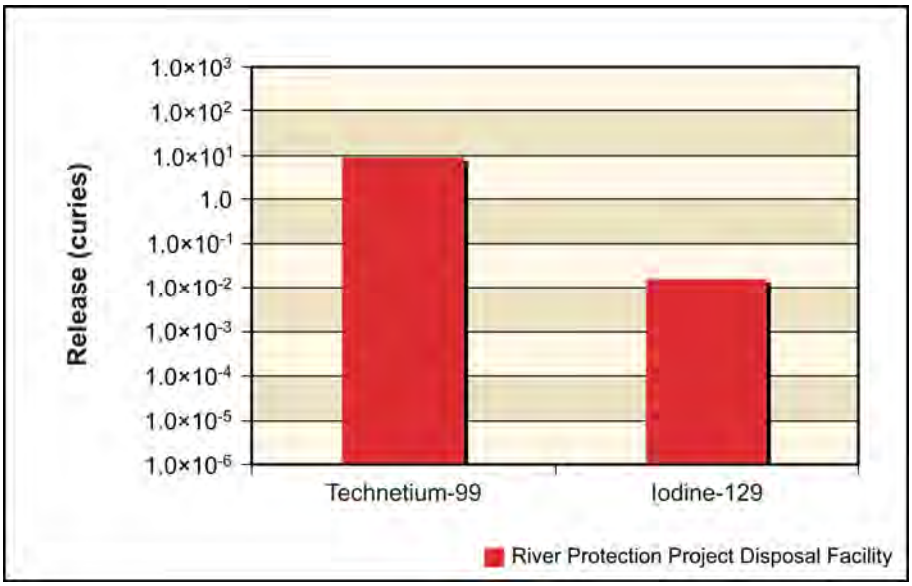


Figure 5–719. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Radiological Releases at River Protection Project Disposal Facility to Columbia River

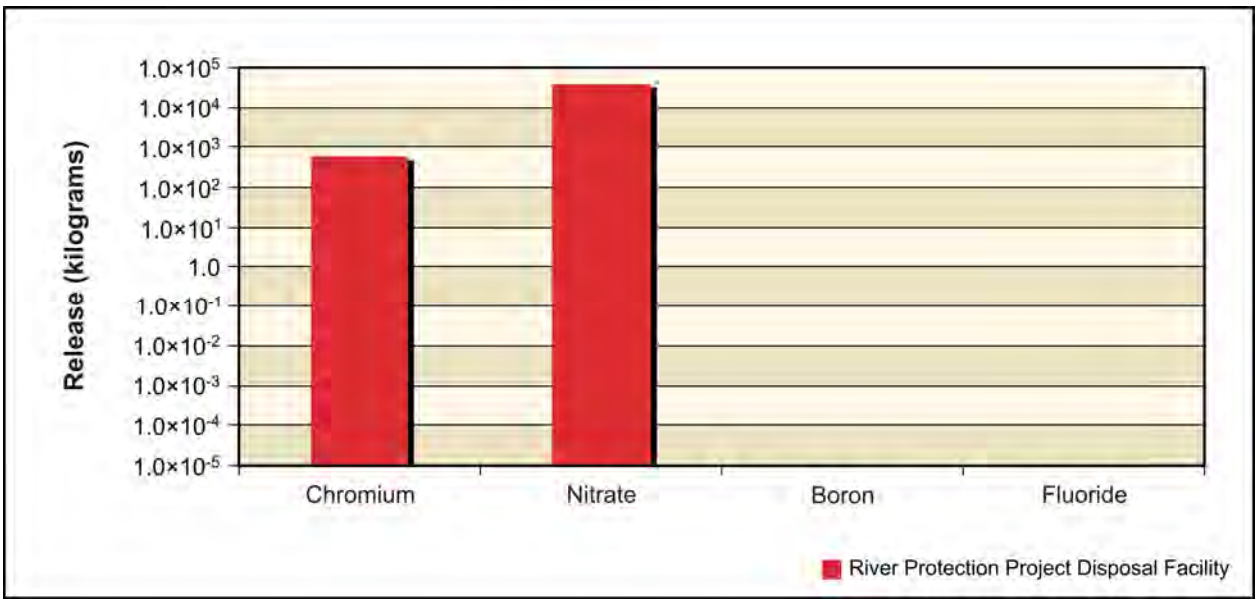


Figure 5–720. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–89 lists the maximum concentrations of the COPCs in the peak year at the IDF-East, RPPDF, Core Zone Boundary, and Columbia River nearshore.

Table 5–89. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	471	**20,200**	33	**7,560**	**1,130**	900
	(8991)	(3713)	(3825)	(3690)	(4528)	
Iodine-129	**1**	**173**	0.1	**60**	**8**	1
	(11243)	(3797)	(3772)	(3853)	(4729)	
Chemical in microgram per liter						
Chromium	4	2	2	3	1	100
	(8511)	(3696)	(3856)	(3628)	(8879)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	14,200	17	149	5,630	2,440	45,000
	(8522)	(3703)	(3811)	(9653)	(8043)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–721 through 5–724 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. Releases from IDF-East, IDF-West, and the RPPDF cause groundwater concentrations of iodine-129 to exceed benchmark concentrations at the Core Zone Boundary and Columbia River nearshore by approximately one order of magnitude. Iodine-129 extending above the benchmark occurs in the earlier part of the period of analysis. Technetium-99 has one peak at the Core Zone Boundary that exceeds the benchmark by one order of magnitude. This peak only lasts for approximately 10 percent of the period of analysis. Nitrate and chromium do not exceed benchmark concentrations at the Core Zone Boundary or Columbia River nearshore.

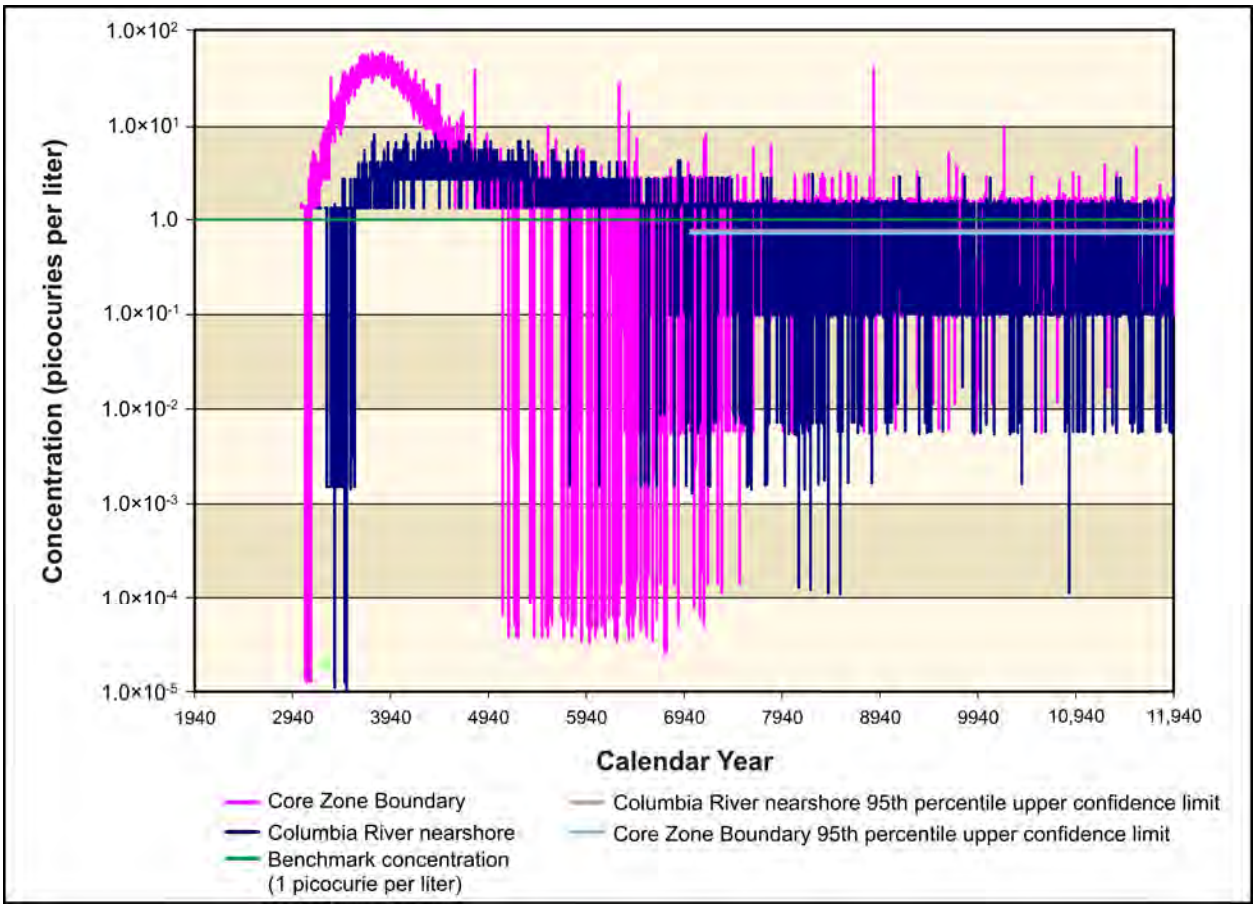


Figure 5–721. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Iodine-129 Concentration Versus Time

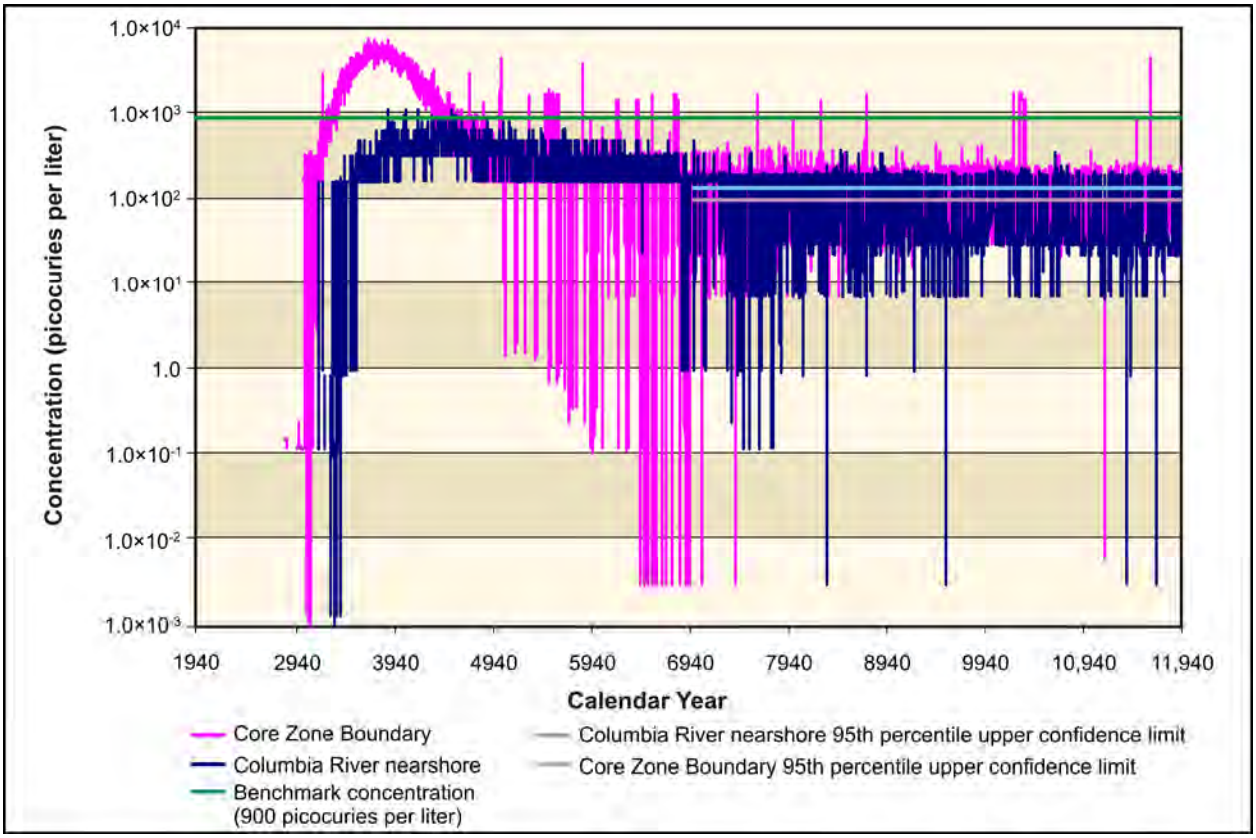


Figure 5–722. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Technetium-99 Concentration Versus Time

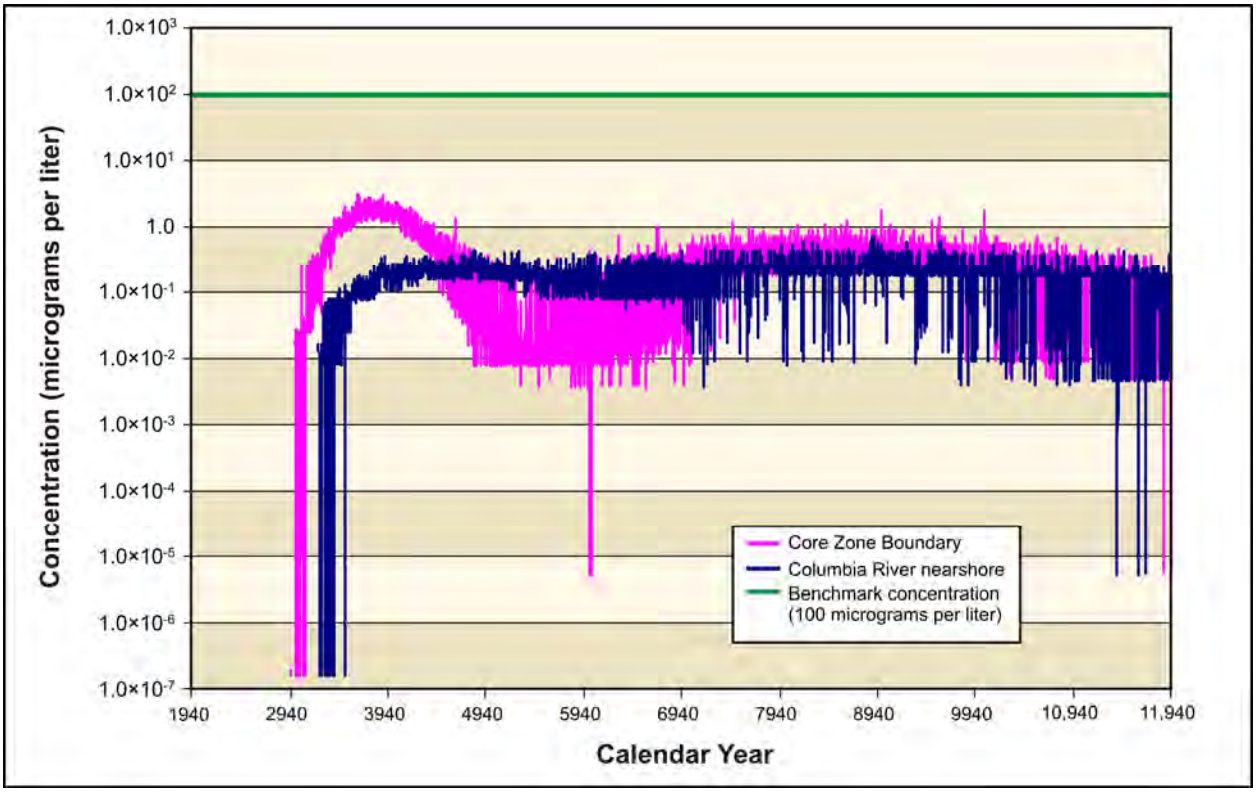


Figure 5–723. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chromium Concentration Versus Time

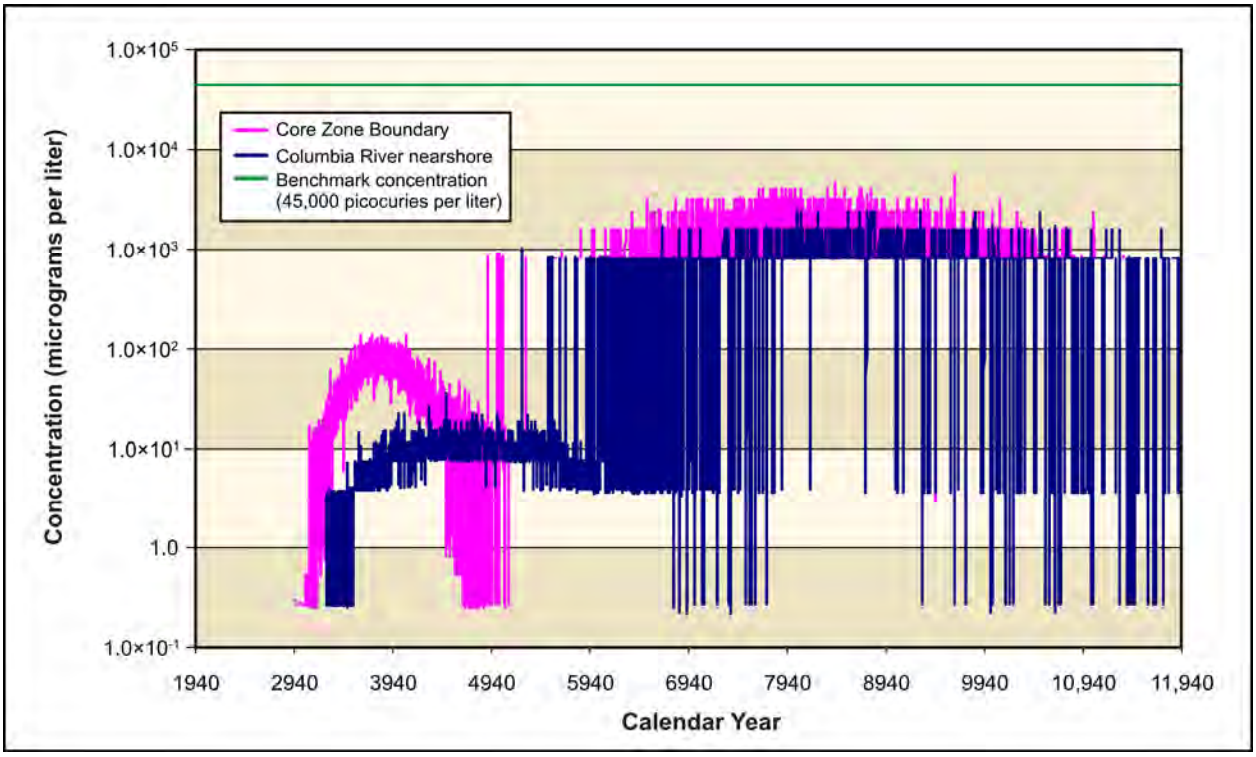


Figure 5–724. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Nitrate Concentration Versus Time

Figures 5–725 and 5–726 show concentration versus time for uranium-238 and total uranium. Because uranium-238 and total uranium are slow moving through the vadose zone, releases from IDF-East, IDF-West, and the RPPDF result in groundwater concentrations that are several orders of magnitude lower than benchmark concentrations. Uranium-238 and total uranium concentrations, while minimal, continue to rise throughout the duration of the period of analysis, but they never get higher than three orders of magnitude below the benchmark concentrations by the end of the period of analysis.

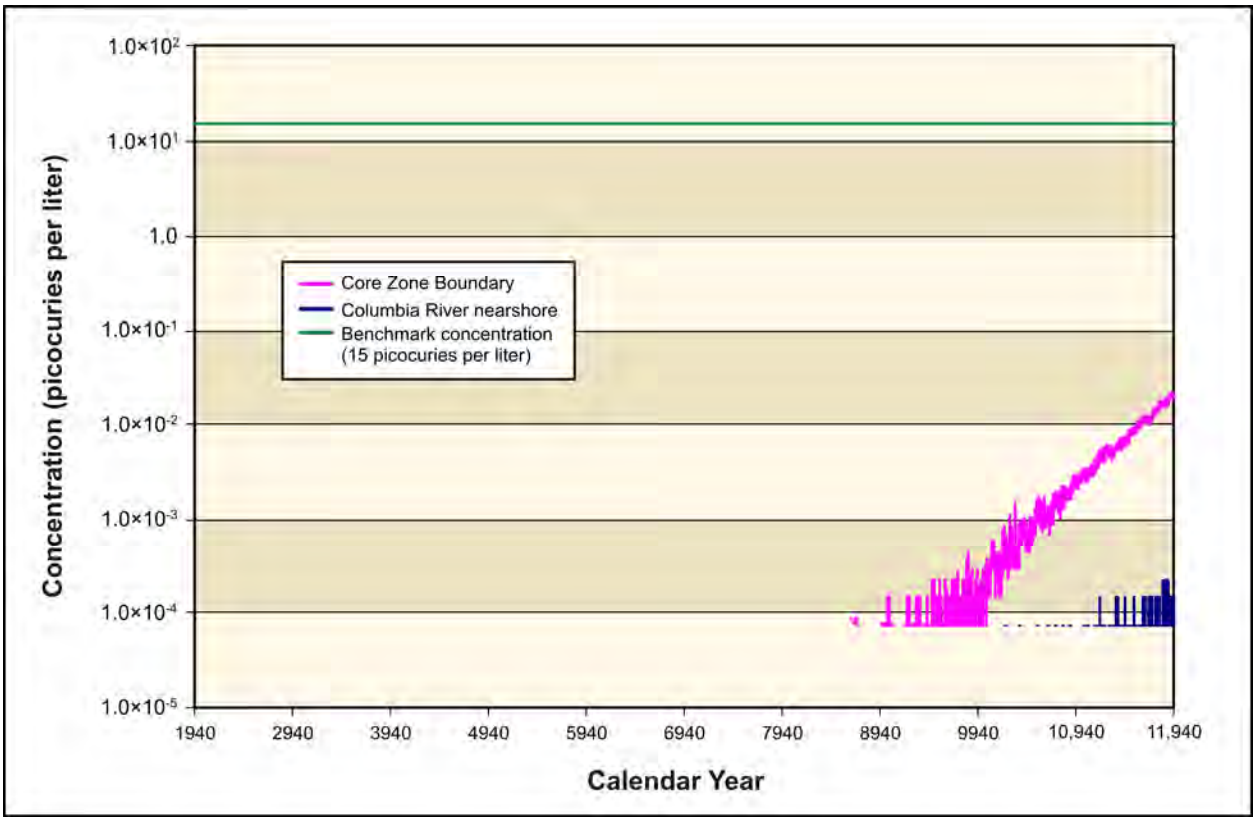


Figure 5–725. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Uranium-238 Concentration Versus Time

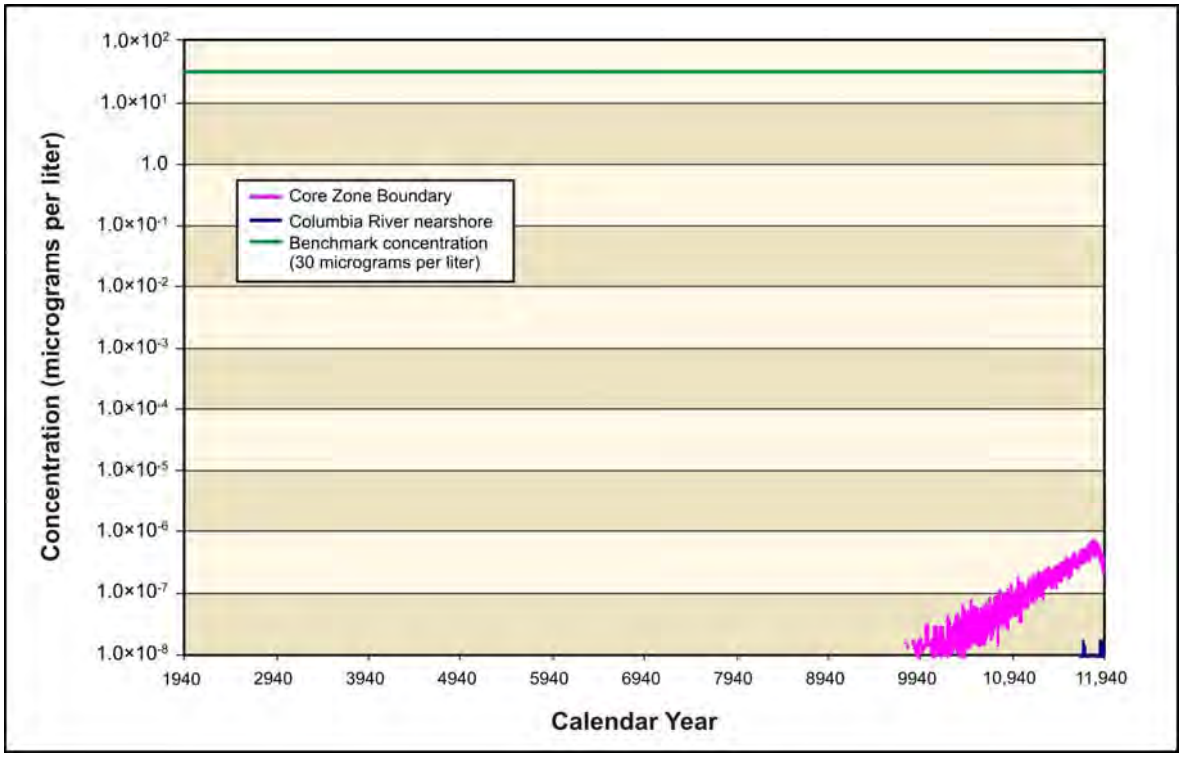
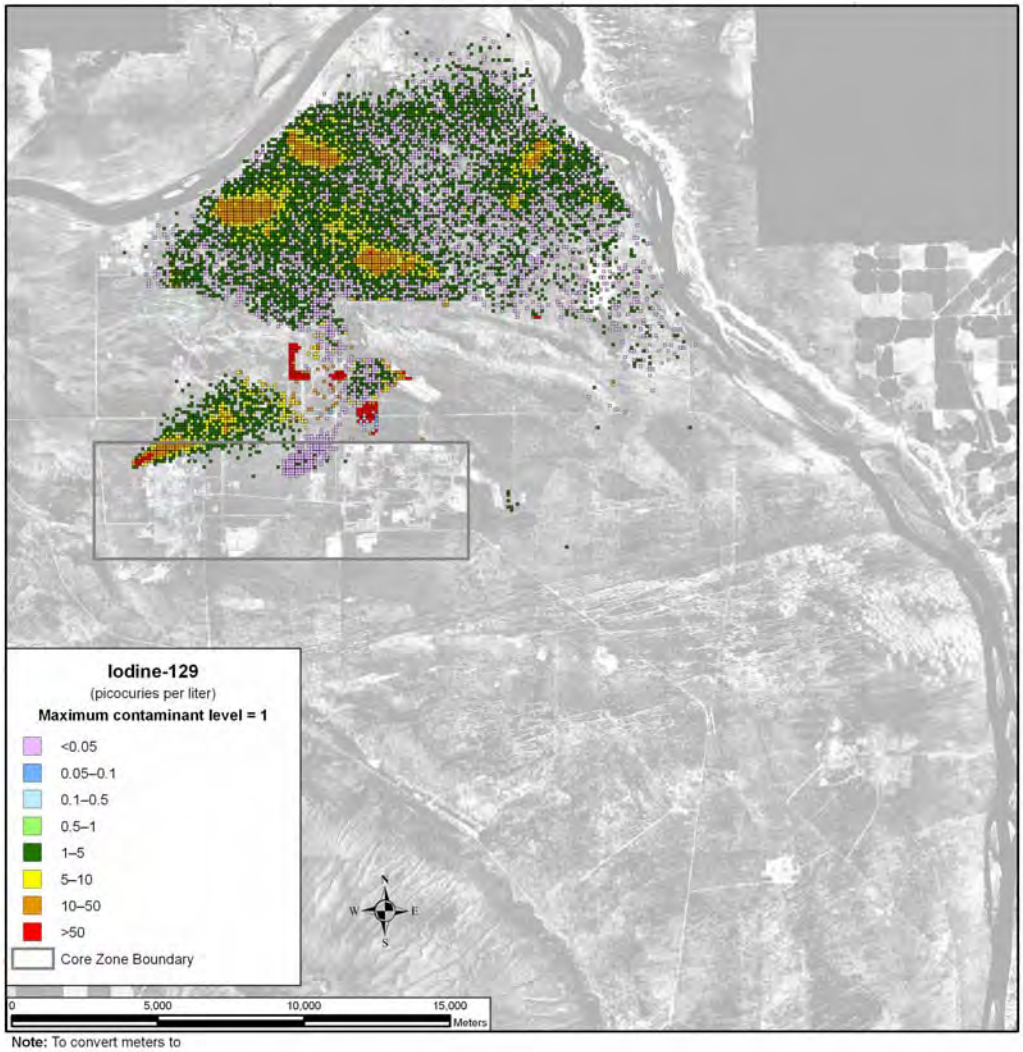


Figure 5–726. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

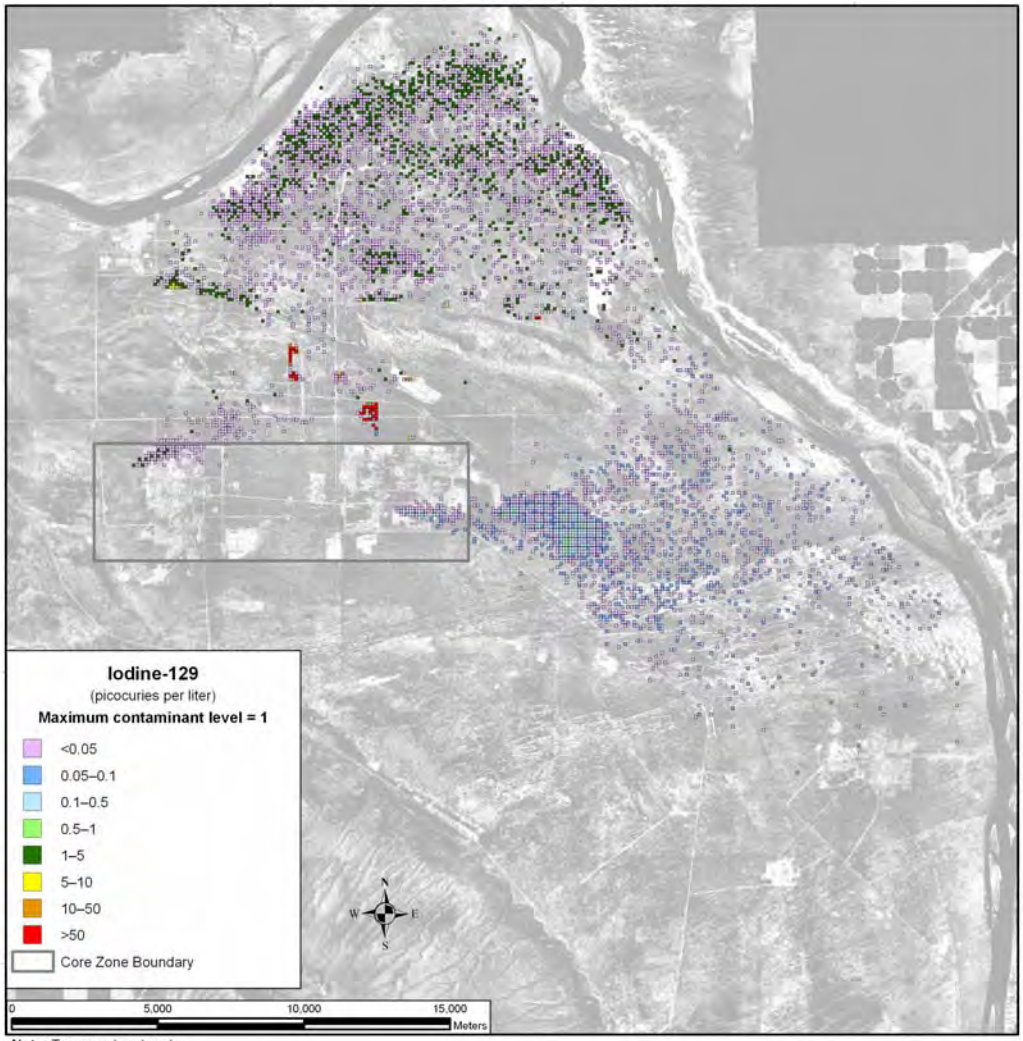
This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in terms of the spatial distribution of groundwater concentrations at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations lower than the benchmark concentration by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figure 5–727 shows the spatial distribution of groundwater concentrations of iodine-129 during CY 3890. Releases from IDF-West and the RPPDF result in a groundwater plume starting in the Core Zone and heading north through Gable Mountain. This plume exceeds the benchmark concentration at the Core Zone Boundary and north of the Core Zone Boundary by one to two orders of magnitude. During CY 7140, releases from IDF-East create a groundwater plume, not exceeding the benchmark, extending from the 200-East Area and moving eastward toward the Columbia River (see Figure 5–728). Also by CY 7140, most of the IDF-West and RPPDF plume continued to move north and reached the Columbia River. By CY 11,885, most of the mass in the IDF-East plume is still moving eastward toward the Columbia River with only small isolated pockets of concentration exceeding the benchmark (see Figure 5–729). Technetium-99 (see Figures 5–730 through 5–732) shows similar spatial distributions at selected times and exceeds the benchmark concentrations at approximately the same time and locations. Chromium (see Figures 5–733 through 5–735), and nitrate (see Figures 5–736 through 5–738) show similar spatial distributions at selected times, but none of them exceed the benchmark concentrations. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).



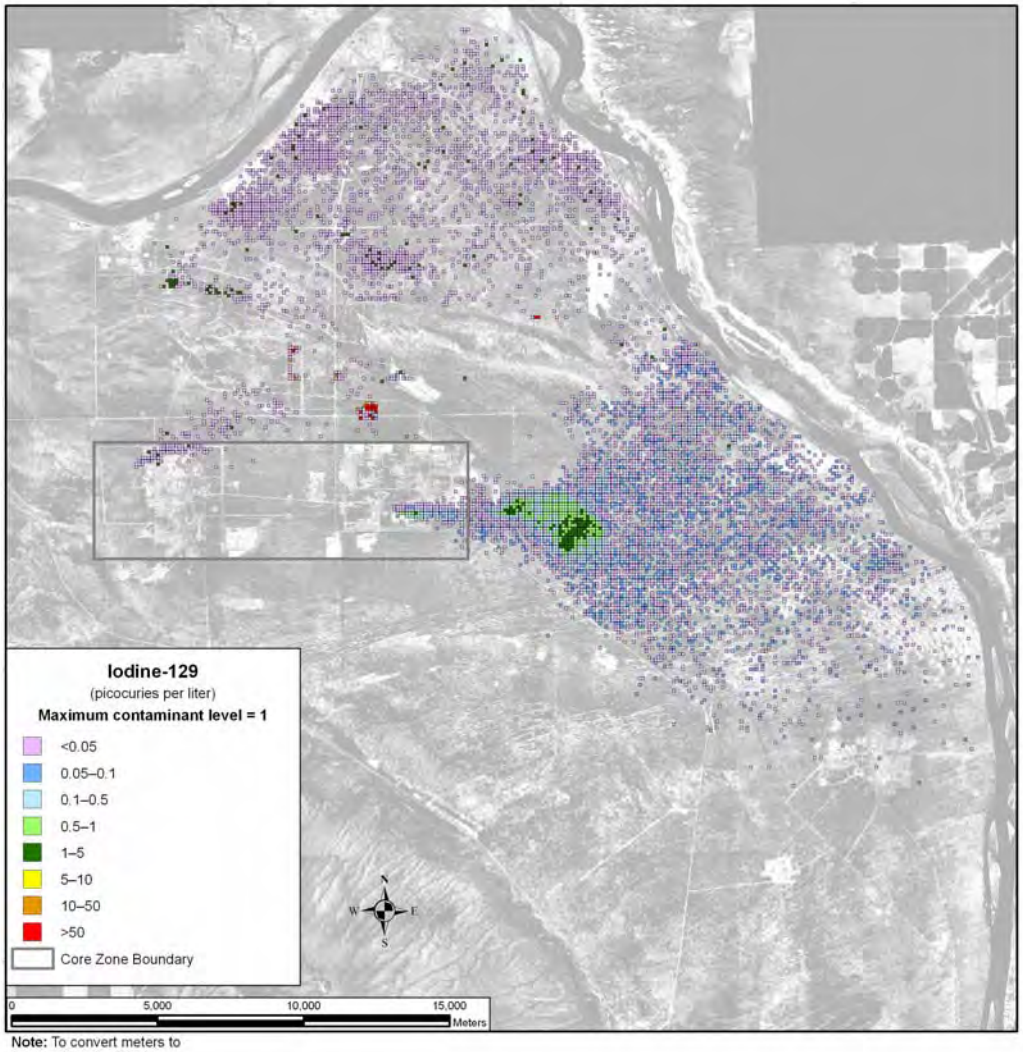
Note: To convert meters to feet, multiply by 3.281

Figure 5–727. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



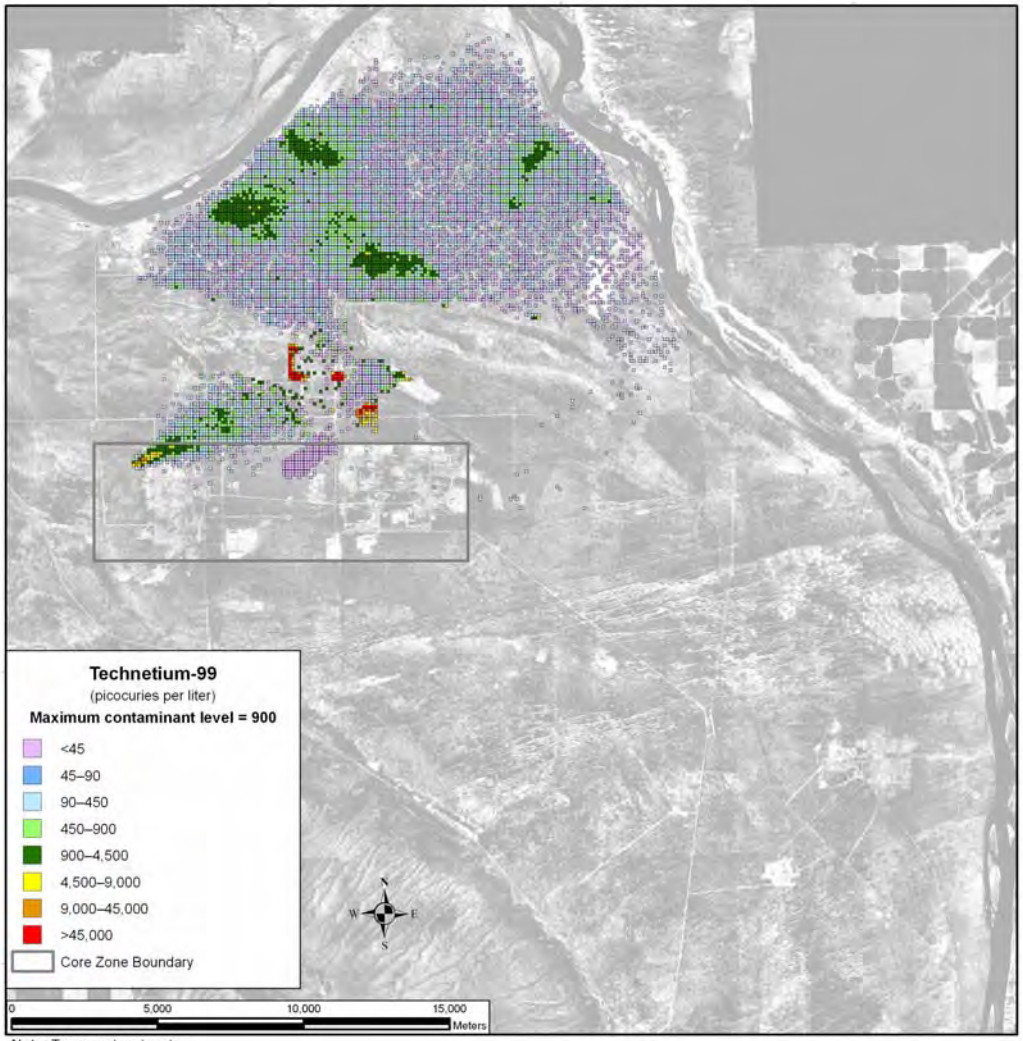
Note: To convert meters to feet, multiply by 3.281

Figure 5–728. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



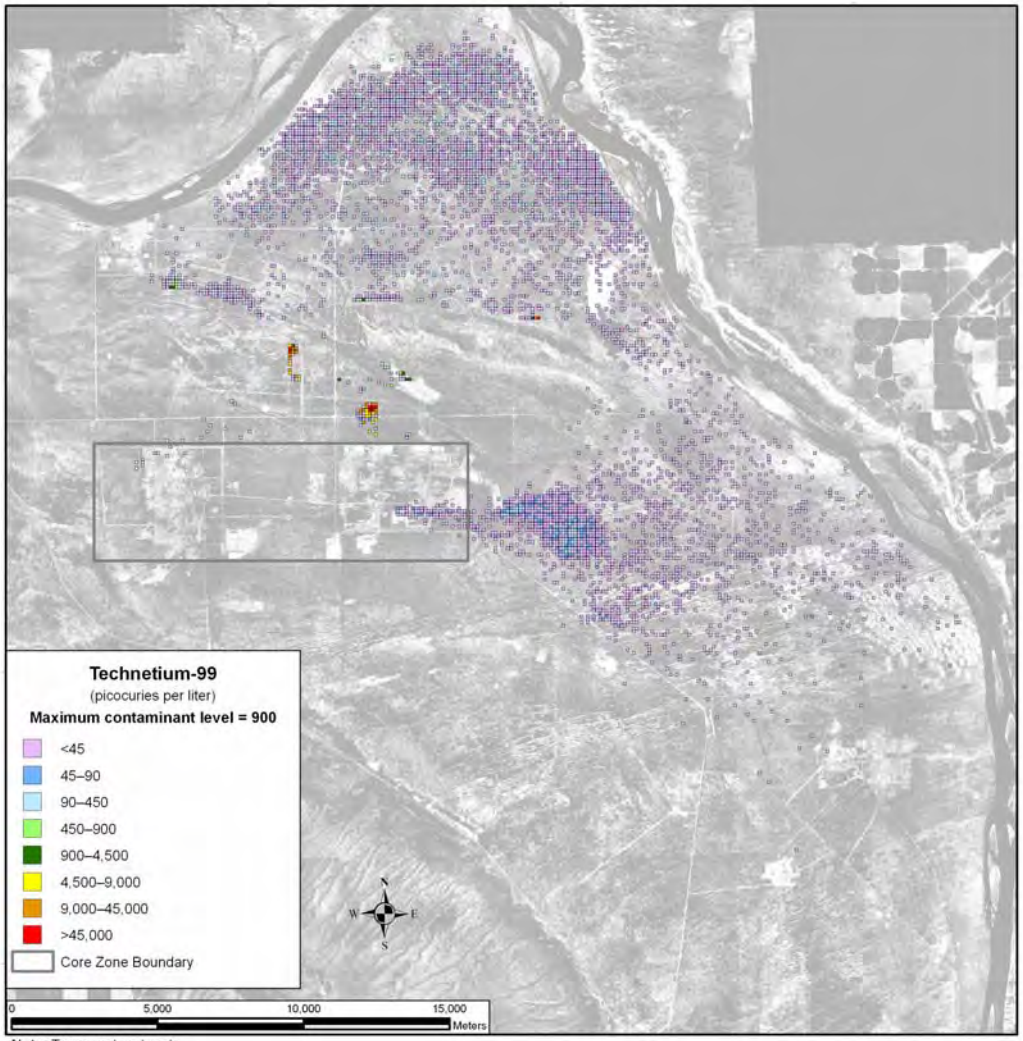
Note: To convert meters to feet, multiply by 3.281

Figure 5–729. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



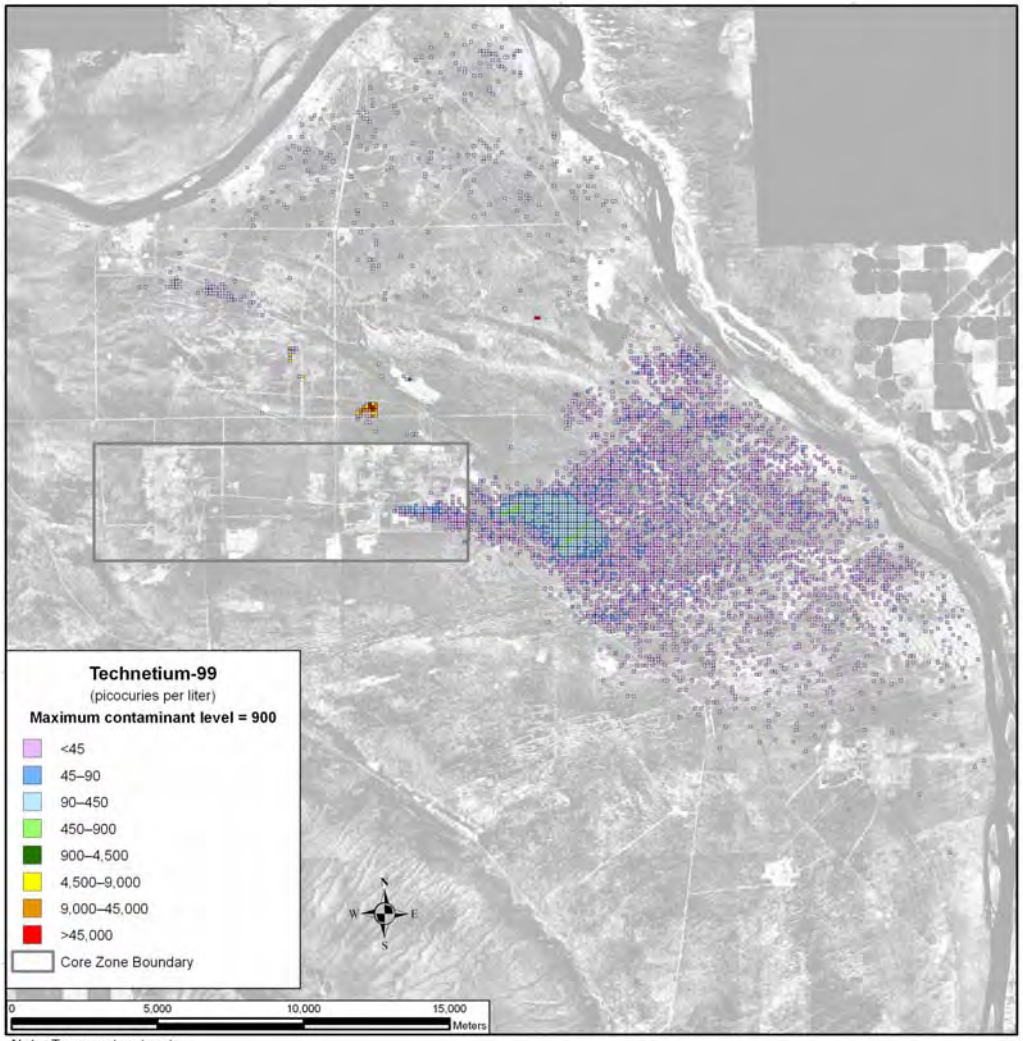
Note: To convert meters to feet, multiply by 3.281

Figure 5–730. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



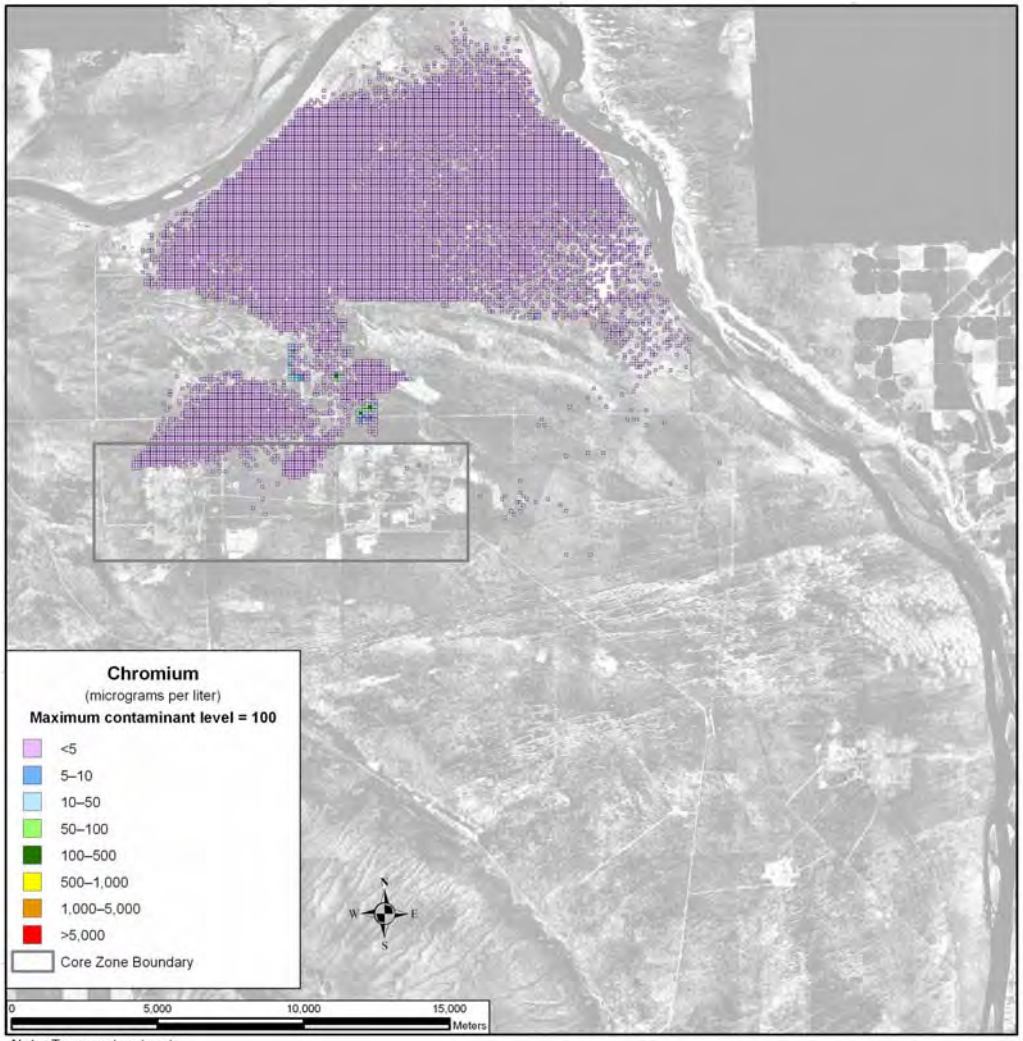
Note: To convert meters to feet, multiply by 3.281

Figure 5–731. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



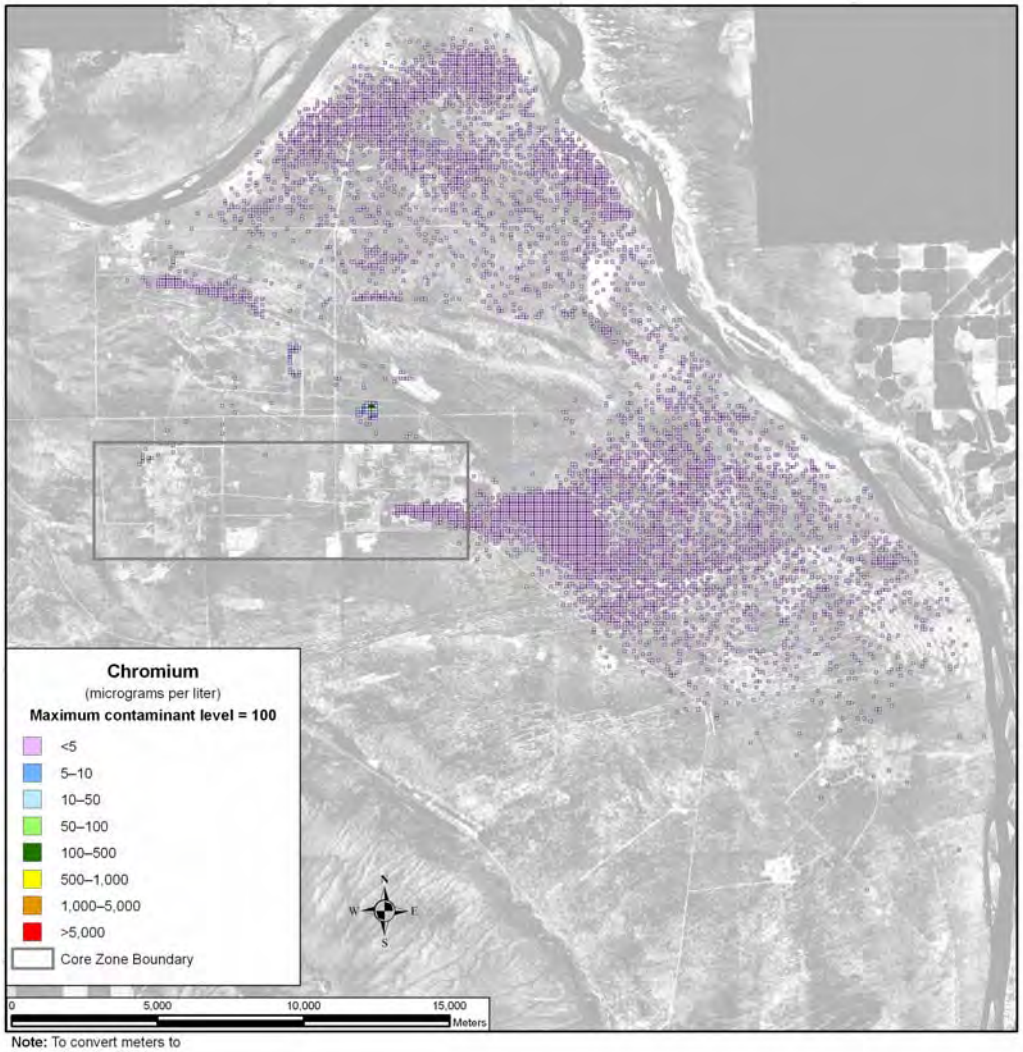
Note: To convert meters to feet, multiply by 3.281

Figure 5–732. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



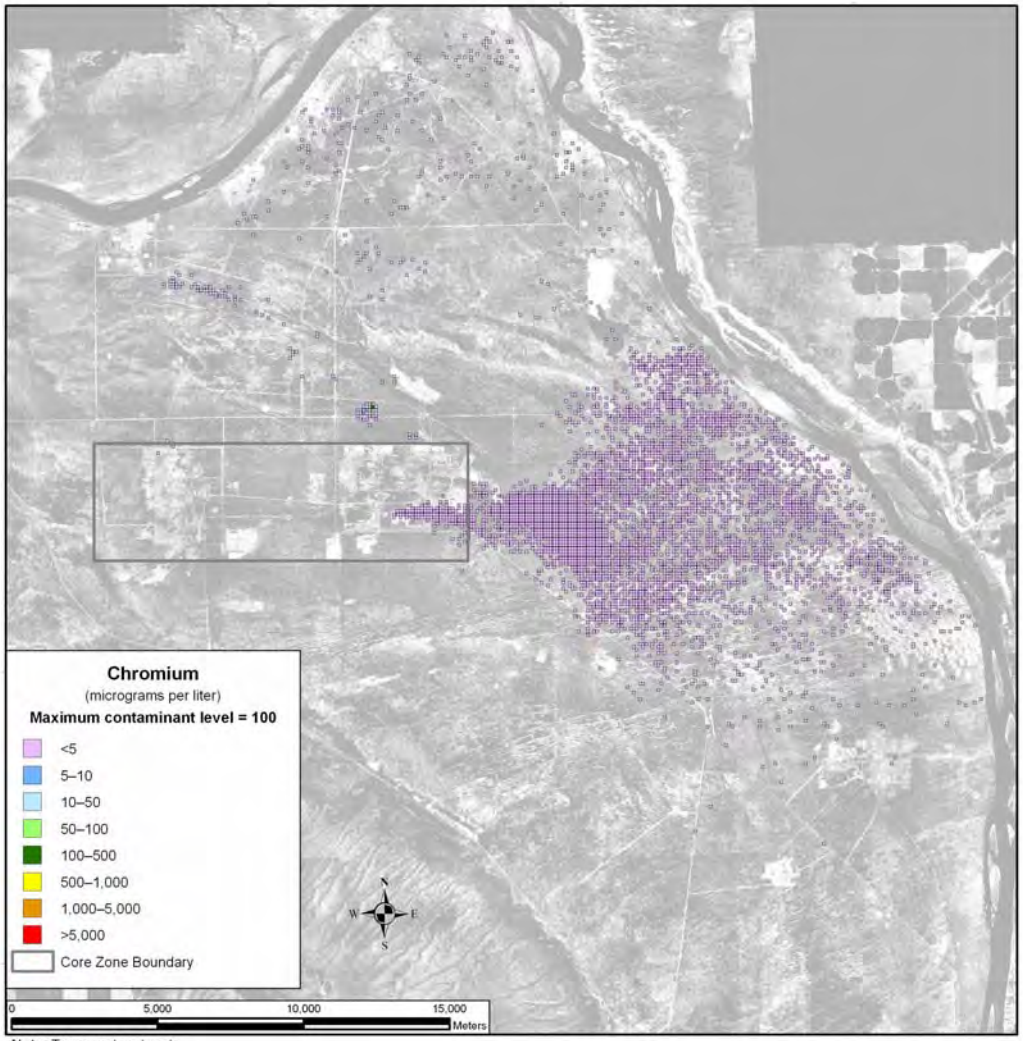
Note: To convert meters to feet, multiply by 3.281

Figure 5–733. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



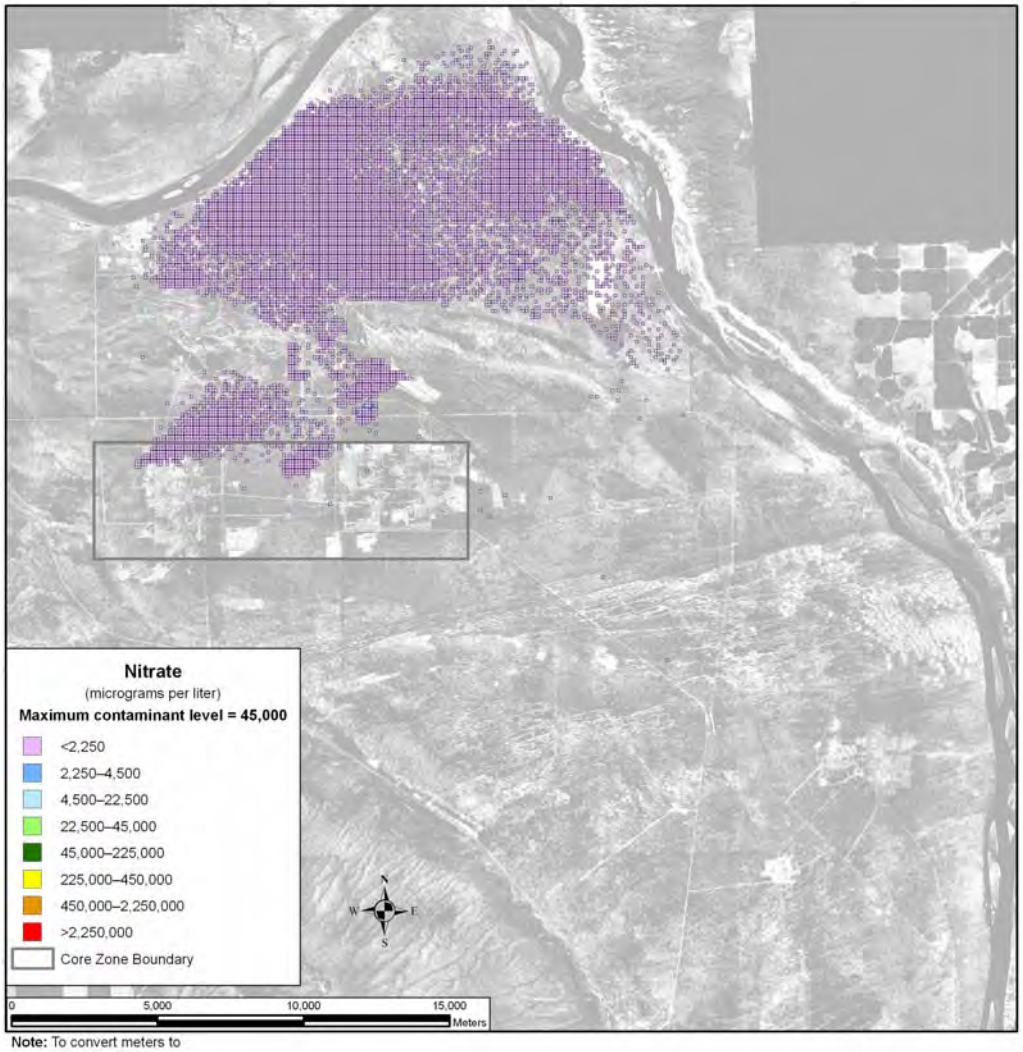
Note: To convert meters to feet, multiply by 3.281

Figure 5–734. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



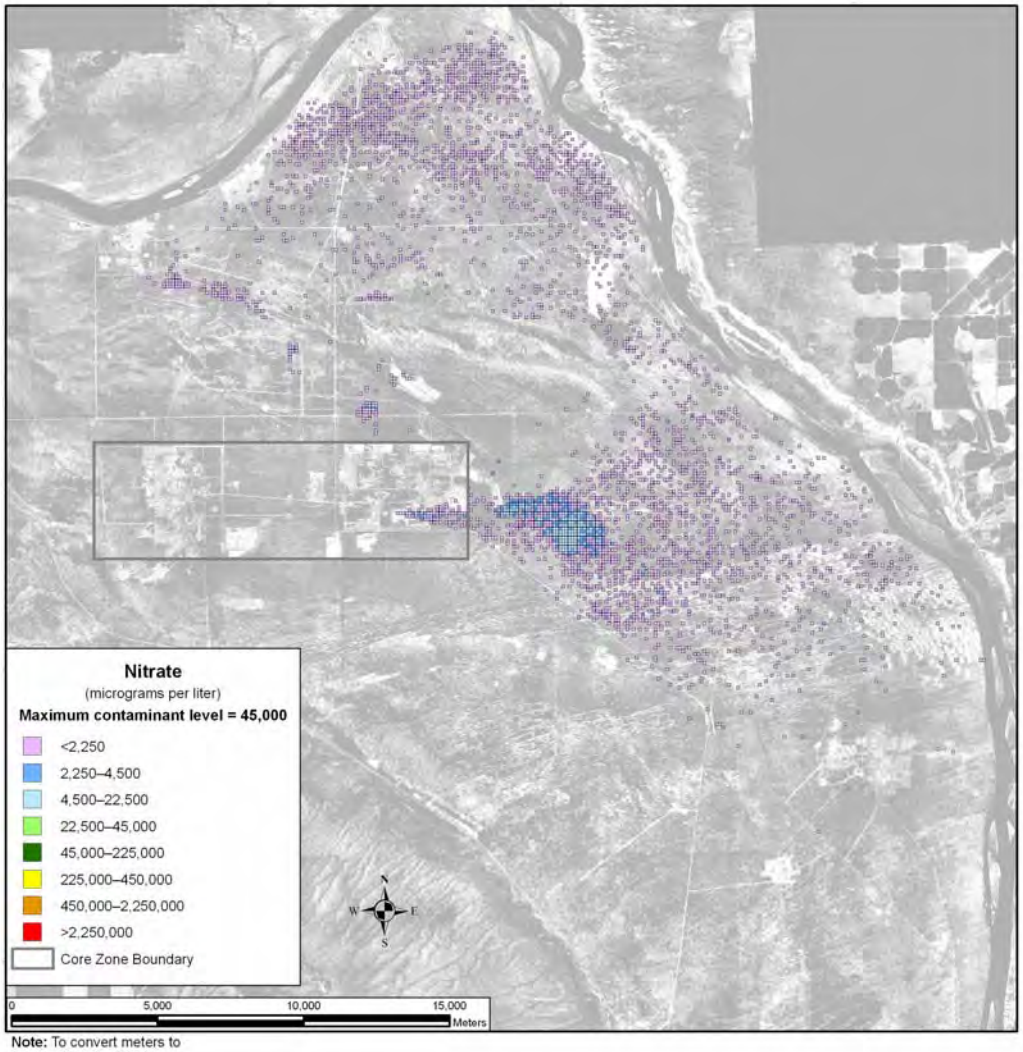
Note: To convert meters to feet, multiply by 3.281

Figure 5–735. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



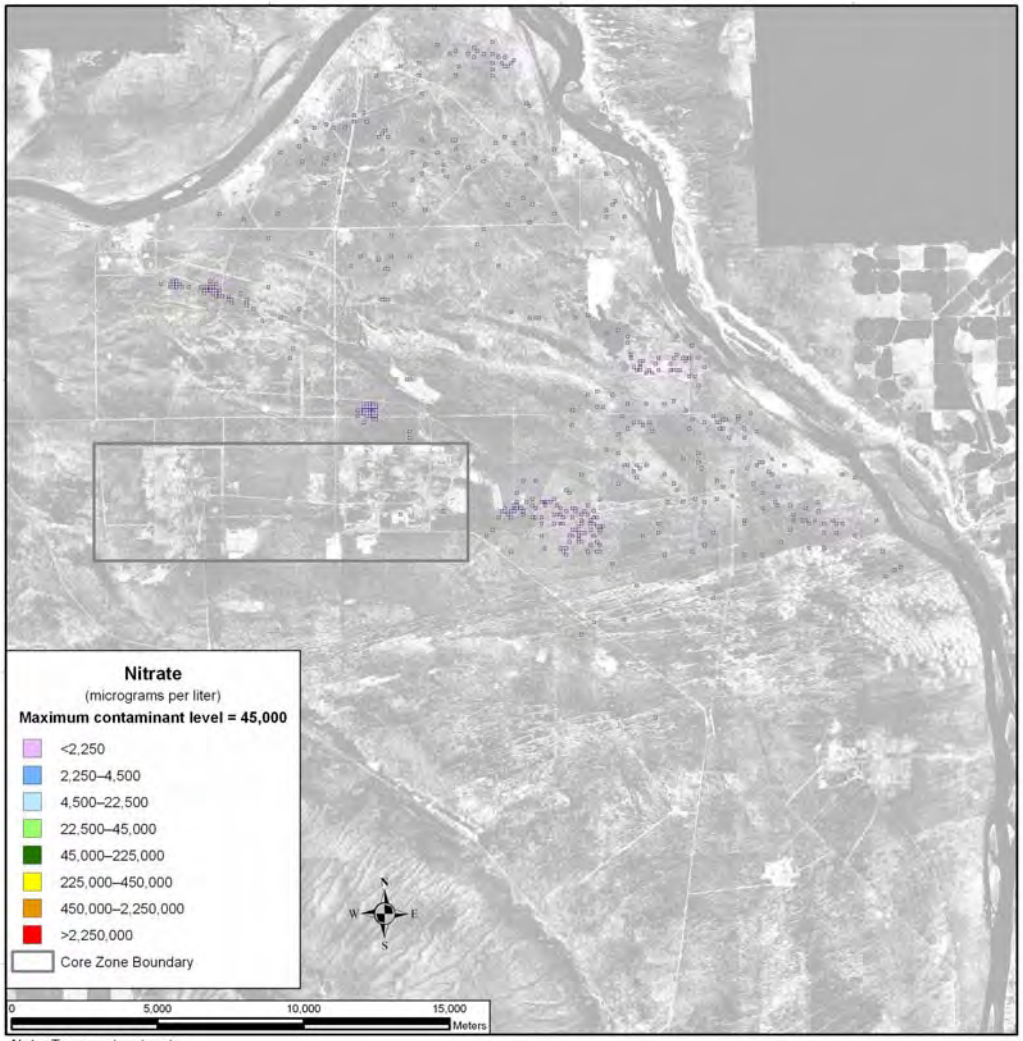
Note: To convert meters to feet, multiply by 3.281

Figure 5–736. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

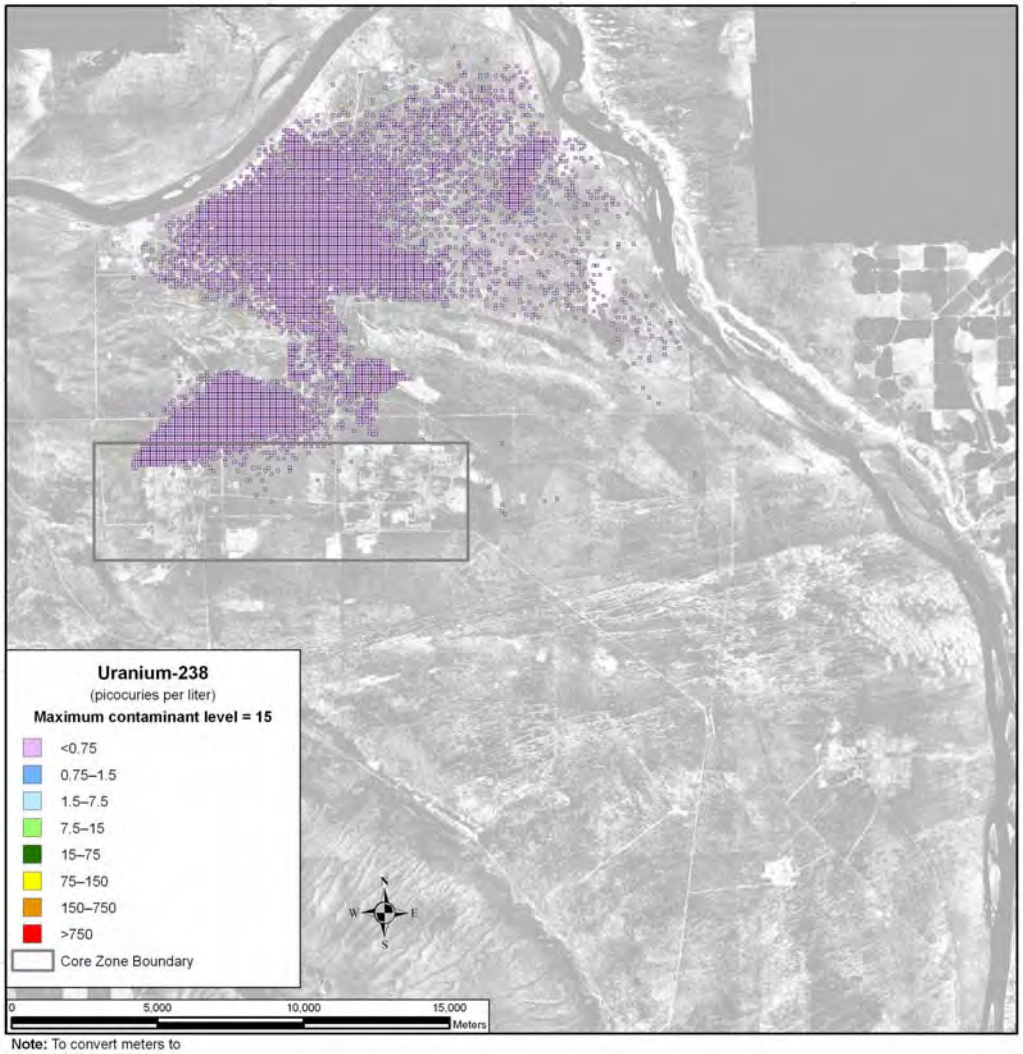
Figure 5–737. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

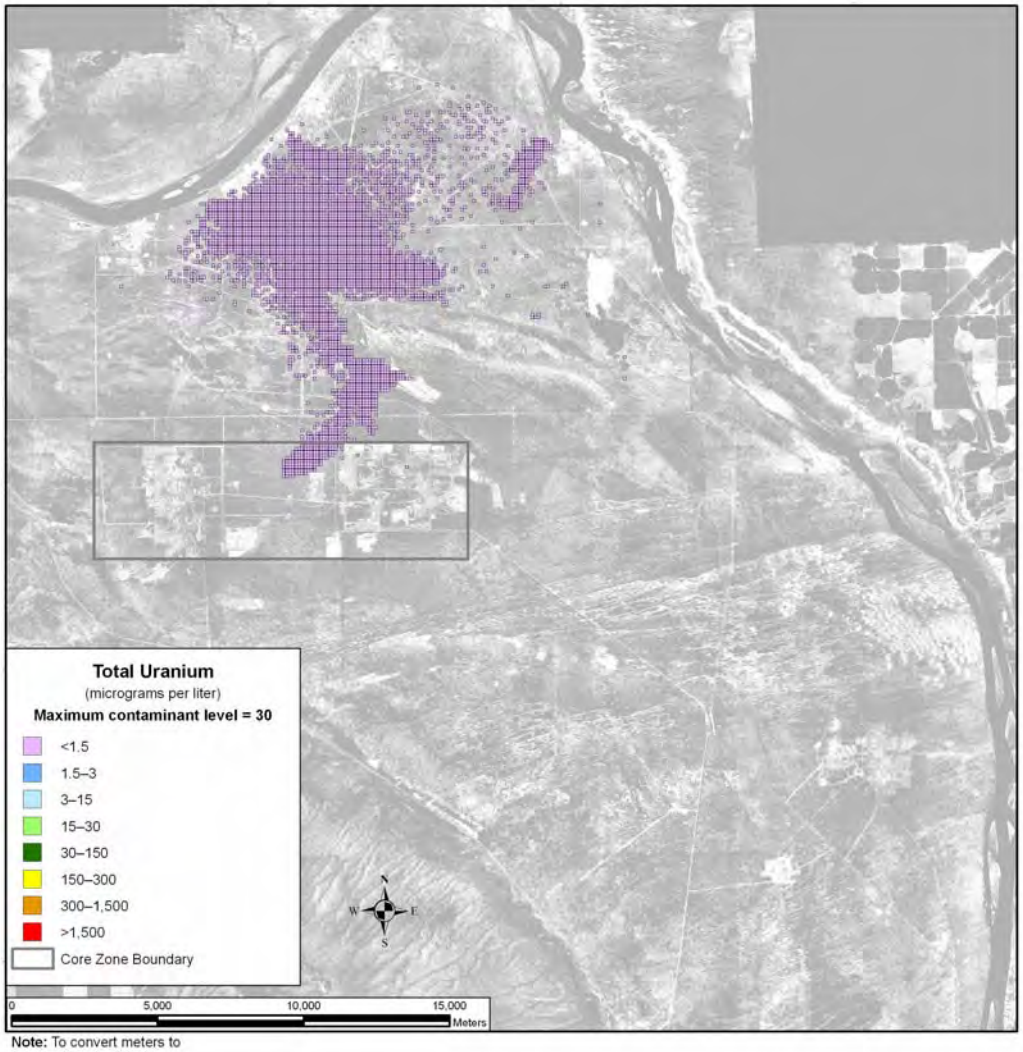
Figure 5–738. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Uranium-238 and total uranium show a different spatial distribution over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figures 5–739 and 5–740 show the distribution of uranium-238 and total uranium during CY 11,885. Releases from IDF-West and the RPPDF result in a groundwater plume that starts in the Core Zone and moves north through Gable Mountain. However, this plume does not exceed the benchmark concentration during the period of analysis.



Note: To convert meters to feet, multiply by 3.281

Figure 5–739. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–740. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in general, the inventories remaining at IDF-East, IDF-West, and the RPPDF, and available for release to the environment at the start of the post-disposal period are predominant contributors.

For the conservative tracers, concentrations slightly outside the Core Zone Boundary exceed benchmark standards by one to two orders of magnitude during most of the period of analysis. Concentration at the Columbia River is about one to two orders of magnitude lower. The intensities and areas of these groundwater plumes peak between CY 3890 and CY 7140.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframe and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or Columbia River nearshore.

5.3.1.3.1.2 Disposal Group 1, Subgroup 1-B

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-B covers disposal of waste generated under Tank Closure Alternative 3A and either FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Tank Closure waste would be converted to IHLW, ILAW glass, and bulk vitrification glass.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continue through CY 2050, when the disposal facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF would become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier that limits infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, nitrate) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B (IDF-East, IDF-West, and RPPDF releases), in terms of total amount of COPCs released to the vadose

zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms (see Figures 5–741 through 5–758). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

IDF-East has five subtotals plotted representing releases from ILAW glass, bulk vitrification glass, ETF-generated secondary waste, retired melters, and tank closure secondary waste.

Figure 5–741 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–742, the chemical hazard drivers. For all five types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 is bulk vitrification glass and of iodine-129 is ETF-generated secondary waste. The predominant sources of chromium are tank closure secondary waste, while the predominant source of nitrate is ETF-generated secondary waste. Boron and fluoride are not released from IDF-East.

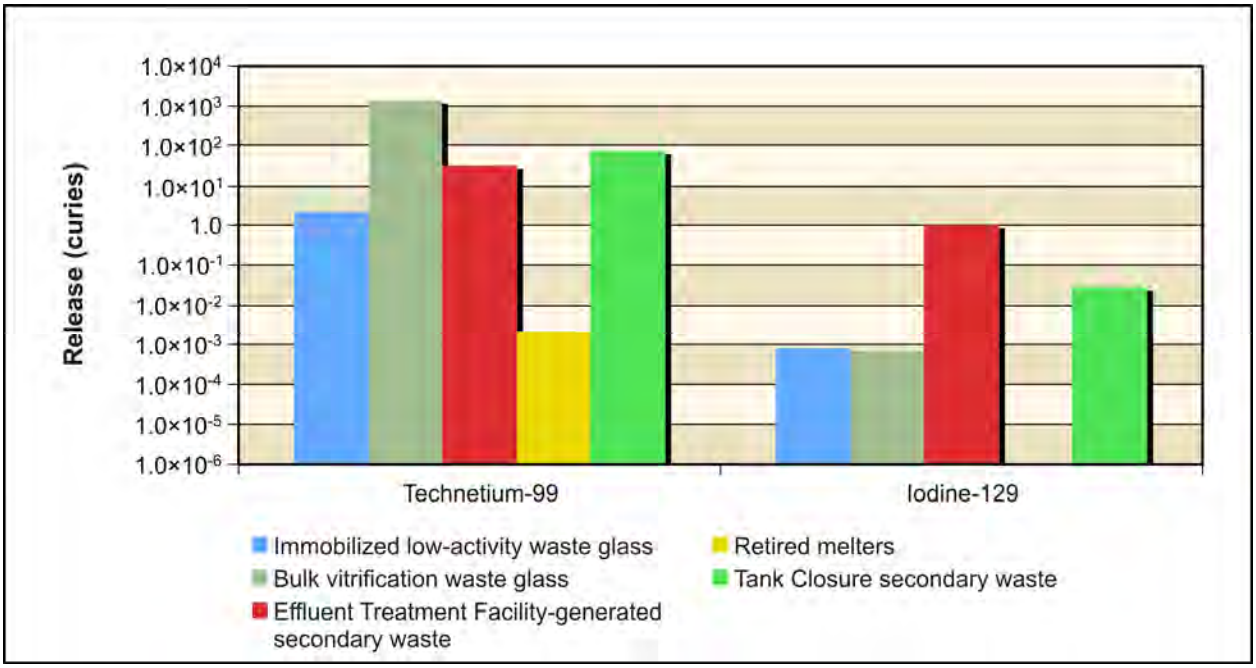


Figure 5–741. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–743 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–744, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. This means that there is less than one order of magnitude difference. Overall, about 87 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reached the groundwater; approximately 100 percent of the chemical quantity (kilograms) reached the groundwater.

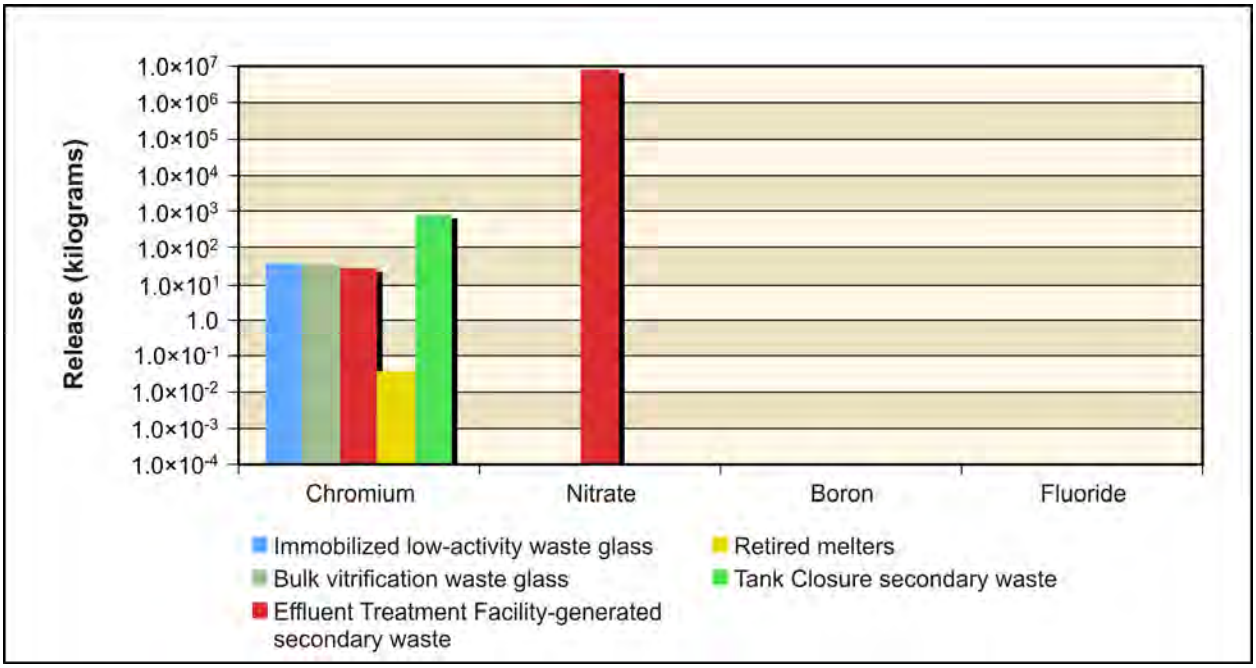


Figure 5–742. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

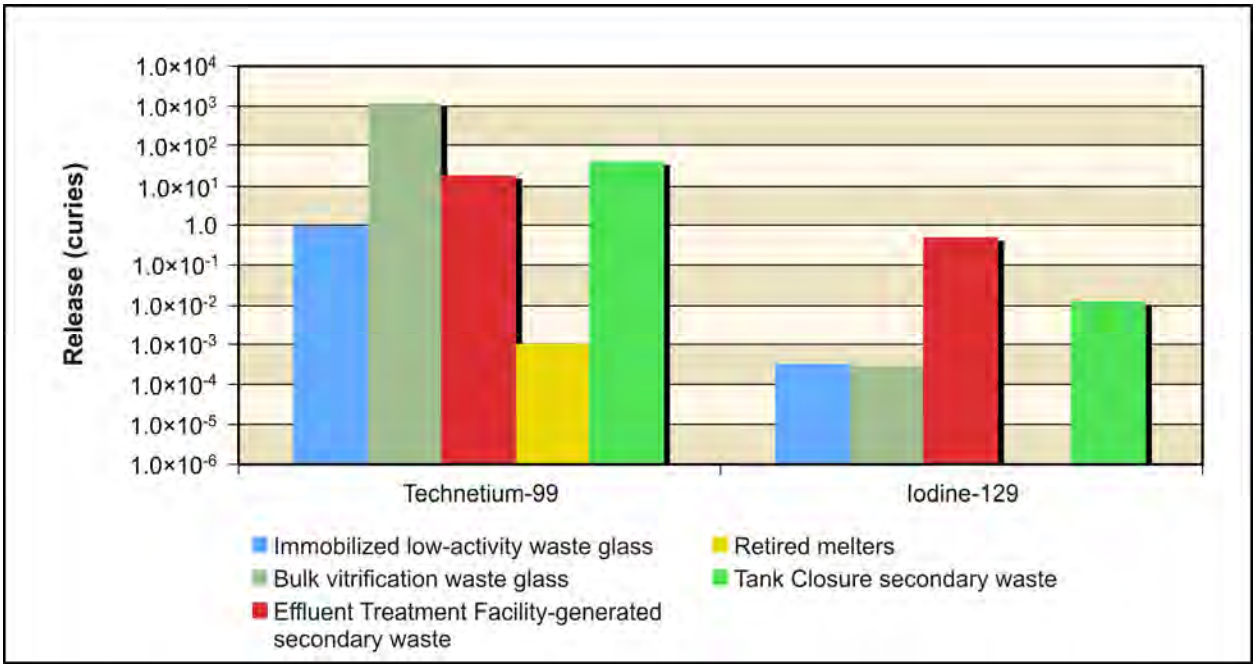


Figure 5–743. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

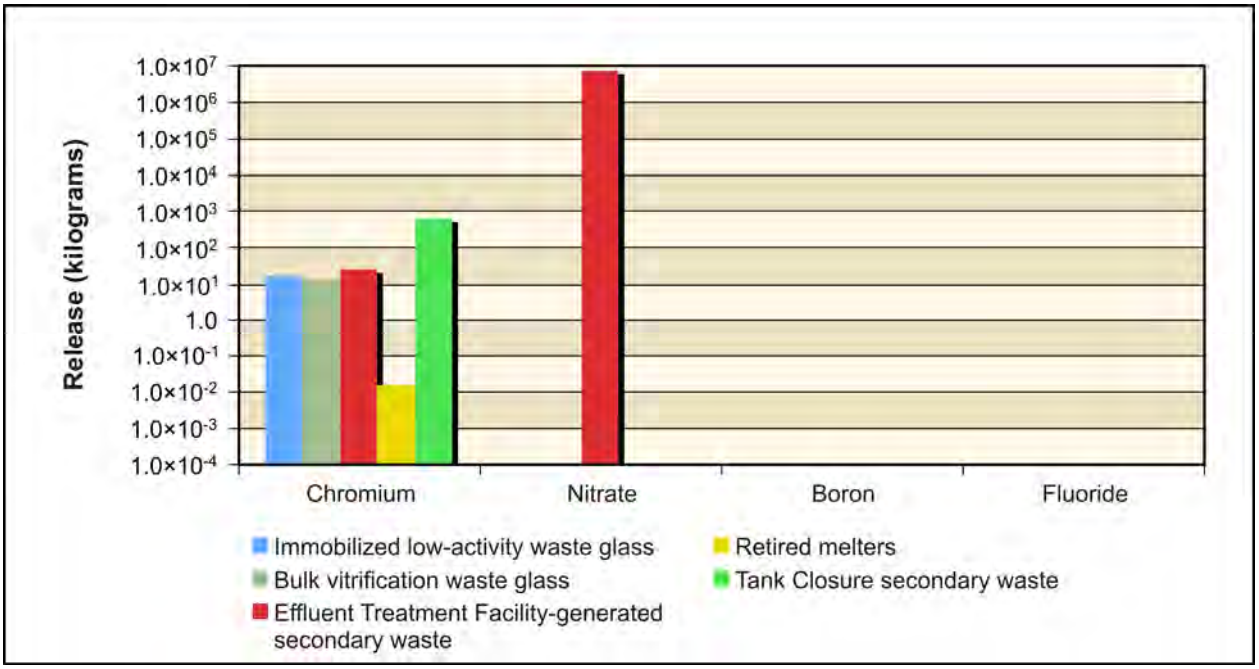


Figure 5–744. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–745 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–746, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, iodine-129, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 96 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reached the river; approximately 99 percent of the chemical quantity (kilograms) reached the river.

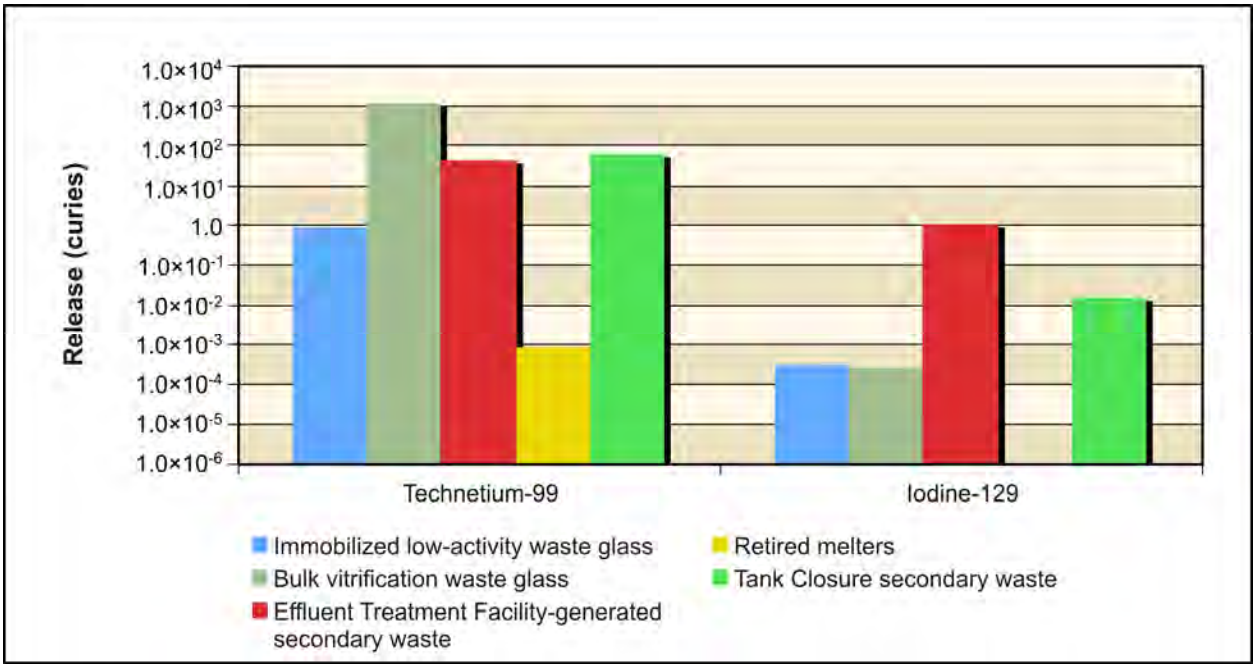


Figure 5–745. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

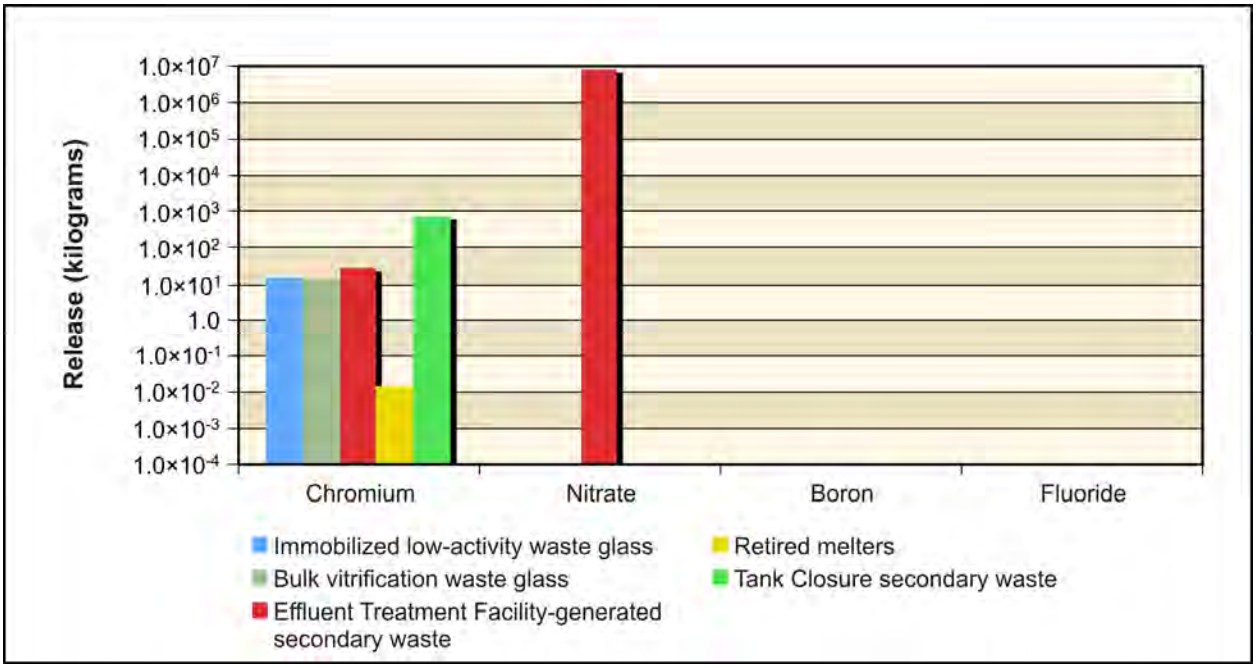


Figure 5–746. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases from FFTF Decommissioning Alternative 3 waste, waste management secondary waste and onsite- and offsite-generated waste.

Figure 5–747 shows the estimated release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–748, the chemical hazard drivers. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 and iodine-129 is offsite-generated waste. The predominant sources of chromium, nitrate, boron, and fluoride are waste management secondary and onsite-generated waste.

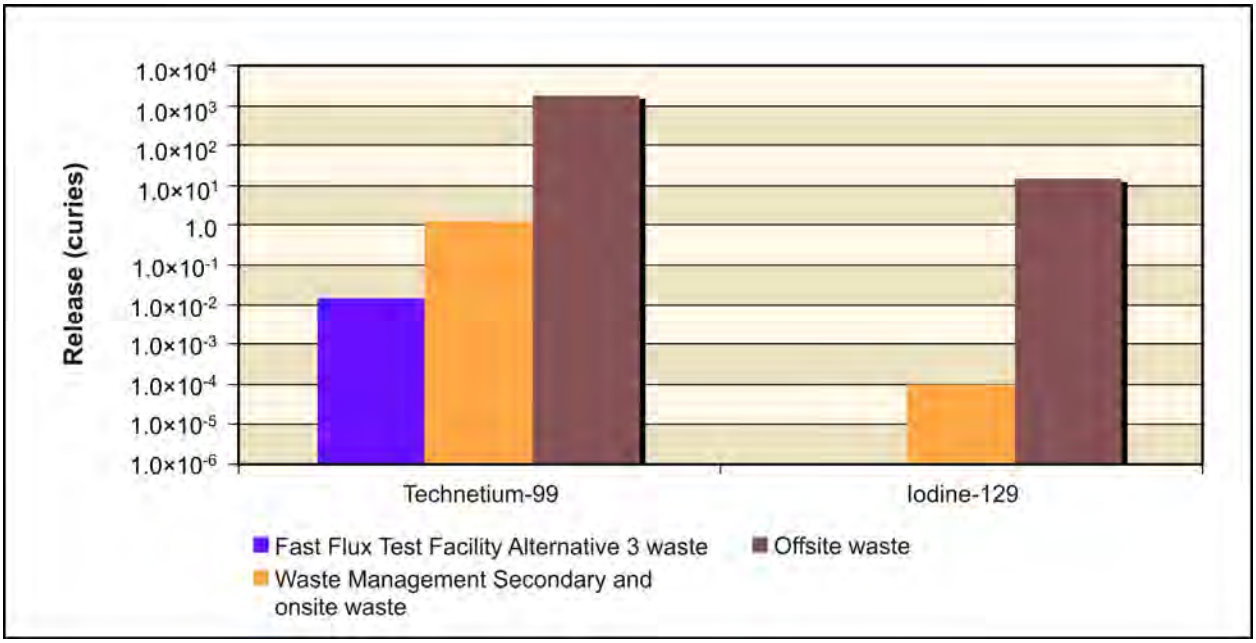


Figure 5–747. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

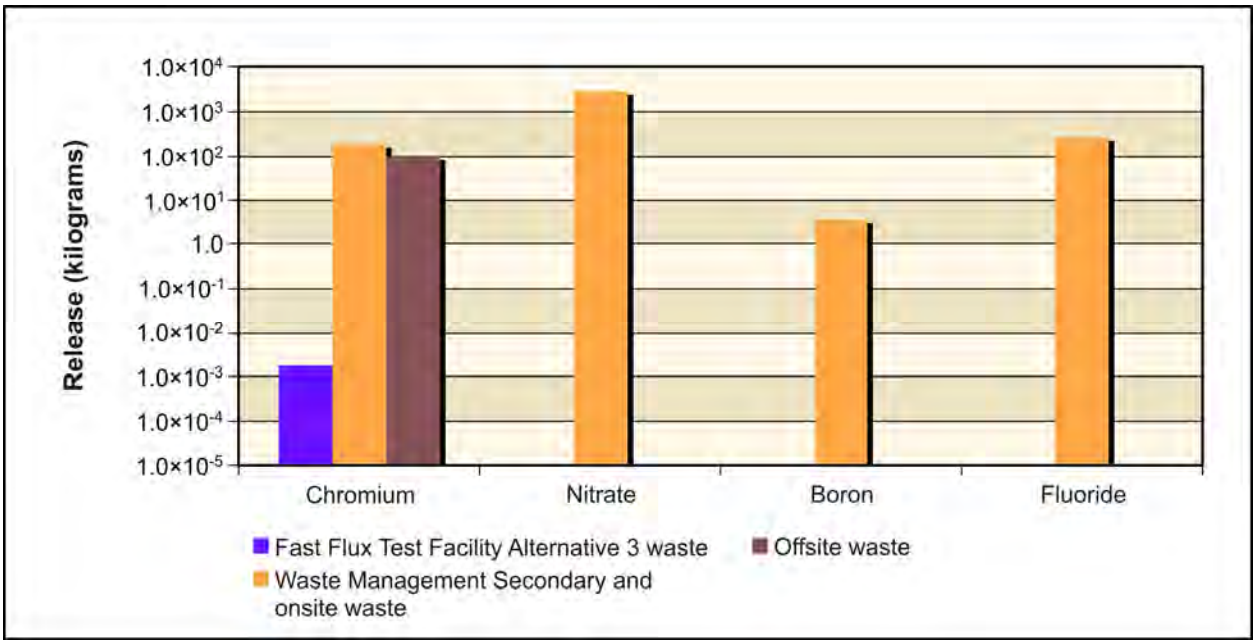


Figure 5–748. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–749 shows the estimated release at IDF-West to groundwater for the radiological risk drivers and Figure 5–750, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, nitrate, boron, and fluoride, the amount released to groundwater is essentially equal to the amount released to the vadose zone. This means that there is less than one order of magnitude difference. Overall, about 98 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reached the groundwater; approximately 100 percent of the chemical quantity (kilograms) reached the groundwater.

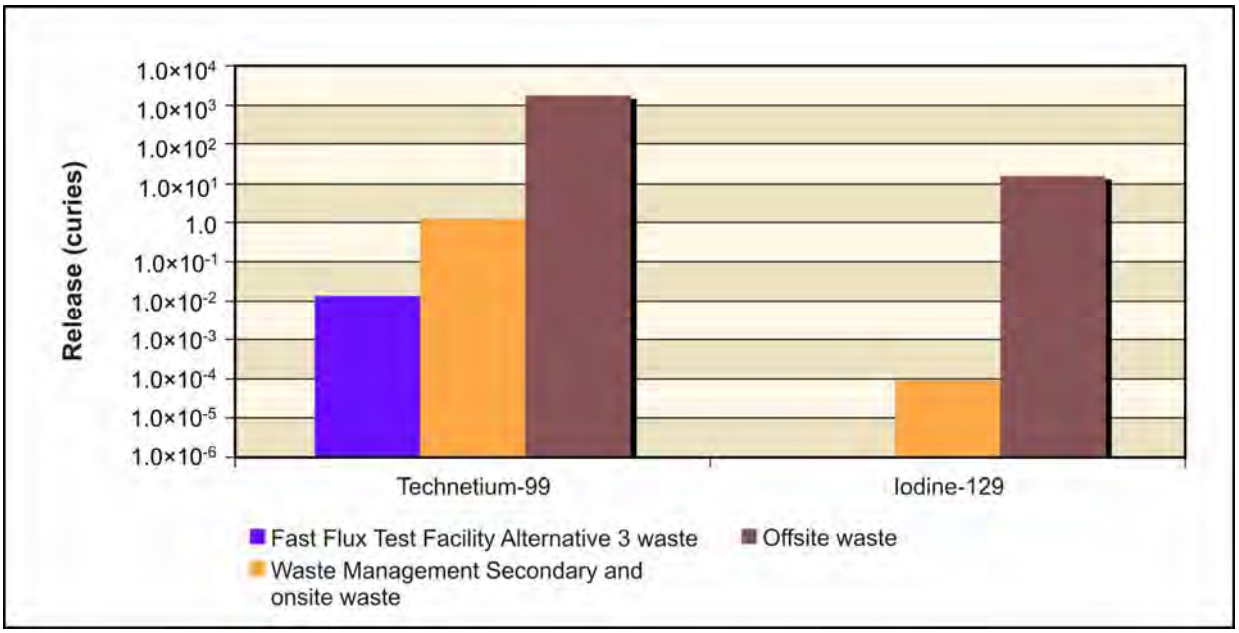


Figure 5–749. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

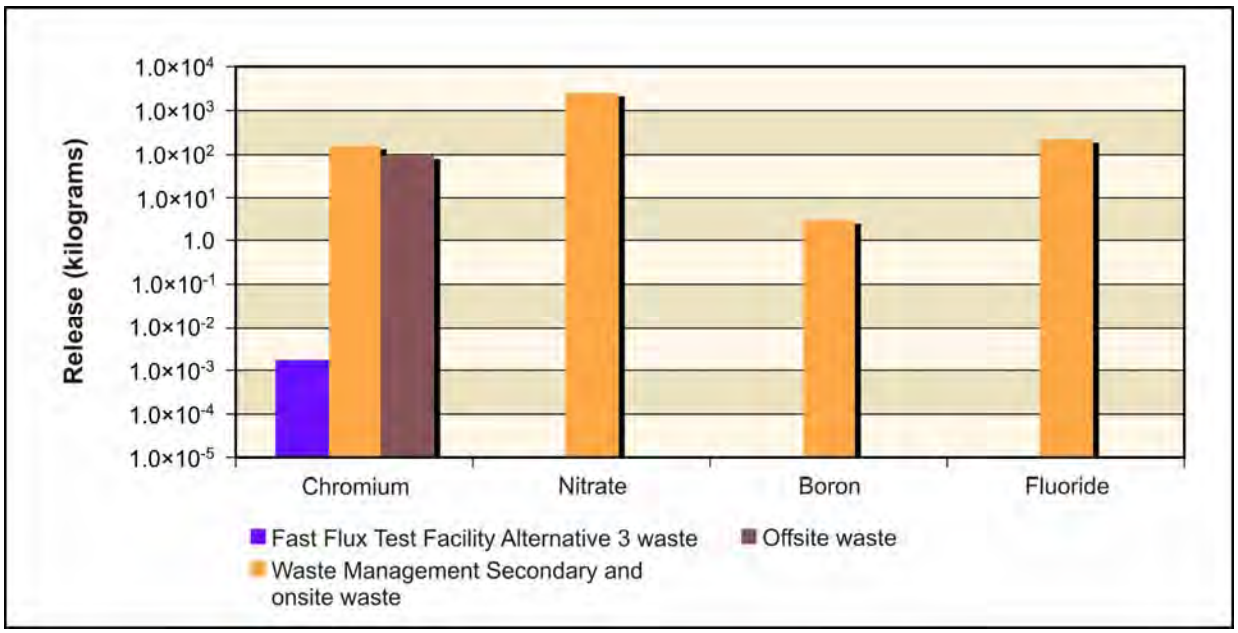


Figure 5–750. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–751 shows the estimated release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–752, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, iodine-129, chromium, nitrate, boron, and fluoride, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 97 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reached the river; approximately 98 percent of the chemical quantity (kilograms) reached the river.

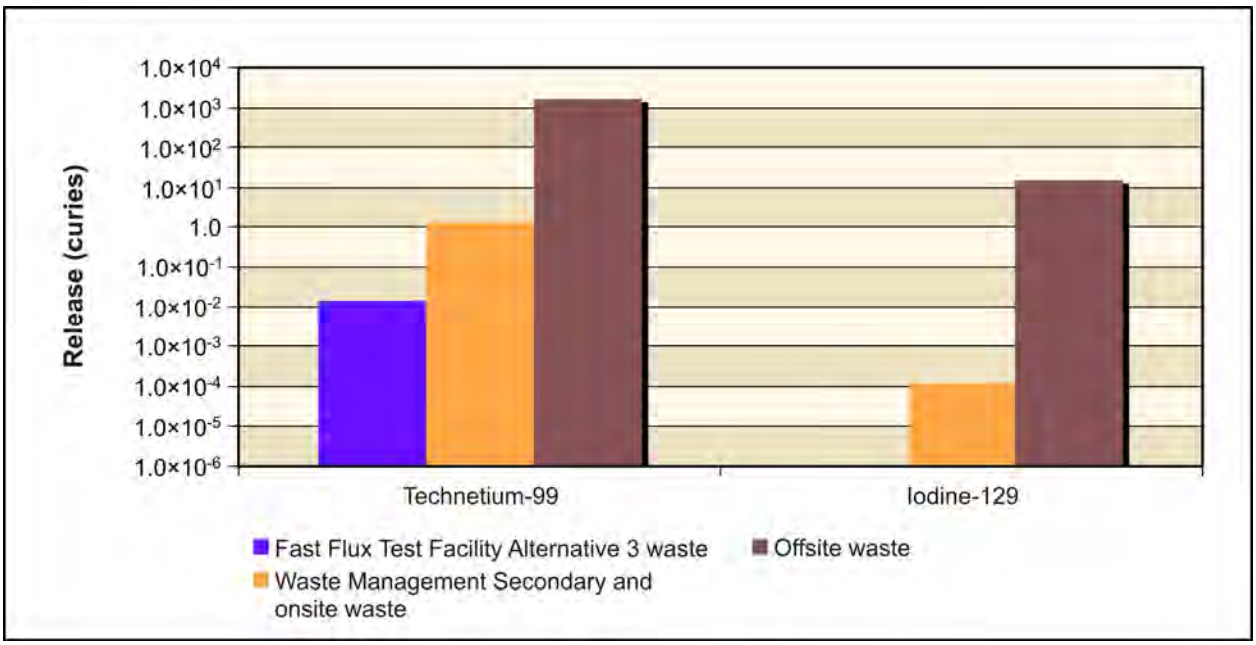


Figure 5–751. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

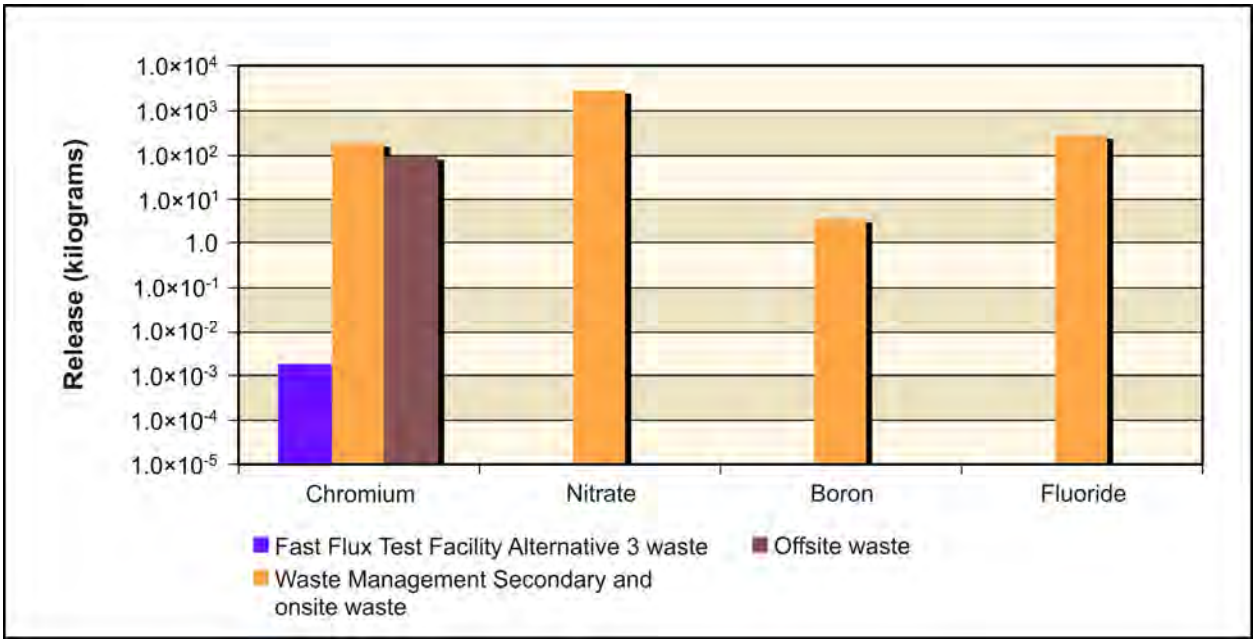


Figure 5–752. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–753 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–754, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The vadose zone radiological sources from the RPPDF are technetium-99 (largest) and iodine-129 (smallest). The chemical hazard sources from the RPPDF are nitrate (largest) and chromium (smallest). Fluoride and boron are not released from the RPPDF.

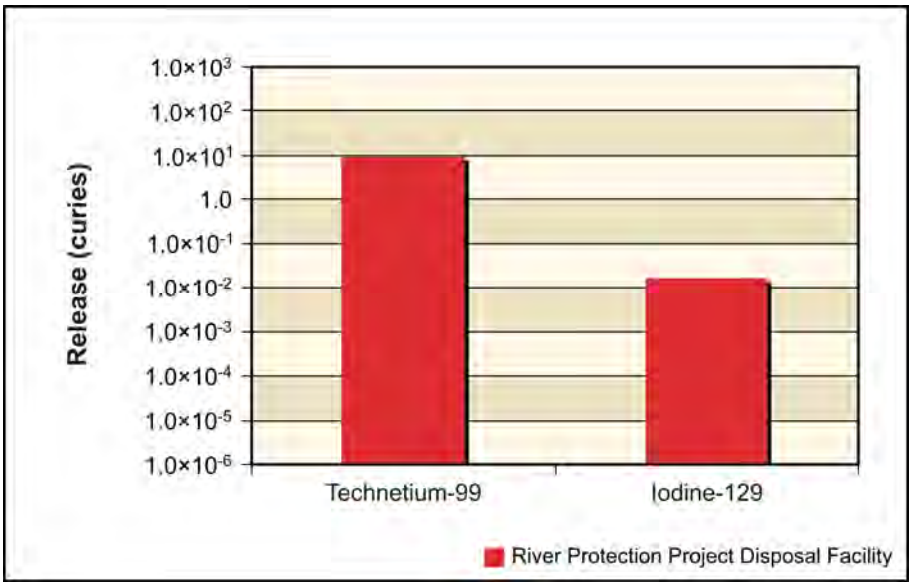


Figure 5–753. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

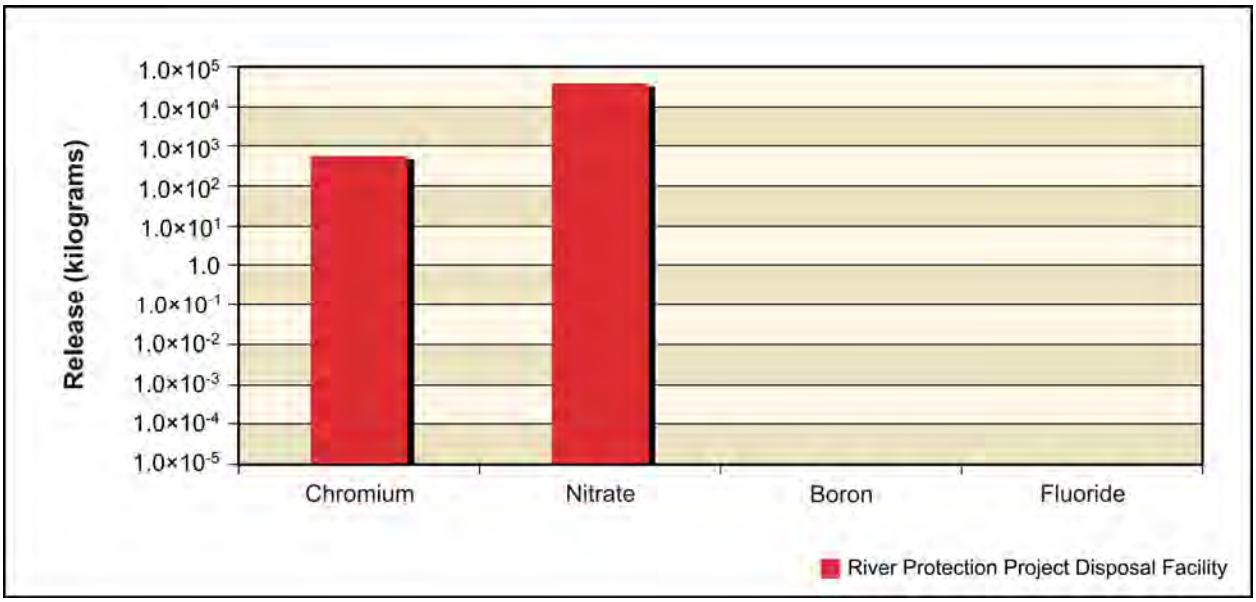


Figure 5–754. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–755 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–756, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. Overall, about 100 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reached the groundwater; approximately 100 percent of the chemical quantity (kilograms) reached the groundwater.

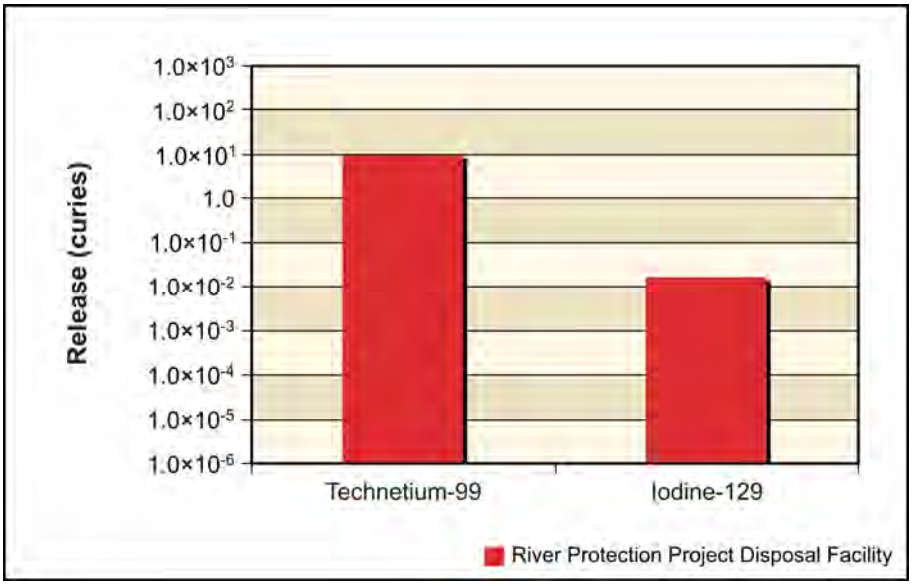


Figure 5–755. Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Groundwater

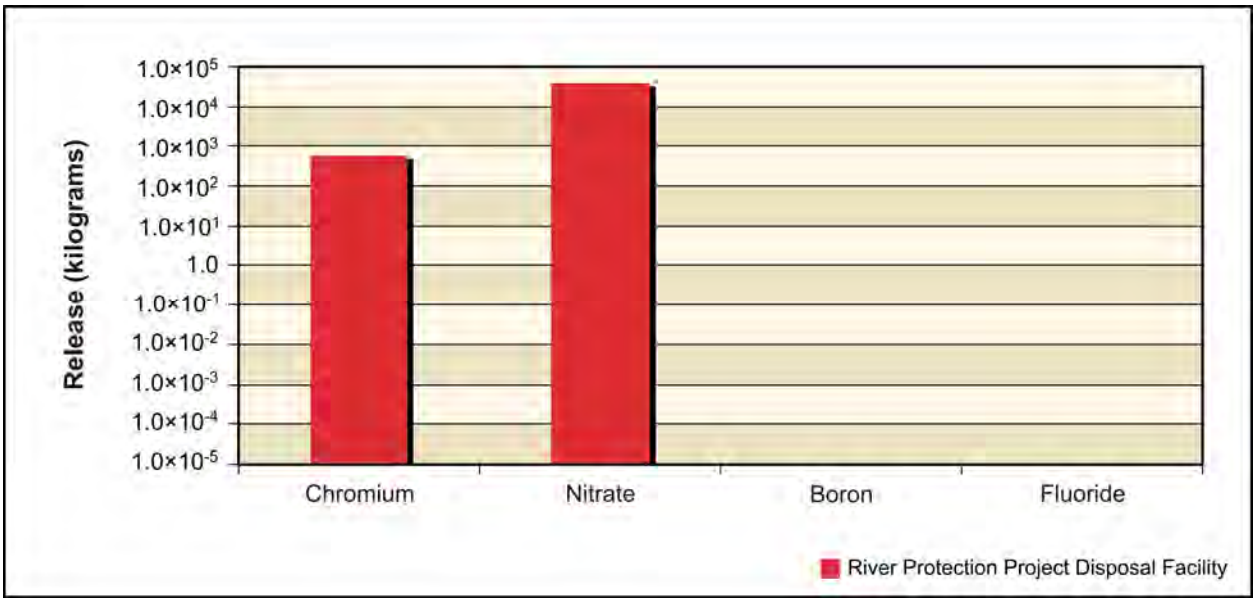


Figure 5–756. Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–757 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–758, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For iodine-129, technetium-99, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. Overall, 96 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reached the river; 96 percent of the chemical quantity (kilograms) reached the river.

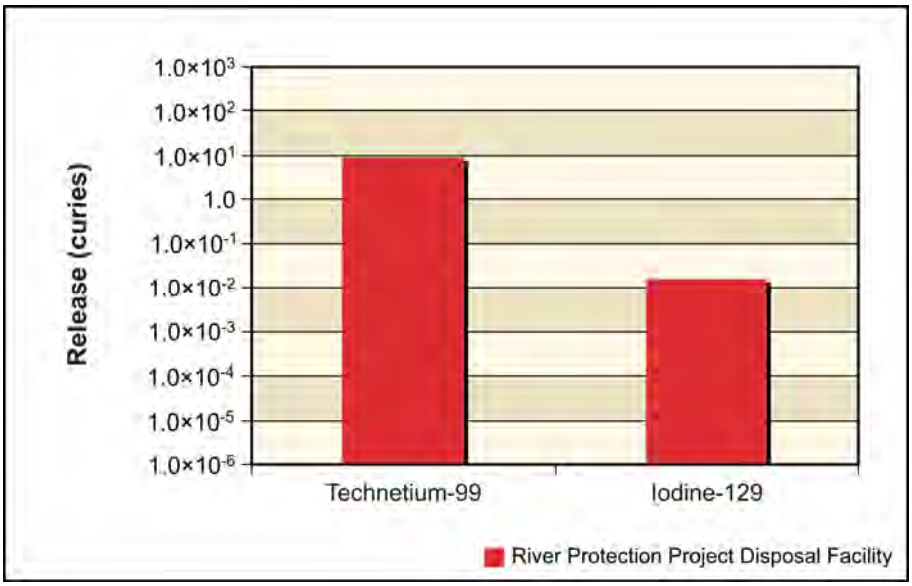


Figure 5–757. Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Columbia River

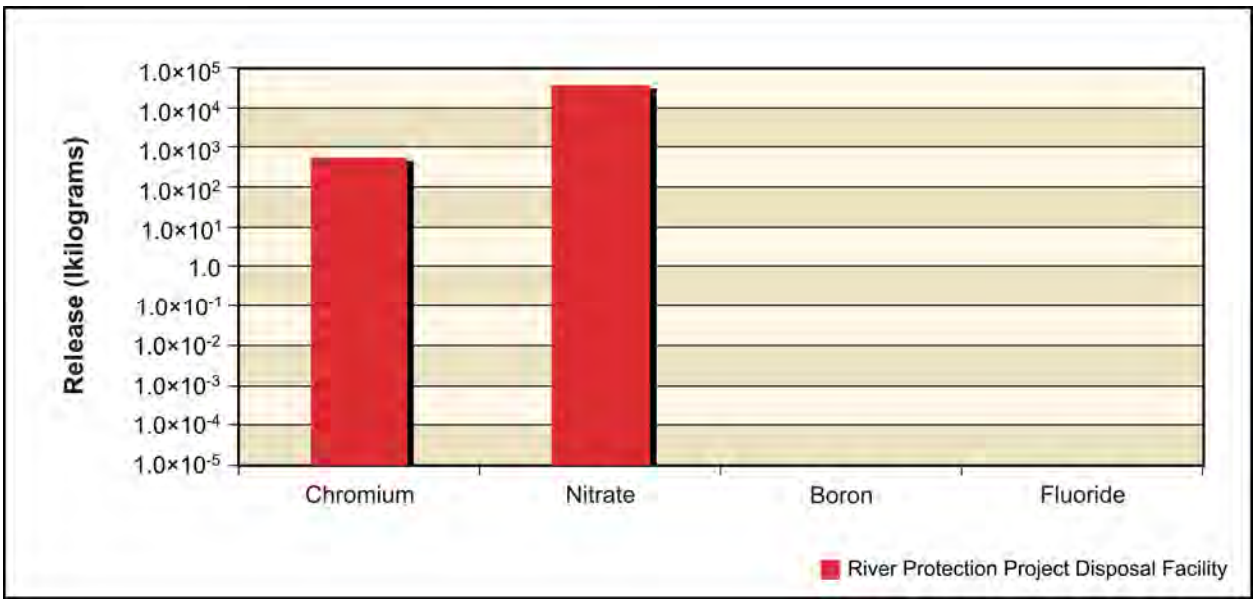


Figure 5–758. Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–759 through 5–764). The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–90 lists the maximum concentrations of the COPCs in the peak year at IDF-East, IDF-West, and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Table 5–90. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	**1,600**	**20,200**	33	**7,560**	**1,130**	900
	(8486)	(3713)	(3825)	(3690)	(4528)	
Iodine-129	**2**	**173**	0.1	**60**	**8**	1
	(11,284)	(3797)	(3772)	(3853)	(4729)	
Chemical in micrograms per liter						
Chromium	2	2	2	3	0	100
	(8278)	(3696)	(3856)	(3628)	(4812)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	14,400	17	149	5,860	3,680	45,000
	(7821)	(3703)	(3811)	(8905)	(8144)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text**.**

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–759 through 5–762 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate, respectively. Releases from IDF-East, IDF-West, and the RPPDF cause groundwater concentrations to exceed benchmark concentrations at the Core Zone Boundary and Columbia River nearshore by approximately one order of magnitude for iodine-129. This exceedance occurs in the earlier part of the period of analysis. Technetium-99 has one peak at the Core Zone Boundary that exceeds the benchmark by one order of magnitude. This peak only lasts for approximately 10 percent of the period of analysis. Nitrate and chromium do not exceed benchmark concentrations at the Core Zone Boundary or Columbia River nearshore.

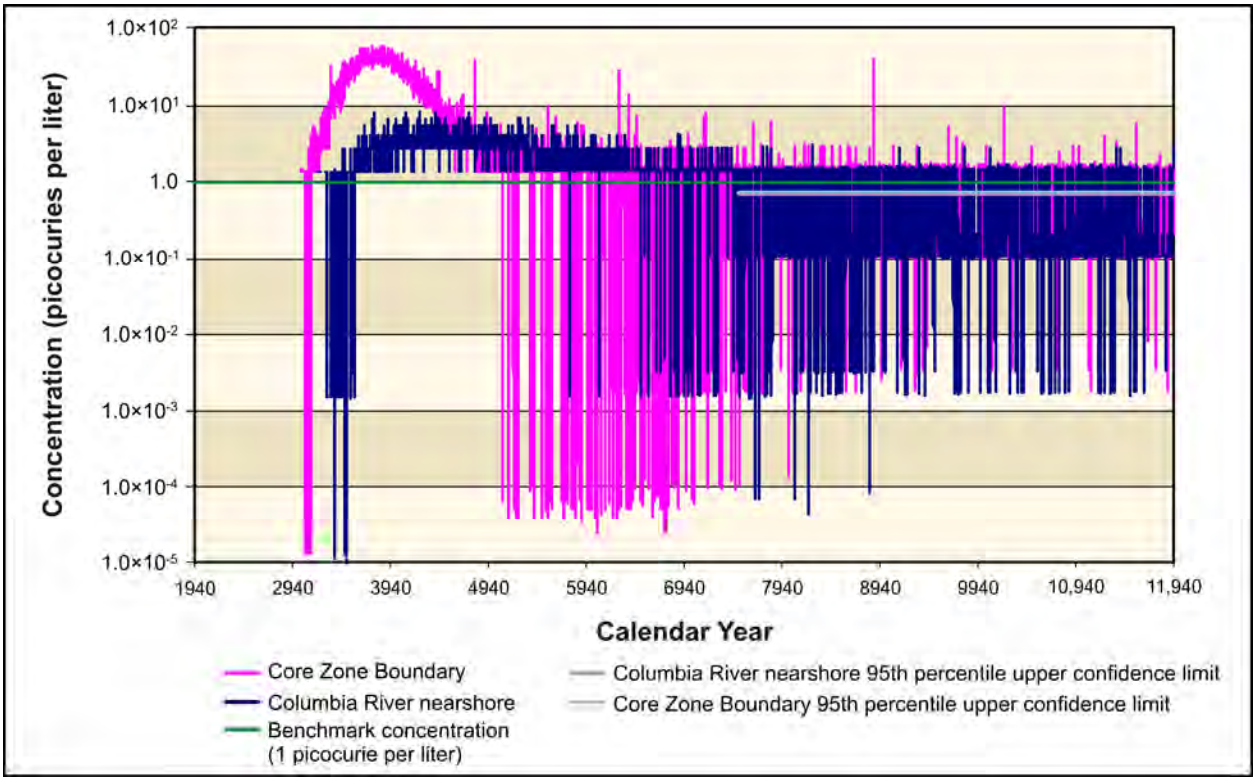


Figure 5–759. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Iodine-129 Concentration Versus Time

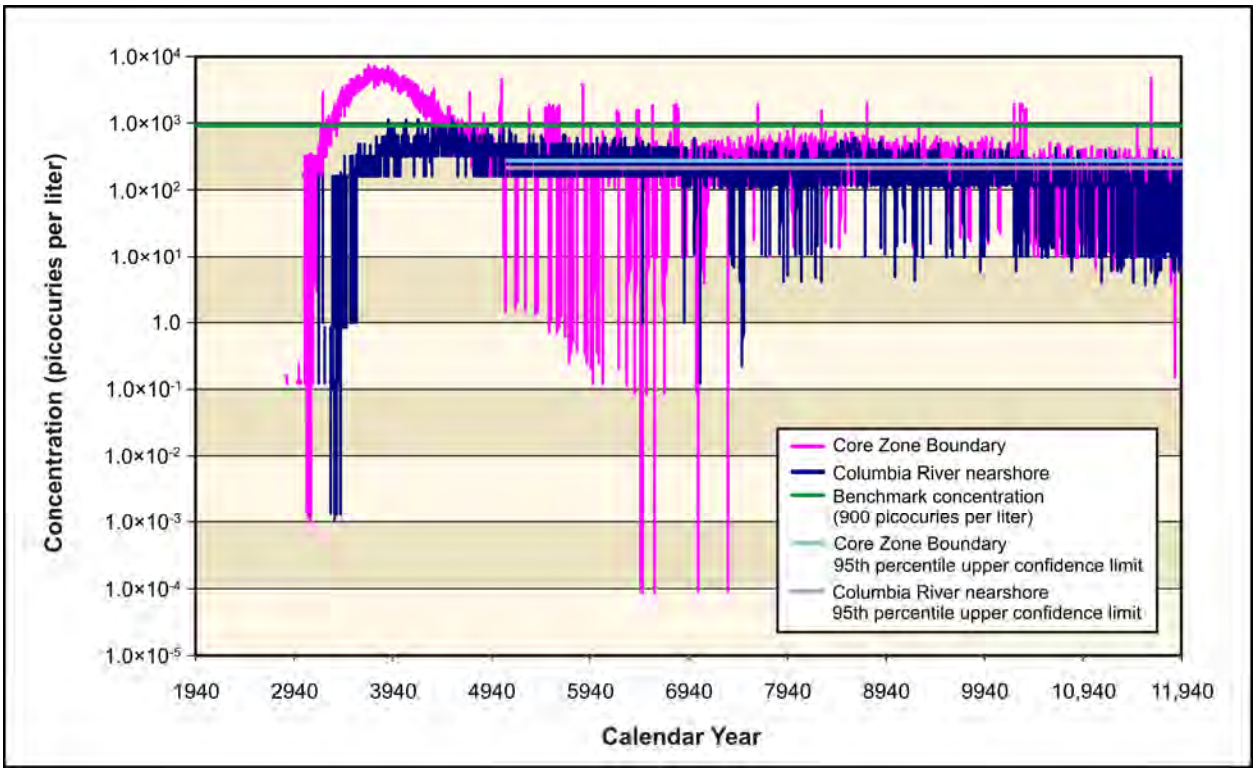


Figure 5–760. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Technetium-99 Concentration Versus Time

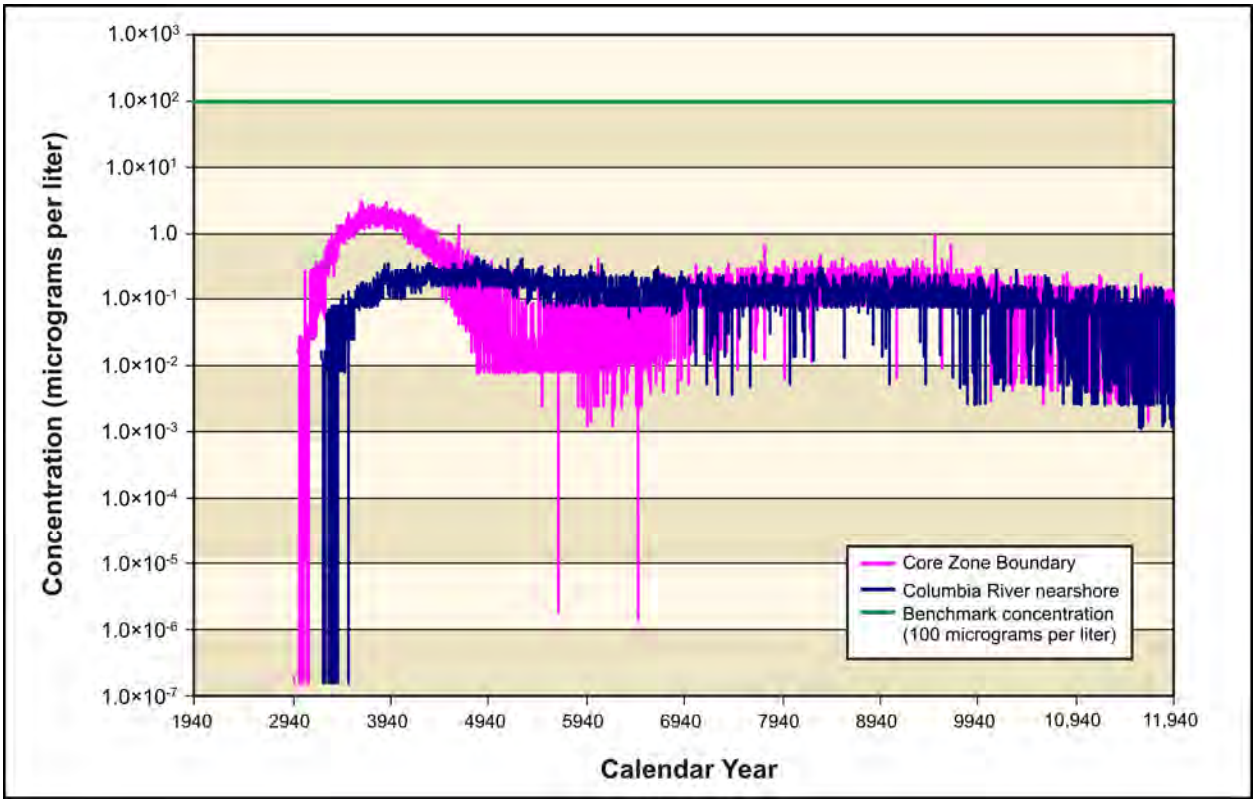


Figure 5–761. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chromium Concentration Versus Time

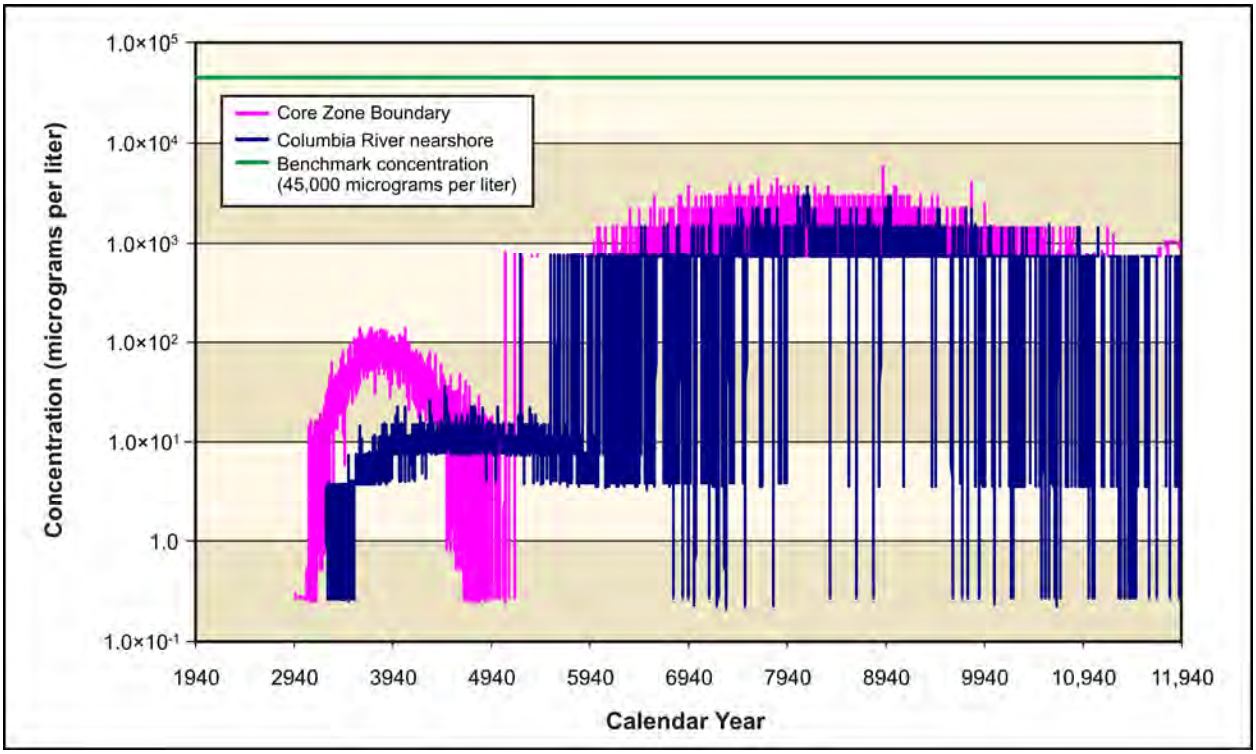


Figure 5–762. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Nitrate Concentration Versus Time

Figures 5–763 and 5–764 show concentration versus time for uranium-238 and total uranium, respectively. Because uranium-238 and total uranium move slowly through the vadose zone, releases from IDF-East, IDF-West, and the RPPDF result in groundwater concentrations that are several orders of magnitude lower than benchmark concentrations. Uranium-238 and total uranium concentrations, while very minimal, continue to rise throughout the duration of the period of analysis, but never get closer than three orders of magnitude of exceeding benchmark concentrations by the end of the period of analysis.

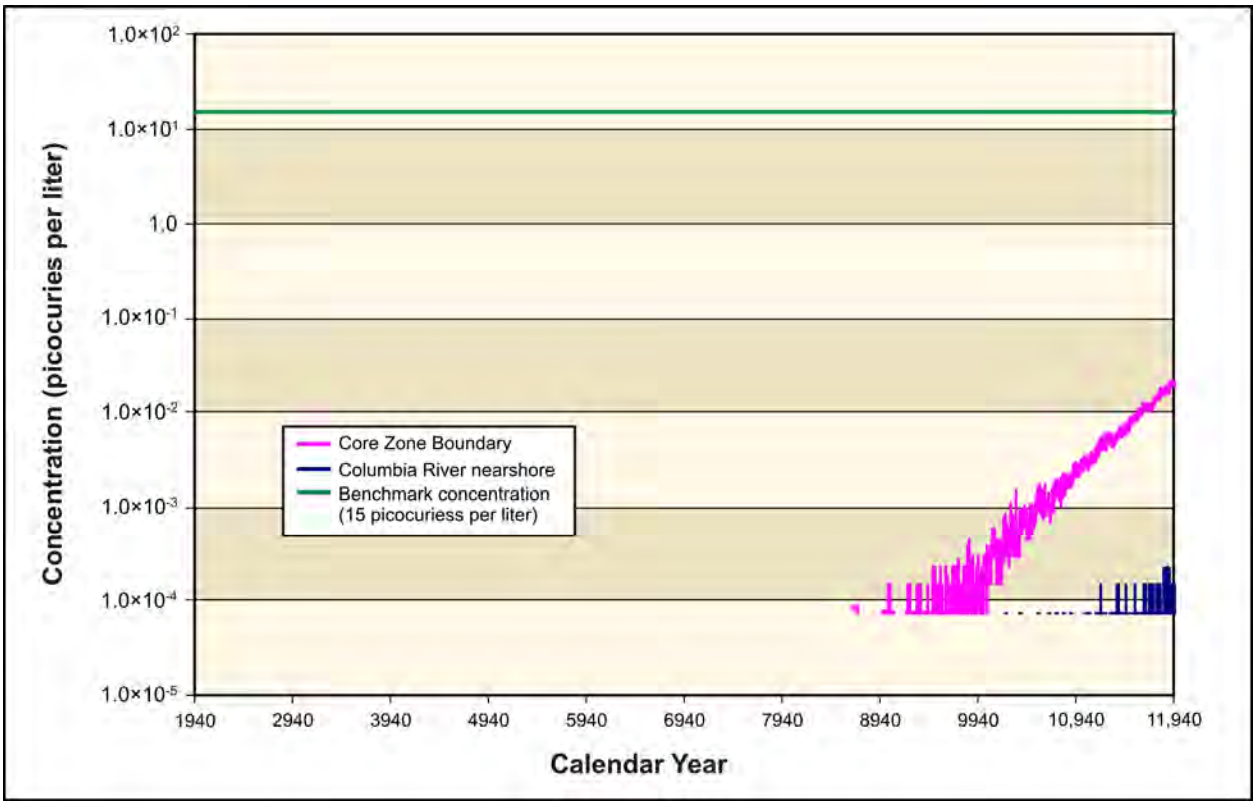


Figure 5–763. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Uranium-238 Concentration Versus Time

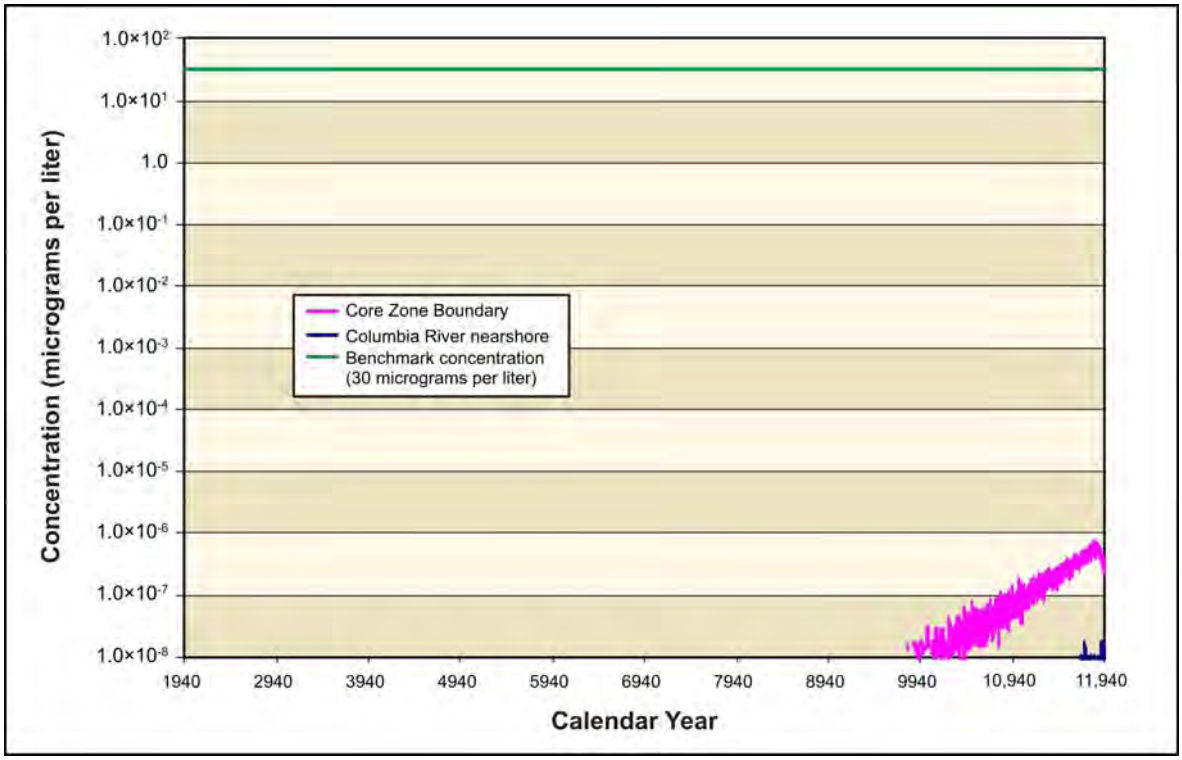
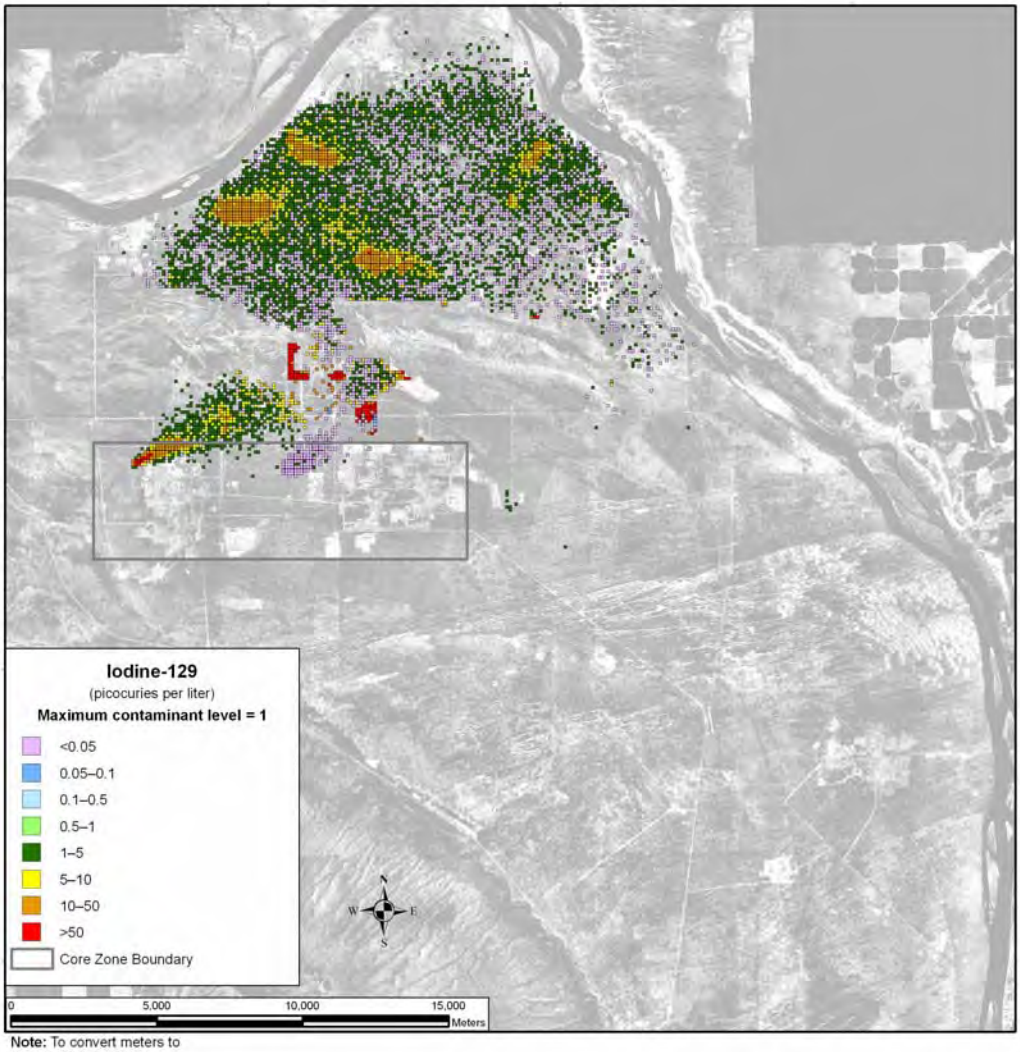


Figure 5–764. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

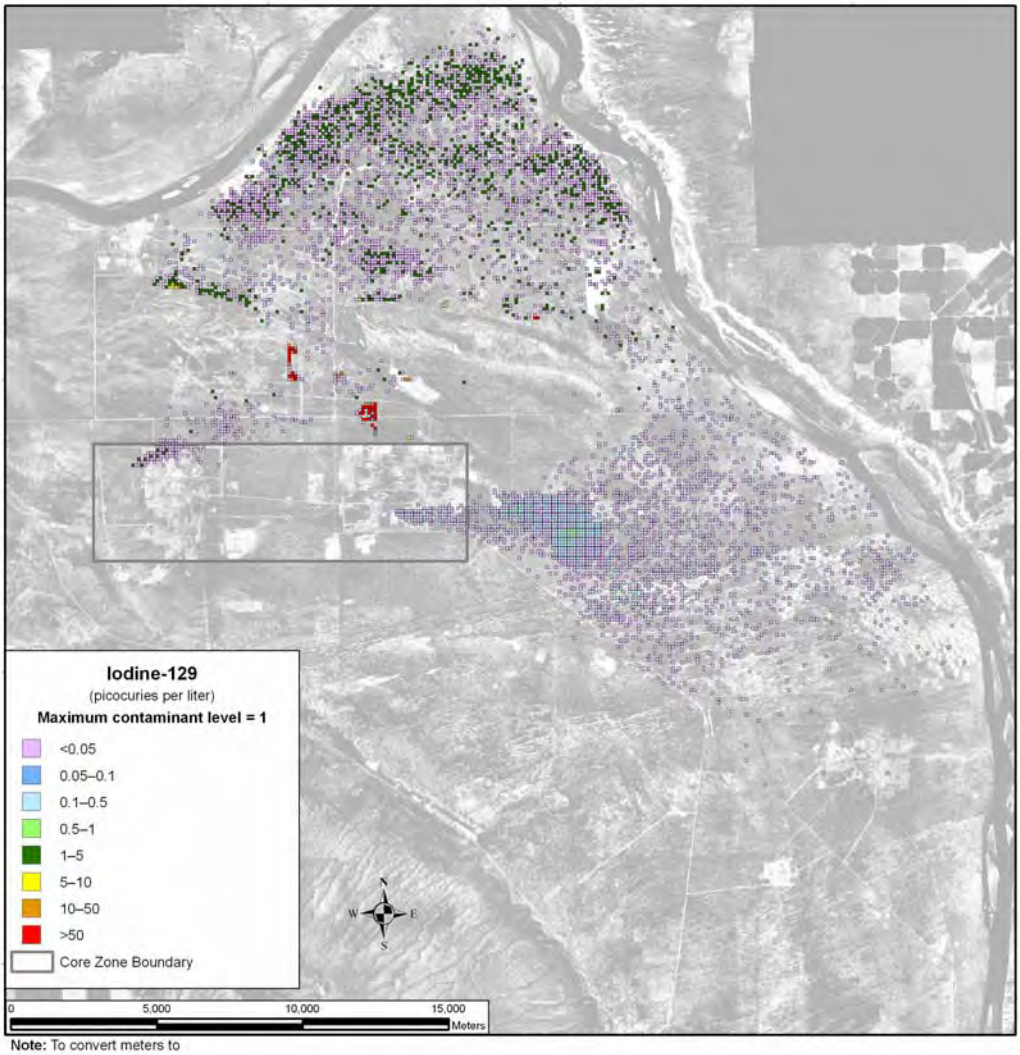
This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–765 through 5–778). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figure 5–765 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890. Releases from IDF-West and the RPPDF result in a groundwater plume starting in the Core Zone and heading north through Gable Mountain. This plume exceeds the benchmark concentration at the Core Zone Boundary and north of the Core Zone Boundary by one to two orders of magnitude. During CY 7140, releases from IDF-East create a groundwater plume, not exceeding the benchmark, extending from the 200-East Area, moving eastward towards the Columbia River (see Figure 5–766). Also, by CY 7140, most of the IDF-West and RPPDF plume continued to move north and reached the Columbia River. By CY 11,885, most of the mass in the IDF-East plume is still moving eastward toward the Columbia River, with only small isolated pockets of concentration exceeding the benchmark (see Figure 5–767). Technetium-99 (see Figures 5–768 through 5–770) shows similar spatial distributions at selected times and exceeds the benchmark concentrations at approximately the same time and locations. Chromium (see Figures 5–771 through 5–773) and nitrate (see Figures 5–774 through 5–776) show similar spatial distributions at selected times, except none of them exceed the benchmark concentrations. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).



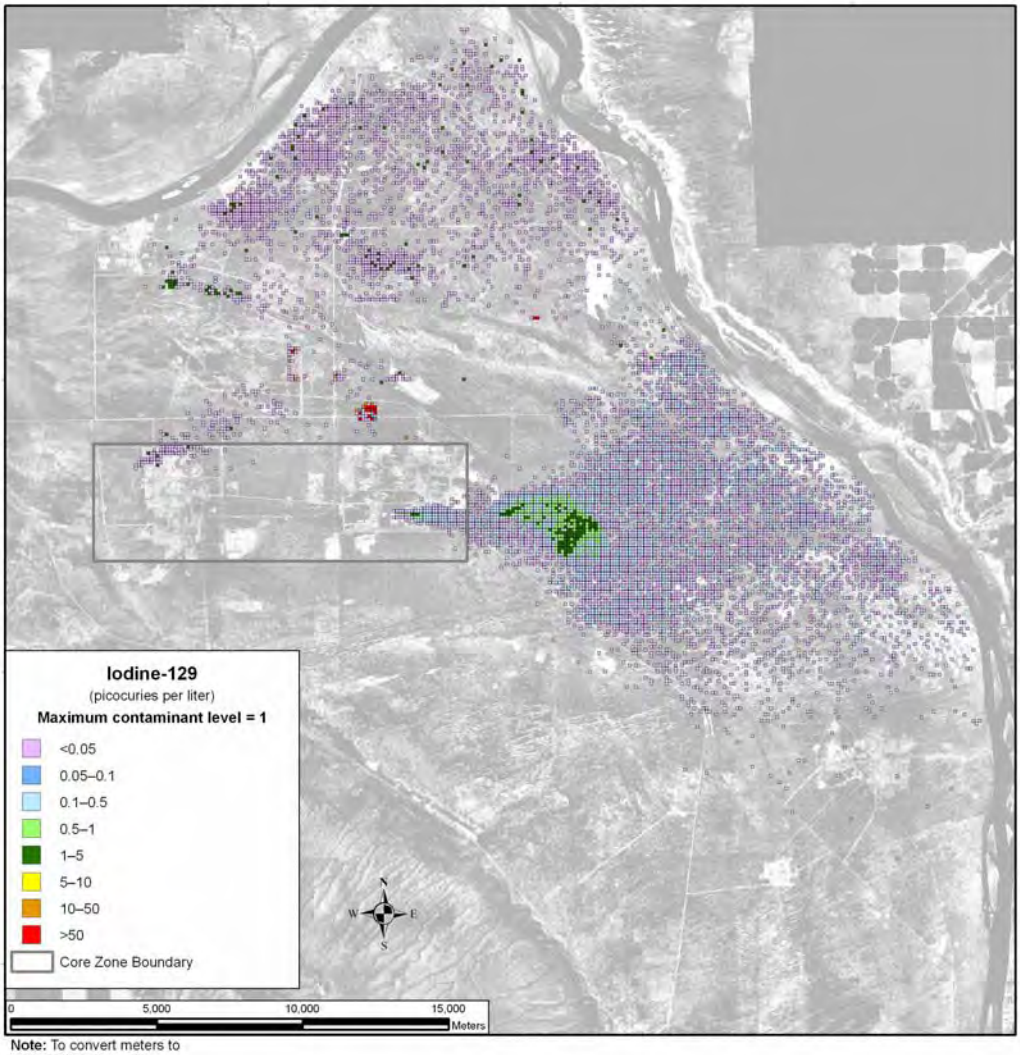
Note: To convert meters to feet, multiply by 3.281

Figure 5–765. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



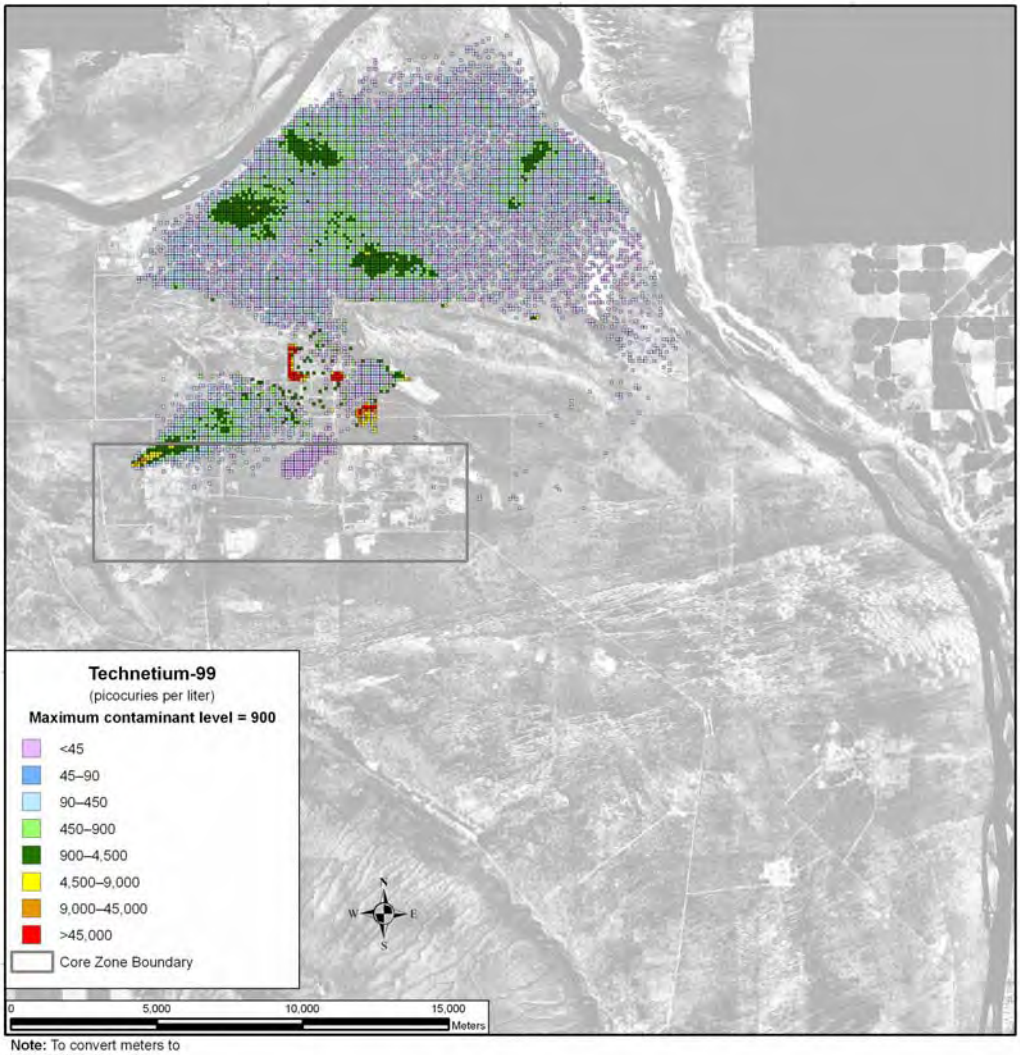
Note: To convert meters to feet, multiply by 3.281

Figure 5–766. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



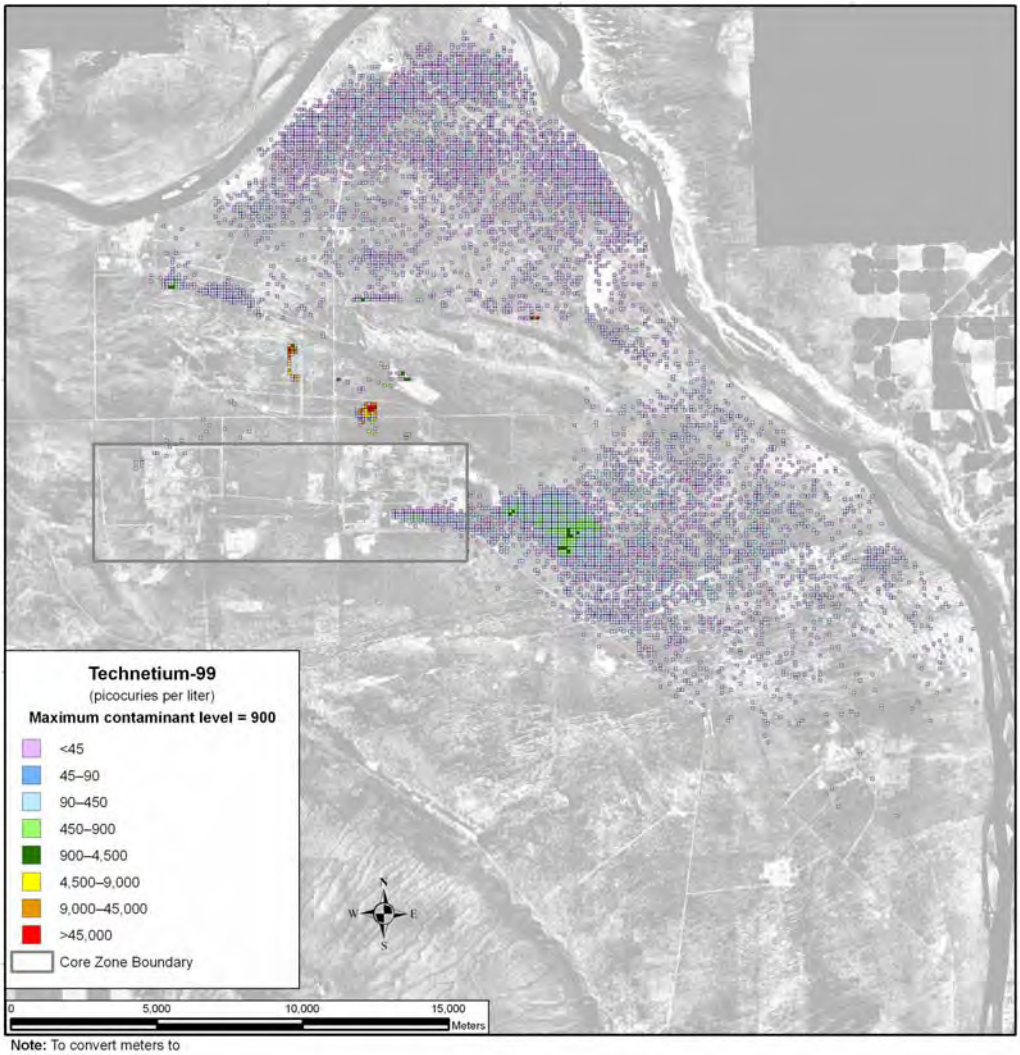
Note: To convert meters to feet, multiply by 3.281

Figure 5–767. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



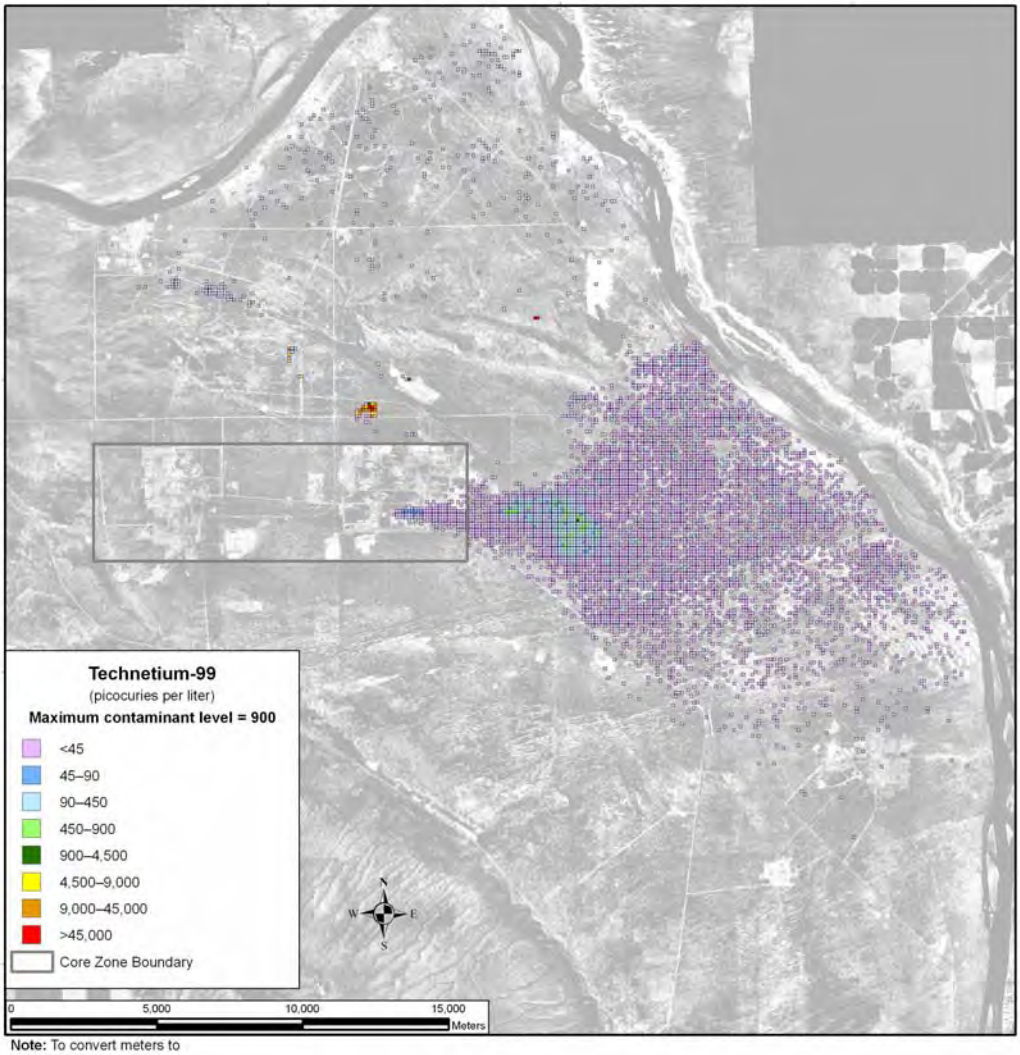
Note: To convert meters to feet, multiply by 3.281

Figure 5–768. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



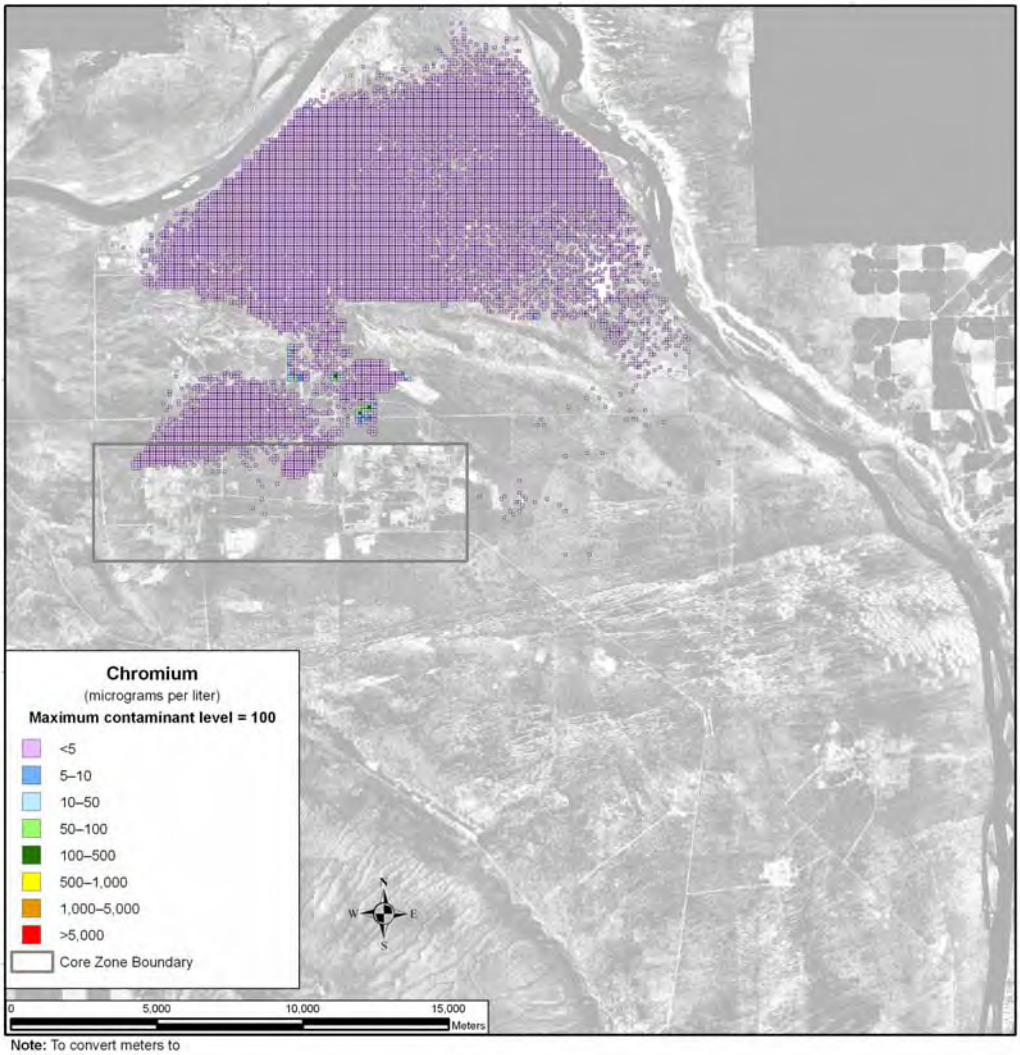
Note: To convert meters to feet, multiply by 3.281

Figure 5–769. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



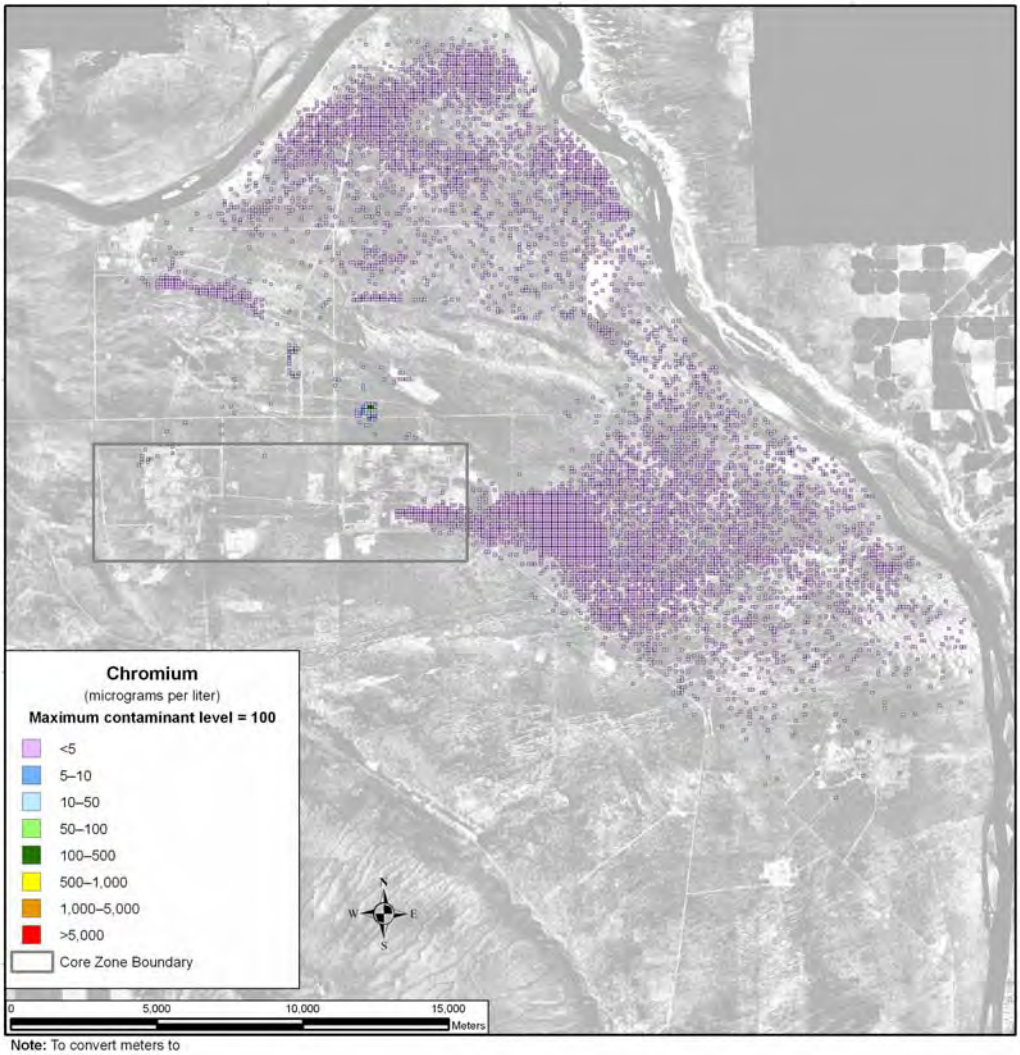
Note: To convert meters to feet, multiply by 3.281

Figure 5–770. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



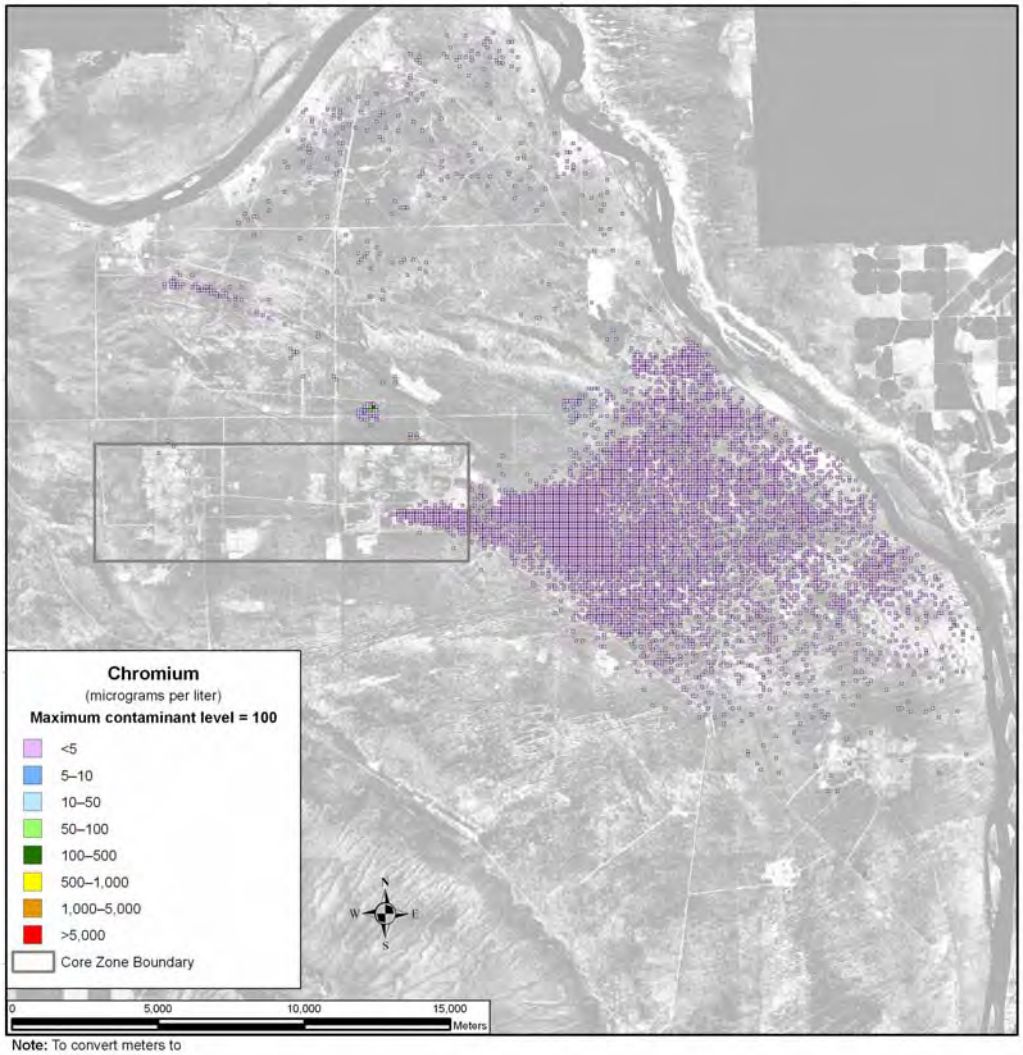
Note: To convert meters to feet, multiply by 3.281

Figure 5–771. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



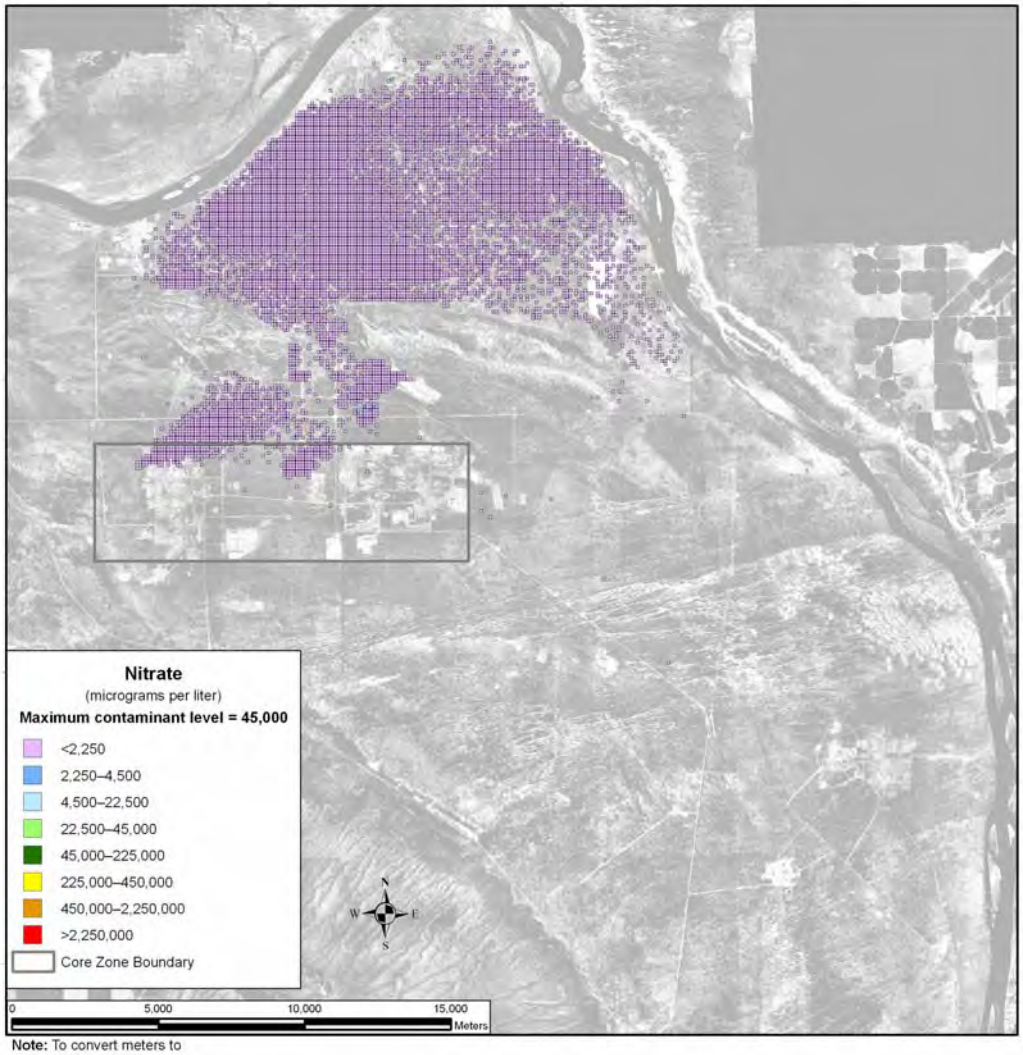
Note: To convert meters to feet, multiply by 3.281

Figure 5–772. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



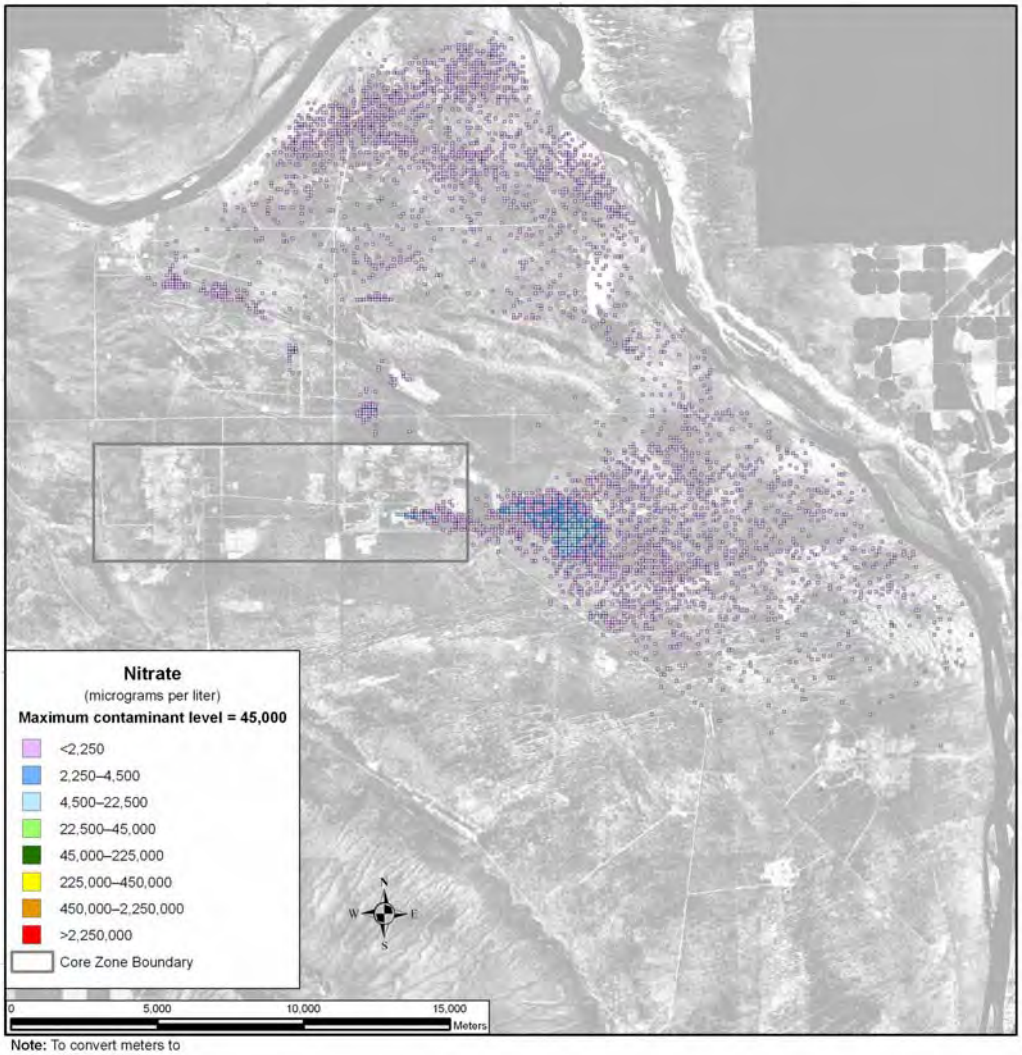
Note: To convert meters to feet, multiply by 3.281

Figure 5–773. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



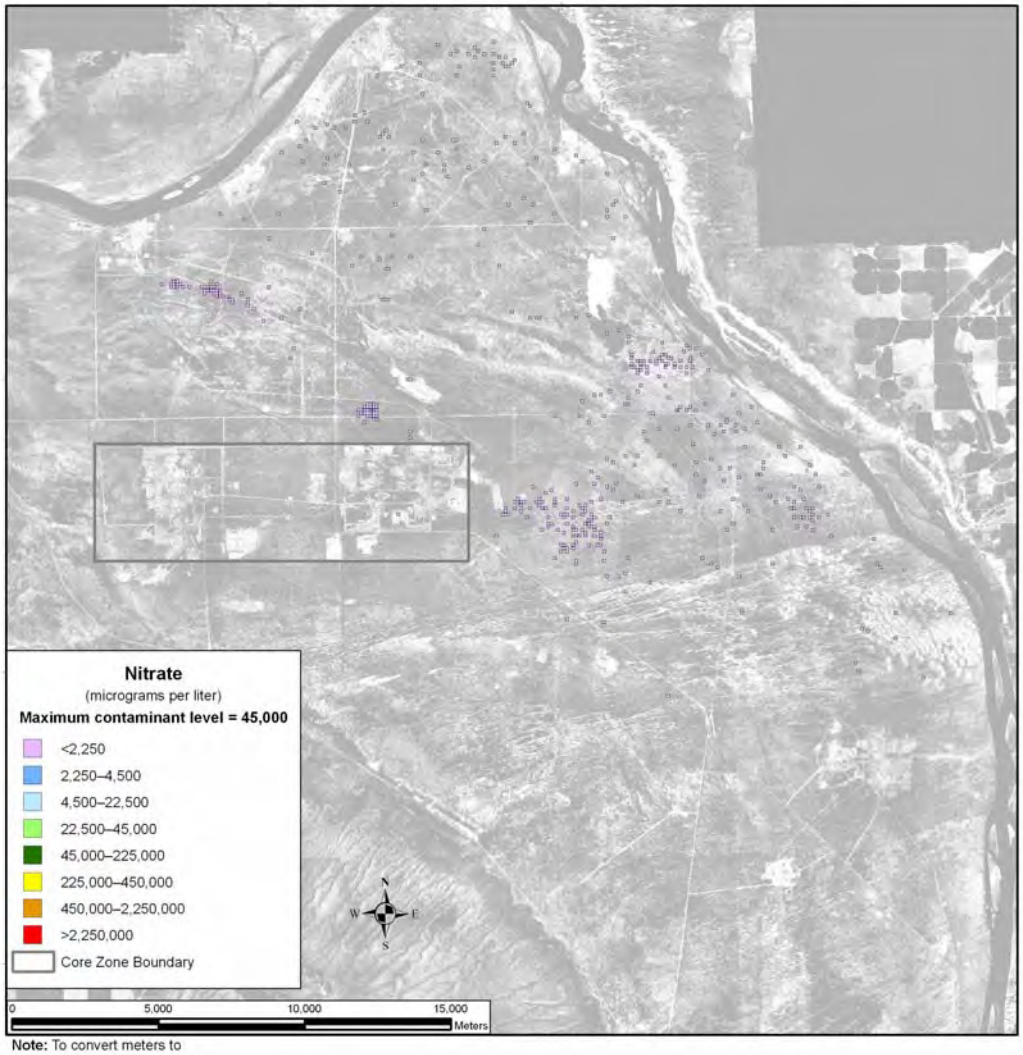
Note: To convert meters to feet, multiply by 3.281

Figure 5–774. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

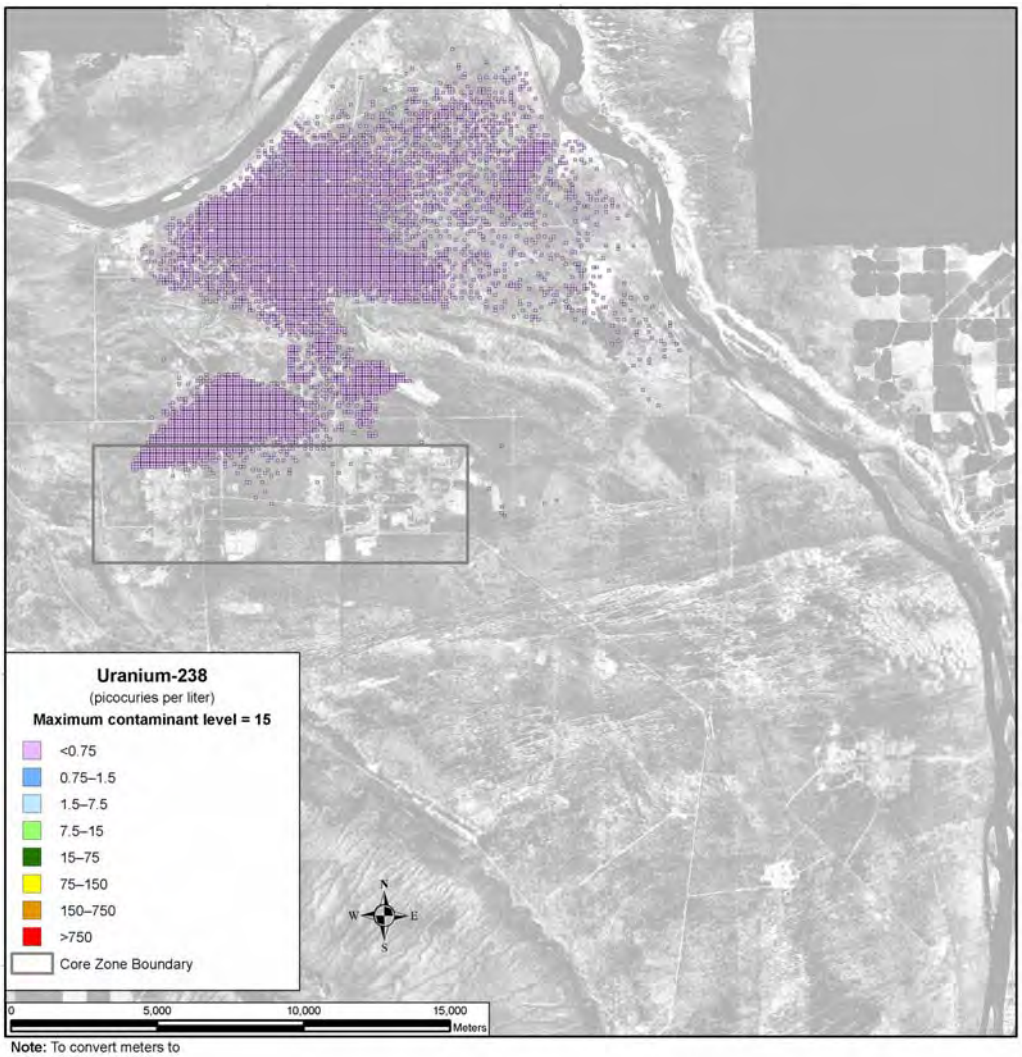
Figure 5–775. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–776. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Uranium-238 and total uranium show a different spatial distribution over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figures 5–777 and 5–778 show the distribution of uranium-238 and total uranium, respectively, during CY 11,885. Releases from IDF-West and the RPPDF result in a groundwater plume that starts in the Core Zone and moves north through Gable Mountain. However, this plume does not exceed the benchmark concentration during the period of analysis.



Note: To convert meters to feet, multiply by 3.281

Figure 5–777. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

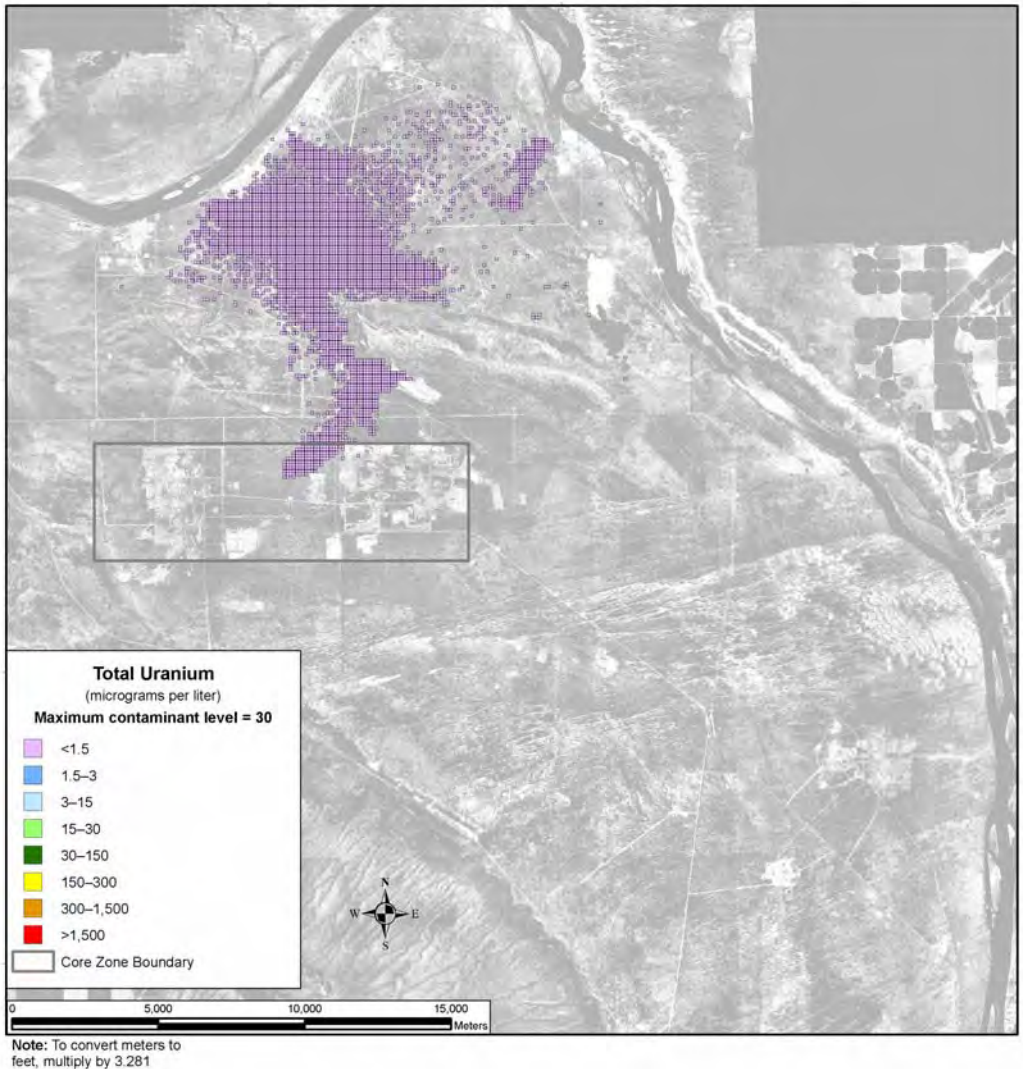


Figure 5–778. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, in general, the inventories remaining at IDF-East, IDF-West, and the RPPDF, which are available for release to the environment at the start of the post-disposal period, are predominant contributors.

For the conservative tracers, concentrations slightly outside the Core Zone Boundary exceed benchmark standards by one to two orders of magnitude during most of the period of analysis. Concentration at the Columbia River is about one to two orders of magnitude smaller. The intensities and areas of these groundwater plumes peak between CY 3890 and CY 7140.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or Columbia River.

5.3.1.3.1.3 Disposal Group 1, Subgroup 1-C

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-C covers disposal of waste generated under Tank Closure Alternative 3B, FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste. Waste would be converted to IHLW, ILAW glass, and cast stone waste. IHLW would be stored on site, while ILAW glass and cast stone waste would be disposed of at an IDF.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continue through CY 2050, when the disposal facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF would become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier that limits infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: acetonitrile, chromium, nitrate, and total uranium

The COPC drivers for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contribution to risk and hazard are not dominant during the year of peak risk or hazard, they become major contributors toward the end of the period of analysis. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for 100 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C.

The COPC drivers that are discussed in detail in this section fall into two categories. Iodine-129, technetium-99, acetonitrile, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Uranium-238 and total uranium are long-lived or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, in terms of total amount of COPCs released to the vadose zone, to groundwater, and to the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies, chemicals in kilograms. Nine subtotals are plotted representing releases from ILAW glass, cast stone waste, ETF-generated secondary waste, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste and onsite-generated waste, off-site generated waste, and the RPPDF. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over eight orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–779 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–780, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). The predominant source of acetonitrile, chromium, nitrate, iodine-129, and technetium-99 is cast stone waste. Other sources of contamination examined include ILAW glass, ETF-generated secondary waste, retired melters, and tank closure secondary waste.

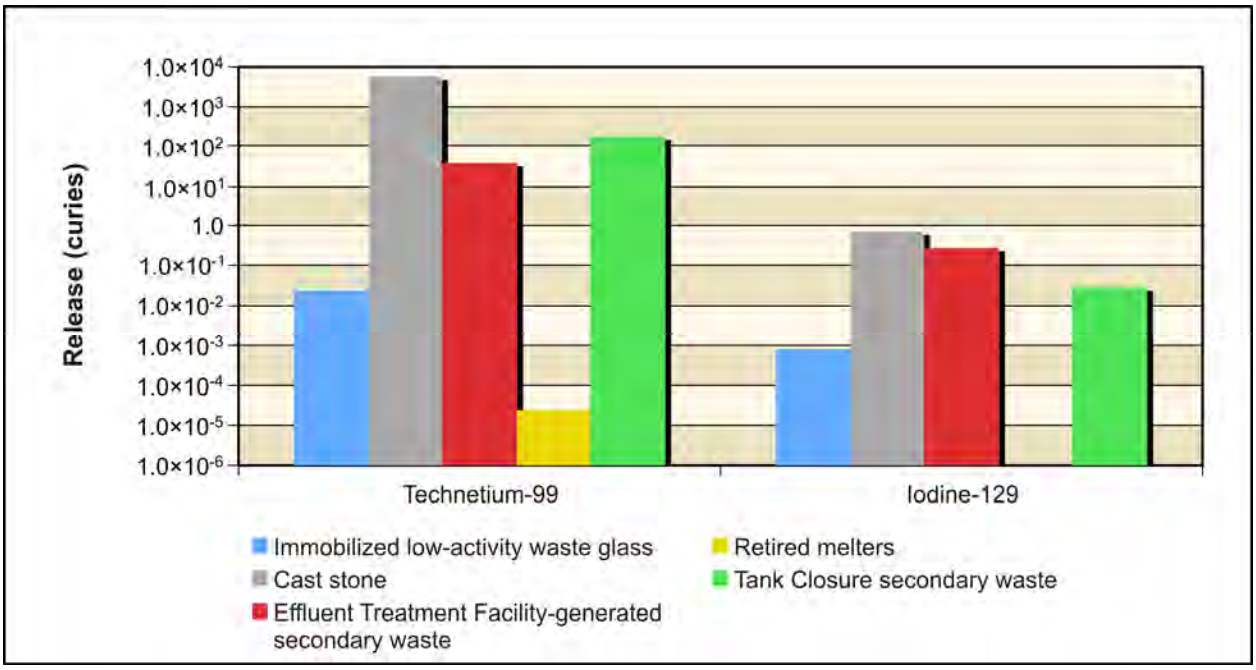


Figure 5–779. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Area to Vadose Zone

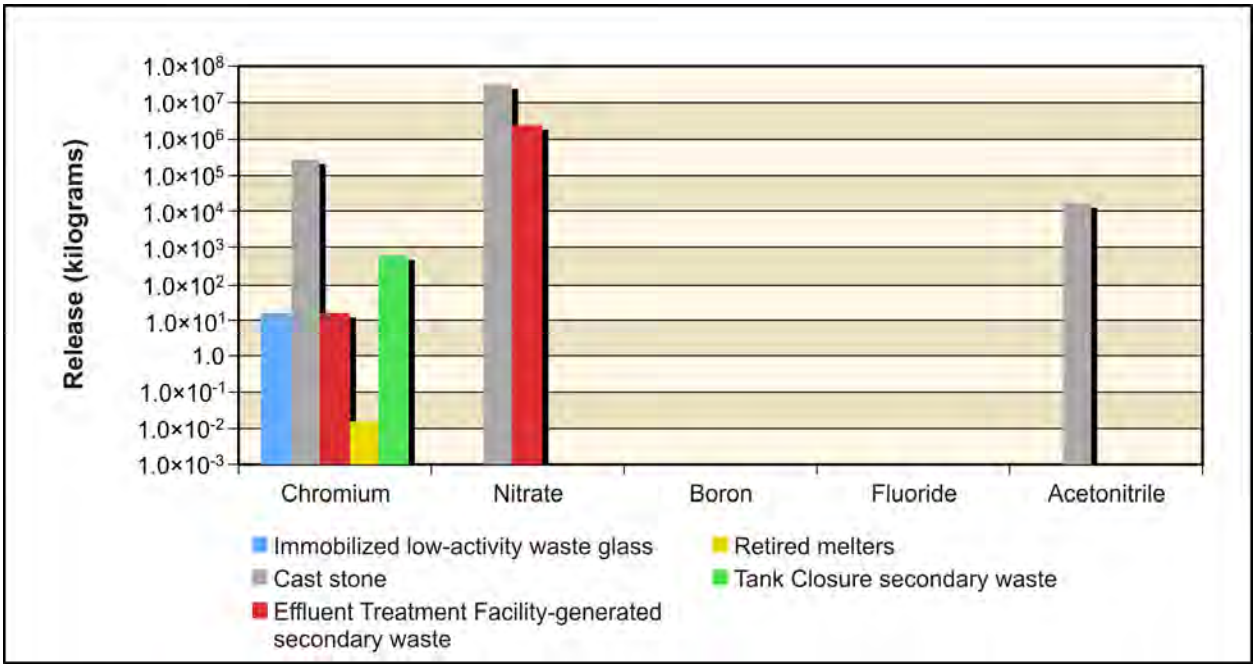


Figure 5–780. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Area to Vadose Zone

Figure 5–781 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–782, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. With the exception of technetium-99 released from ETF-generated secondary waste, of which nearly all released to the vadose zone reached groundwater in the analysis, only 40 to 50 percent of the technetium-99 and iodine-129 released to the vadose zone reached groundwater. Chromium from ILAW glass and retired melters behaves similarly to technetium-99 and iodine-129. When released from other sources, nearly all the chromium that enters the vadose zone reached groundwater in the analysis. For nitrate, fluoride, boron, and acetonitrile, nearly everything released to the vadose zone reached groundwater.

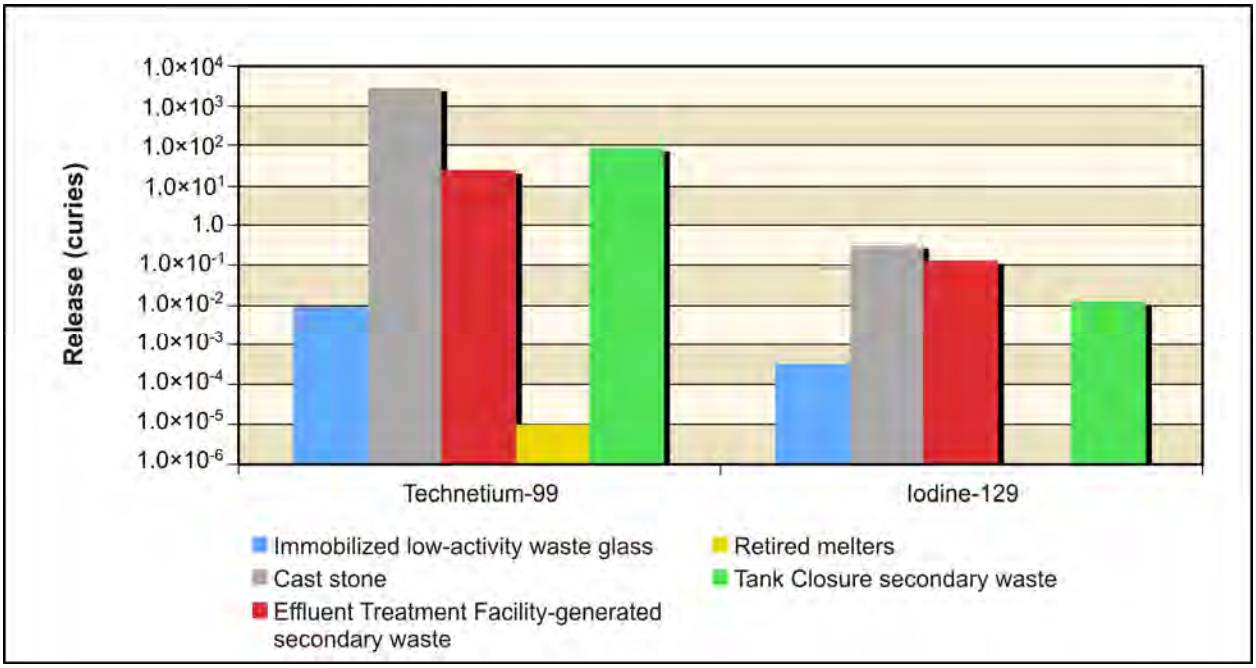


Figure 5–781. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Area to Groundwater

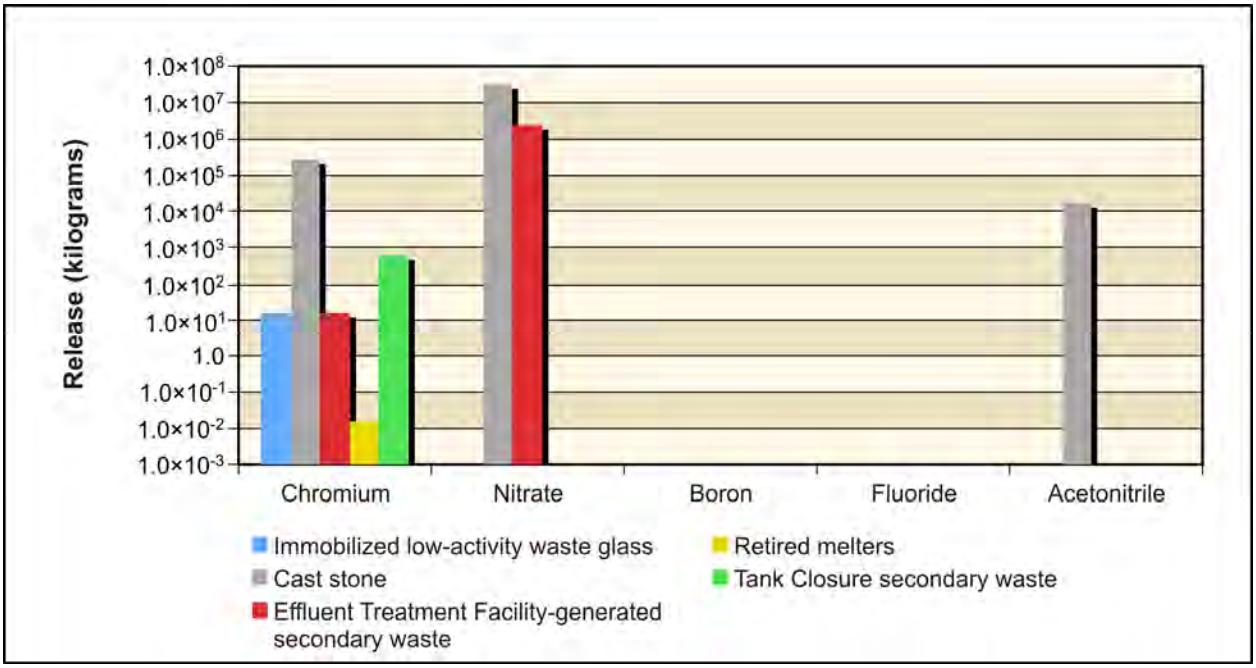


Figure 5–782. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Area to Groundwater

Figure 5–783 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–784, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. In nearly all cases, between 90 and 100 percent of the amount released to groundwater reached the Columbia River in the analysis. The exception to this trend is waste from retired melters for technetium-99. In this case, nothing released to groundwater reached the Columbia River.

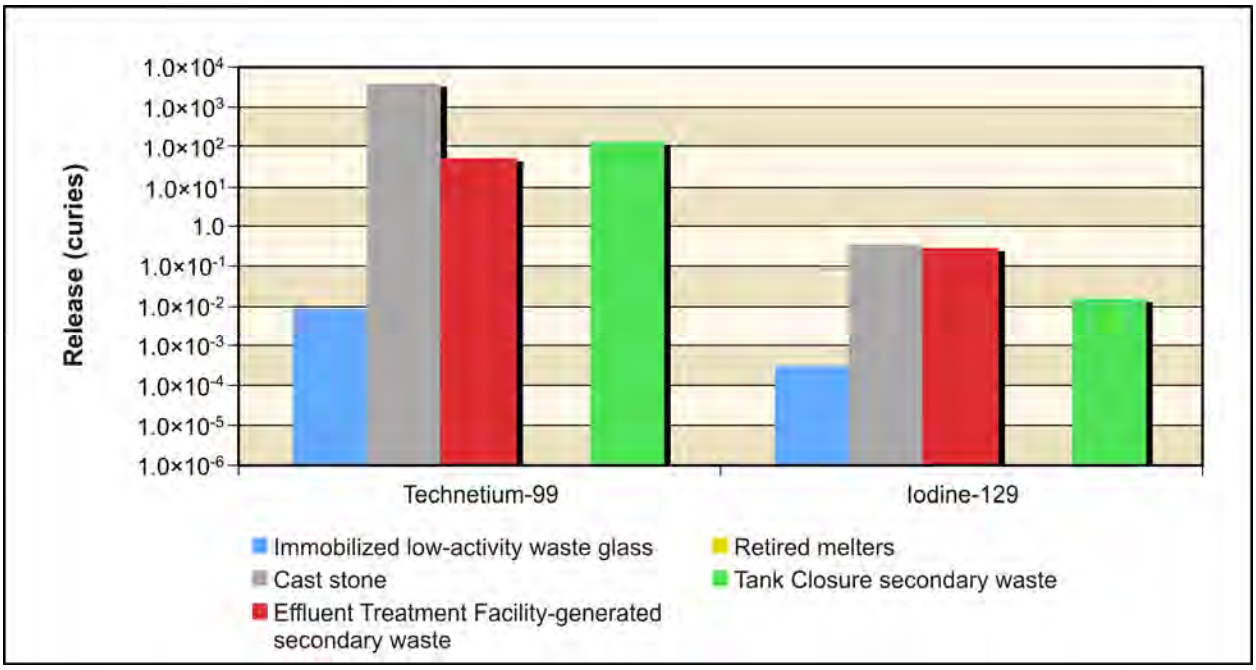


Figure 5–783. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Area to Columbia River

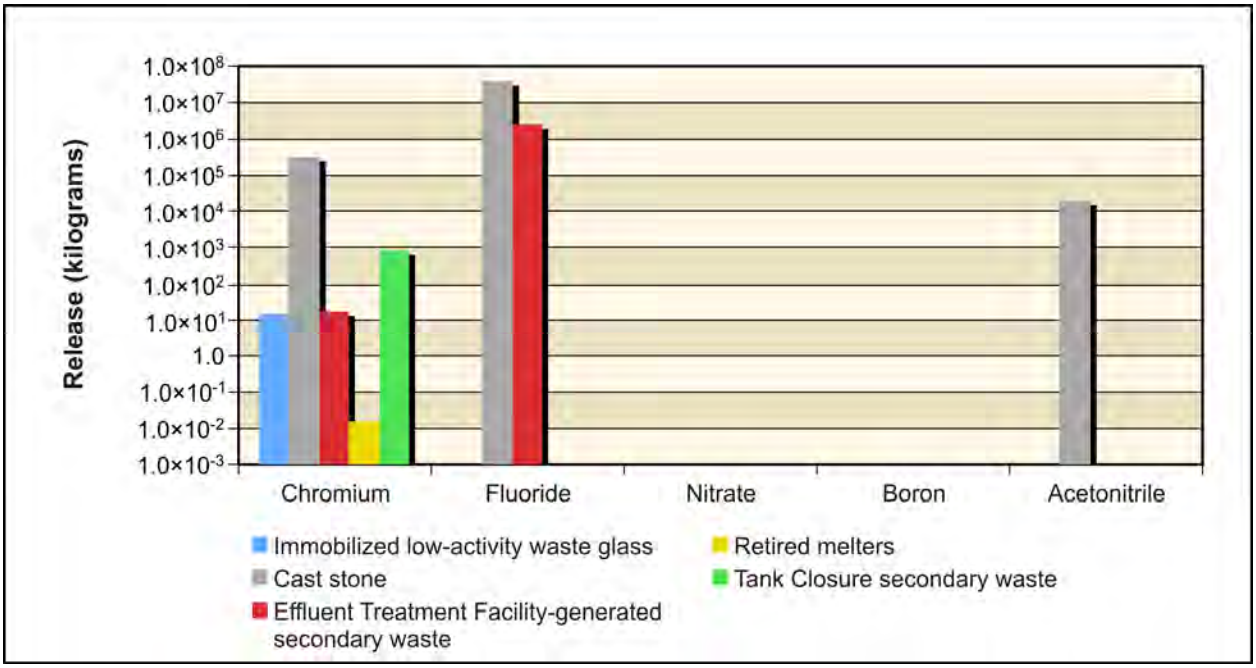


Figure 5–784. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Area to Columbia River

200-West Area Integrated Disposal Facility

Figure 5–785 shows the estimated release at IDF-West to the vadose zone for the radiological risk drivers for Figure 5–786, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, boron, chromium, fluoride, and nitrate are all present at IDF-West.

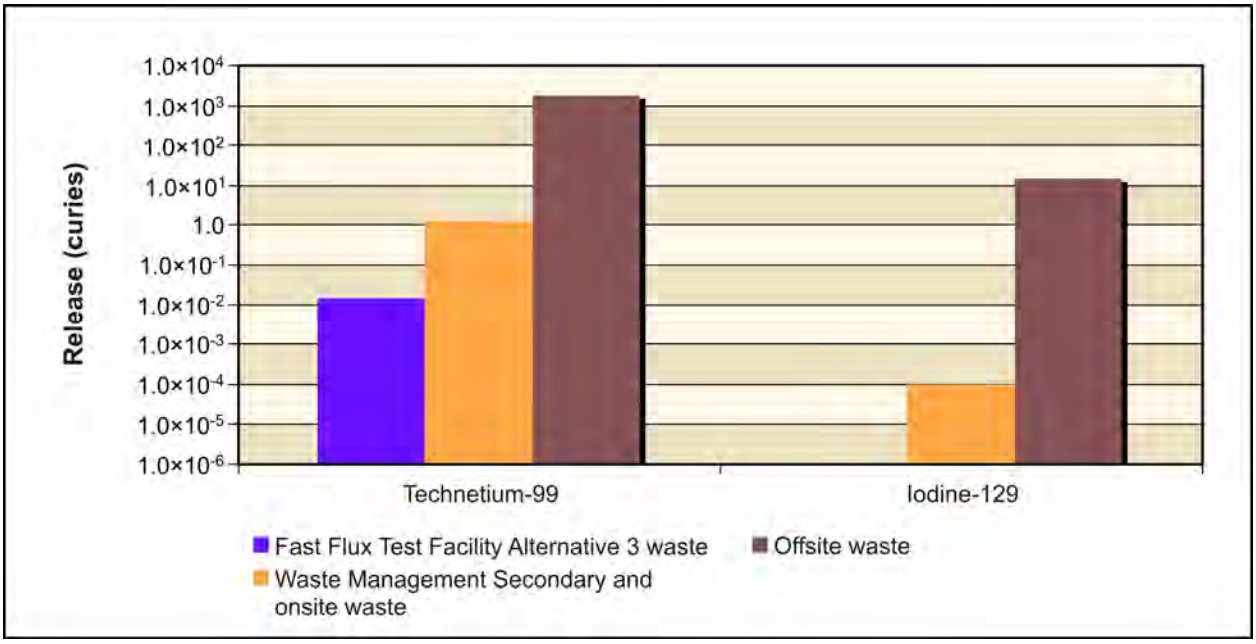


Figure 5–785. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-West Area Integrated Disposal Area to Vadose Zone

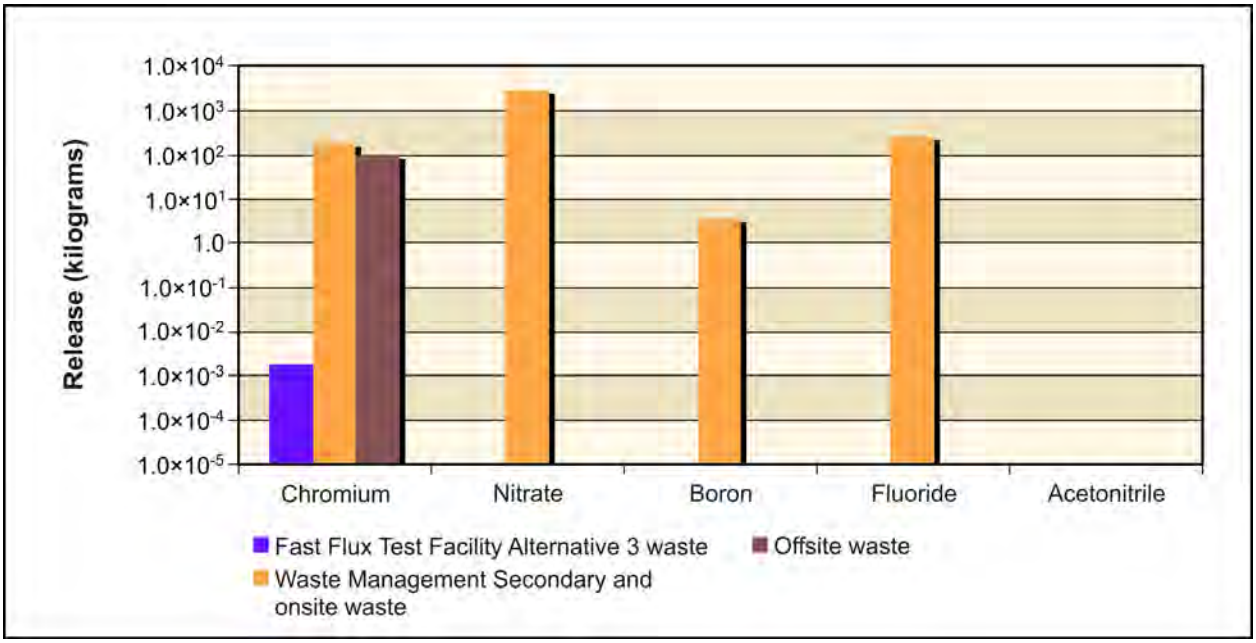


Figure 5–786. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-West Area Integrated Disposal Area to Vadose Zone

Figure 5–787 shows the estimated release at IDF-West to groundwater for the radiological risk drivers and Figure 5–788, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present at IDF-West behave as conservative tracers; essentially all of the mass released to the vadose zone reached groundwater in the analysis.

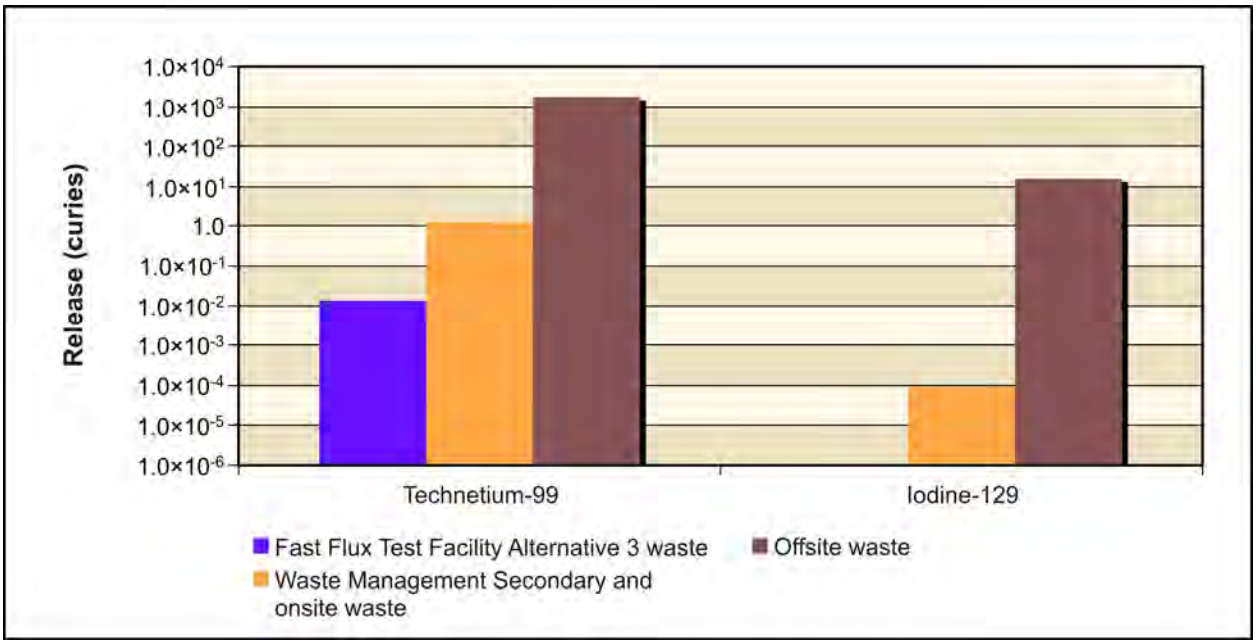


Figure 5–787. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-West Area Integrated Disposal Area to Groundwater

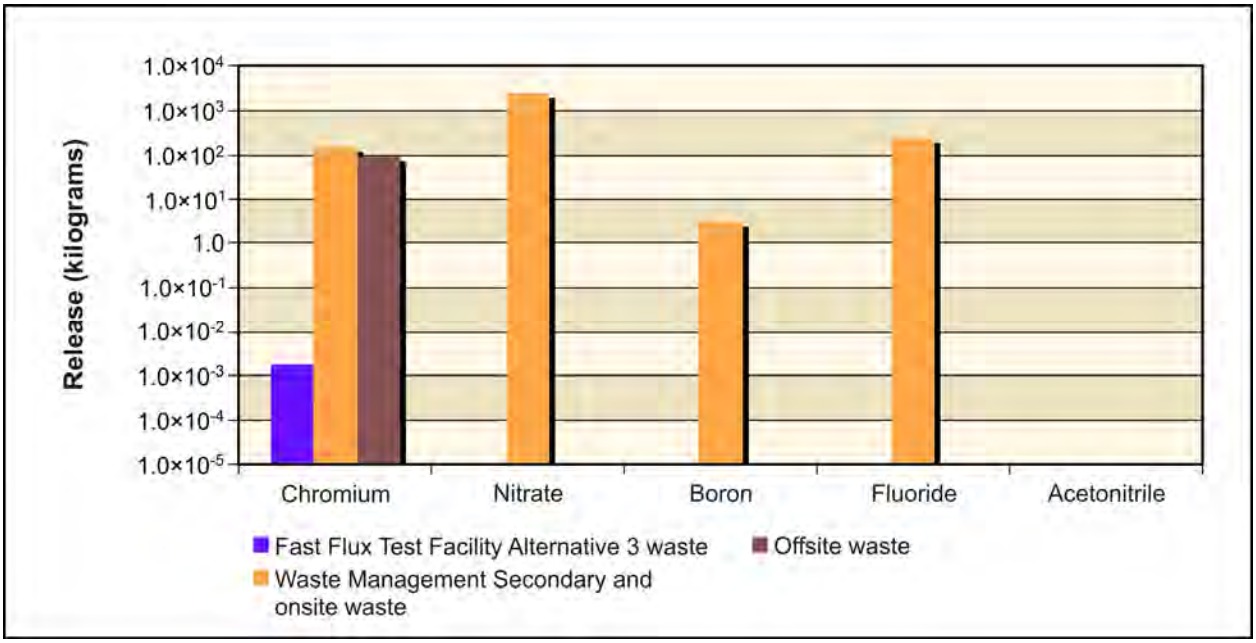


Figure 5–788. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-West Area Integrated Disposal Area to Groundwater

Figure 5–789 shows the estimated release at the IDF-West to the Columbia River for the radiological risk drivers and Figure 5–790, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. In the analysis, essentially everything released to groundwater reached the Columbia River for all COPC drivers present.

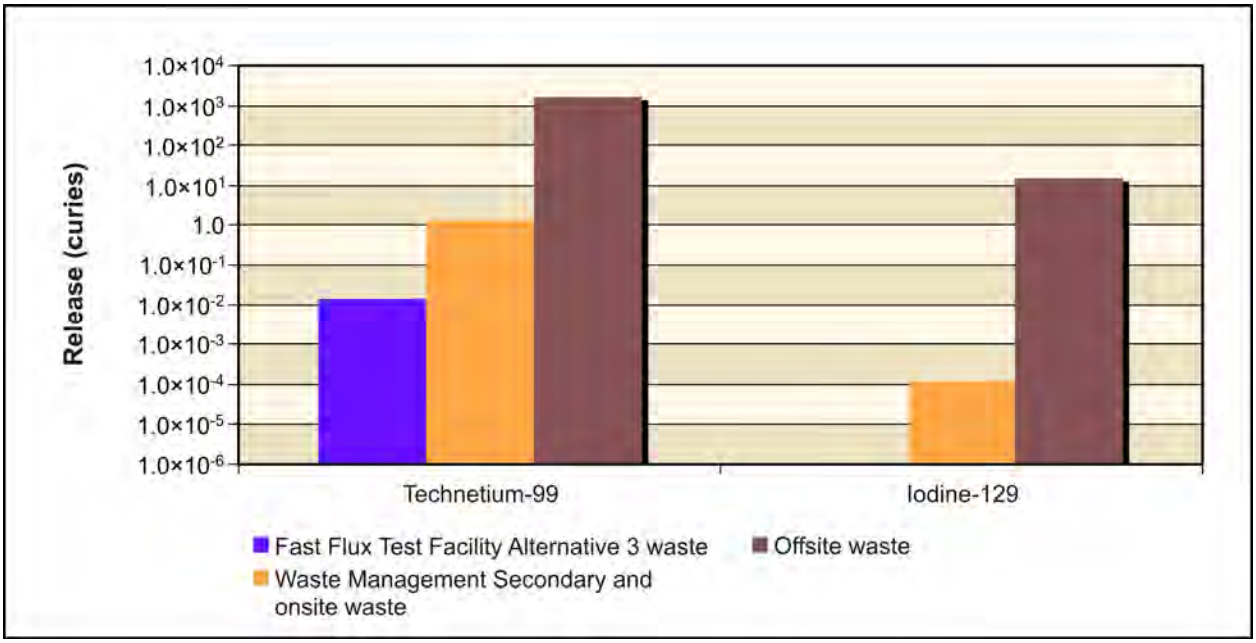


Figure 5–789. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-West Area Integrated Disposal Area to Columbia River

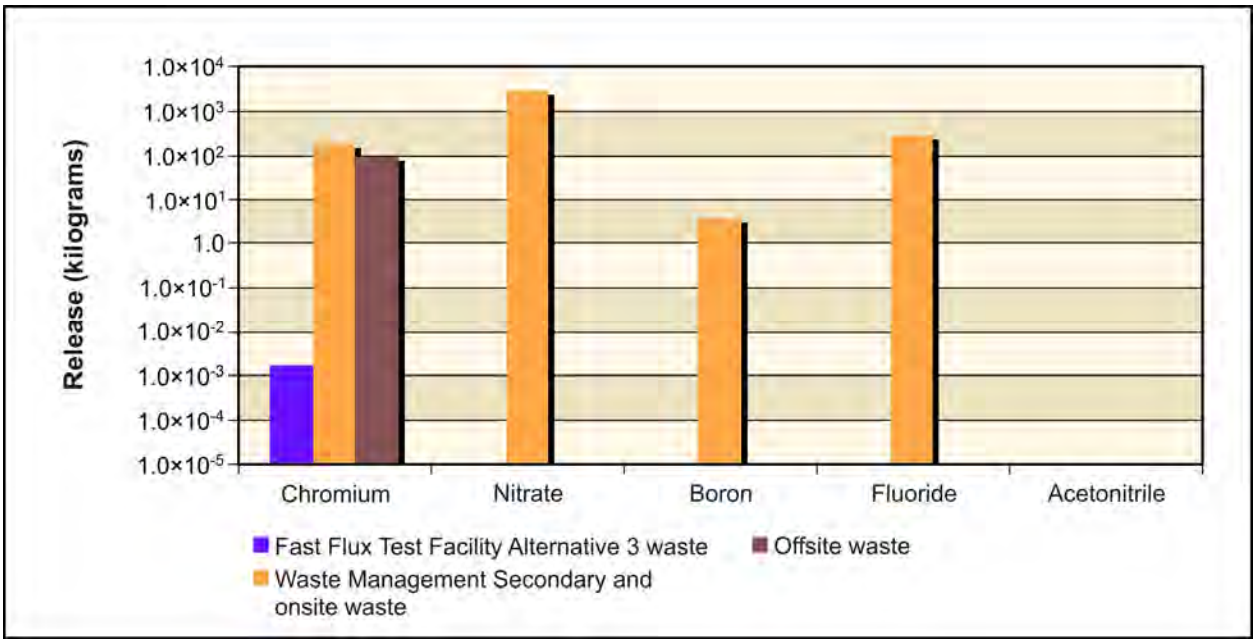


Figure 5–790. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-West Area Integrated Disposal Area to Columbia River

River Protection Project Disposal Facility

Figure 5–791 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–792, the chemical hazard. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, chromium, and nitrate are all present at the RPPDF.

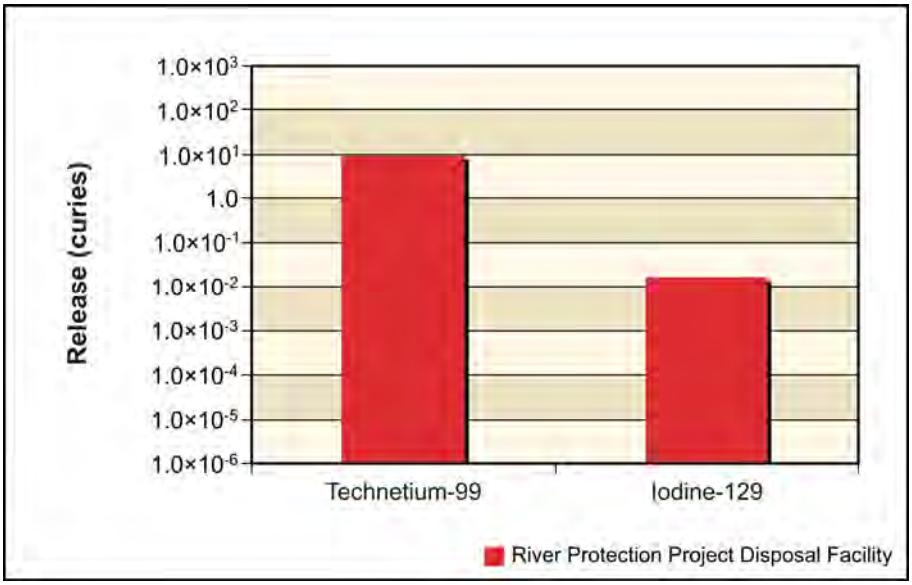


Figure 5–791. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Area to Vadose Zone

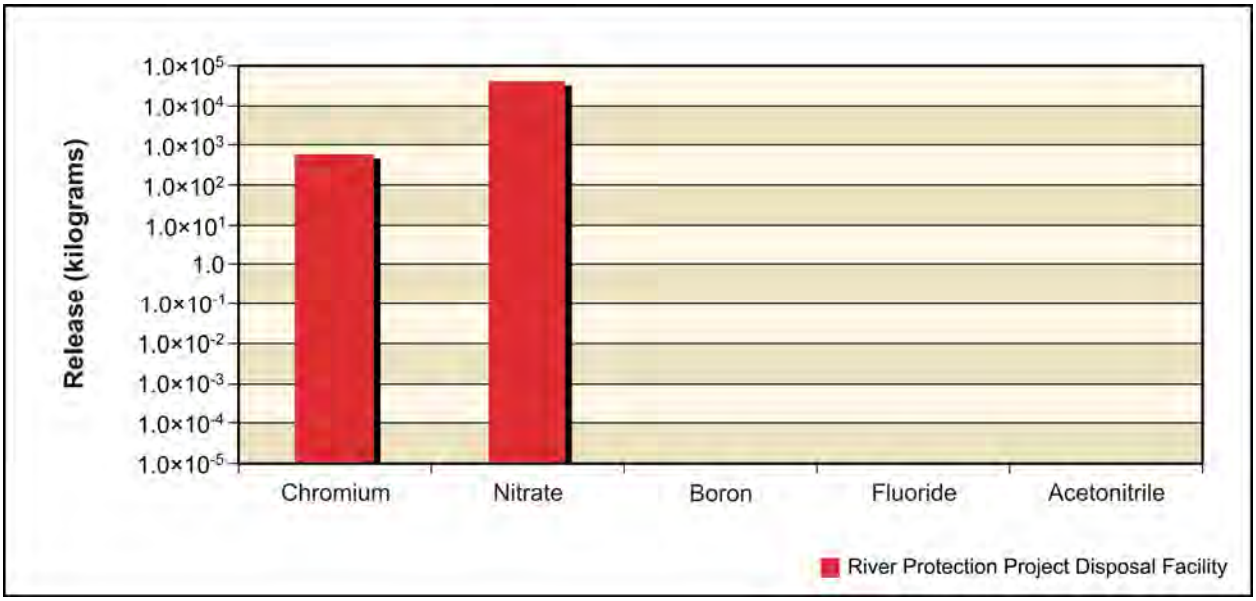


Figure 5–792. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Area to Vadose Zone

Figure 5–793 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–794, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present at the RPPDF behave as conservative tracers; essentially all of the mass released to the vadose zone reached groundwater in the analysis.

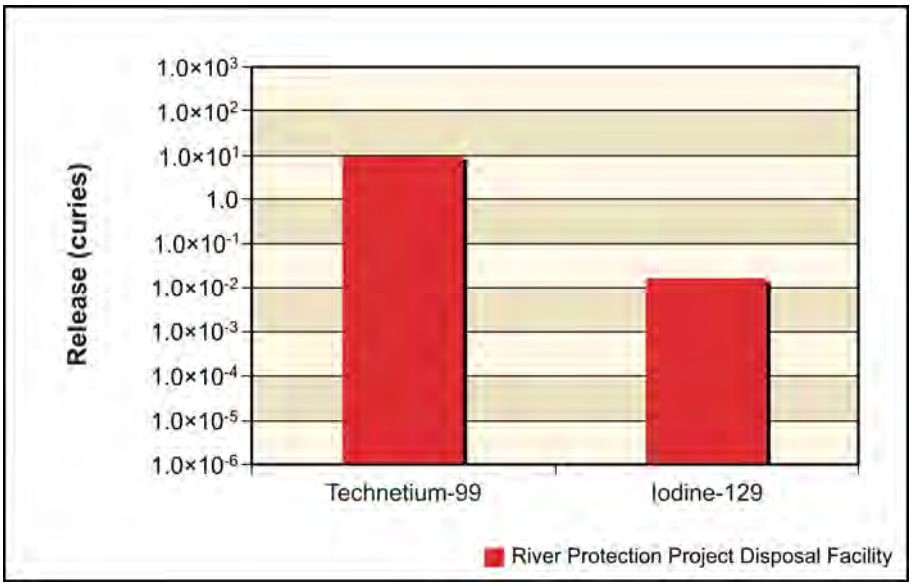


Figure 5–793. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Area to Groundwater

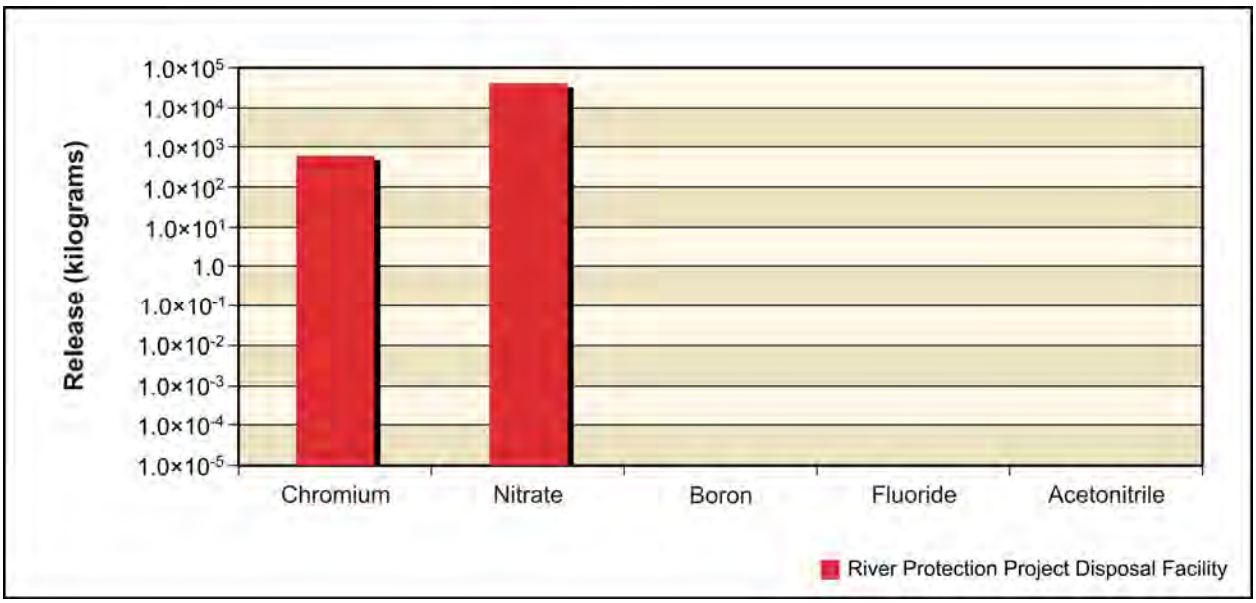


Figure 5–794. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Area to Groundwater

Figure 5–795 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–796, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. In the analysis, essentially everything released to groundwater reached the Columbia River for all COPC drivers present.

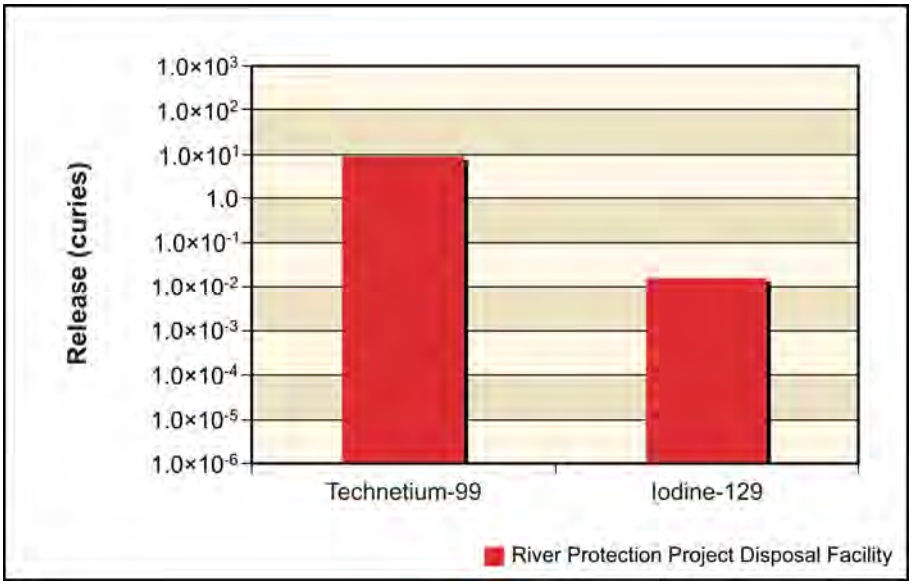


Figure 5–795. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Area to Columbia River

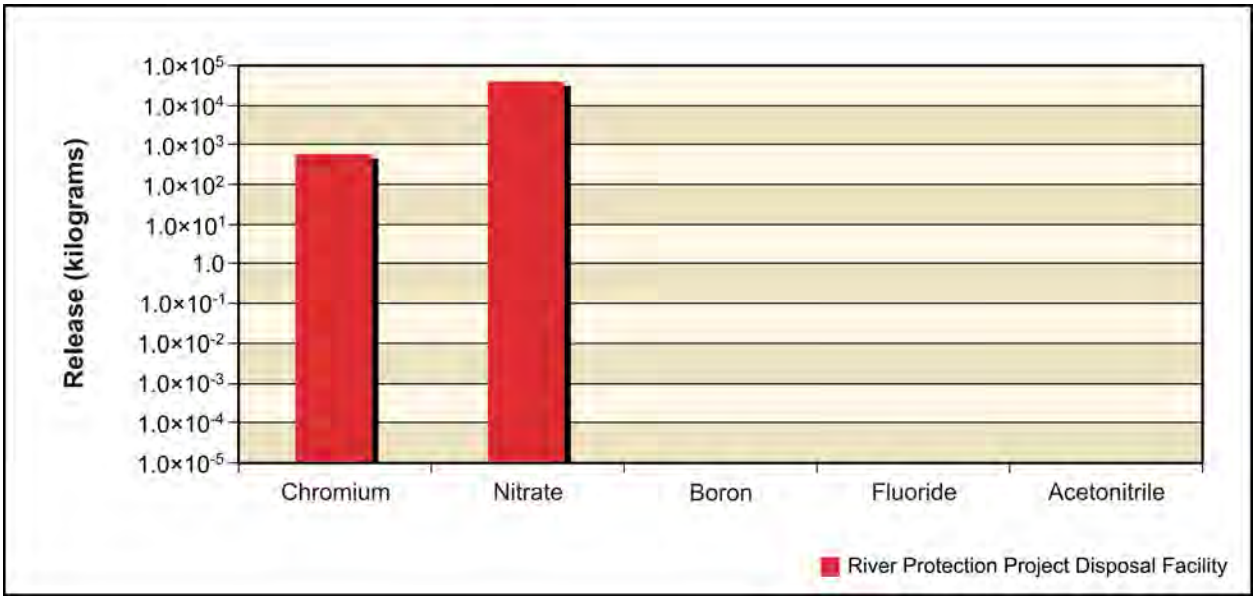


Figure 5–796. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Area to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–91 shows the maximum concentrations in groundwater.

Table 5–91. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	**5,020**	**20,200**	33	**7,840**	**1,690**	900
	(9048)	(3713)	(3825)	(9163)	(8939)	
Iodine-129	0.7	**173**	0.1	**60**	**8**	1
	(10915)	(3797)	(3772)	(3853)	(4729)	
Chemical in micrograms per liter						
Acetonitrile	25	0	0	9	7	100
	(8281)	(1940)	(1940)	(8313)	(8973)	
Chromium	**436**	2	2	**265**	**116**	100
	(8940)	(3696)	(3856)	(8760)	(9311)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	**50,200**	17	149	21,200	14,100	45,000
	(8665)	(3703)	(3811)	(8290)	(9453)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–797 through 5–800 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers), respectively. For technetium-99, concentrations rise early in the simulation, reaching a peak around CY 3940 at about one order of magnitude above the benchmark concentration. Concentrations drop until CY 5400, when they start climbing again, although not as quickly. Around CY 7940, concentrations begin to hold steady just below the benchmark. Iodine-129 does not have the secondary rise in concentration, instead stabilizing below the benchmark after its initial peak, nearly two orders of magnitude above the benchmark. Chromium and nitrate show a different pattern, with their initial peak concentrations about one order of magnitude lower than their second, more stable peaks. Both chromium and nitrate remain below the benchmark throughout the simulation, although chromium more closely approaches the benchmark concentration.

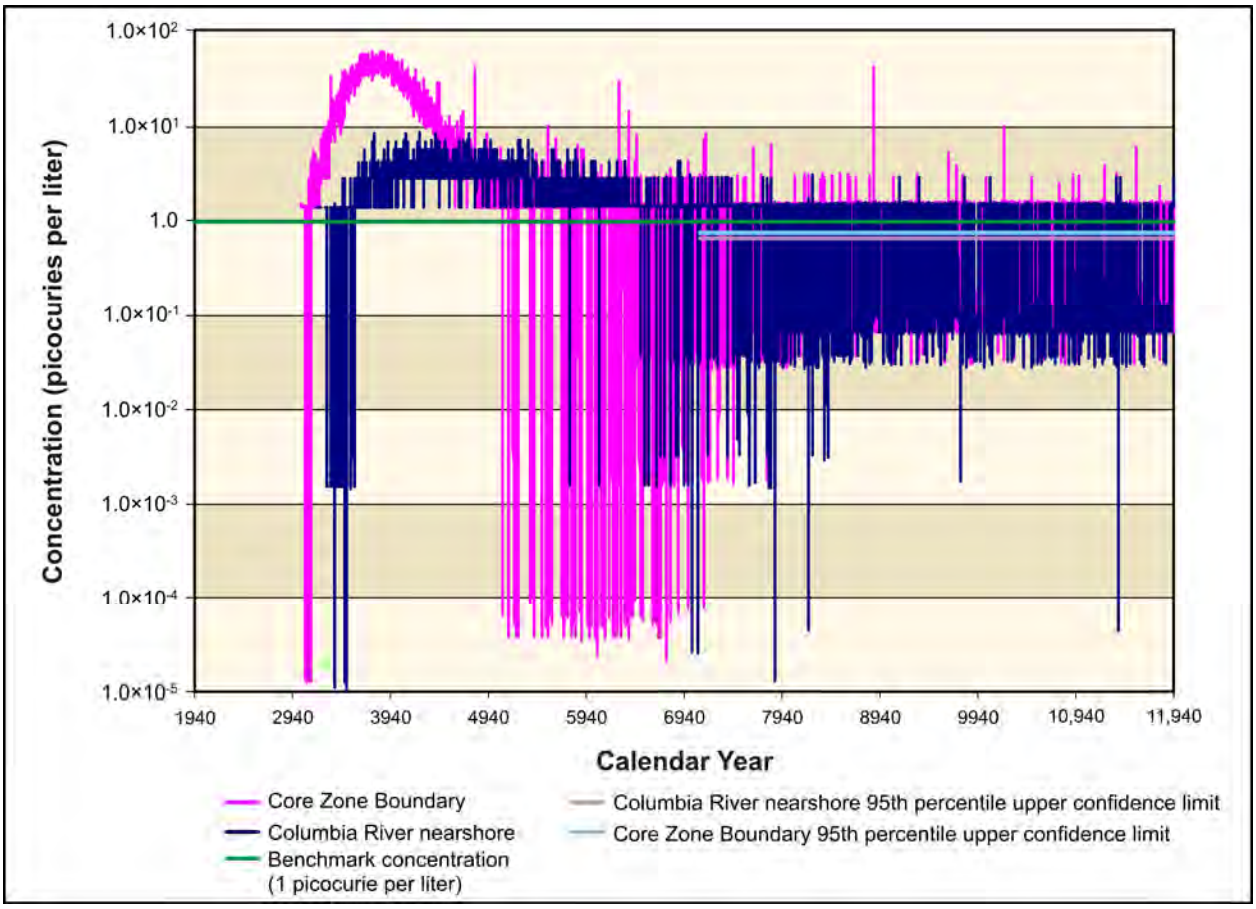


Figure 5–797. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Iodine-129 Concentration Versus Time

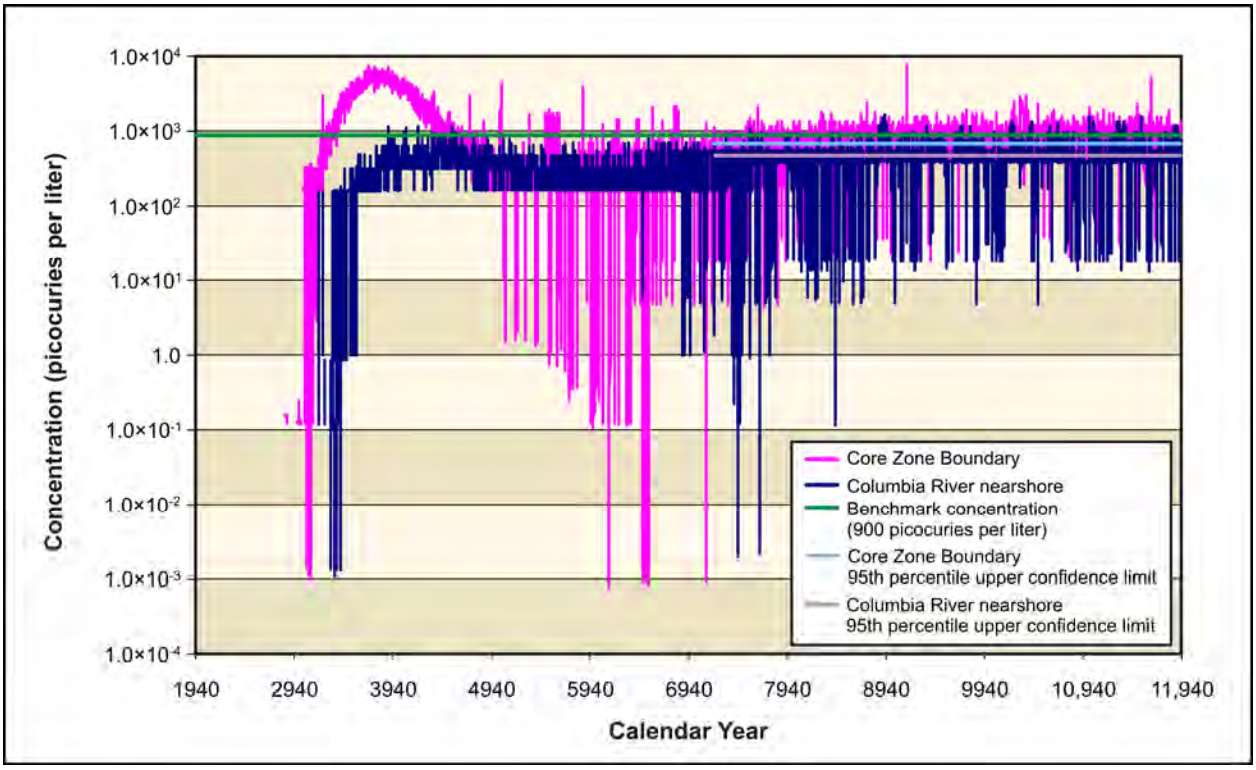


Figure 5–798. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Technetium-99 Concentration Versus Time

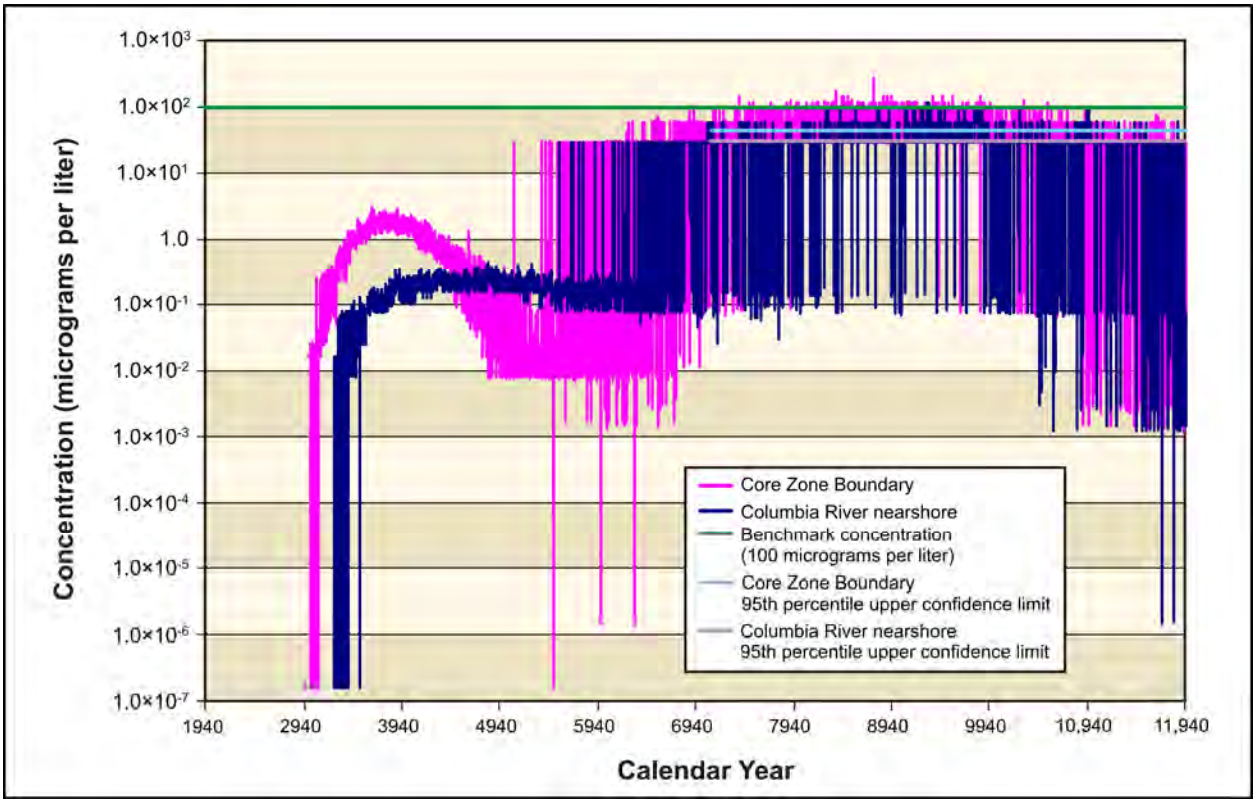


Figure 5–799. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chromium Concentration Versus Time

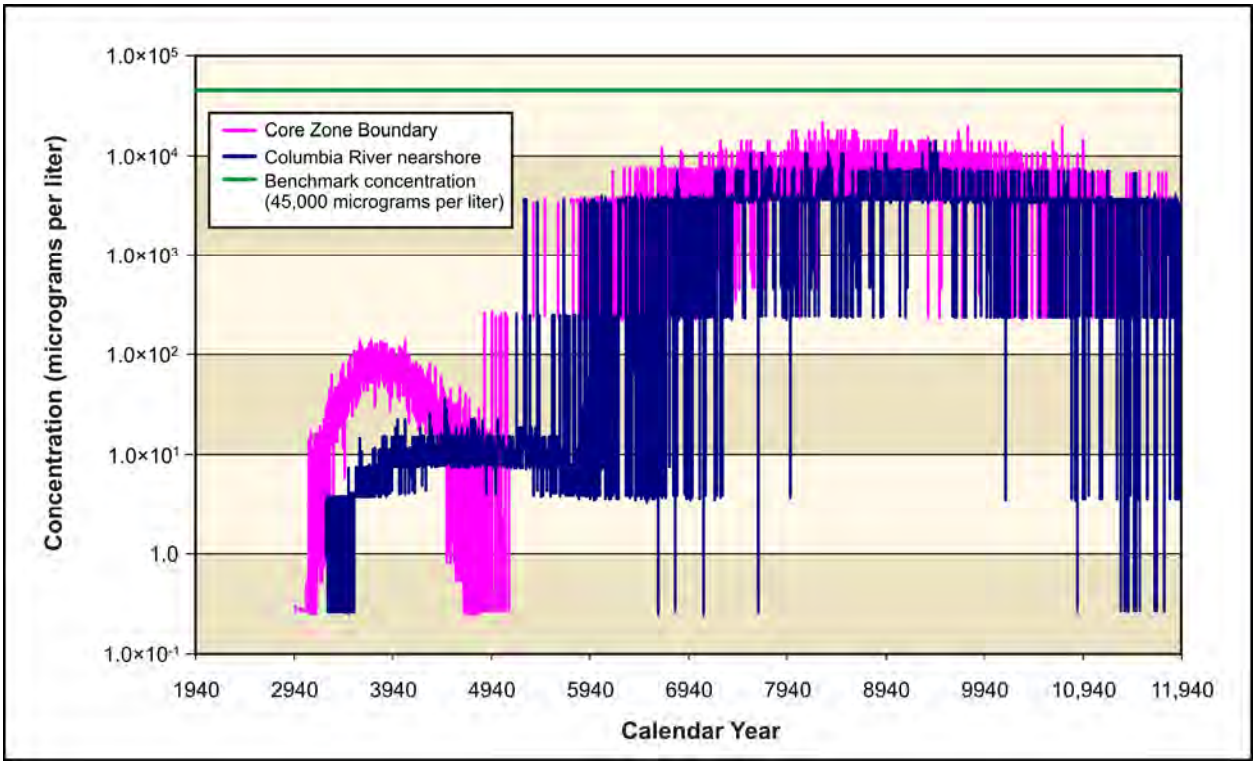


Figure 5–800. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Nitrate Concentration Versus Time

Figures 5–801 and 5–802 show concentration versus time for uranium-238 and total uranium. Because of the high retardation of uranium, no contamination appears until CY 8940, when uranium-238 concentrations at the Core Zone Boundary first surpass 1.0×10^{-8} micrograms per liter. Uranium-238 remains three orders of magnitude below the benchmark during the simulation. Total uranium remains over seven orders of magnitude below the benchmark concentration at the Core Zone Boundary throughout the simulation.

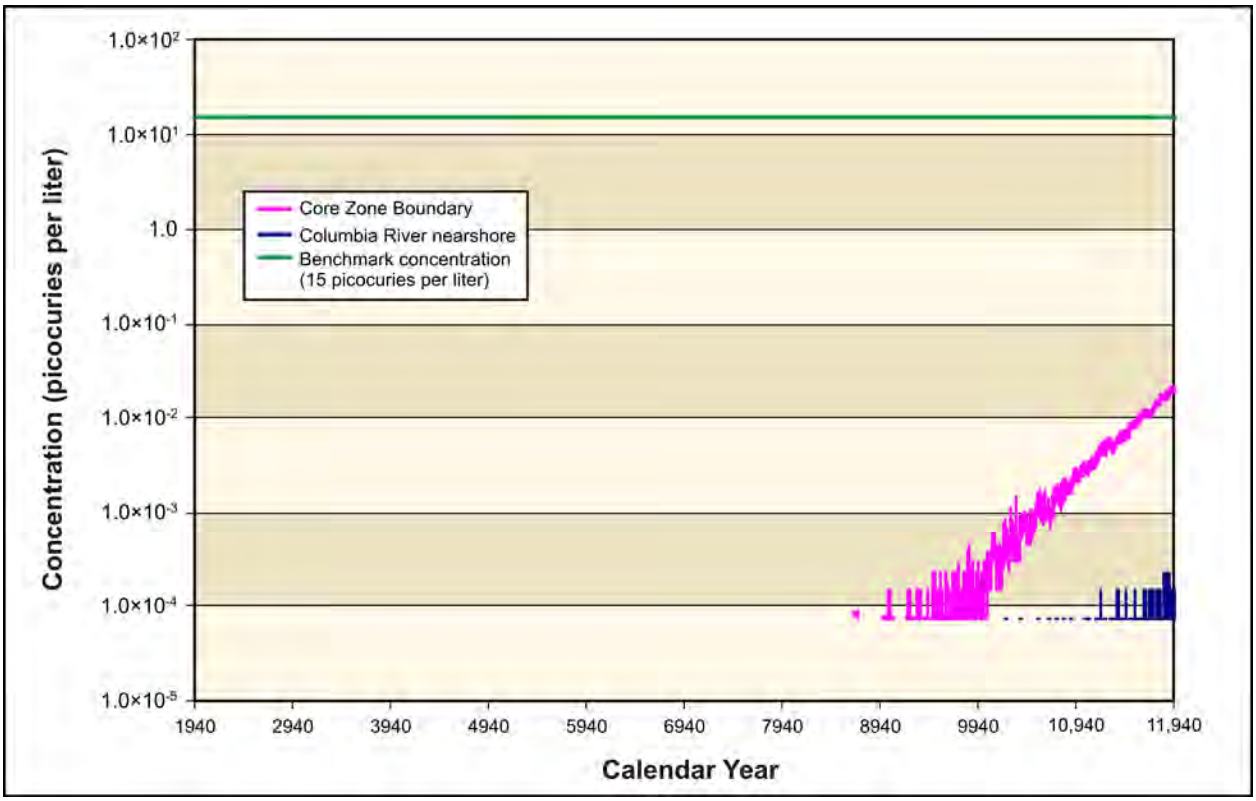


Figure 5–801. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Uranium-238 Concentration Versus Time

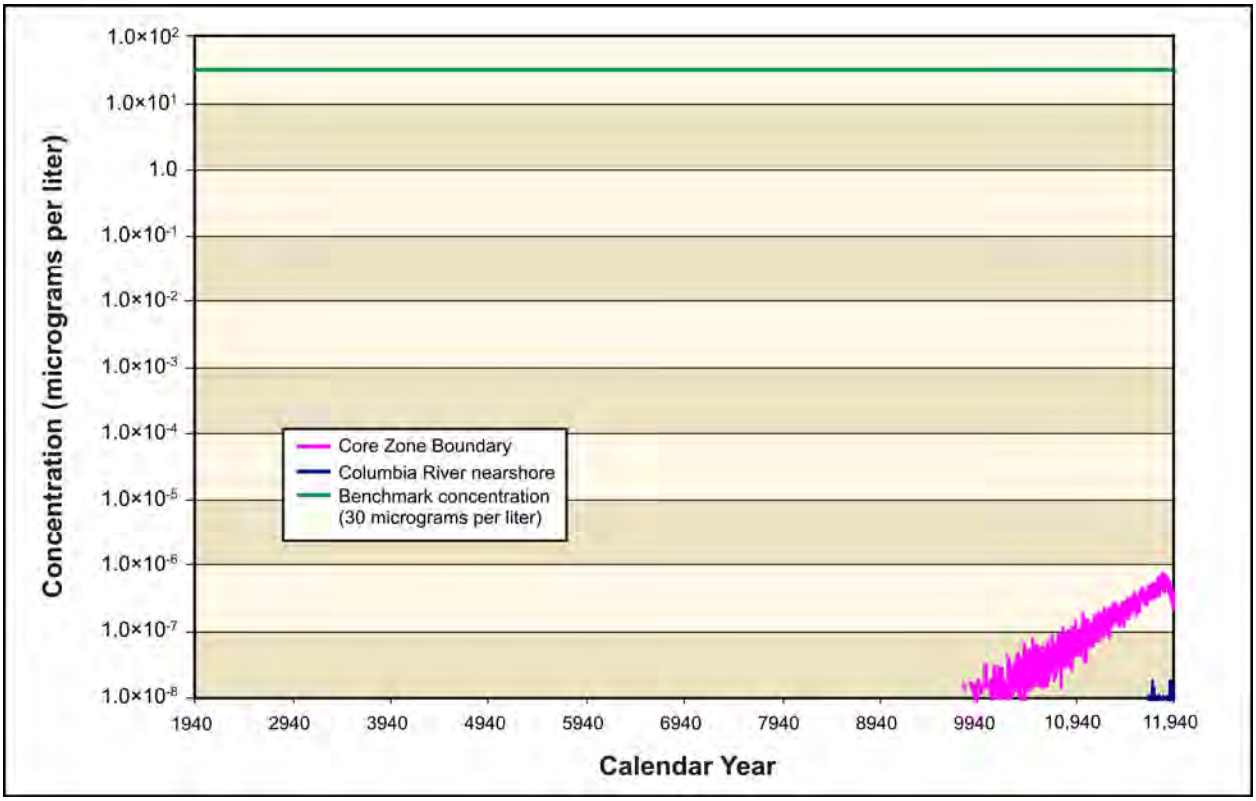
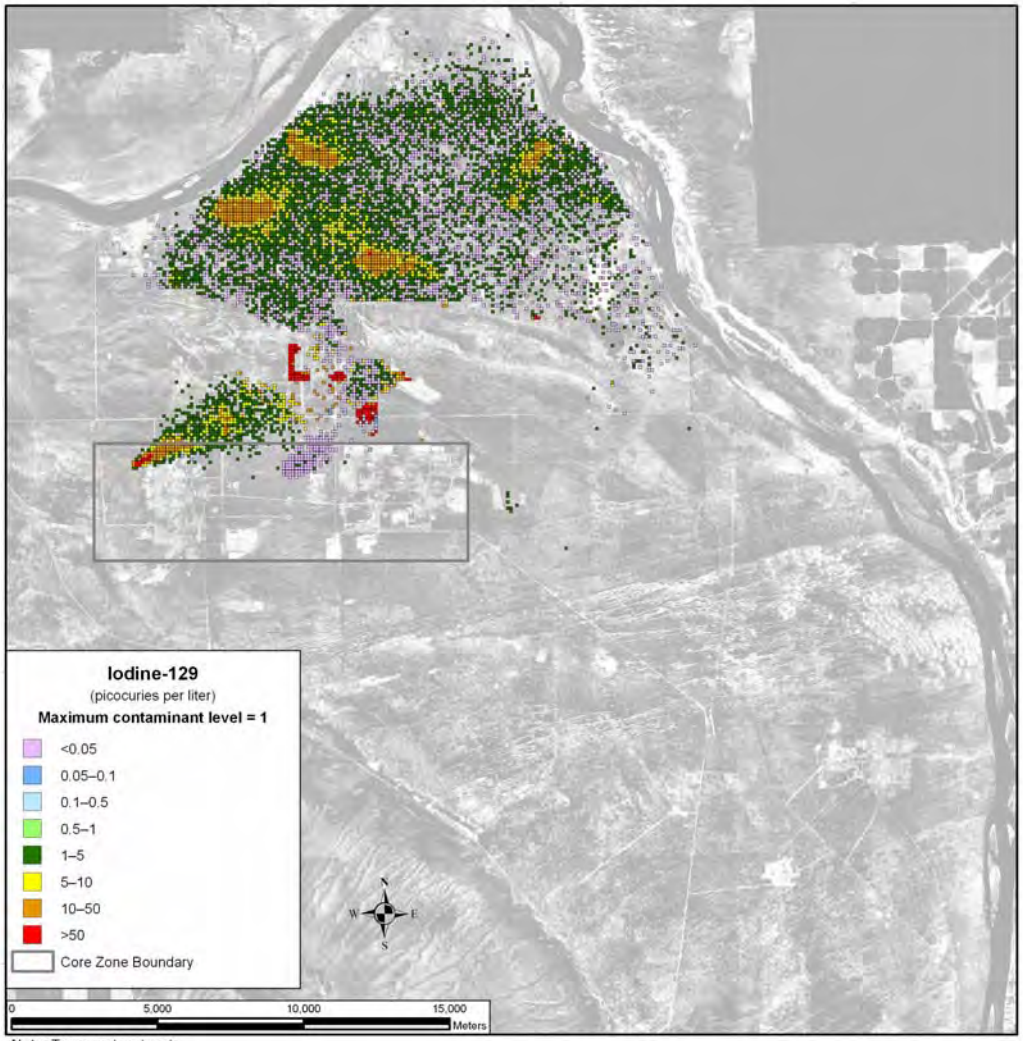


Figure 5–802. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

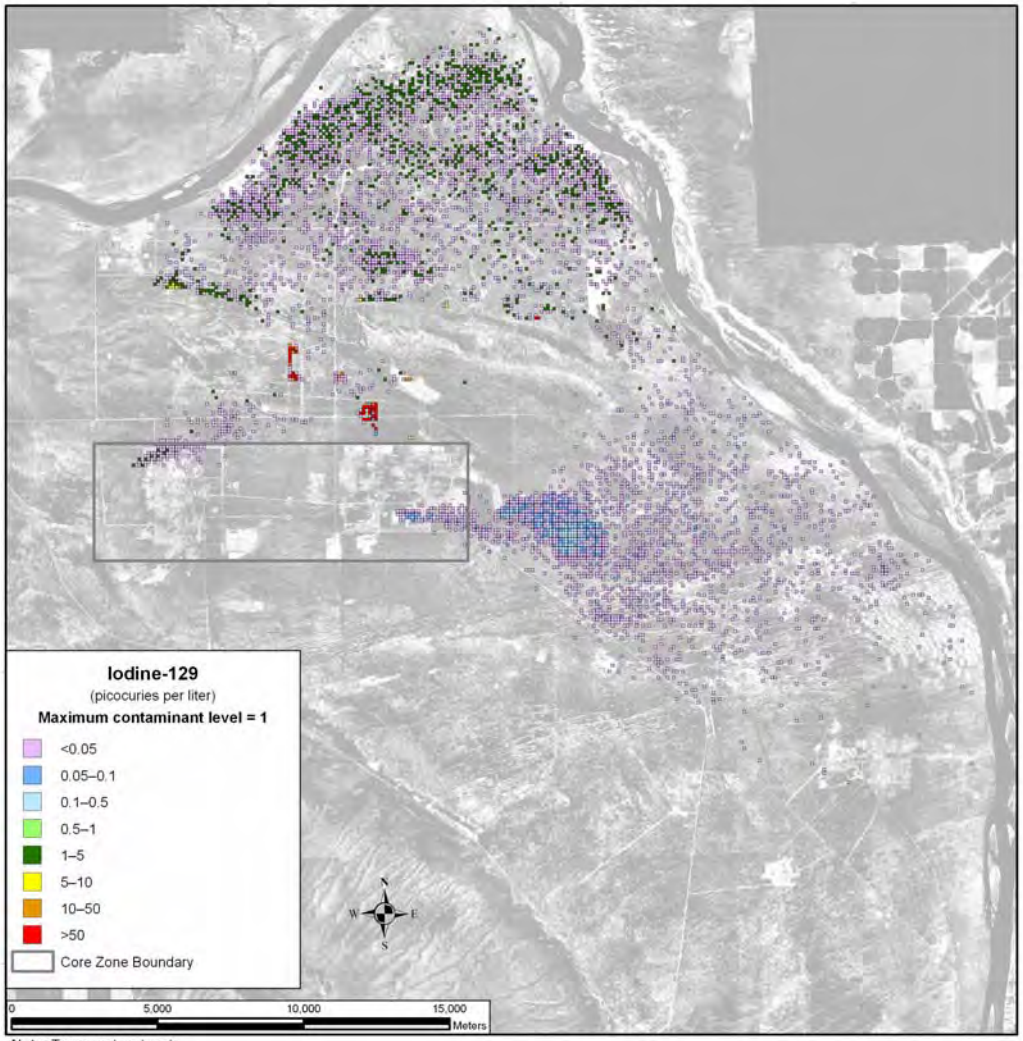
This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

At CY 3890, (see Figure 5–803), there is a high-concentration plume of iodine-129 stretching northeast of IDF-West and a low-concentration plume stretching north from the RPPDF and through Gable Gap. Four separate high-concentration areas have also formed north of Gable Mountain and Gable Butte. By CY 7140, (see Figure 5–804) the plumes from IDF-West and the RPPDF have dissipated, but a new plume has formed, traveling east from IDF-East. Concentrations in this plume remain close to the benchmark. Figure 5–805 shows concentration distributions at CY 11,885. Technetium-99 (see Figures 5–806 through 5–808) shows a similar spatial distribution, but has higher concentrations in the plume from IDF-East and lower concentrations in the plume from IDF-West. Chromium (see Figures 5–809 through 5–811), and nitrate (see Figures 5–812 through 5–814) show similar spatial distributions at selected times, but have consistently lower concentrations. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).



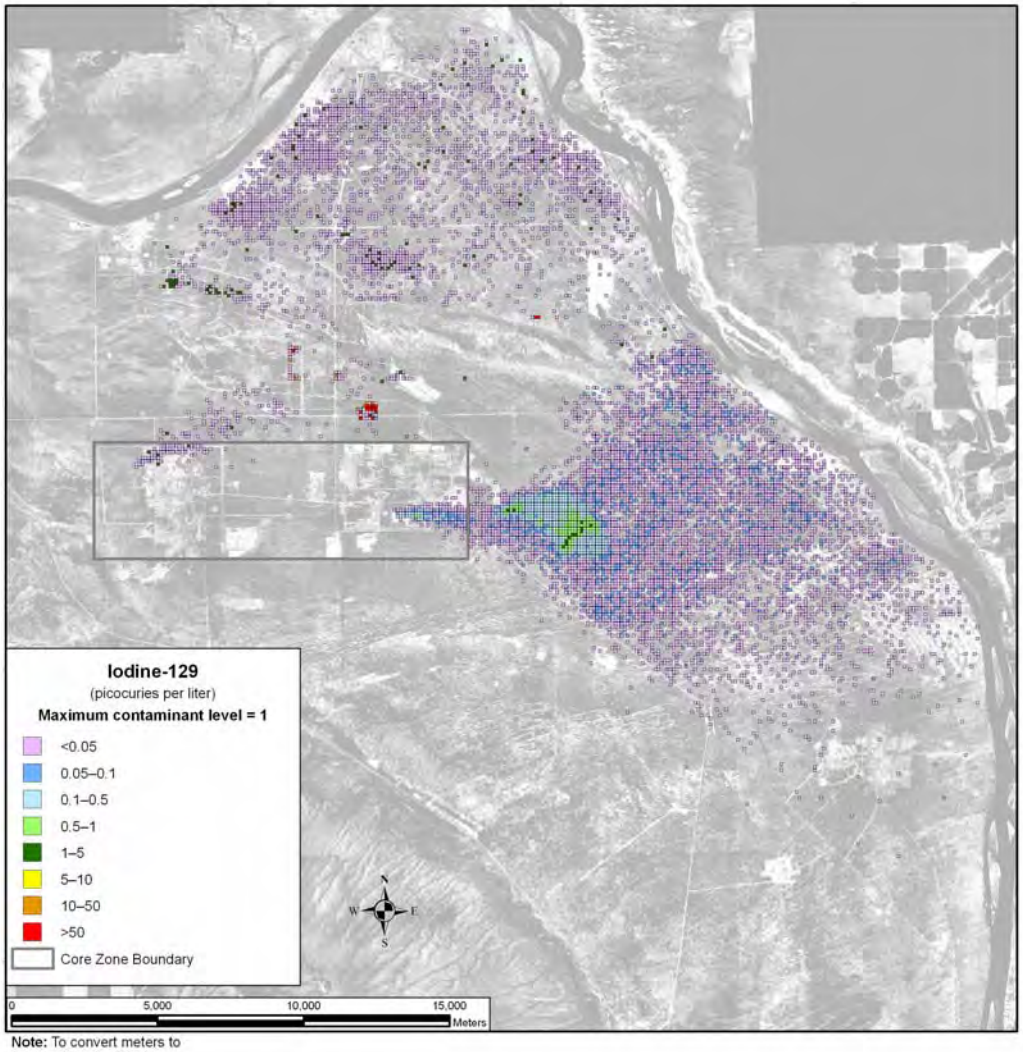
Note: To convert meters to feet, multiply by 3.281

Figure 5–803. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



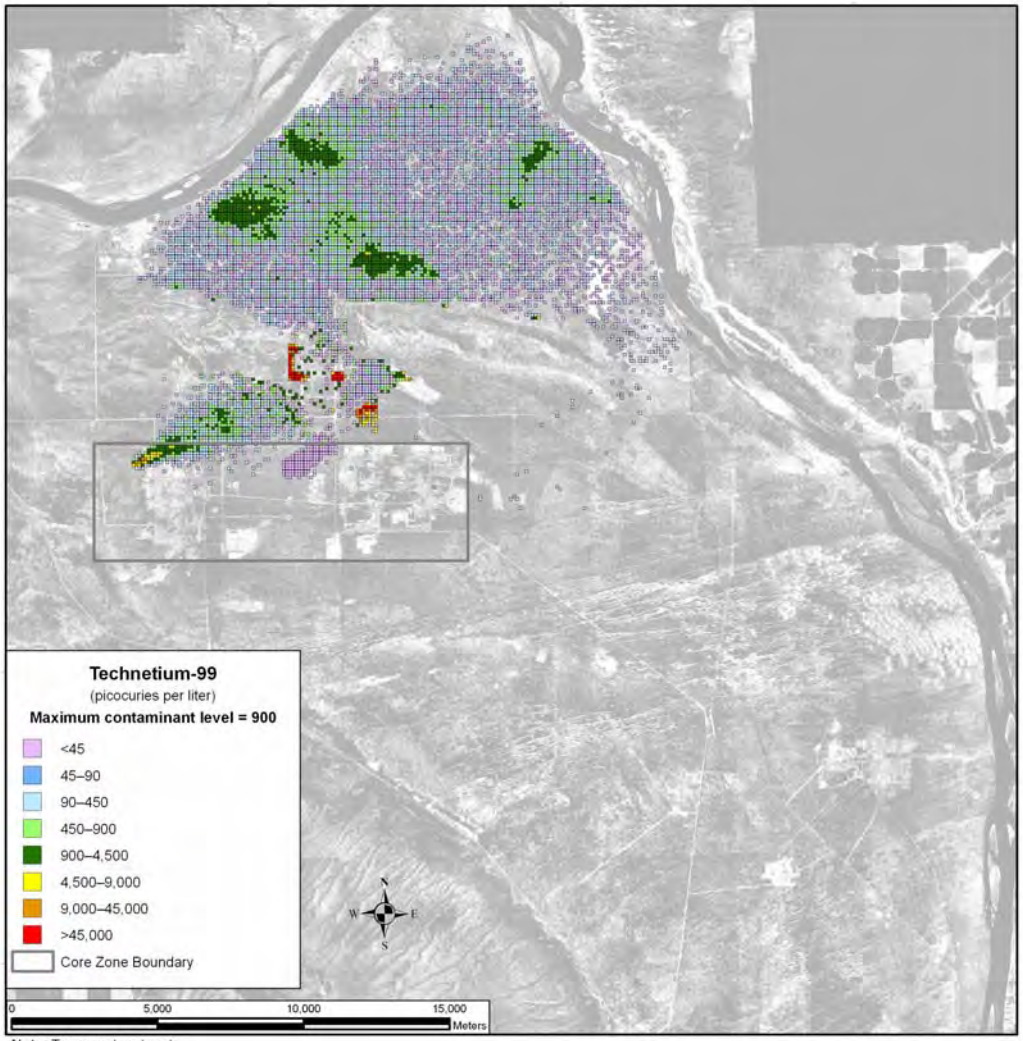
Note: To convert meters to feet, multiply by 3.281

Figure 5–804. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



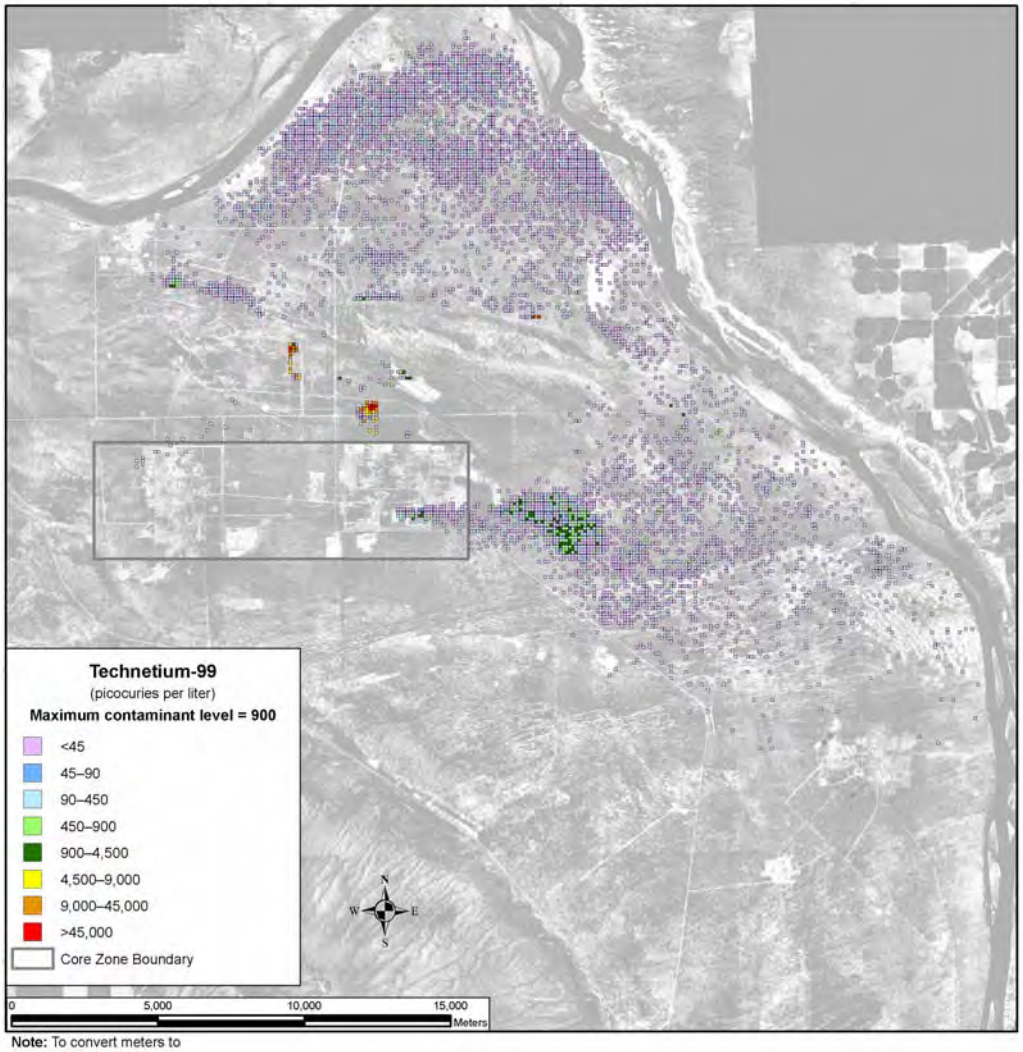
Note: To convert meters to feet, multiply by 3.281

Figure 5–805. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



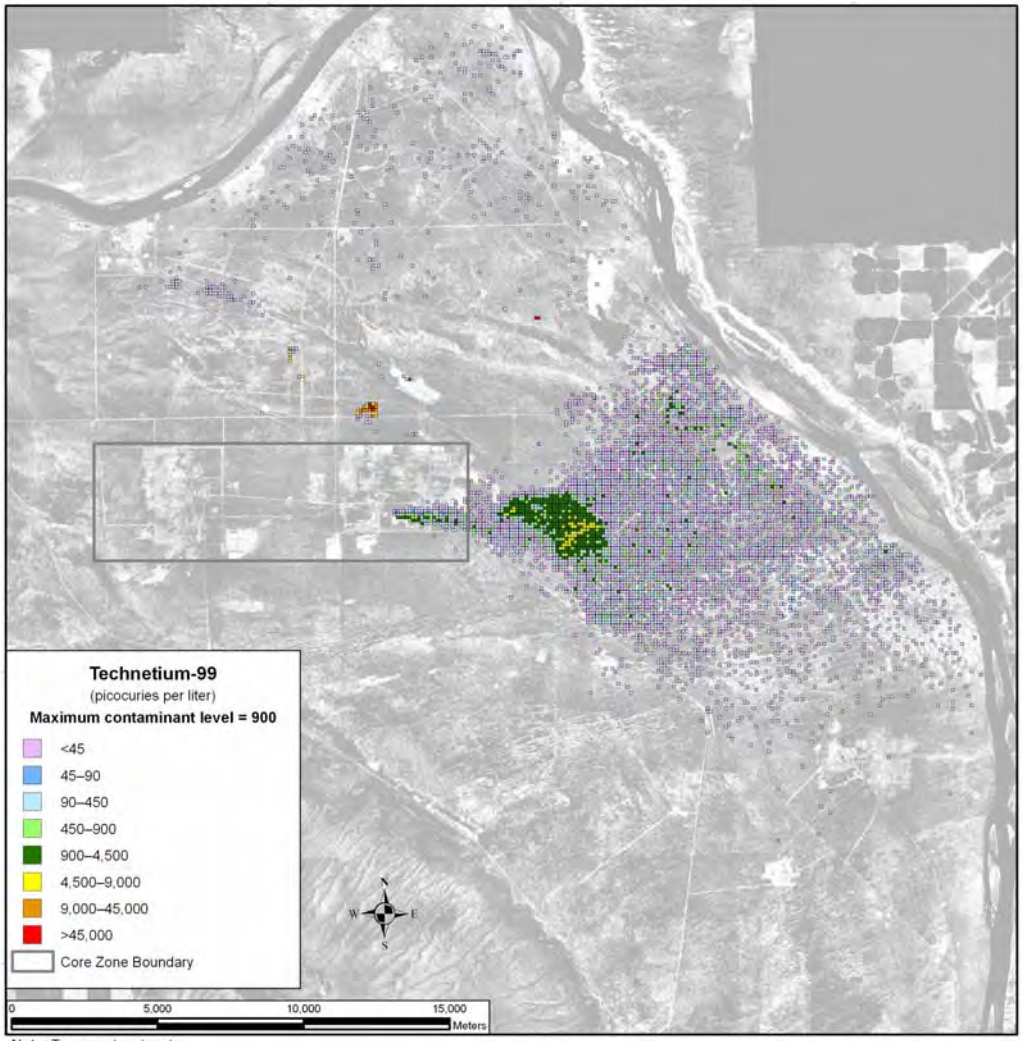
Note: To convert meters to feet, multiply by 3.281

Figure 5–806. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



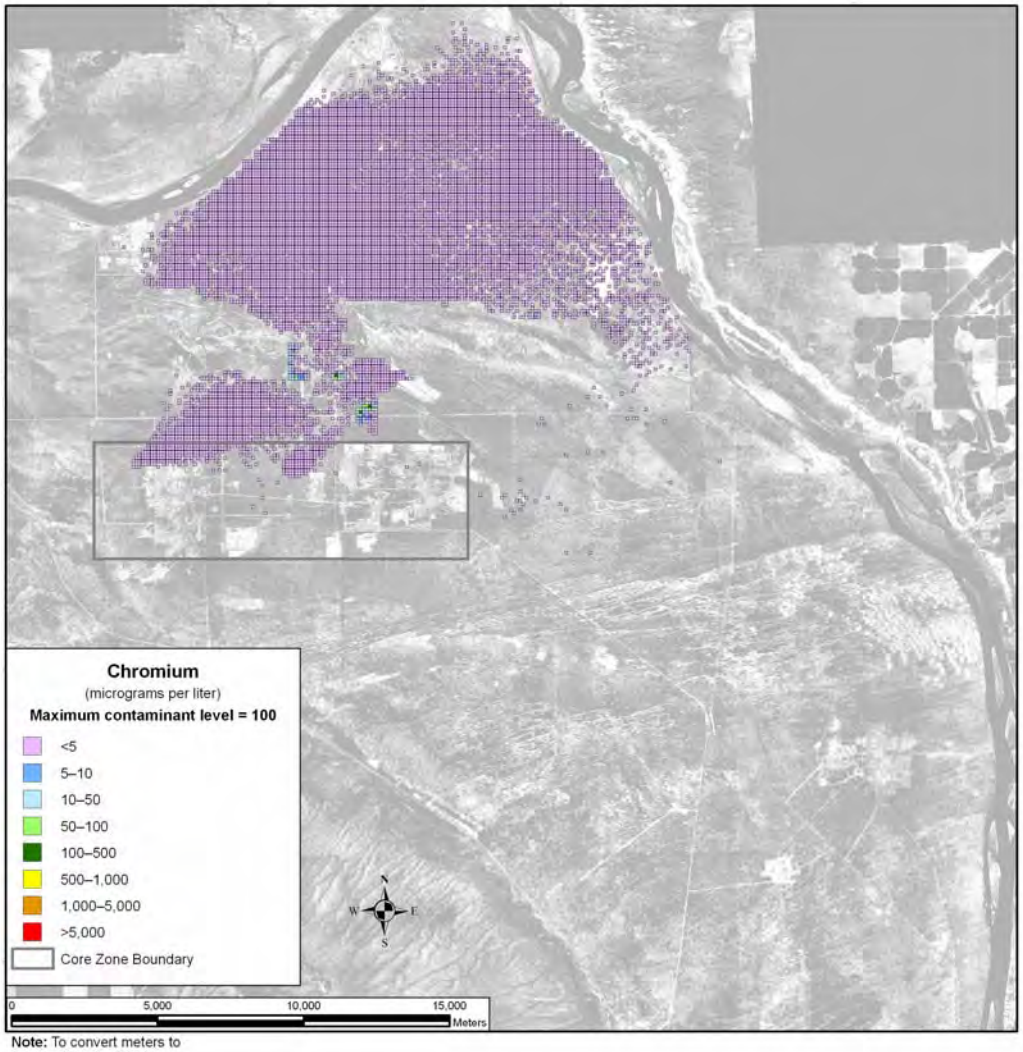
Note: To convert meters to feet, multiply by 3.281

Figure 5–807. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



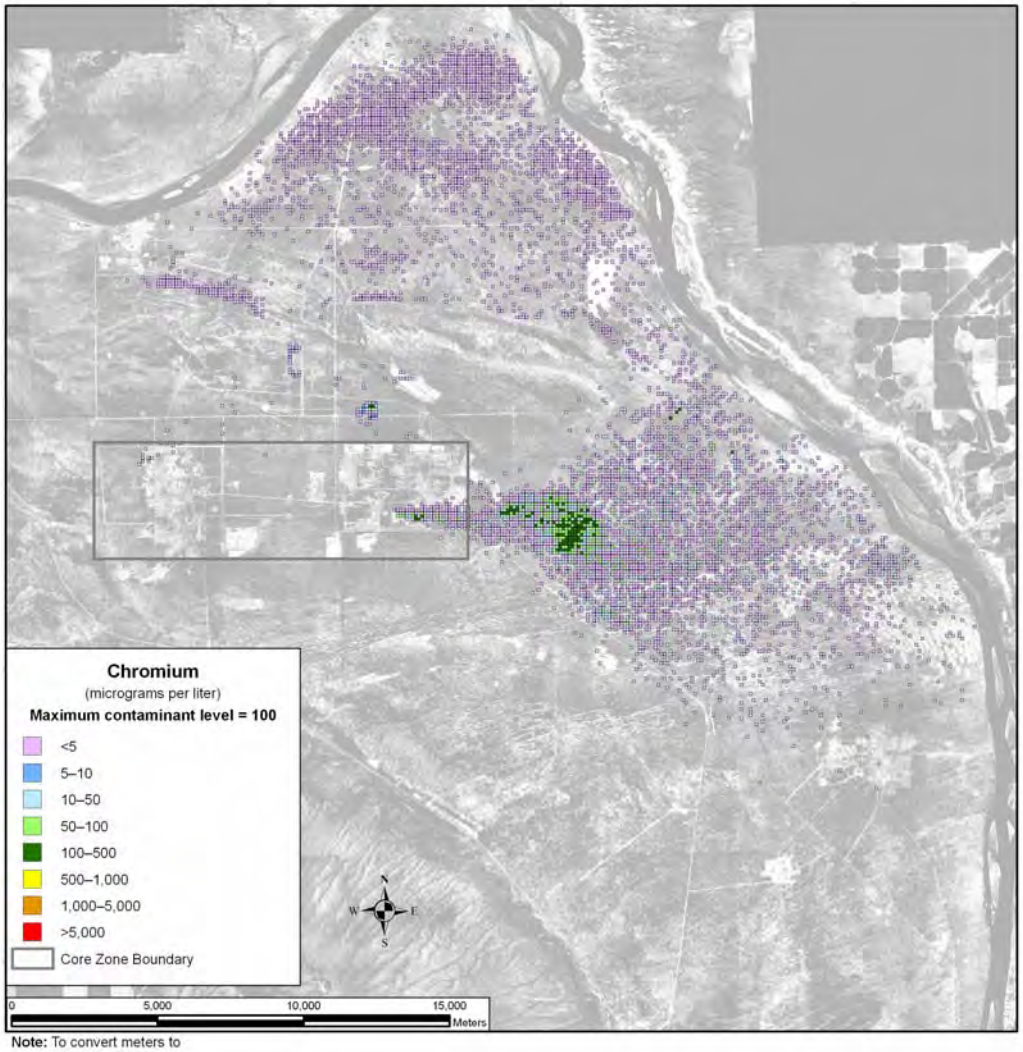
Note: To convert meters to feet, multiply by 3.281

Figure 5–808. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



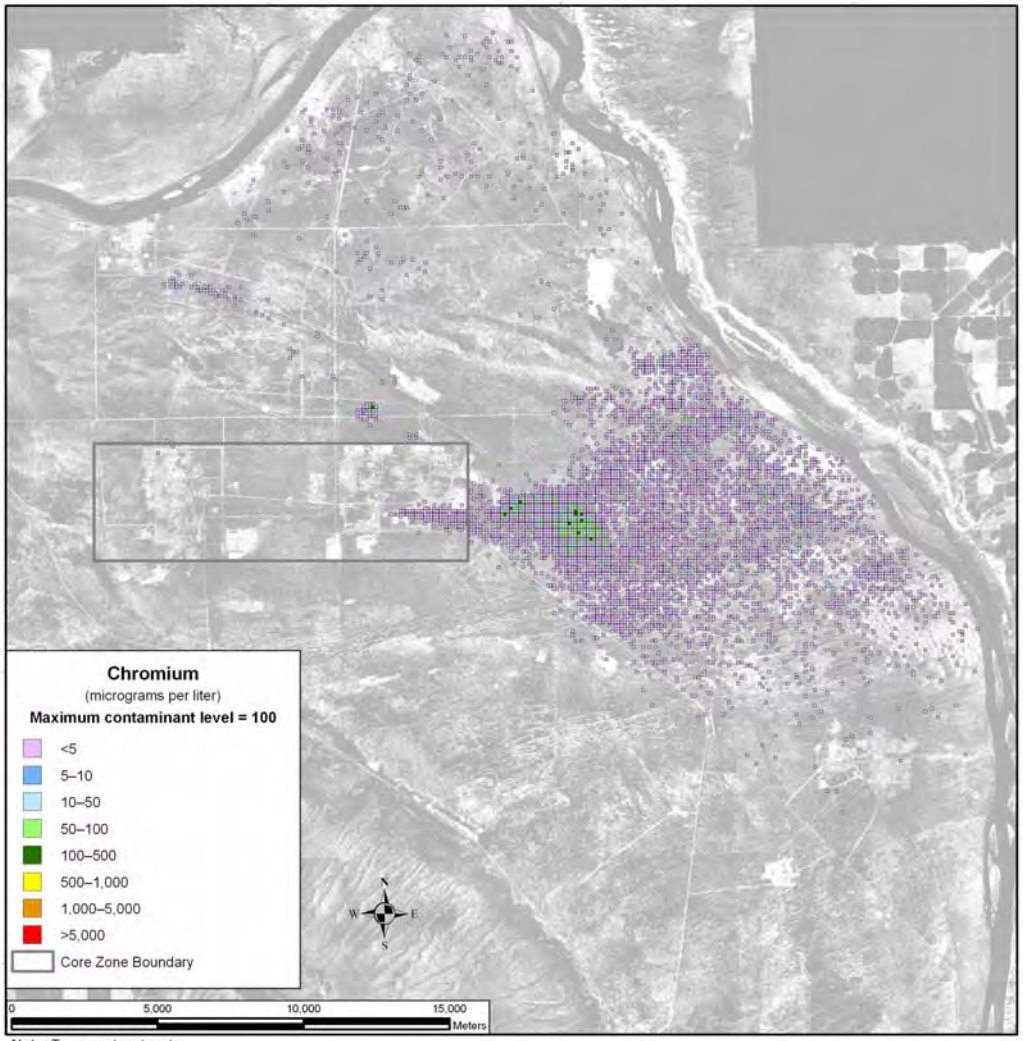
Note: To convert meters to feet, multiply by 3.281

Figure 5–809. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



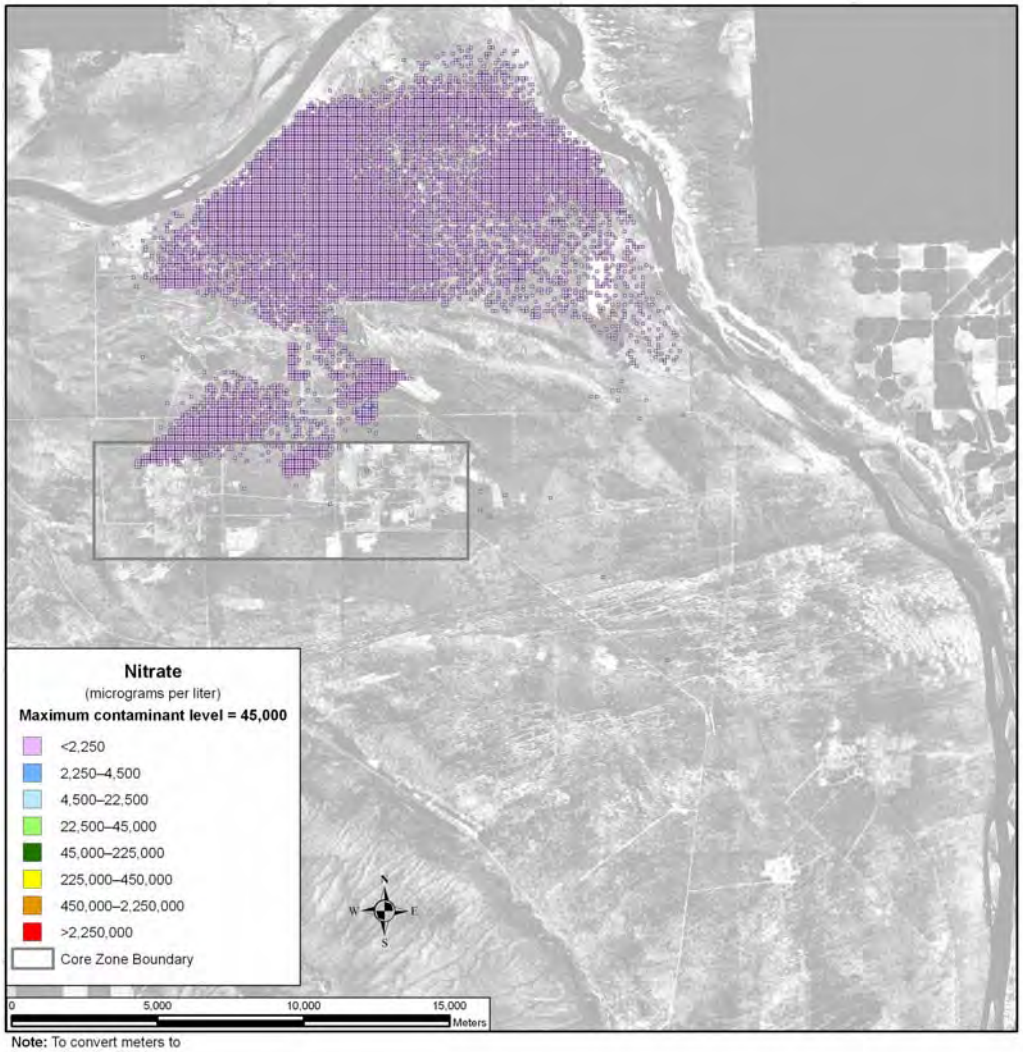
Note: To convert meters to feet, multiply by 3.281

Figure 5–810. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



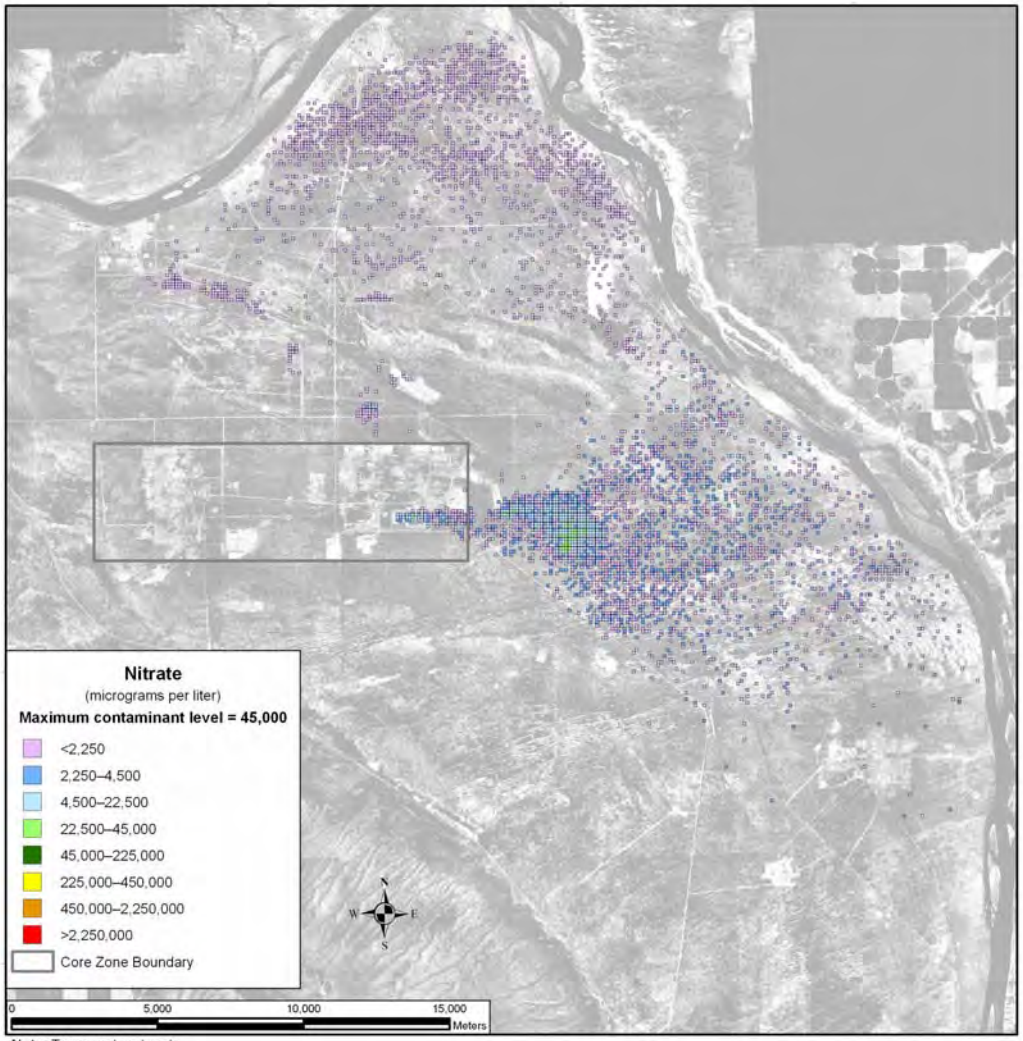
Note: To convert meters to feet, multiply by 3.281

Figure 5–811. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



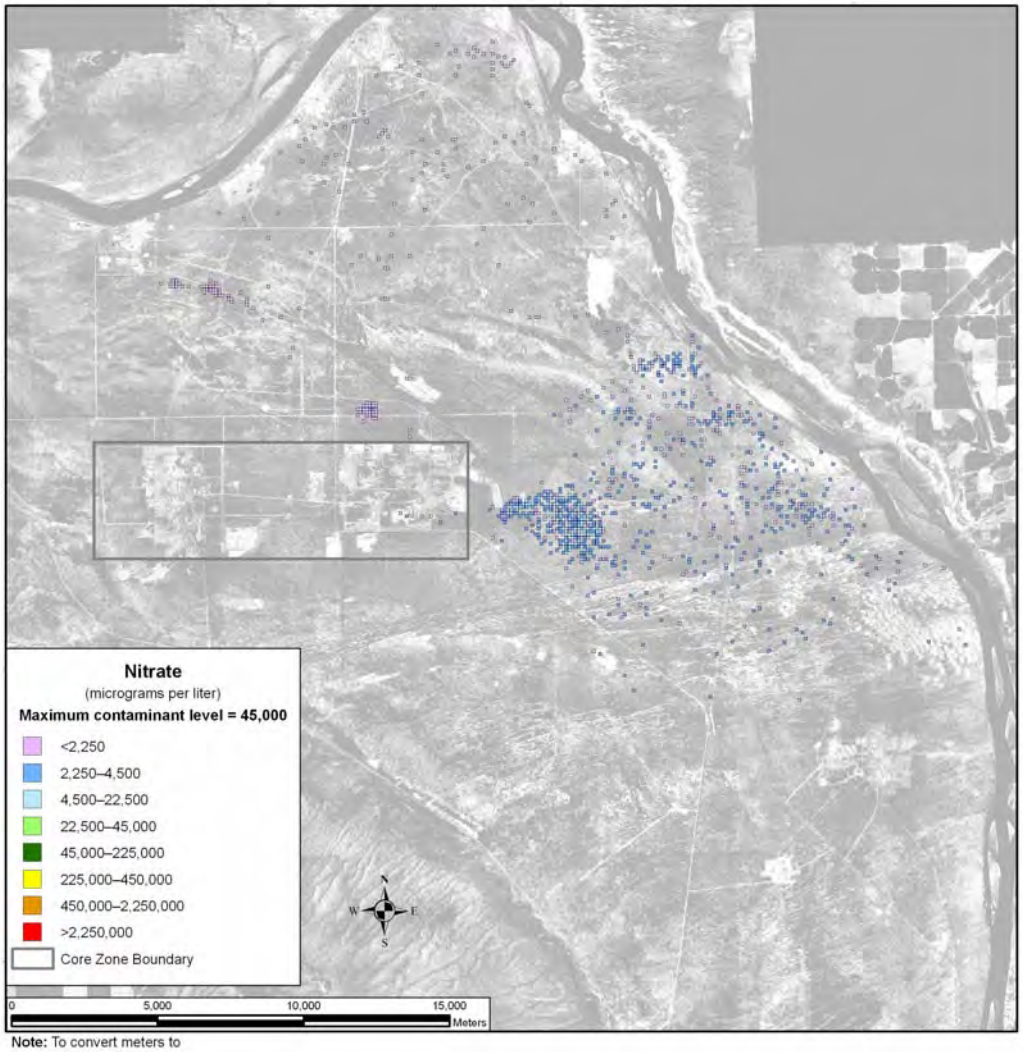
Note: To convert meters to feet, multiply by 3.281

Figure 5–812. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

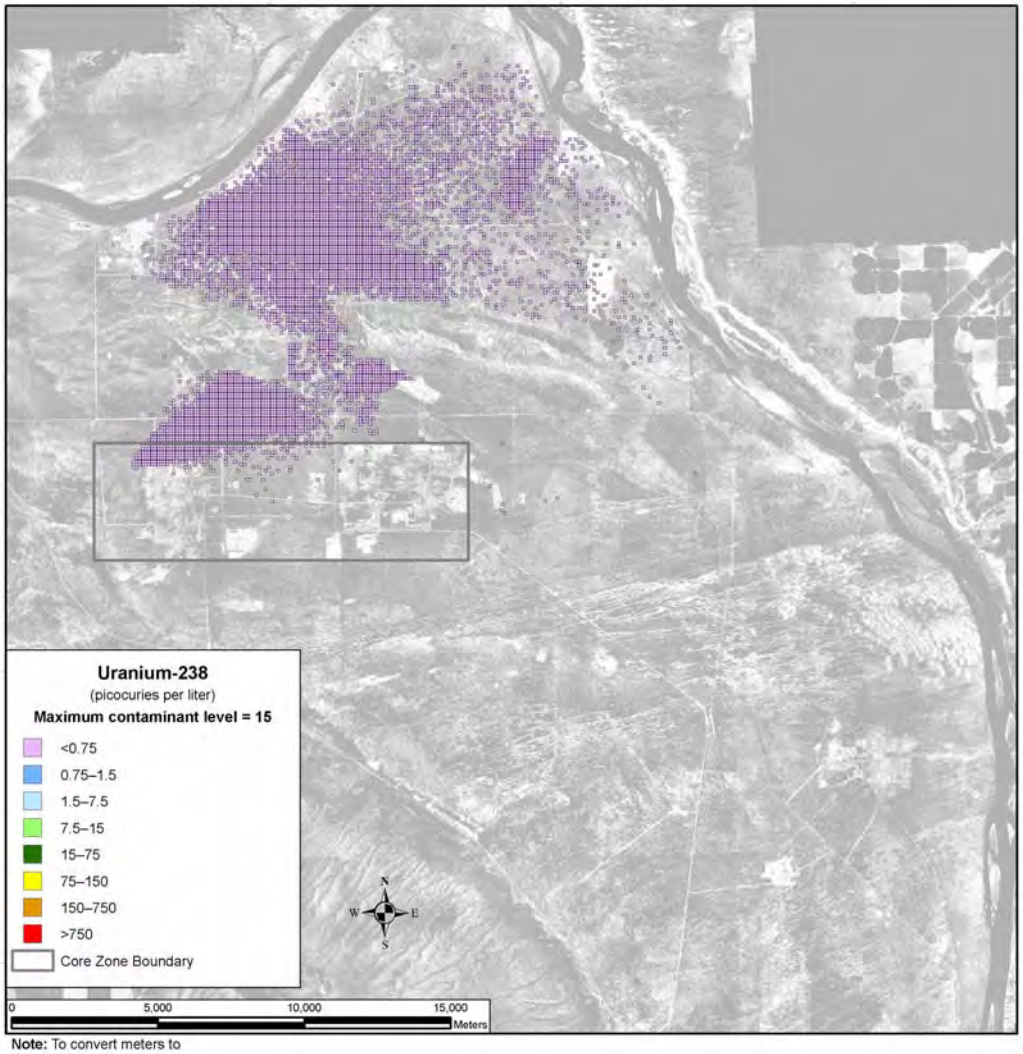
Figure 5–813. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

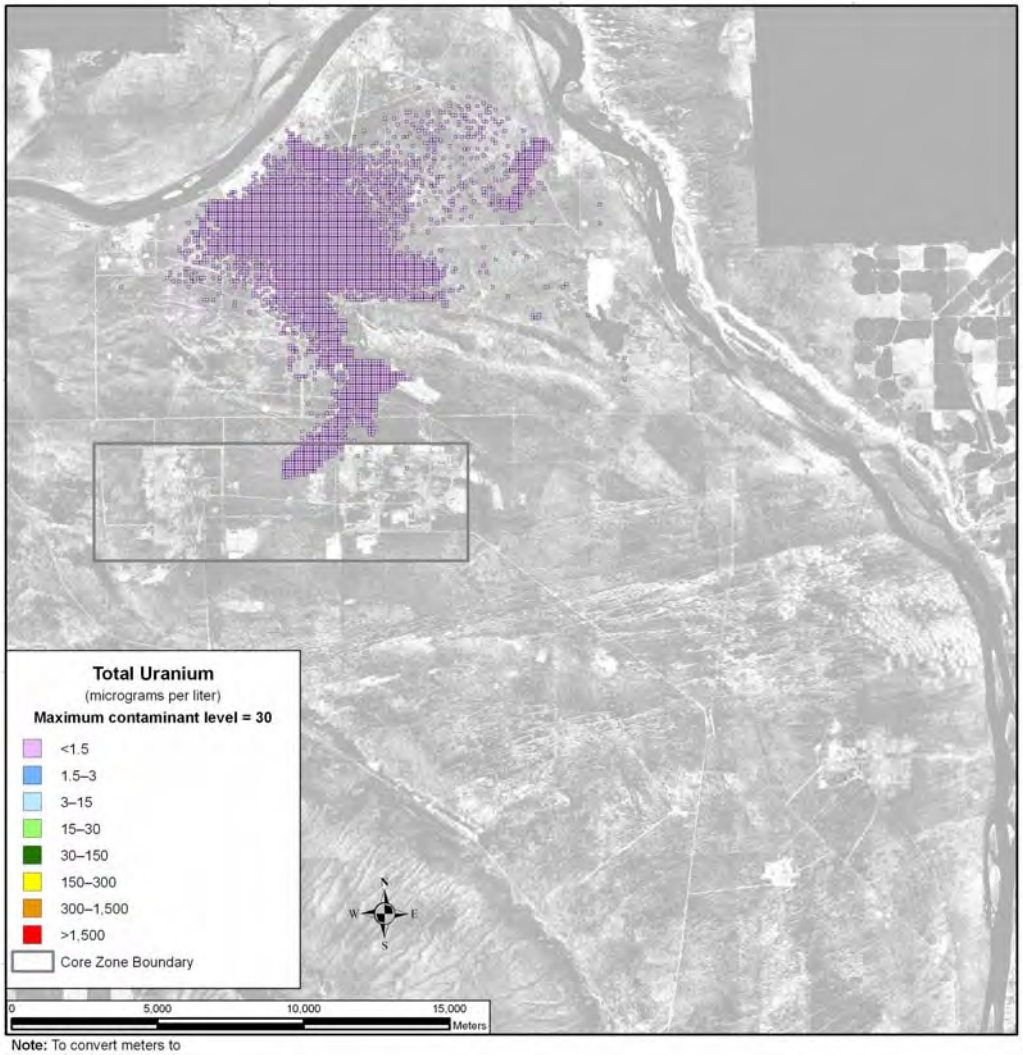
Figure 5–814. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Total uranium and uranium-238 show a different spatial distribution over time. They are not as mobile as the COPCs discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. By CY 11,885, there is a uranium-238 plume extending northeast from IDF-West through Gable Gap (see Figure 5–815). A total uranium plume extends through Gable Gap from the RPPDF (see Figure 5–816). Concentrations in all areas of the plumes remain below one-twentieth of the benchmark.



Note: To convert meters to feet, multiply by 3.281

Figure 5–815. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–816. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, in general, discharges from IDF-West are the predominant contributors. Discharges from IDF-East and the RPPDF are secondary contributors.

Concentrations of iodine-129 and technetium-99 show a sharp rise and fall between CY 2940 and CY 4940 that exceeds the benchmark by an order of magnitude or slightly more. Chromium and nitrate show a similar rise and fall, but both remain below their respective benchmarks. For all of the conservative tracers, concentrations at the Core Zone Boundary remain within an order of magnitude of the benchmark concentration during the last 5,000 years of the period of analysis. Concentrations at the Columbia River nearshore are slightly lower, but within an order of magnitude of the concentrations at the Core Zone Boundary. The intensities and areas of these groundwater plumes stabilize around CY 6940.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species remain well below the benchmark at the Core Zone Boundary and the Columbia River nearshore throughout the simulation. The peak intensity and area of the contamination plume is near the end of the period of analysis.

5.3.1.3.1.4 Disposal Group 1, Subgroup 1-D

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-D covers disposal of waste generated under Tank Closure Alternative 3C and FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Summaries of the proposed actions and timelines for Waste Management Alternative 3 are provided in Chapter 2, Section 2.5.

IDF-East has five subtotals that represent the releases from ILAW glass, steam reforming waste, ETF-generated secondary waste, retired melters, and tank closure secondary waste.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, as follows:

- The disposal period was assumed to start with the onset of disposal operations for IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continue through CY 2050, when the disposal facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF would become available for release to the environment. For the purpose of analyzing long-term groundwater impacts, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier that limits infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, and nitrate) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other

COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D (IDF-East, IDF-West, and RPPDF releases), in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-EAST AREA INTEGRATED DISPOSAL FACILITY

Figure 5–817 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–818, the chemical hazard drivers. The inventories in the five waste forms are a major factor in the release quantities to the vadose zone. The predominant sources of technetium-99 are steam reforming waste (greater than 99 percent) and chromium (greater than 99 percent). The predominant sources of iodine-129 are steam reforming (71 percent) and ETF-generated secondary waste (29 percent) forms. The predominant source of nitrate (greater than 99 percent) is ETF-generated secondary waste. No boron or fluoride is released from IDF-East.

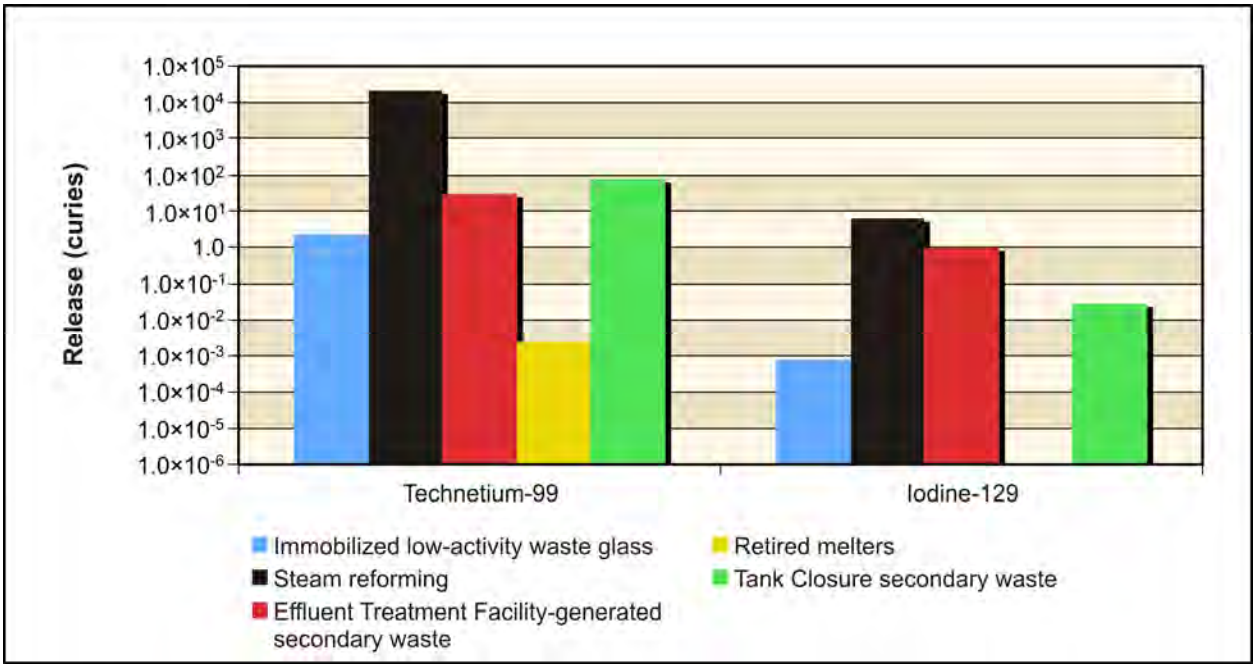


Figure 5–817. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

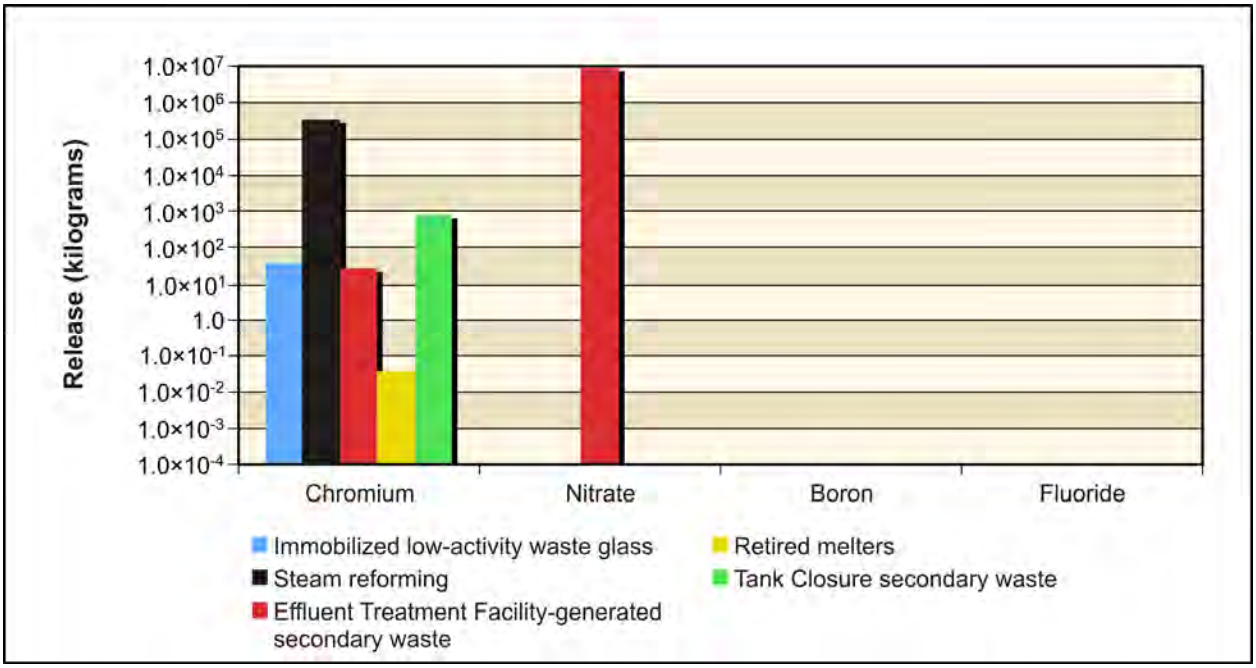


Figure 5–818. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–819 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–820, the chemical hazard drivers. In addition to the waste inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Most of the vadose zone technetium-99 (97 percent) and iodine-129 (83 percent) and essentially all (greater than 99 percent) of the chromium and nitrate are released to groundwater during the period of analysis.

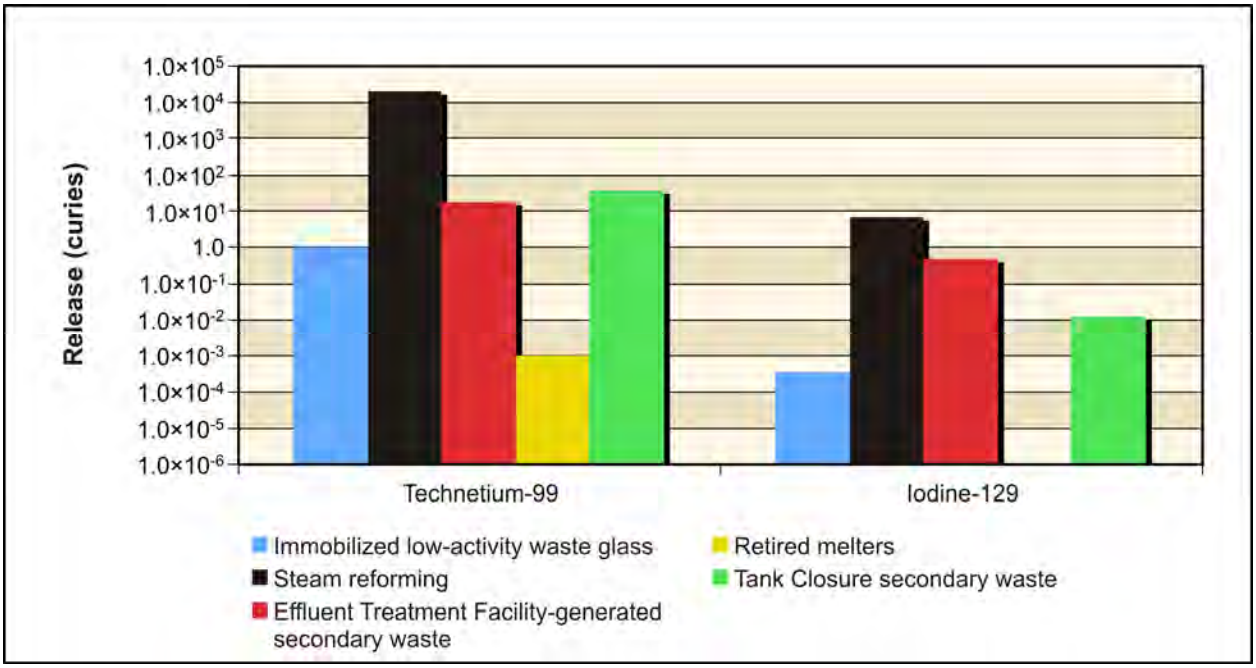


Figure 5–819. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

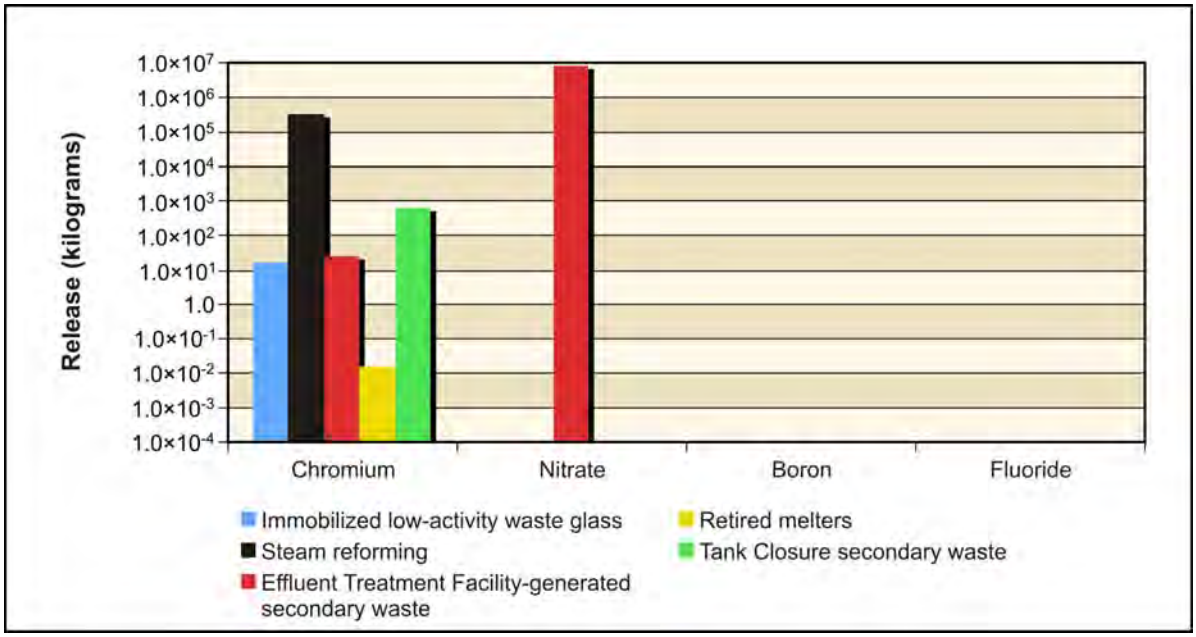


Figure 5–820. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–821 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–822, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Essentially all of the groundwater technetium-99 (97 percent) and iodine-129 (97 percent), chromium (97 percent), and nitrate (99 percent) are released to the Columbia River.

Overall, almost all of the IDF-East vadose zone technetium-99 (95 percent), chromium (96 percent), and nitrate (98 percent), and most of the iodine-129 (80 percent), reached the Columbia River during the period of analysis.

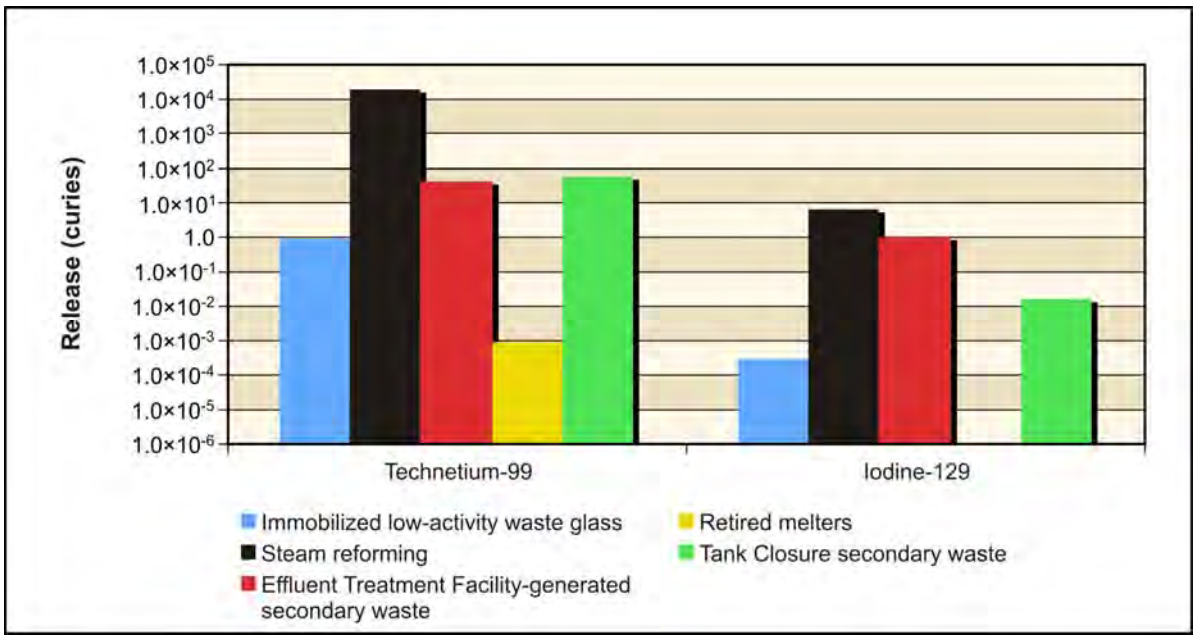


Figure 5–821. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

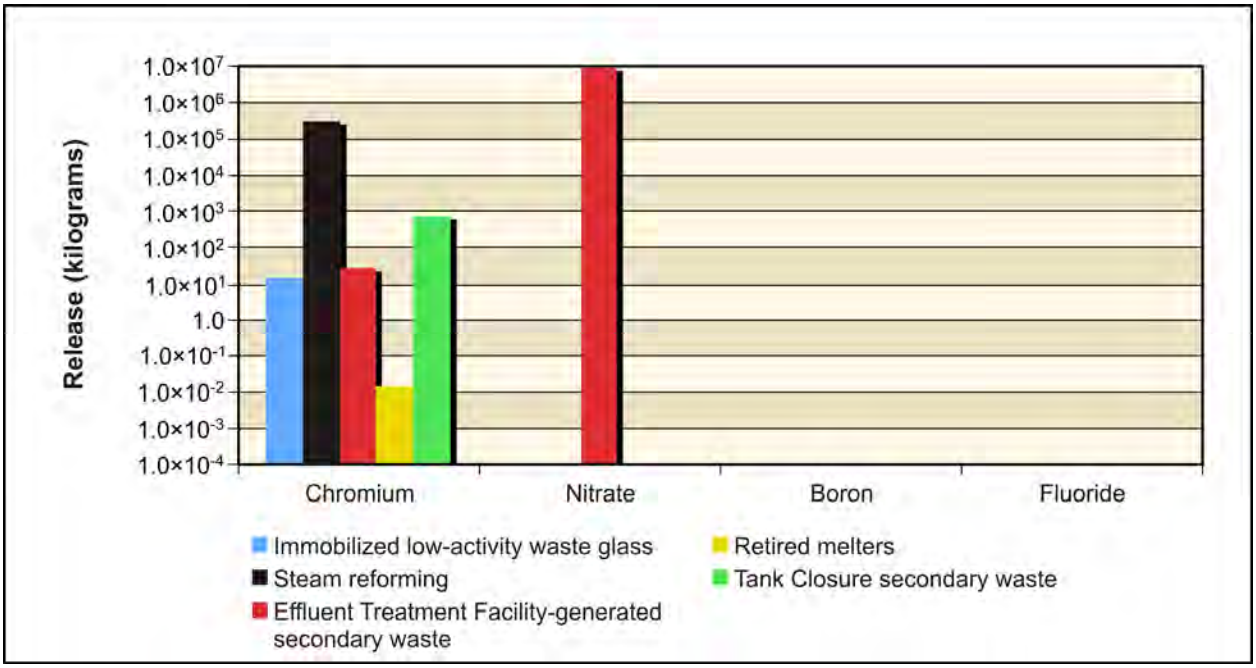


Figure 5–822. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-WEST AREA INTEGRATED DISPOSAL FACILITY

IDF-West has three subtotals plotted representing releases from FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste.

Figure 5–823 shows the estimated release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–824, the chemical hazard drivers. The inventories in the three waste forms are a major factor in the release quantities to the vadose zone. The predominant source of technetium-99 (greater than 99 percent) and iodine-129 (greater than 99 percent) is offsite-generated waste released to the vadose zone. Essentially all (greater than 99 percent) of the nitrate, boron, and fluoride that are released to the vadose zone are from waste management secondary and onsite-generated waste. The chromium released to the vadose zone is from waste management secondary and onsite-generated waste (66 percent) and offsite-generated waste (34 percent).

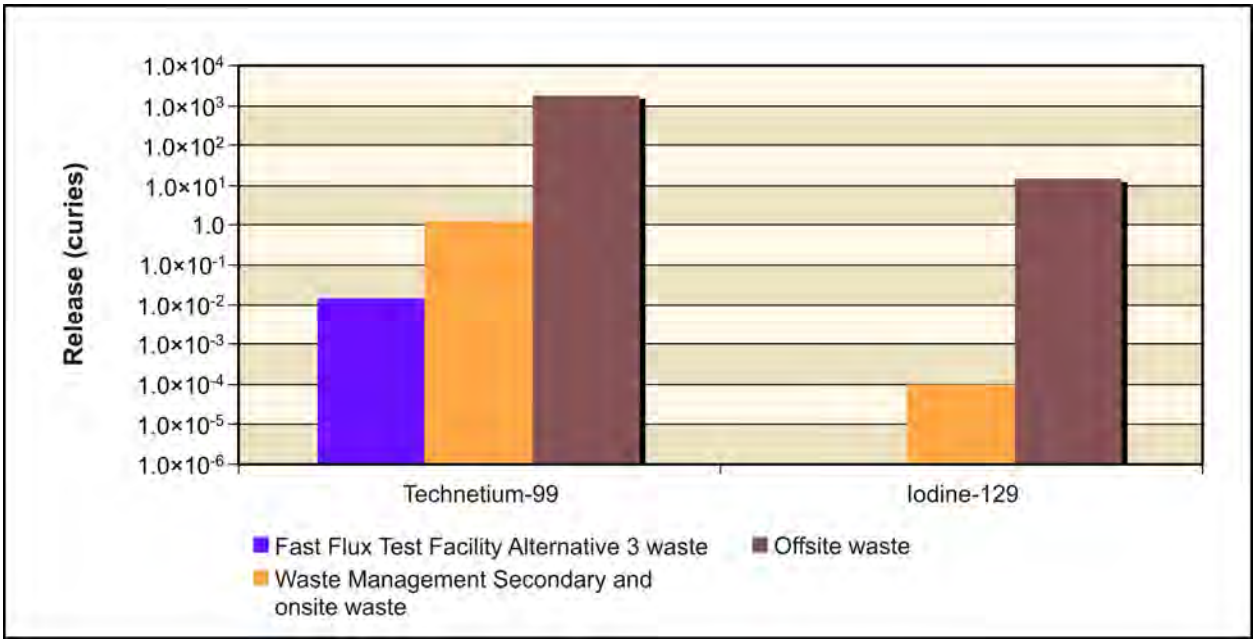


Figure 5–823. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

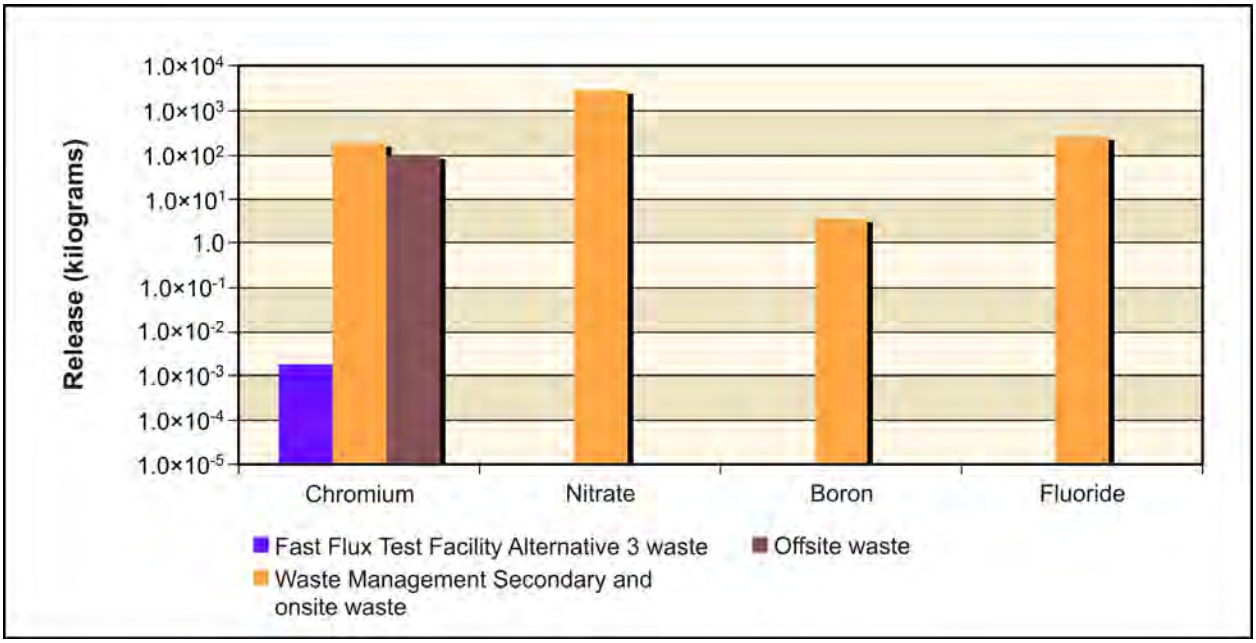


Figure 5–824. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–825 shows the estimated release at IDF-West to groundwater for the radiological risk drivers and Figure 5–826, the chemical hazard drivers. In addition to the waste form inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Almost all of the vadose zone technetium-99 (98 percent), iodine-129 (99 percent), chromium (99 percent), nitrate (greater than 99 percent), boron (greater than 99 percent), and fluoride (greater than 99 percent) are released to groundwater during the period of analysis.

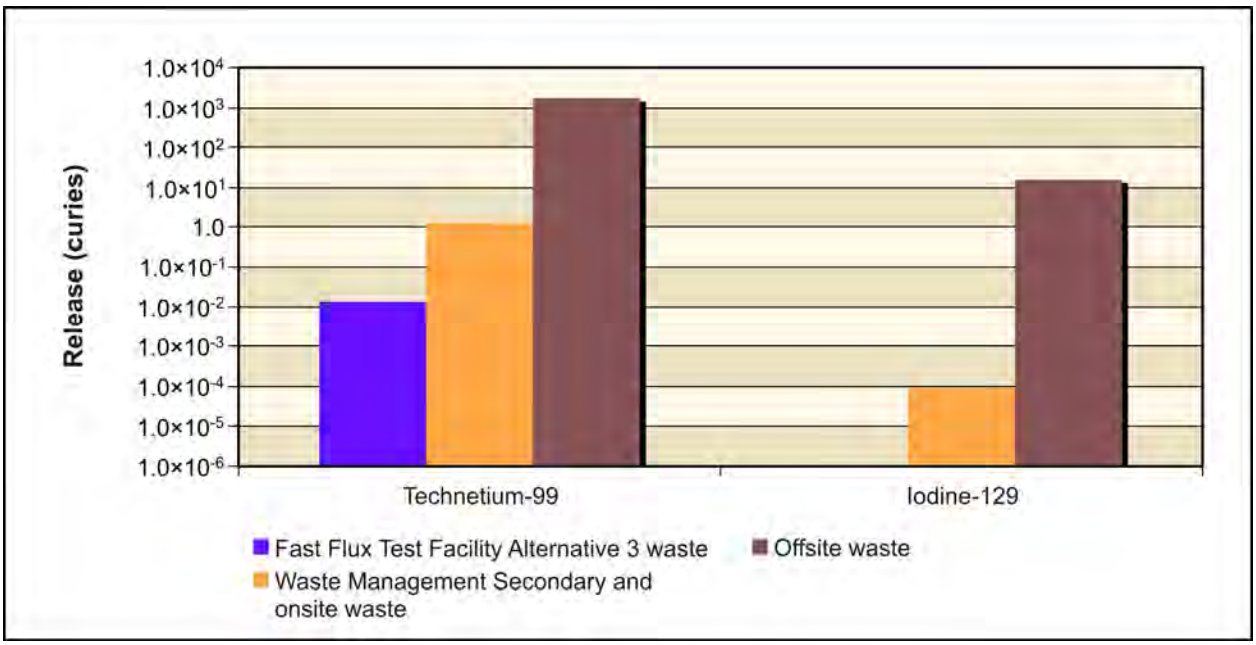


Figure 5–825. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

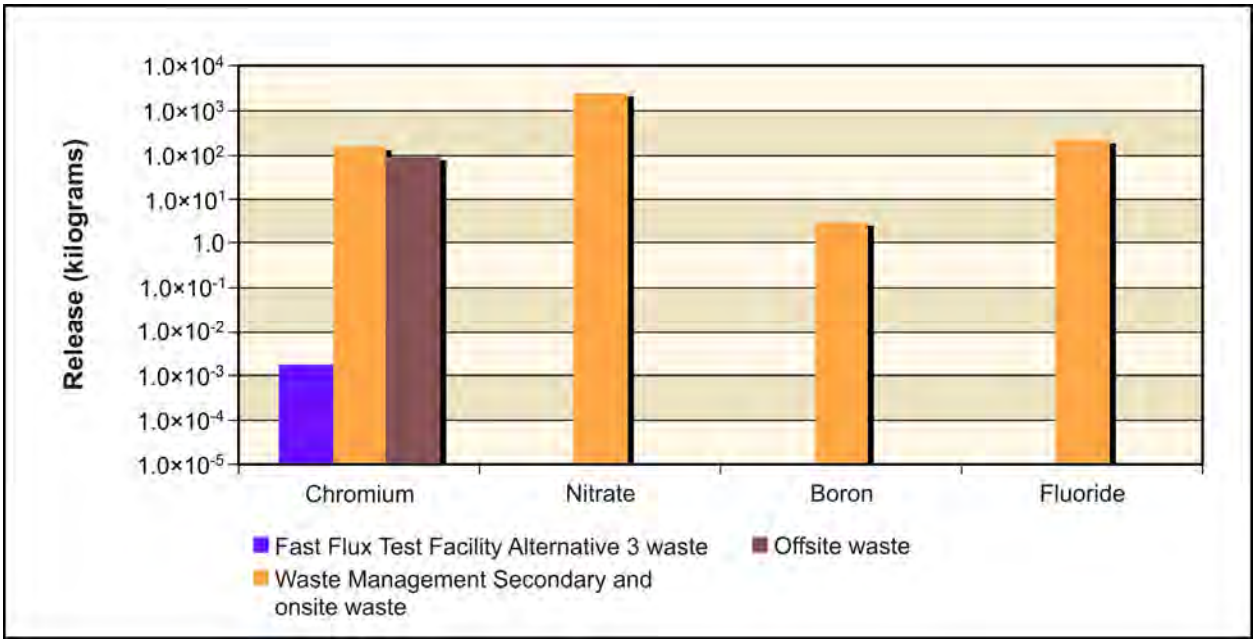


Figure 5–826. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–827 shows the estimated release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–828, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most (97–98 percent) of the IDF-West groundwater technetium-99, iodine-129, chromium, nitrate, boron, and fluoride are released to the Columbia River over the period of analysis.

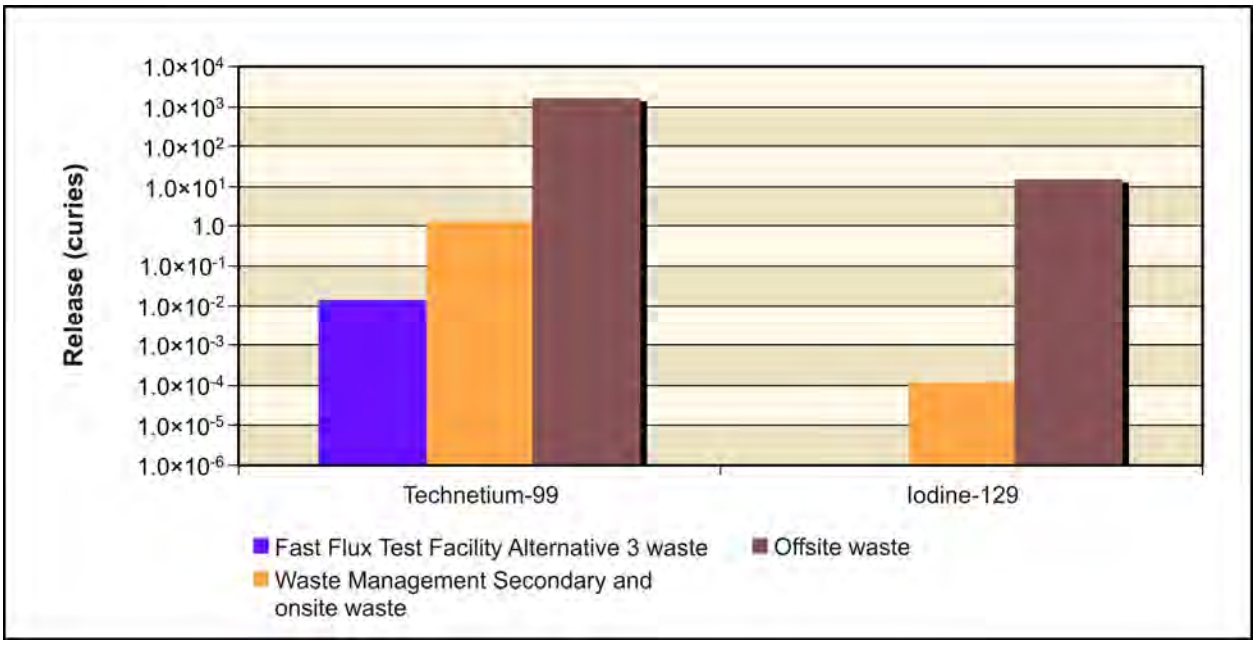


Figure 5–827. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

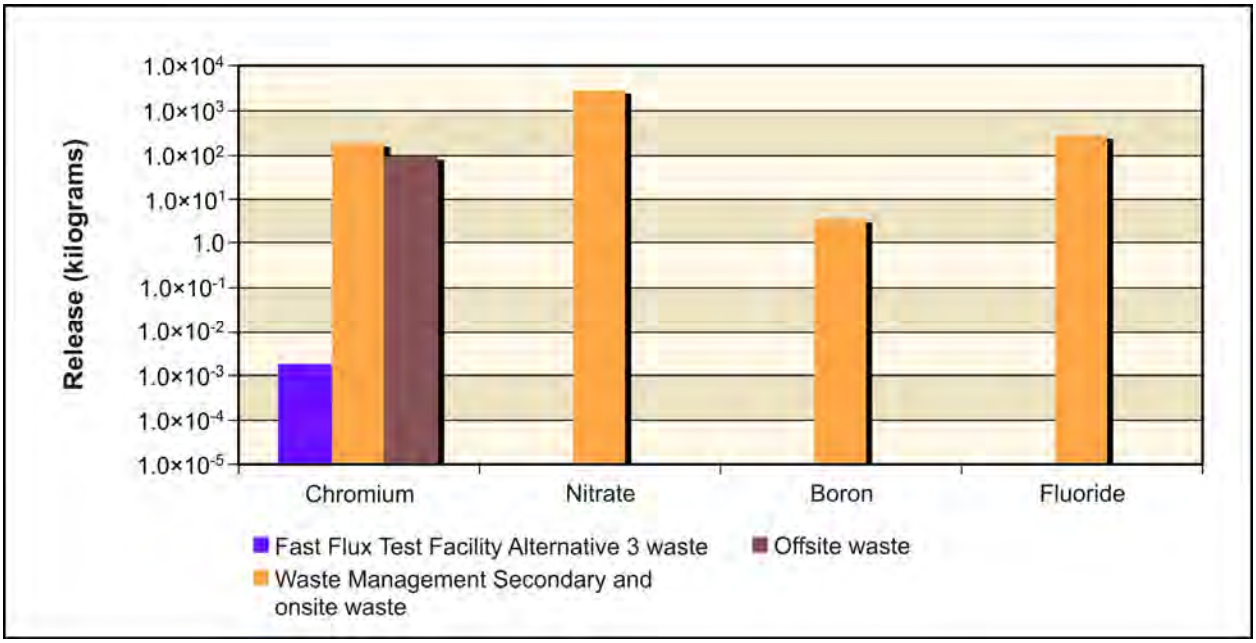


Figure 5–828. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

Overall, almost all (97–98 percent) of the IDF-West vadose zone technetium-99, iodine-129, chromium, nitrate, boron, and fluoride reached the Columbia River over the period of analysis.

RIVER PROTECTION PROJECT DISPOSAL FACILITY

Figure 5–829 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–830, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The vadose zone radiological sources from the RPPDF are technetium-99 (largest) and iodine-129 (smallest). The chemical hazard sources from the RPPDF are nitrate (largest) and chromium (smallest). No fluoride or boron is released from the RPPDF.

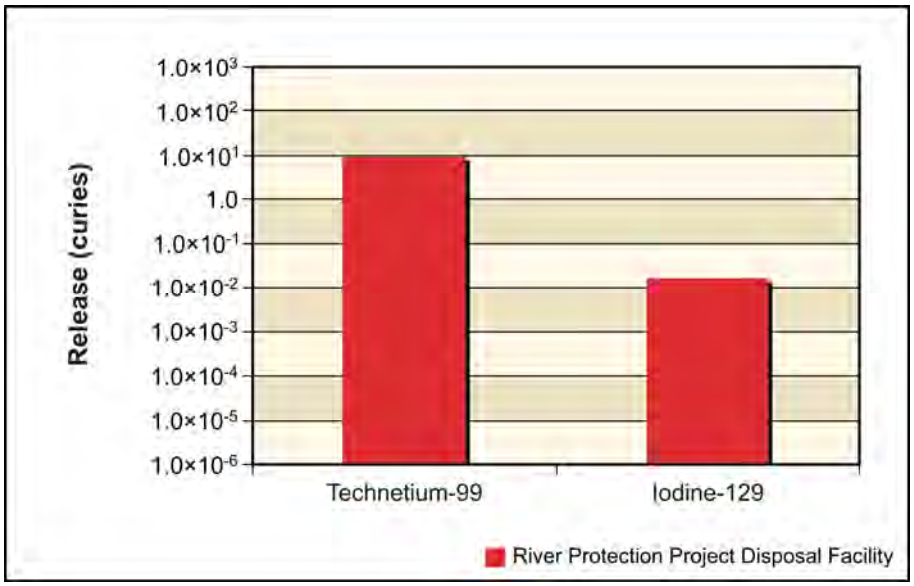


Figure 5–829. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

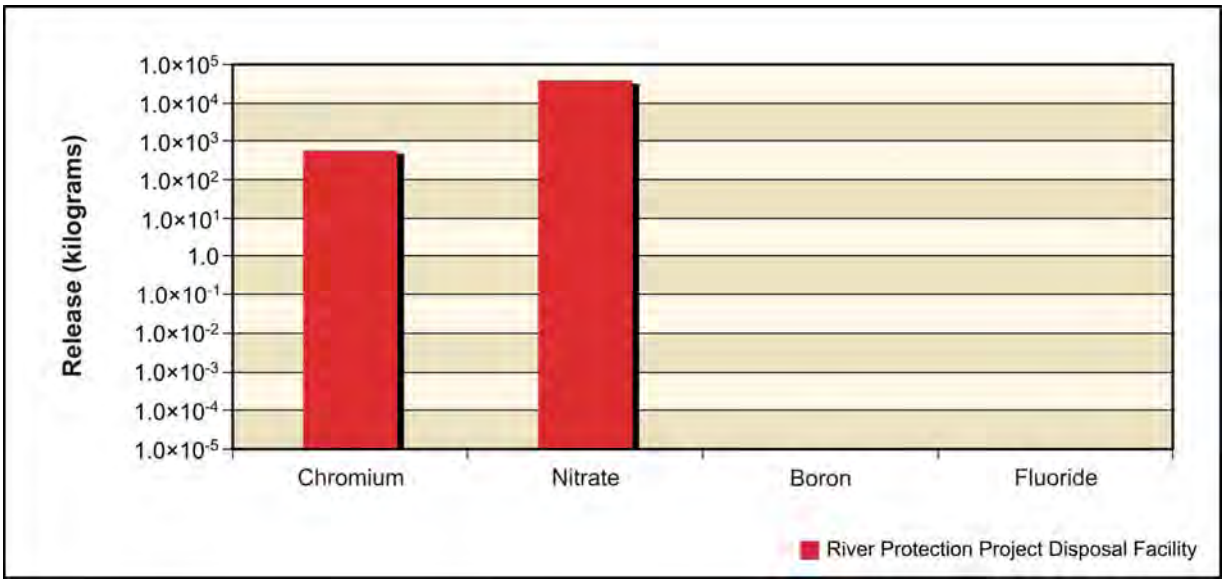


Figure 5–830. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–831 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–832, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Essentially all (99 percent) of the RPPDF vadose zone technetium-99, iodine-129, chromium, and nitrate are released to the groundwater.

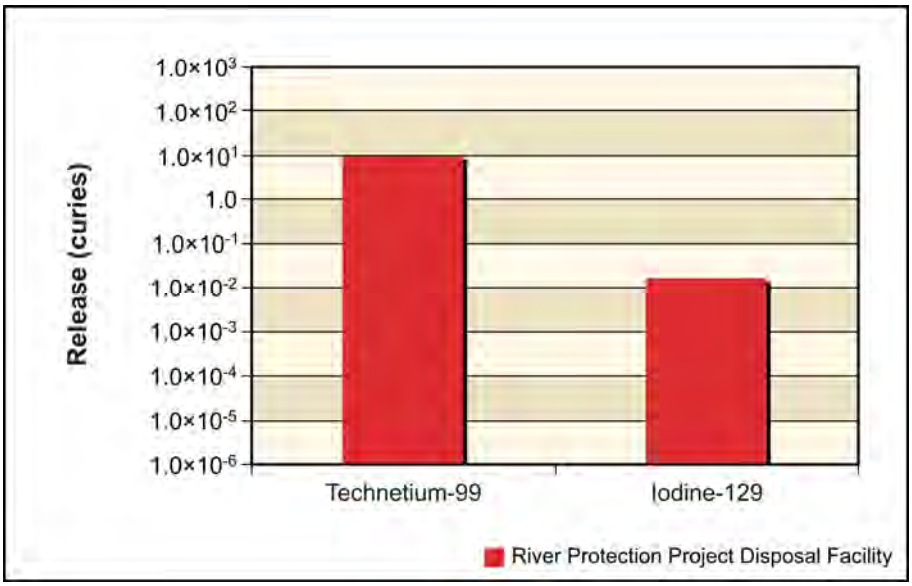


Figure 5–831. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Groundwater

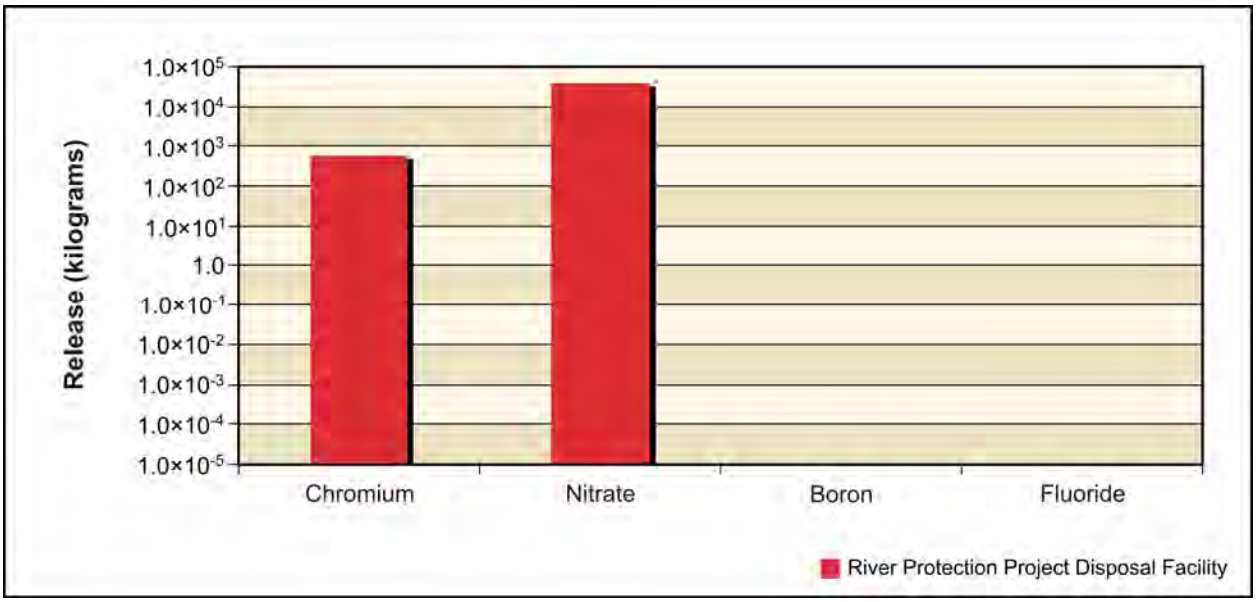


Figure 5–832. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–833 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–834, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most (96 percent) of the groundwater technetium-99, iodine-129, chromium, and nitrate are released to the Columbia River.

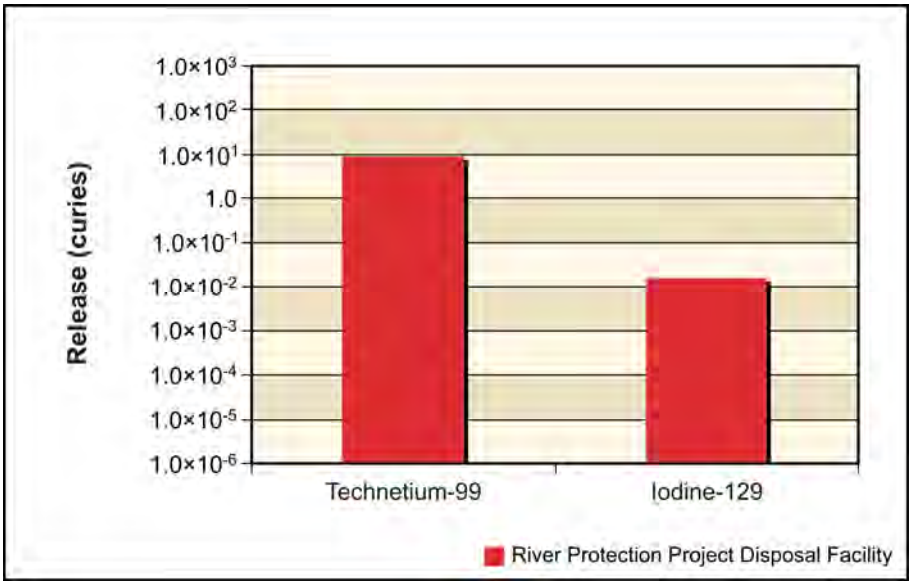


Figure 5–833. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Columbia River

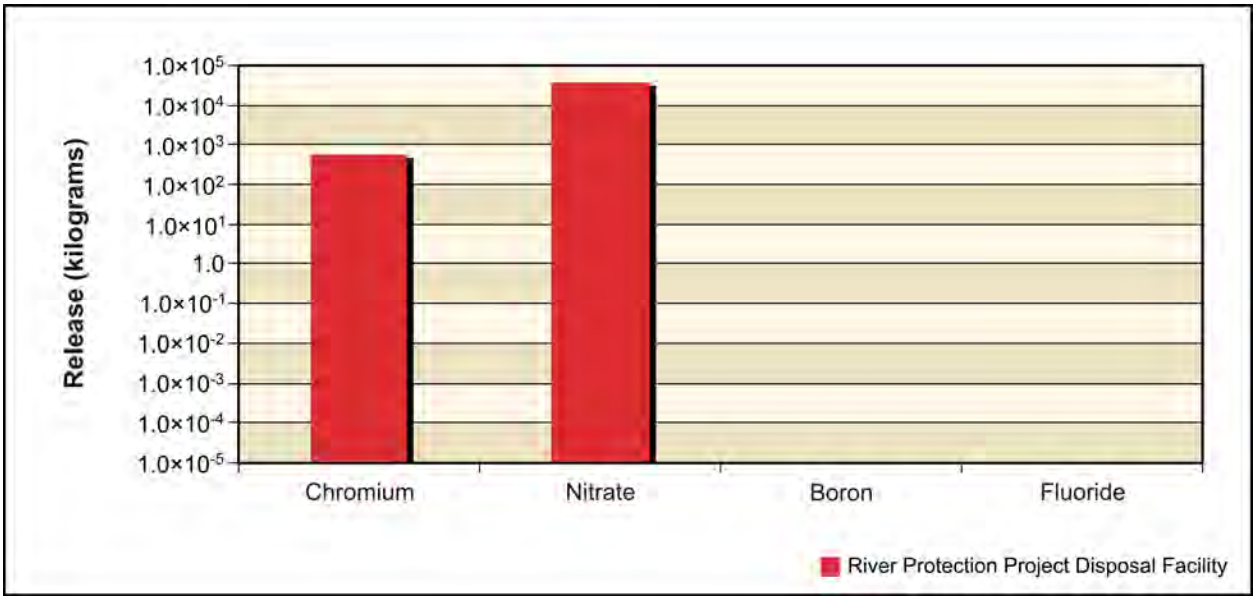


Figure 5–834. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Columbia River

Overall, most (95–96 percent) of the RPPDF vadose zone technetium-99, iodine-129, chromium, and nitrate reached the Columbia River during the period of analysis.

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–92 shows the maximum concentrations in groundwater.

Table 5–92. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	**29,200**	**20,200**	33	**24,600**	**7,450**	900
	(9032)	(3713)	(3825)	(9067)	(9206)	
Iodine-129	**11**	**173**	0.1	**60**	**8**	1
	(8514)	(3797)	(3772)	(3853)	(4729)	
Chemical in micrograms per liter						
Chromium	**436**	2	2	**174**	**116**	100
	(9071)	(3696)	(3856)	(8397)	(9878)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	14,500	17	149	4,970	3,320	45,000
	(7859)	(3703)	(3811)	(7269)	(7528)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–835 through 5–838 show concentration versus time for technetium-99, iodine-129, chromium, and nitrate. The releases of technetium-99 from IDF-East, IDF-West, and the RPPDF result in concentrations at the Core Zone Boundary and the Columbia River nearshore that exceed the technetium-99 benchmark concentration over two-thirds of the period of analysis (see Figure 5–835). After the post-disposal period there is a short period (1,000 years) when the Core Zone Boundary concentration exceeds the benchmark concentration. The Core Zone Boundary concentration then decreases below the benchmark concentration at levels coincident with the Columbia River nearshore. Both the Core Zone Boundary and Columbia River nearshore concentrations then increase and remain above the benchmark concentration through the end of the analysis period. The Core Zone Boundary and Columbia River nearshore concentrations never exceed the benchmark concentrations by more than one order of magnitude.

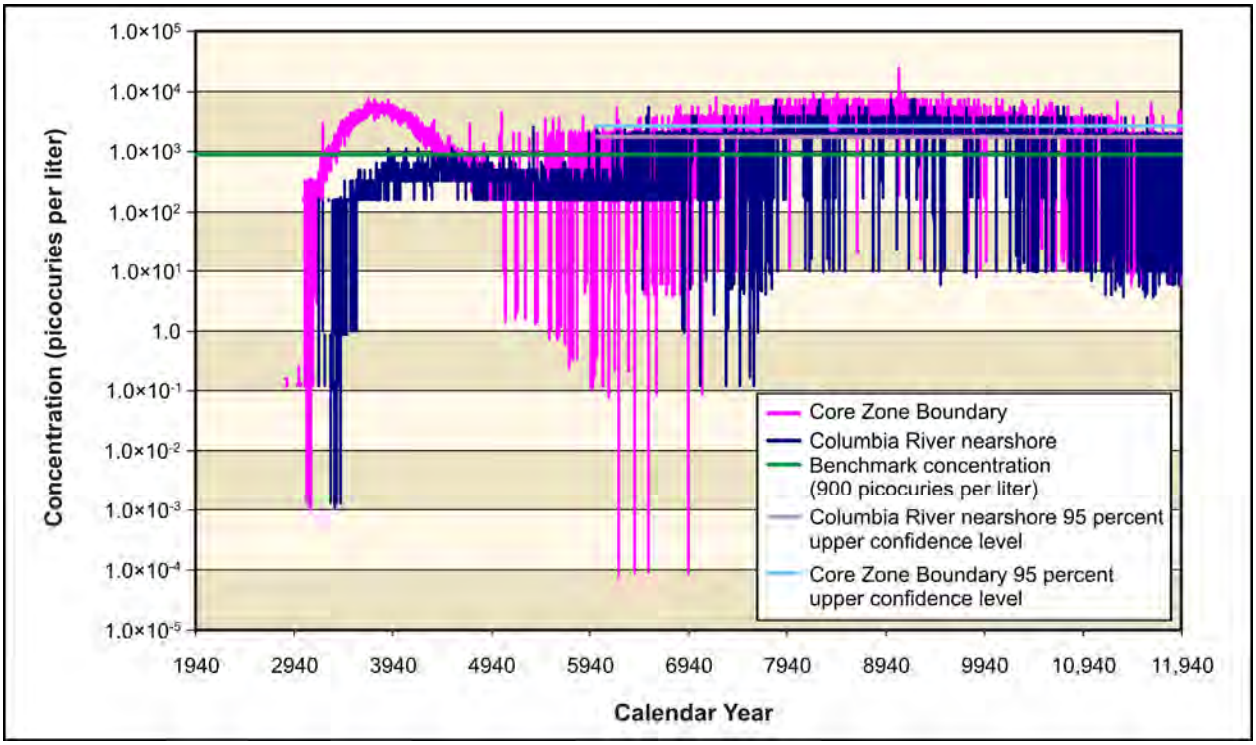


Figure 5–835. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Technetium-99 Concentration Versus Time

The iodine-129 concentrations (see Figure 5–836) at both the Core Zone Boundary and Columbia River nearshore have a similar time versus concentration profile as technetium-99 except that the Core Zone Boundary and Columbia River nearshore concentrations never fall below the iodine-129 benchmark concentration. The initial Core Zone Boundary iodine-129 peak is between one and two orders of magnitude of the benchmark concentration, but then drops to a level coincident with the Columbia River nearshore concentration. After the initial Core Zone Boundary iodine-129 peak, the concentrations at both the Core Zone Boundary and the Columbia River nearshore remain less than one order of magnitude above the benchmark concentration.

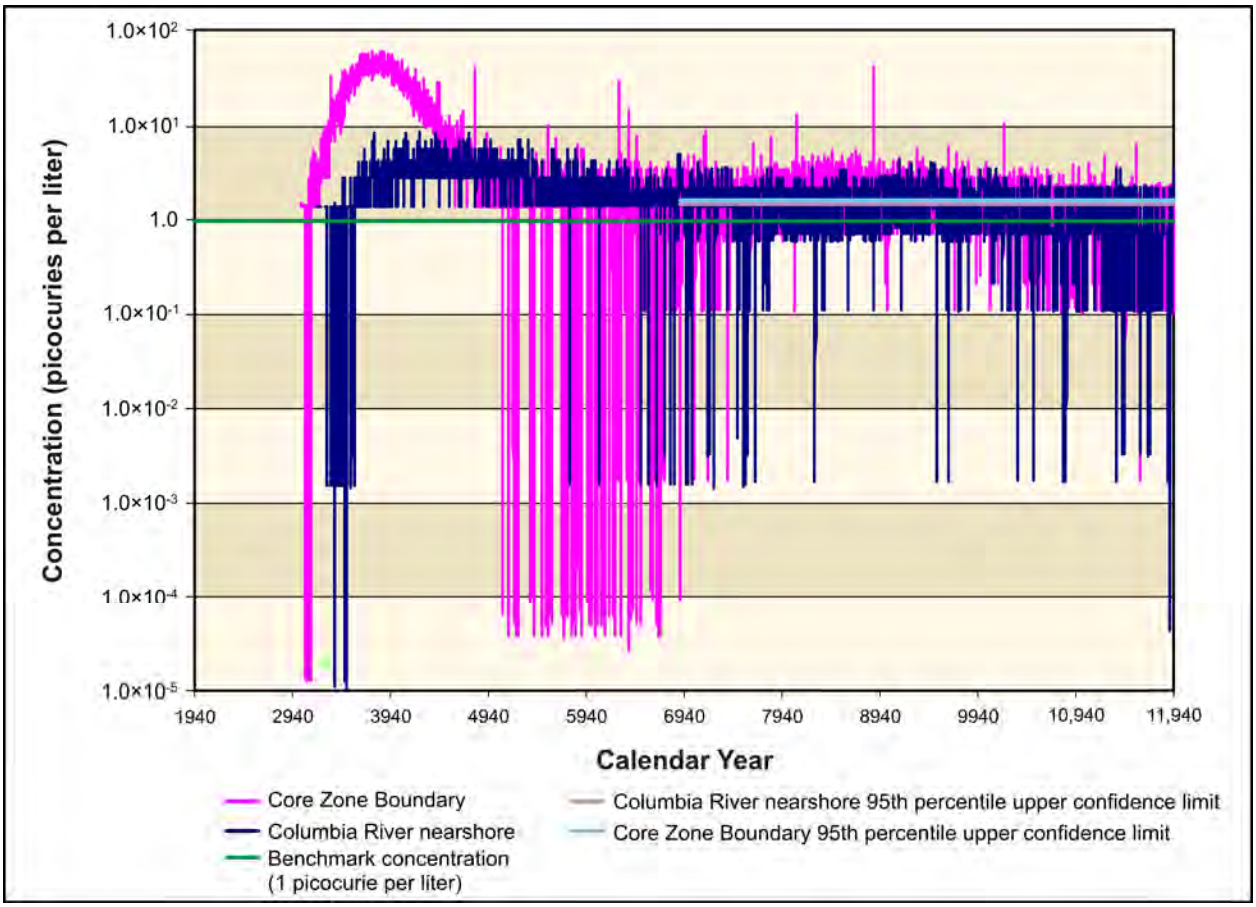


Figure 5–836. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Iodine-129 Concentration Versus Time

The time versus concentration profiles for chromium and nitrate (see Figures 5–837 and 5–838) also show initial peaks for their Core Zone Boundary concentrations. However, unlike technetium-99 and iodine-129, these peaks are less than the concentrations that are reached at later times. Both chromium and nitrate gradually increase through the latter half of the analysis period and then show a decline that continues through the end of the analysis period. The chromium concentrations (at the Core Zone Boundary and Columbia River nearshore) both approach the benchmark concentration, but appear never to exceed it. The nitrate concentrations are always at least one order of magnitude less than the benchmark concentration.

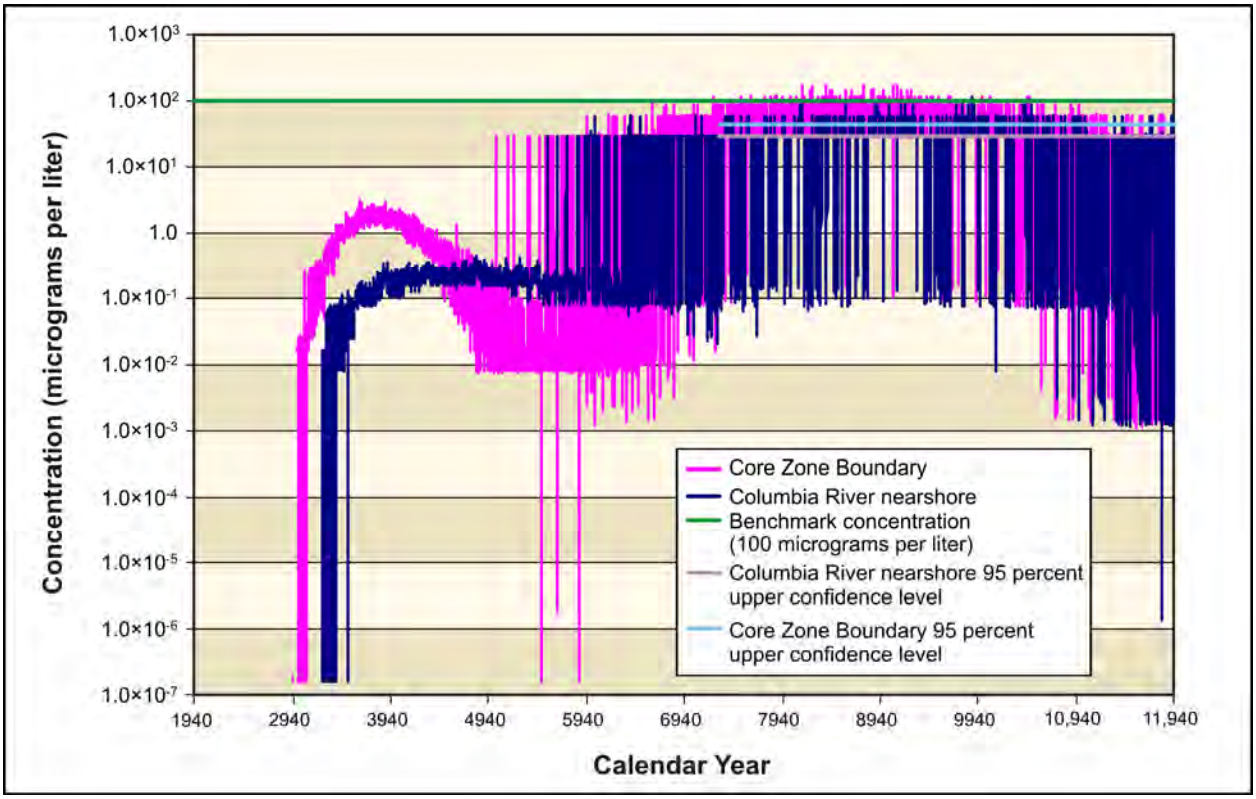


Figure 5–837. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chromium Concentration Versus Time

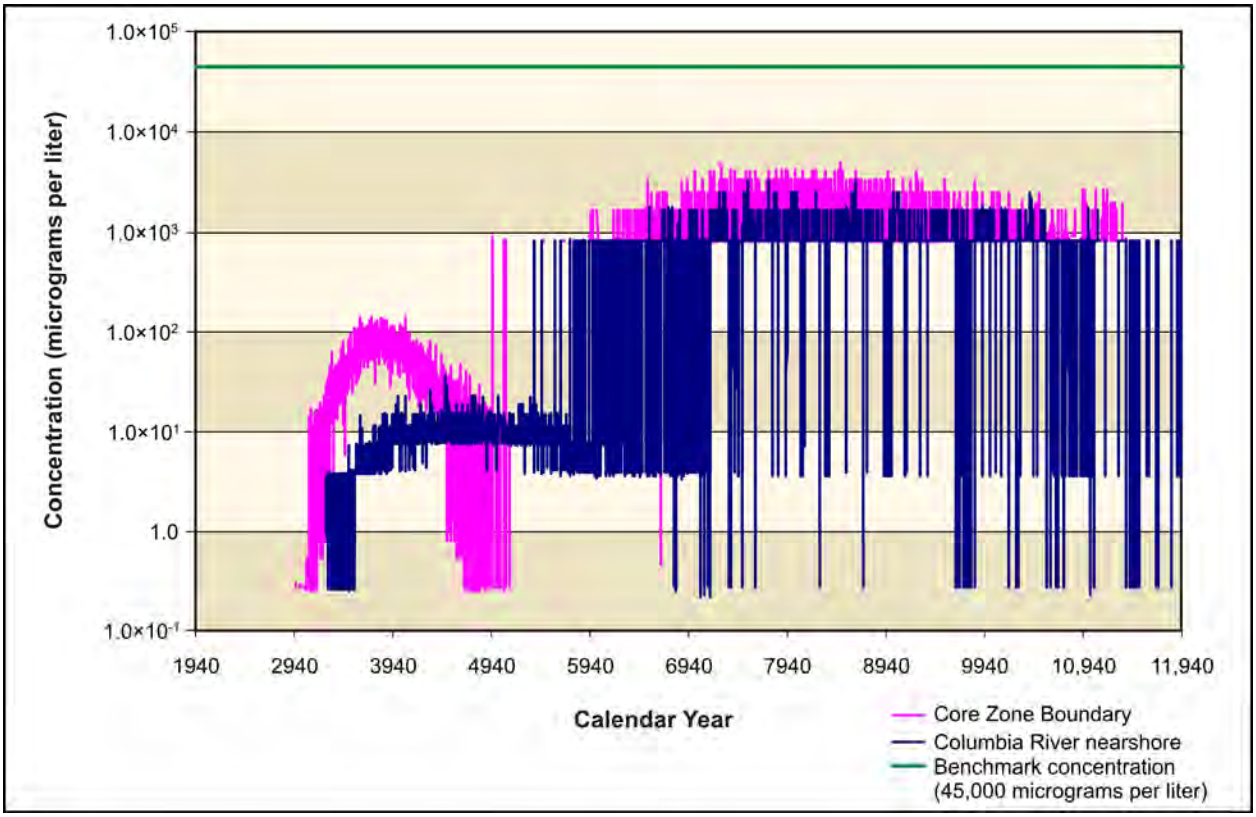


Figure 5–838. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Nitrate Concentration Versus Time

Figures 5–839 and 5–840 show concentration versus time for uranium-238 and total uranium. Because uranium-238 and total uranium move slowly through the vadose zone, releases from IDF-East, IDF-West, and the RPPDF result in groundwater concentrations that are always lower than the benchmark concentrations over the period of analysis. Both uranium-238 (see Figure 5–839) and total uranium (see Figure 5–840) show increasing concentrations in the Core Zone that continue through the end of the analysis period. Over this analysis period, concentrations of uranium-238 at the Core Zone Boundary are at least two orders of magnitude less than the benchmark concentration, while the total uranium is at least seven orders of magnitude below its benchmark concentration. The concentrations at the Columbia River nearshore are much smaller and appear to occur significantly later than the Core Zone Boundary concentrations. The trend for uranium-238 and total uranium shows a continuing increase through the end of the analysis period.

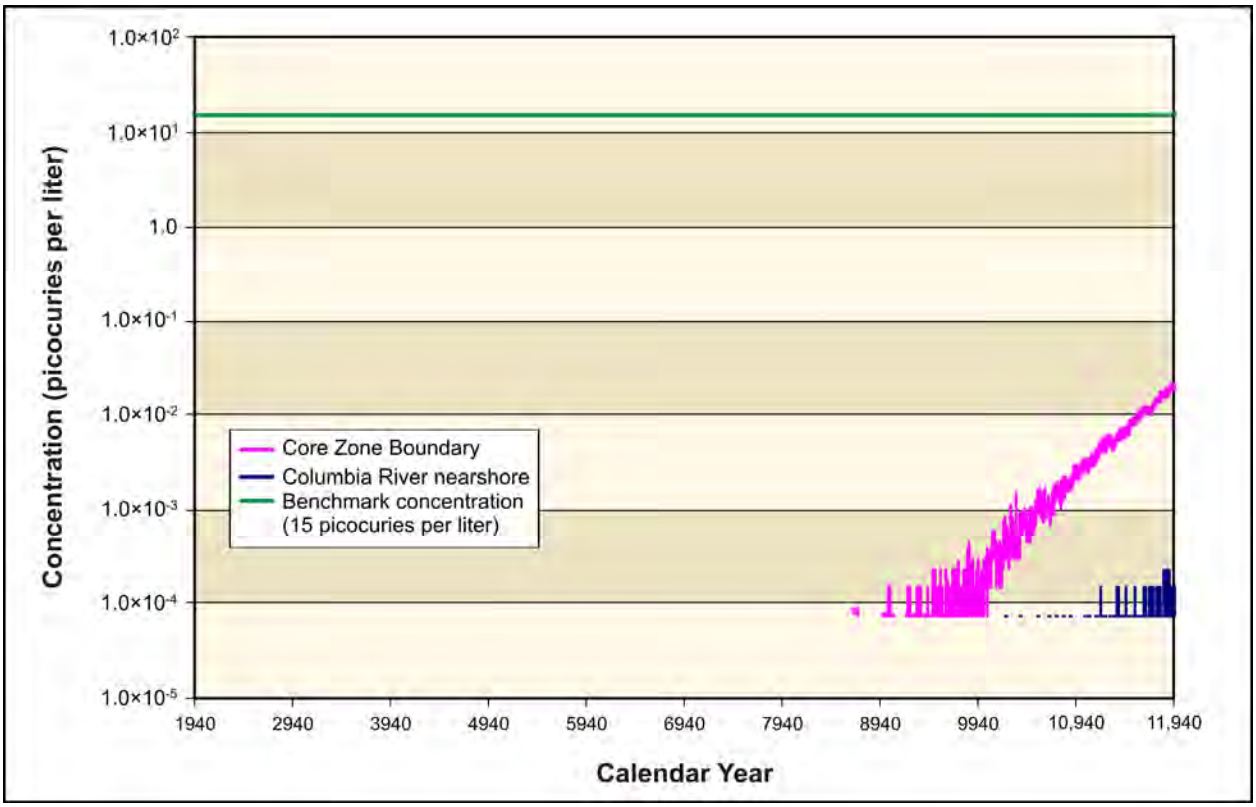


Figure 5–839. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Uranium-238 Concentration Versus Time

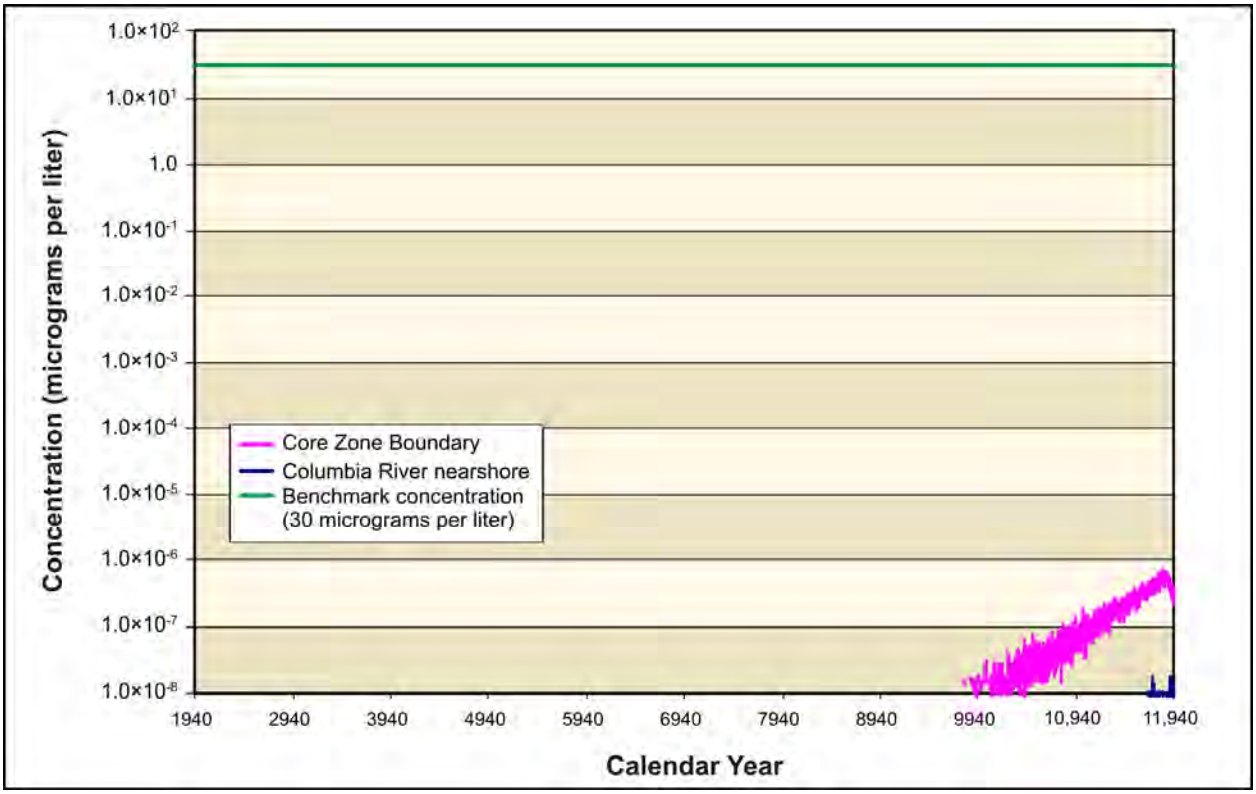


Figure 5–840. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Total Uranium Concentration Versus Time

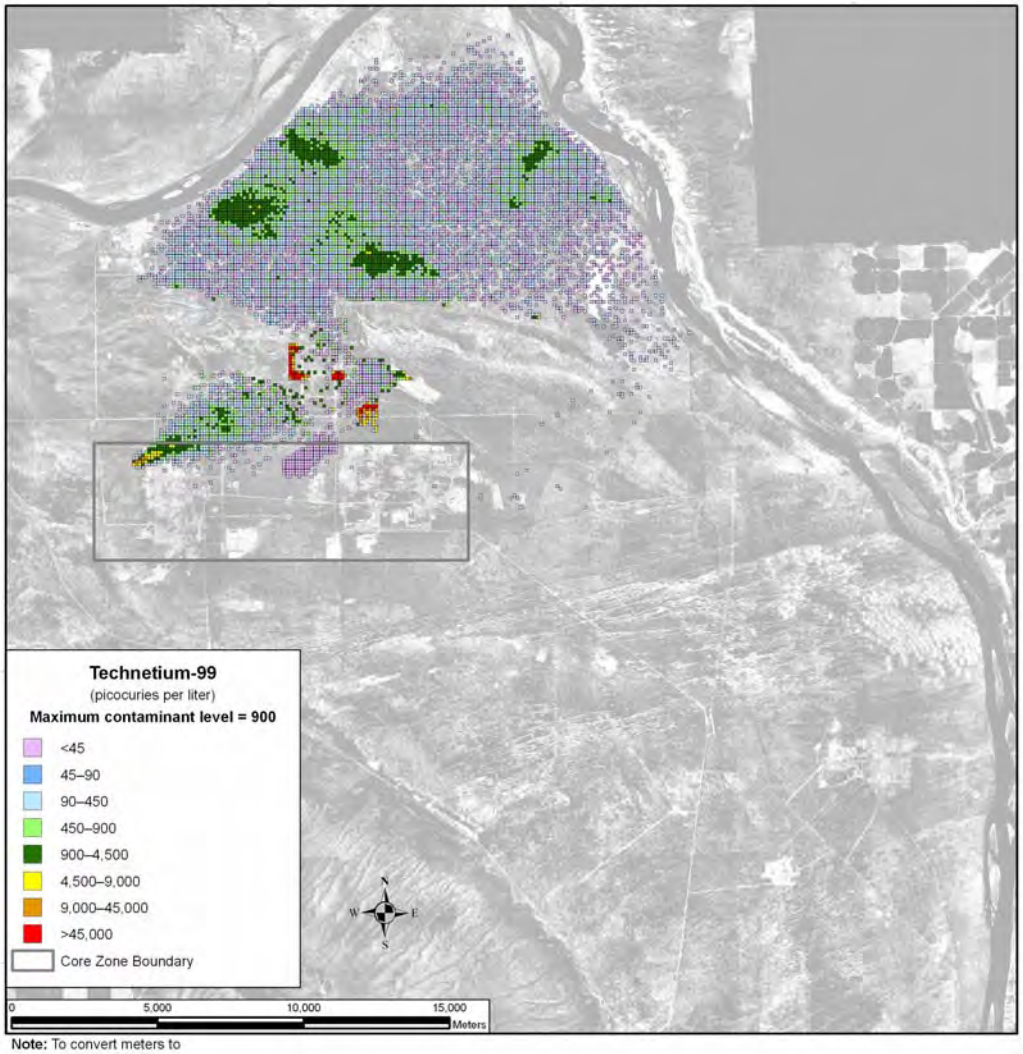
ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figures 5–841 through 5–852 show concentration distributions at CYs 3890, 7140, and 11,885 for technetium-99, iodine-129, nitrate, and chromium. These data show the groundwater releases from the RPPDF and IDF-West that extend north from within the Core Zone to the Columbia River. The IDF-East groundwater releases extend east from within the Core Zone to the Columbia River. The RPPDF and IDF-West releases remain in a fairly narrow channel (Gable Gap) until about halfway to the Columbia River nearshore boundary. The releases then spread out over the northern tip area of Hanford. The IDF-East releases remained in a relatively narrow channel until they reached about the one-quarter distance point to the Columbia River, where the releases spread out and continued to the Columbia River nearshore boundary.

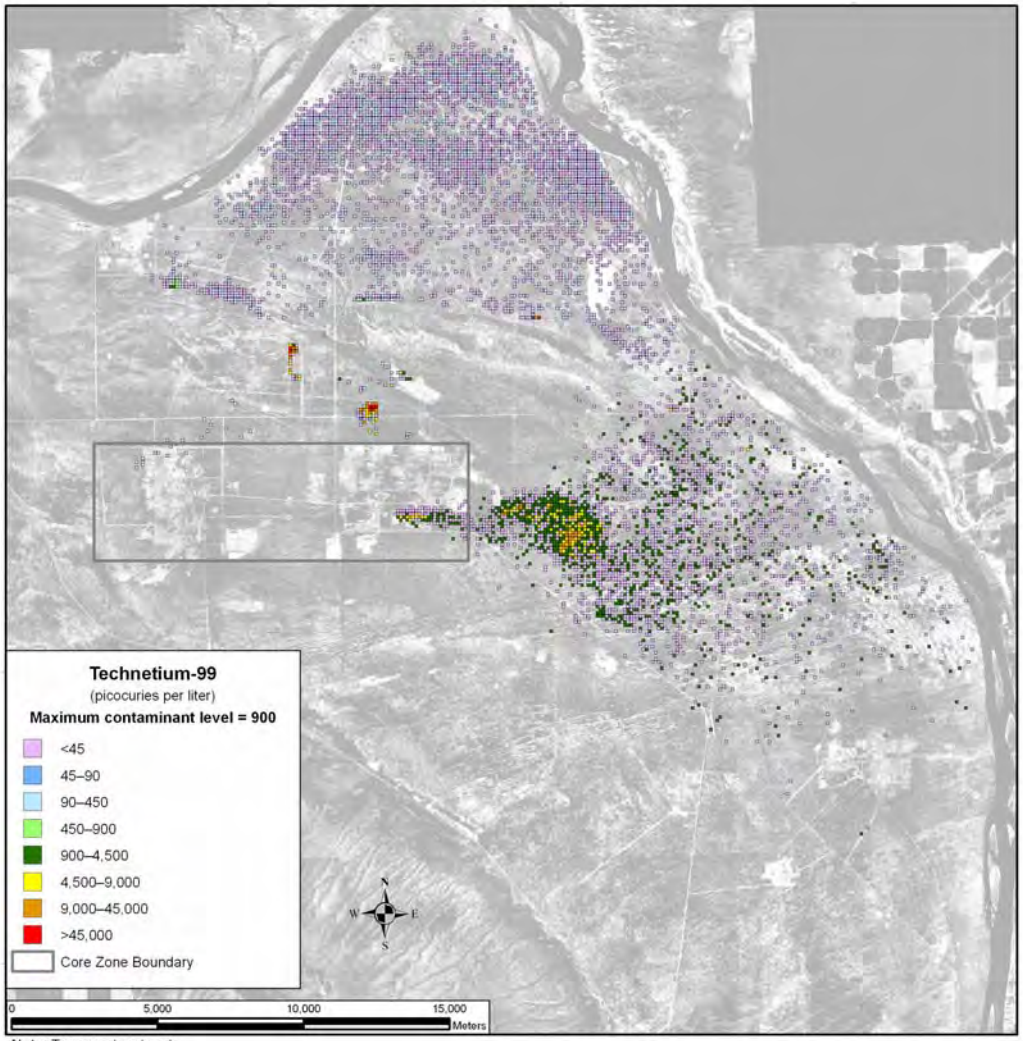
Figure 5–841 (CY 3890) shows the technetium-99 release from IDF-West and the RPPDF in CY 3890. This spatial distribution shows that technetium-99 exceeds the benchmark concentration within the Core Zone (due to the IDF-West release) and in several areas close to the Columbia River nearshore. There are also several small areas with very high concentrations of technetium-99 (several orders of magnitude

larger than the benchmark concentration) just north of the Core Zone Boundary. Figure 5–842 shows that the technetium-99 release from IDF-West and the RPPDF has largely dissipated by CY 7140 and only exists in areas close to the Columbia River nearshore at concentrations at least one order of magnitude lower than the benchmark concentration. This figure also shows a technetium-99 release distribution from IDF-East. There are significant areas where technetium-99 approaches or exceeds the benchmark concentration. Figure 5–843 shows that the IDF-West and RPPDF groundwater technetium-99 is almost completely dissipated in CY 11,885. A very small pocket of high concentration remains north of the Core Zone Boundary. At CY 11,885, technetium-99 has continued to move to the Columbia River. There are several areas where the IDF-East release still approaches or exceeds the benchmark concentration within one order of magnitude.



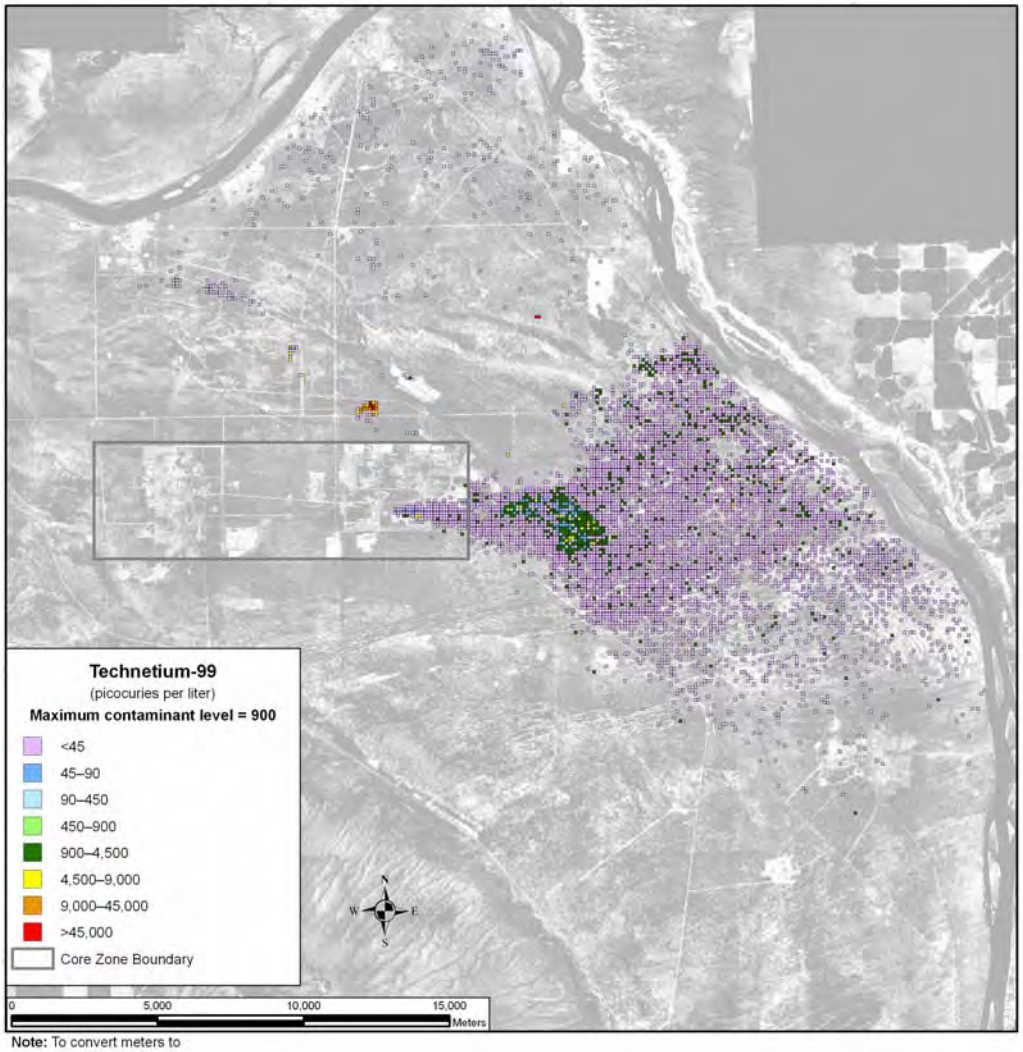
Note: To convert meters to feet, multiply by 3.281

Figure 5–841. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During the Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

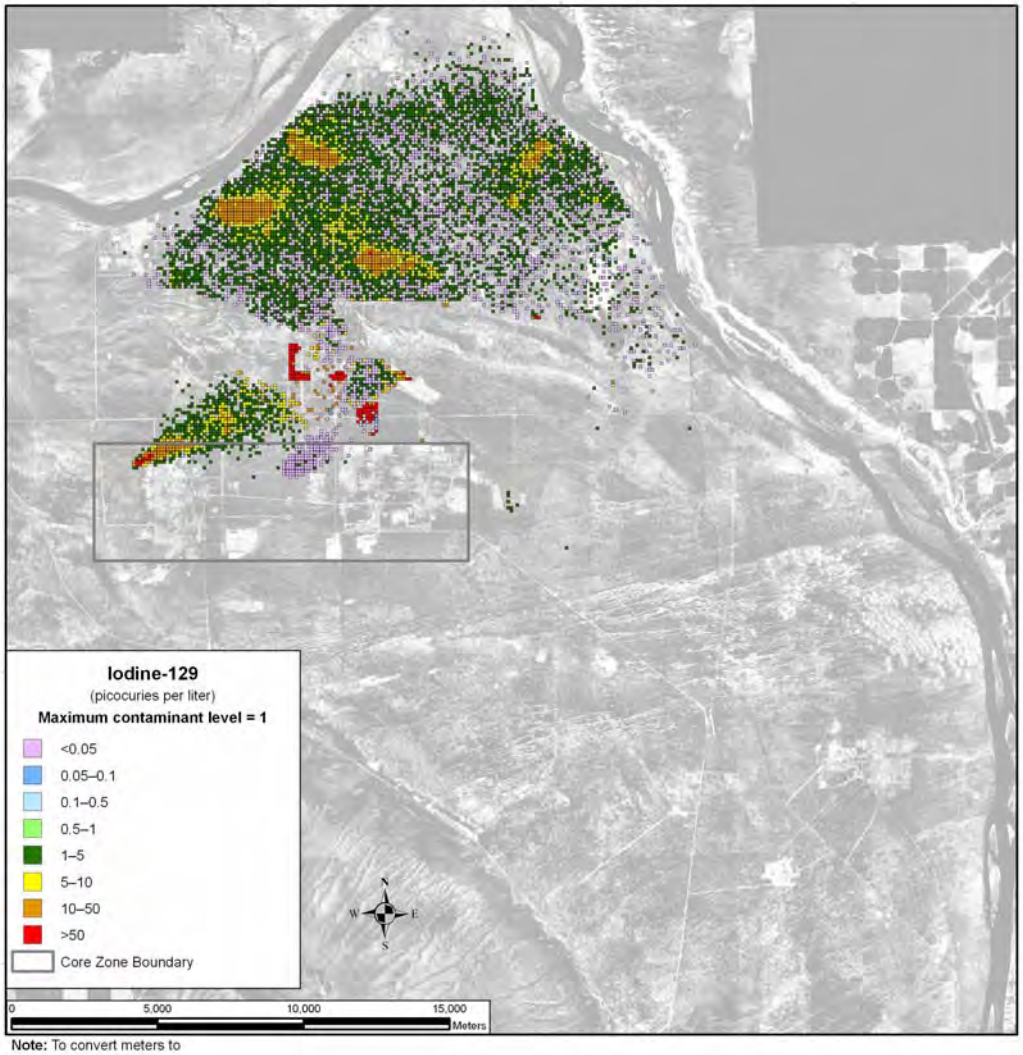
Figure 5–842. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During the Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

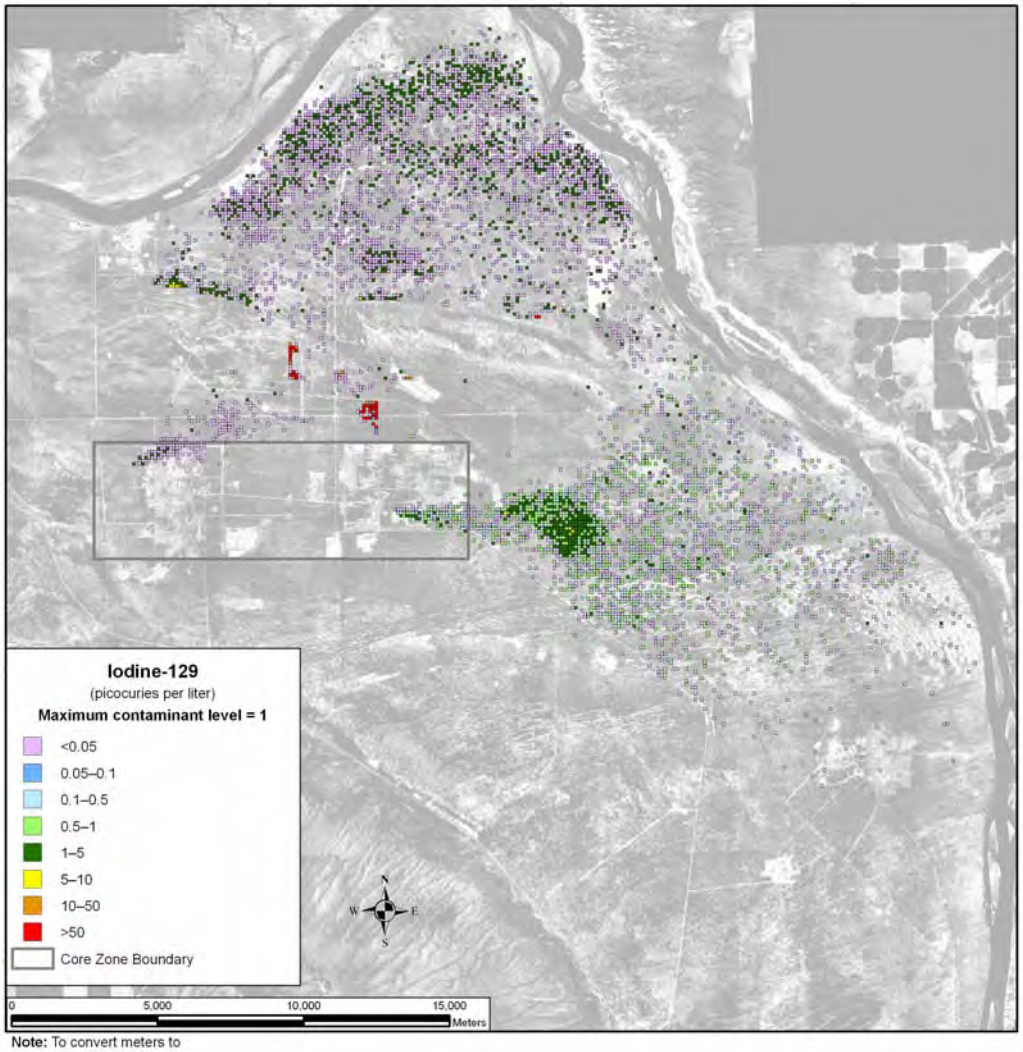
Figure 5–843. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During the Calendar Year 11,885

Figures 5–844 through 5–846 show iodine-129 released at IDF-East, IDF-West, and the RPPDF; the time and spatial distributions of this release are very similar to the technetium-99 release. However, the CY 3890 iodine-129 release (see Figure 5–844) shows significantly higher iodine-129 concentrations compared to benchmark concentrations than the technetium-99 release. The areas of high concentrations are in approximately the same locales but have relatively higher concentrations. By CY 7140 (see Figure 5–845), concentrations of IDF-West and RPPDF iodine-129 have significantly dissipated, but there are areas where concentrations are equal to or above the benchmark concentration. The CY 11,885 IDF-East iodine-129 (see Figure 5–846) shows a continuing iodine-129 distribution with areas that have concentrations that approach or exceed the benchmark concentration.



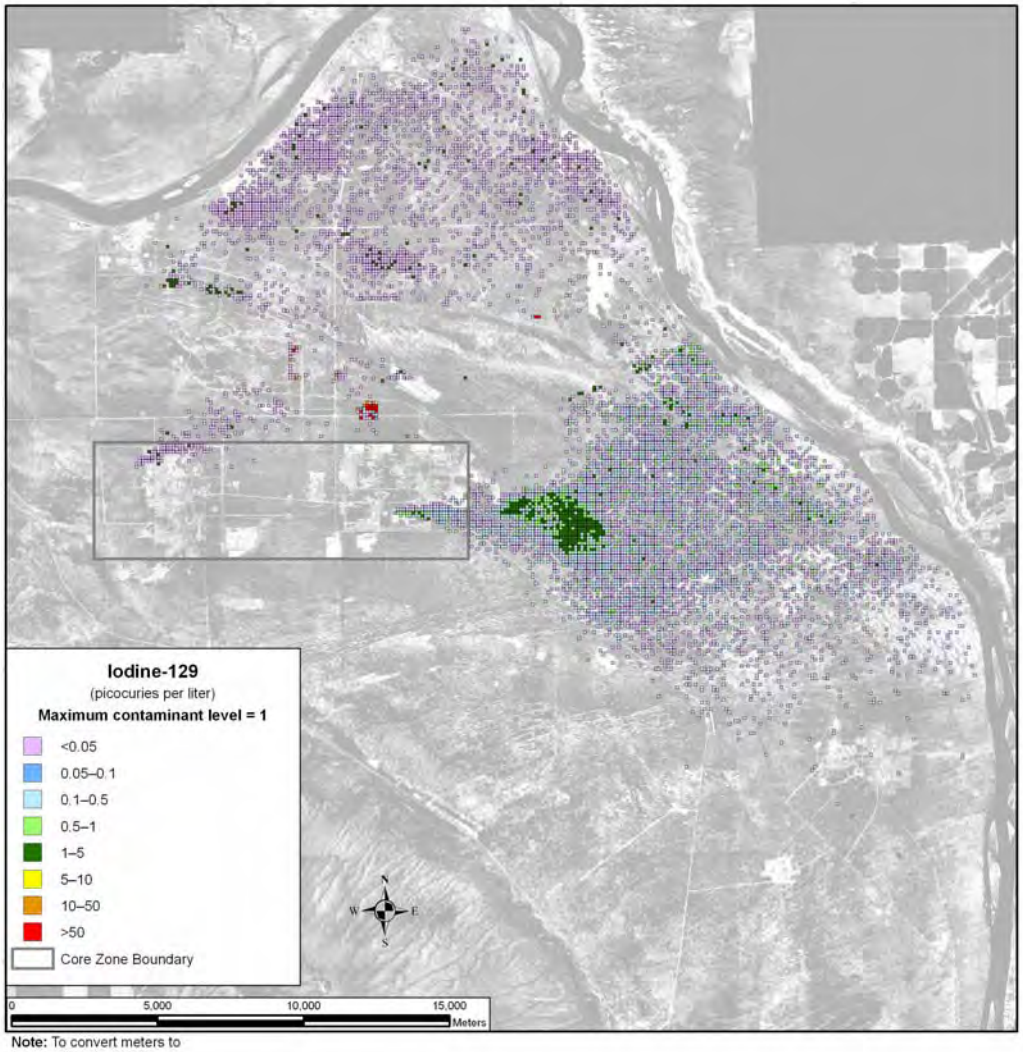
Note: To convert meters to feet, multiply by 3.281

Figure 5–844. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During the Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

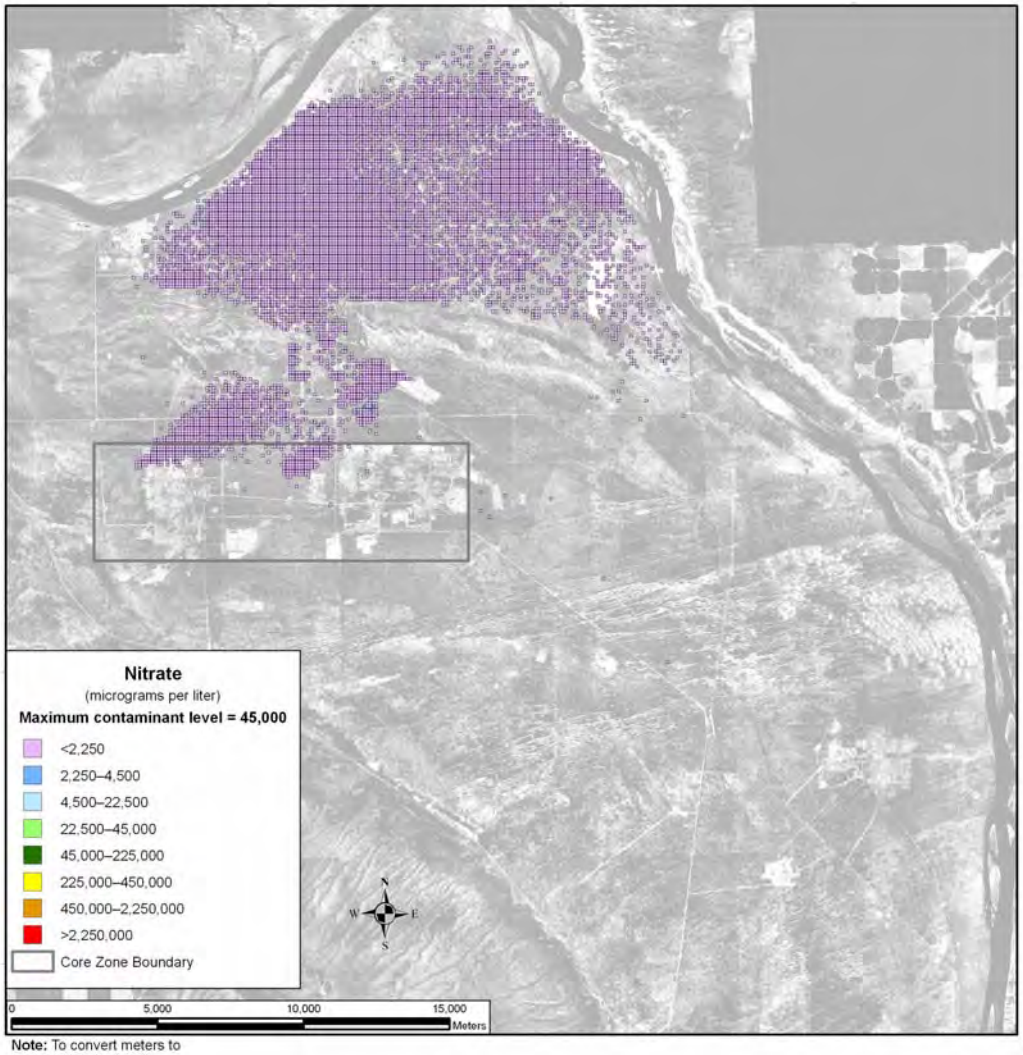
Figure 5–845. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During the Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

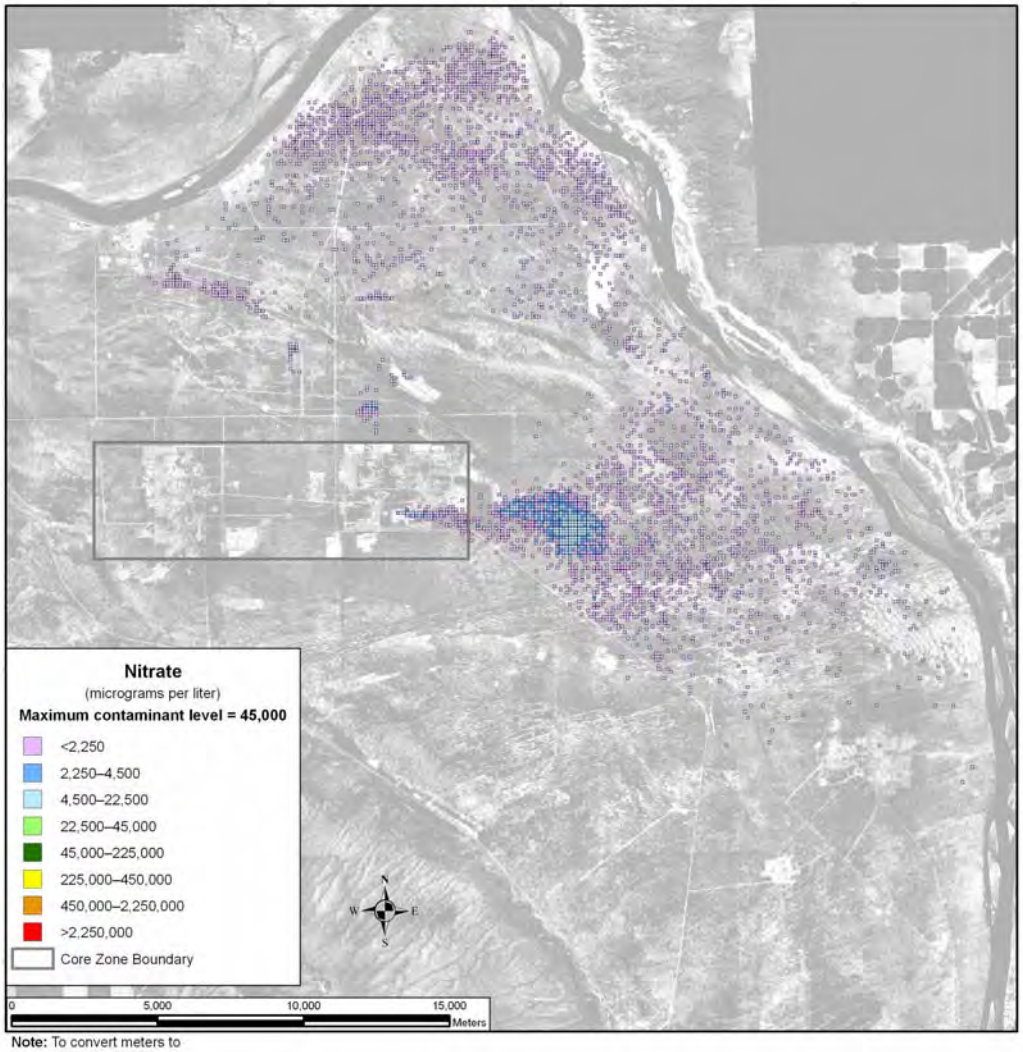
Figure 5–846. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During the Calendar Year 11,885

The IDF-East, IDF-West, and RPPDF nitrate releases, shown in Figures 5–847 through 5–849, show time and spatial distributions similar to the released technetium-99 and iodine-129. These show nitrate concentrations are below benchmark concentrations, with the exception of a very small area just north of the Core Zone Boundary. By CY 11,885, almost all of the groundwater nitrate has dissipated.



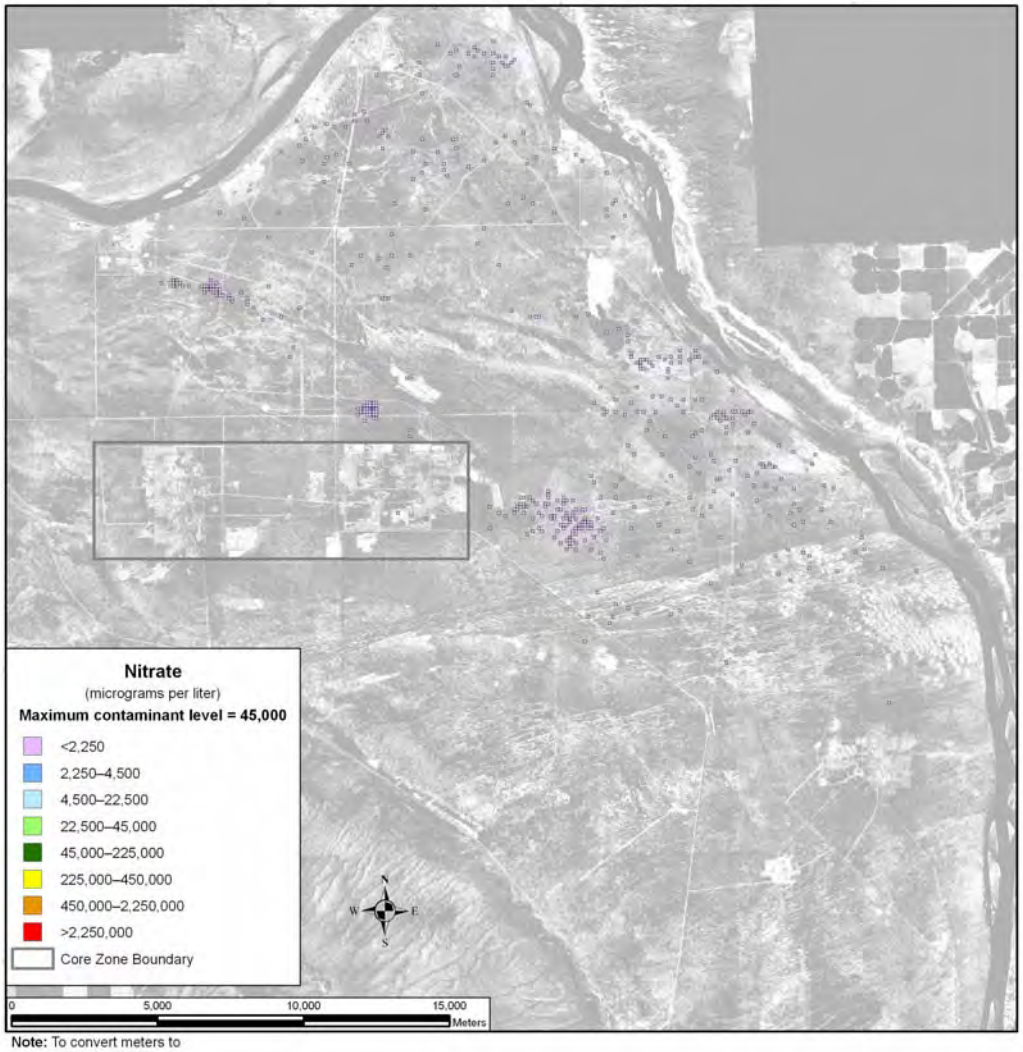
Note: To convert meters to feet, multiply by 3.281

Figure 5–847. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During the Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

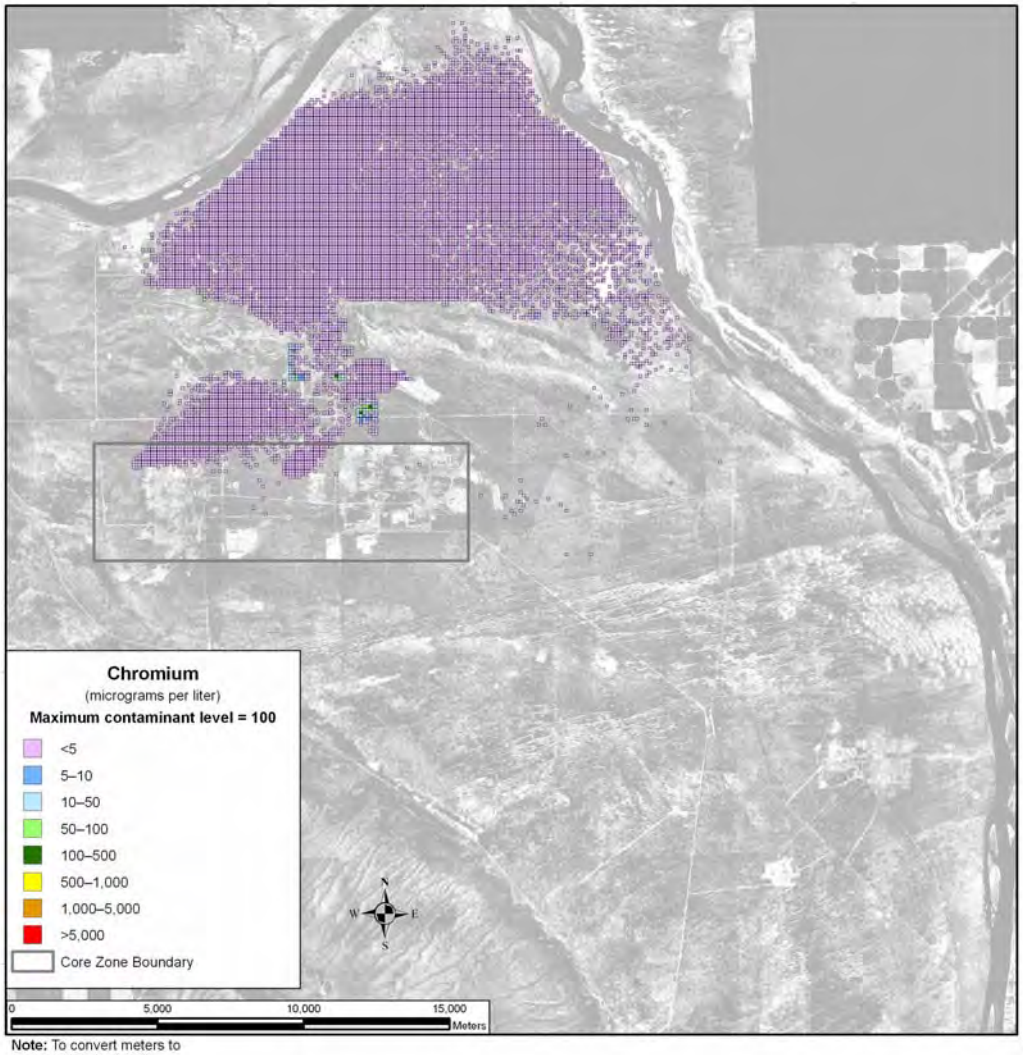
Figure 5–848. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During the Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

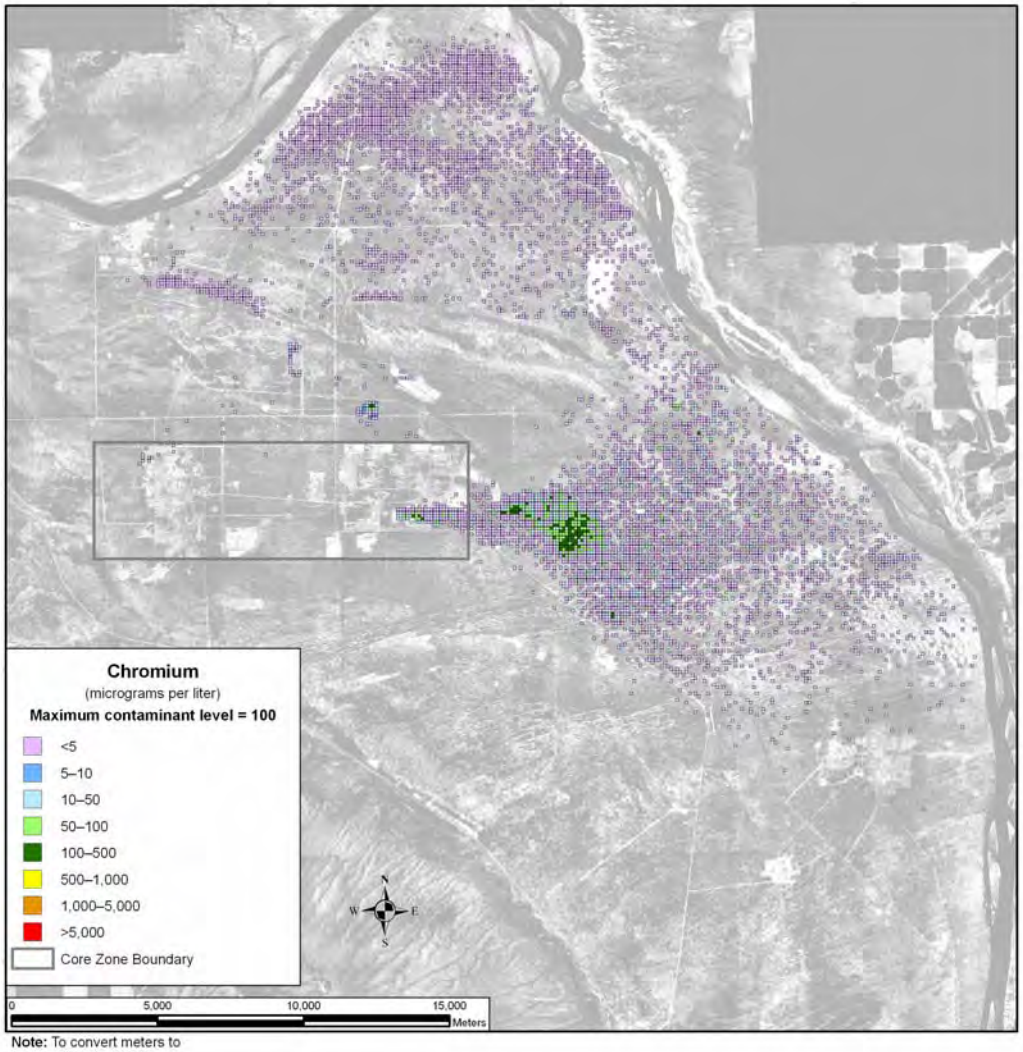
Figure 5–849. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During the Calendar Year 11,885

The CY 3890 and CY 7140 chromium releases in Figures 5–850 and 5–851 are nearly identical to the respective nitrate releases. Chromium concentrations appear to approach the benchmark concentration in the same locale as nitrate. By CY 11,885 (see Figure 5–852), the chromium release has dissipated, but a significant a amount of chromium remains distributed between IDF-East and the Columbia River nearshore. Chromium released from IDF-West and the RPPDF has almost totally dissipated.



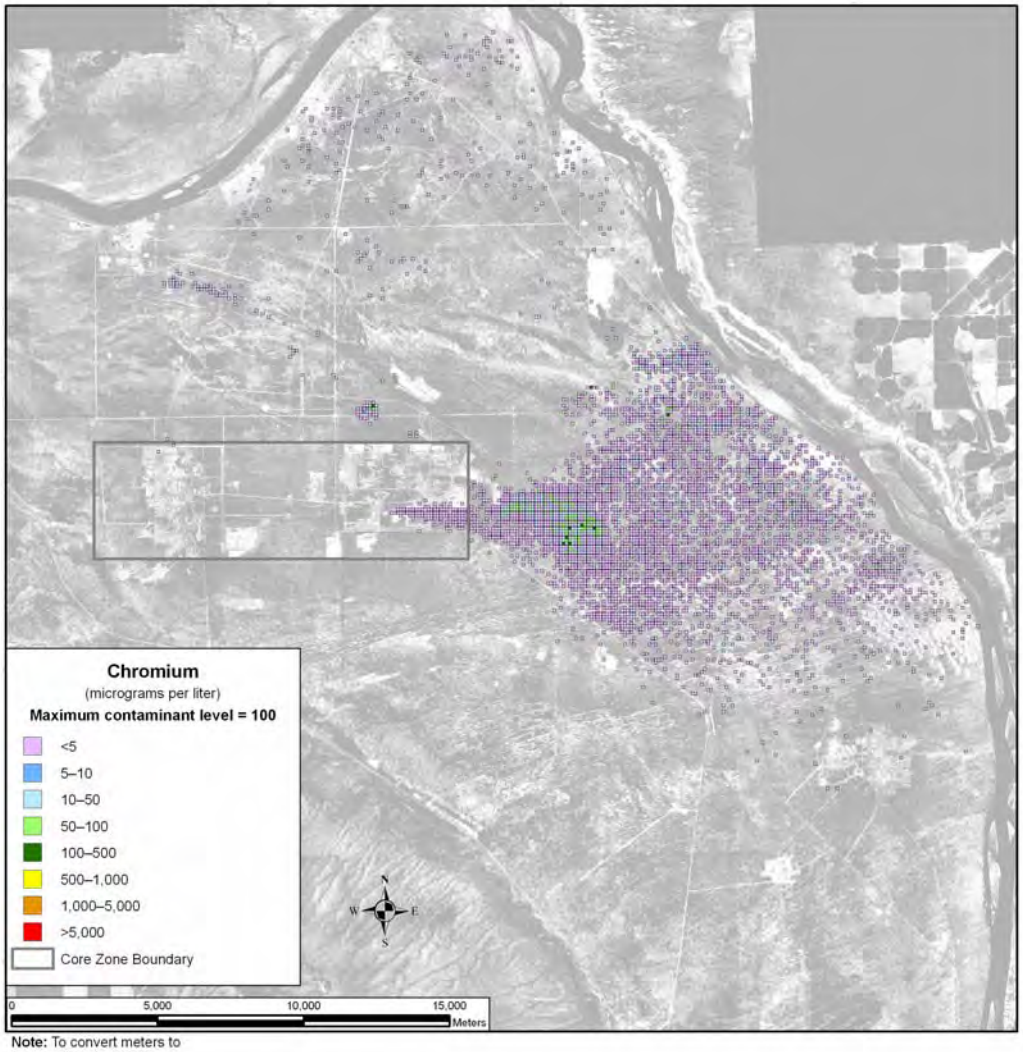
Note: To convert meters to feet, multiply by 3.281

Figure 5–850. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During the Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

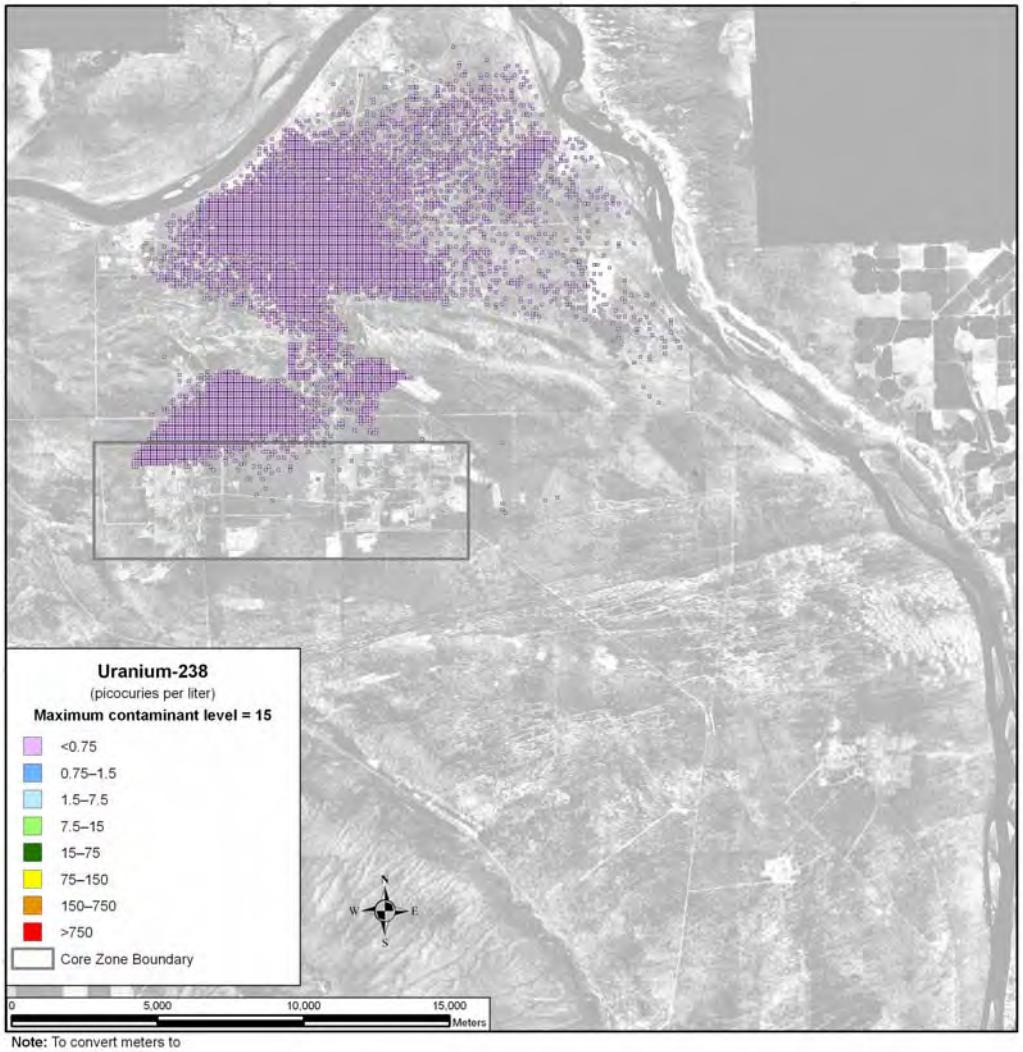
Figure 5–851. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During the Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

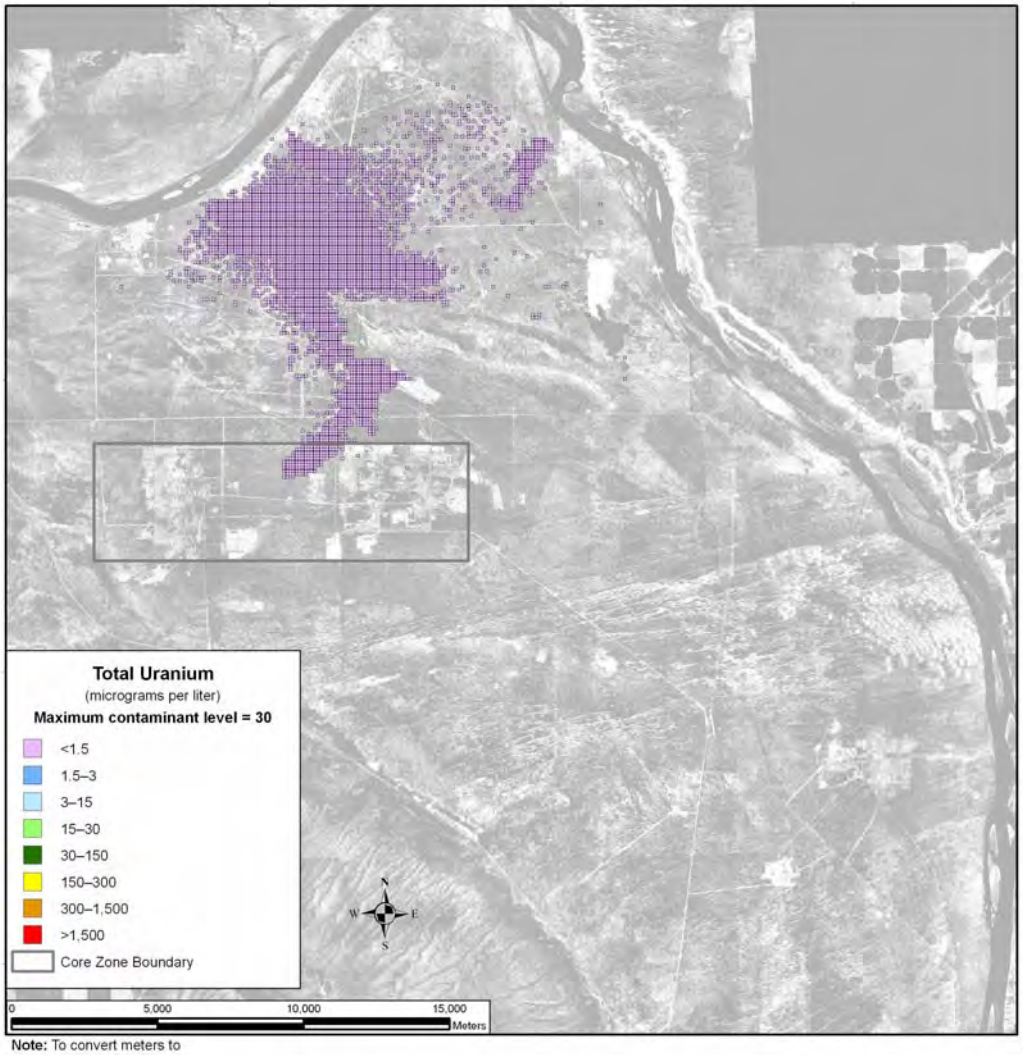
Figure 5–852. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During the Calendar Year 11,885

The uranium-238 and total uranium spatial distributions in Figures 5–853 and 5–854 (both CY 11,885) show a uranium-238 plume from IDF-West and a total uranium plume from the RPPDF. There are no uranium-238 or total uranium releases from IDF-East. The uranium-238 and total uranium releases are distributed in the same locales as the other releases from these sites. The concentrations in both releases remain well below the respective uranium-238 and total uranium benchmark concentrations. The data show retardation with similar distributions and concentrations extending from the release sites to the Columbia River nearshore.



Note: To convert meters to feet, multiply by 3.281

Figure 5–853. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Uranium-238 Concentration During the Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–854. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Total Uranium Concentration During the Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, in general, the inventory remaining at IDF-West are predominant contributors. The releases from IDF-East and the RPPDF are secondary contributors.

By the end of this period of analysis (CY 11,885), the chromium and nitrate distributions have largely dispersed below their benchmark concentrations. A significant spatial distribution of technetium-99 and iodine-129 remain. Most of the distribution area has concentrations below benchmark levels, but there are some small areas where technetium-99 and iodine-129 concentrations exceed the benchmark levels at CY 11,885. The released iodine-129, which occurs at higher concentration levels relative to its benchmark than technetium-99, dissipates much more quickly than technetium-99.

For uranium-238 and total uranium, their relatively, limited mobility is an important factor governing the time-frames and scale of groundwater impacts. The concentrations of these retarded species do not exceed their benchmark levels at the Core Zone Boundary or Columbia River nearshore over this period

of analysis. However, the spatial distributions of both uranium-238 and total uranium exist through the end of the analysis period (CY 11,885). Although the concentrations of uranium-238 and total uranium are both 2 orders of magnitude smaller than either benchmark concentrations during this analysis period, the trend appears to show a continuing increase through the end of the analysis period.

5.3.1.3.1.5 Disposal Group 1, Subgroup 1-E

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E covers disposal of waste generated under Tank Closure Alternative 3C, FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Tank closure waste would be converted to IHLW, ILAW glass, bulk vitrification glass, and cast stone waste.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continue through CY 2050, when the disposal facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period would start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF would become available for release to the environment. For the purpose of analyzing long-term groundwater impacts, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier that limits infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, nitrate, and acetonitrile.

The COPC drivers for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, nitrate, and acetonitrile) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, (IDF-East, IDF-West, and RPPDF releases), in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies, chemicals in kilograms. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–855 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–856, the chemical hazard drivers. The inventories in the six waste forms are a major factor in the release quantities to the vadose zone. The predominant source of vadose zone technetium-99 is cast stone waste (94 percent), with the remainder coming from bulk vitrification glass (5 percent) and tank closure secondary waste (1 percent). The vadose zone iodine-129 is from ETF-generated secondary waste (75 percent) and cast stone waste (23 percent), as well as tank closure secondary waste (2 percent). The predominant source of chromium (greater than 99 percent) and acetonitrile (greater than 99 percent) is cast stone waste. The sources of nitrate release to the vadose zone are cast stone waste (84 percent) and ETF-generated secondary waste (greater than 16 percent). No boron or fluoride is released from IDF-East.

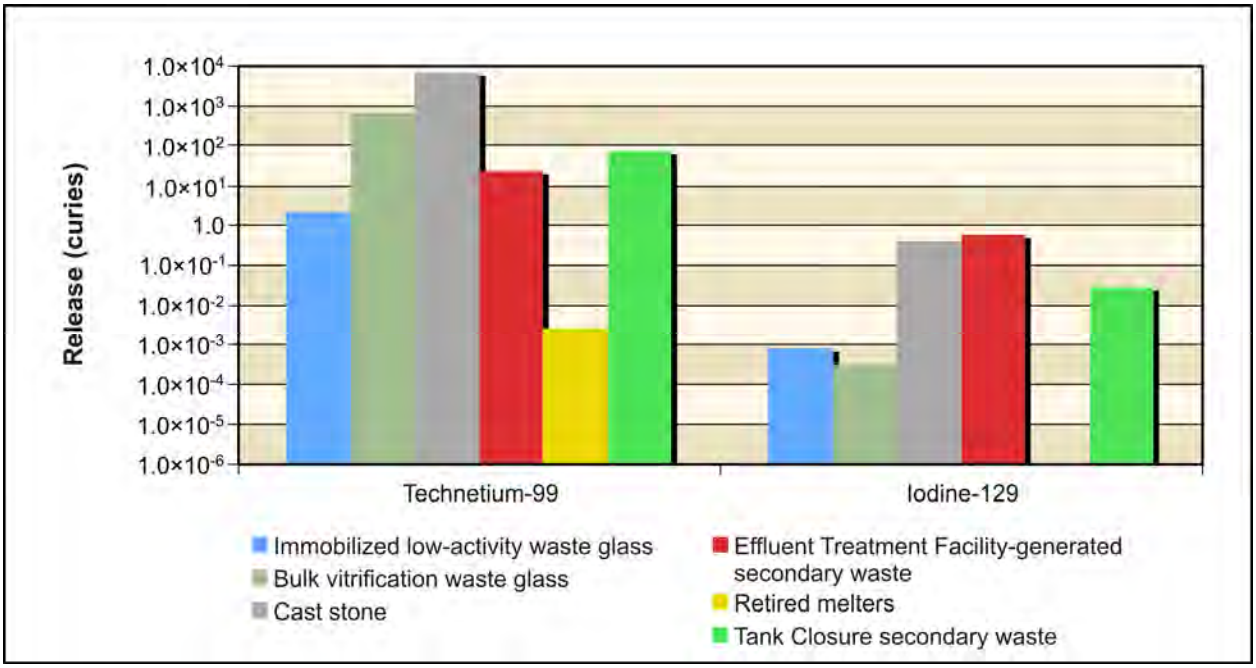


Figure 5–855. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

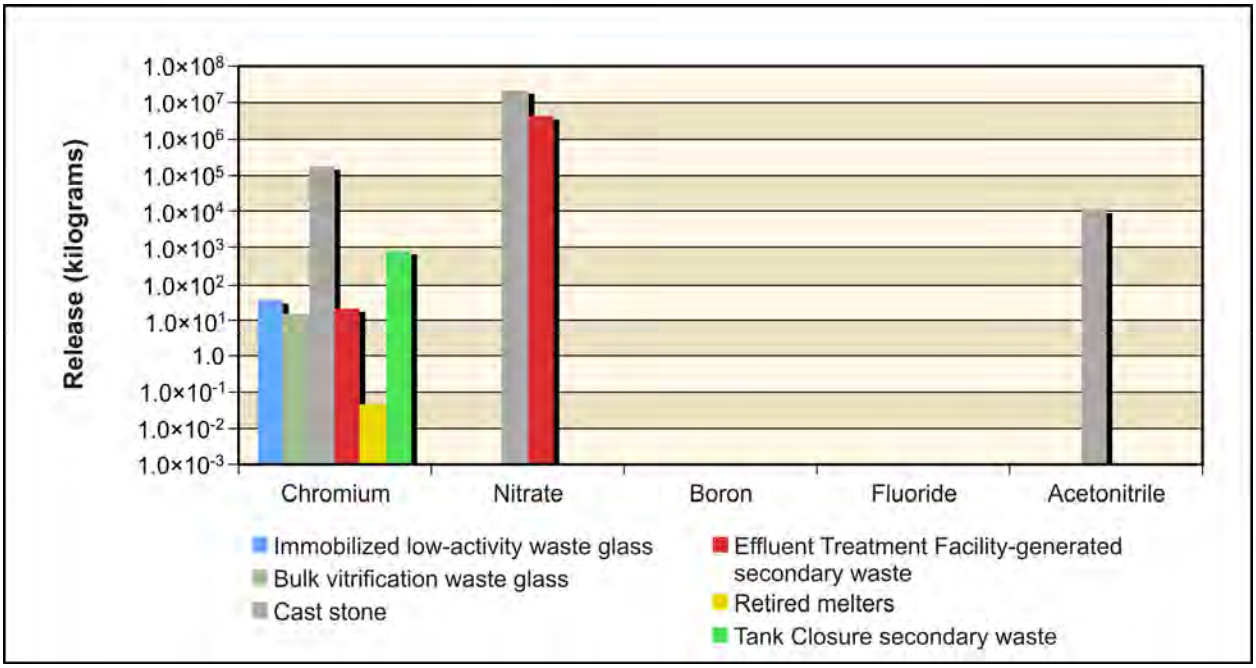


Figure 5–856. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–857 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–858, the chemical hazard drivers. In addition to the waste form inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. The vadose zone releases some technetium-99 (46 percent) and iodine-129 (43 percent) to the groundwater. Nearly all (99 percent) of the vadose zone chromium, nitrate, and acetonitrile are released to the groundwater.

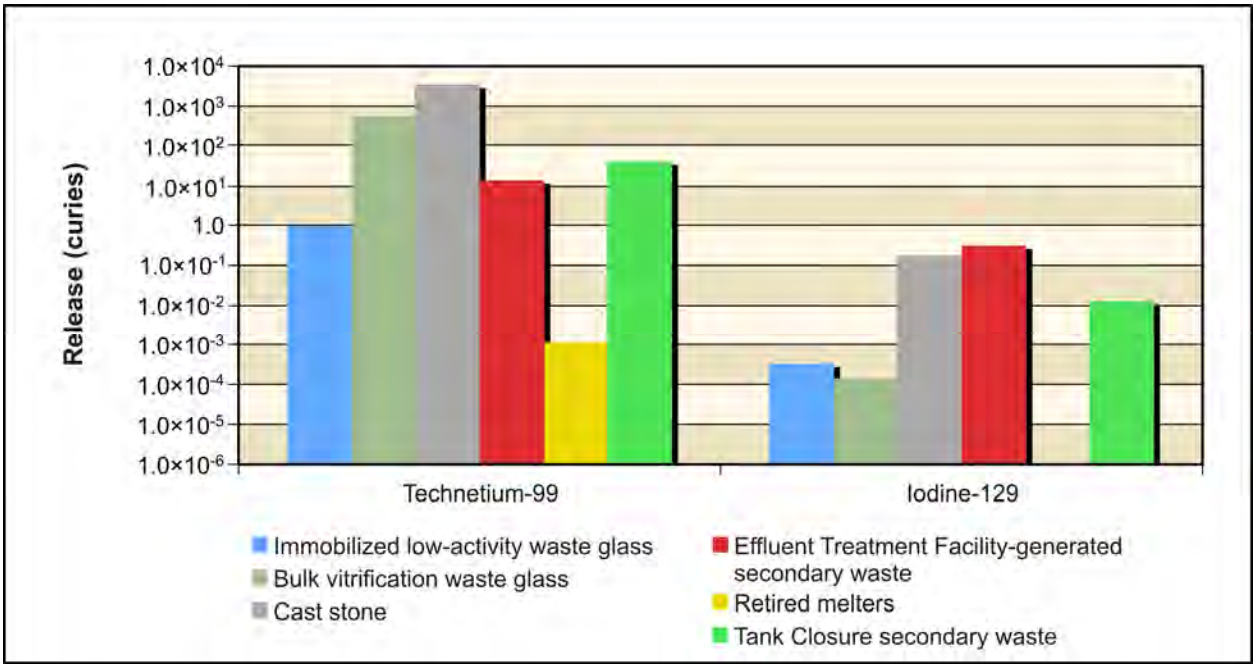


Figure 5–857. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

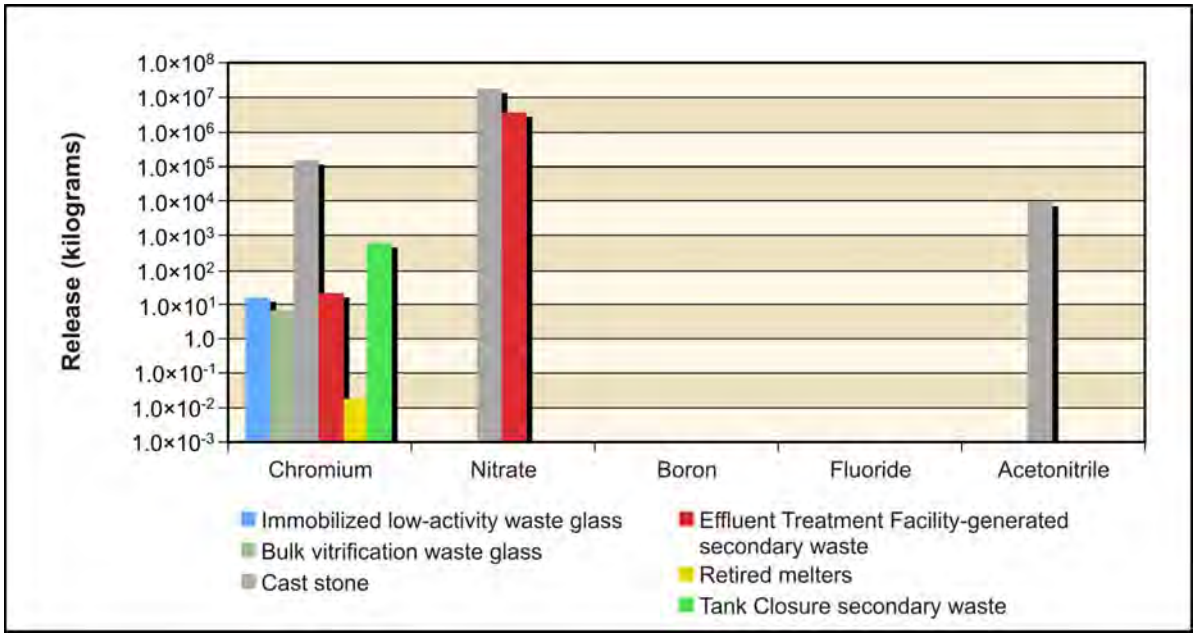


Figure 5–858. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–859 shows the estimated release at the Columbia River for the radiological risk drivers and Figure 5–860, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. The groundwater releases most of its iodine-129 (90 percent), chromium (97 percent), nitrate (98 percent), and acetonitrile (97 percent) to the Columbia River. Some vadose zone technetium-99 (68 percent) is also released.

Overall, most of the IDF-East vadose zone chromium (96 percent), nitrate (97 percent), and acetonitrile (96 percent) and some of the vadose zone technetium-99 (31 percent) and iodine-129 (39 percent) reach the Columbia River over the period of analysis.

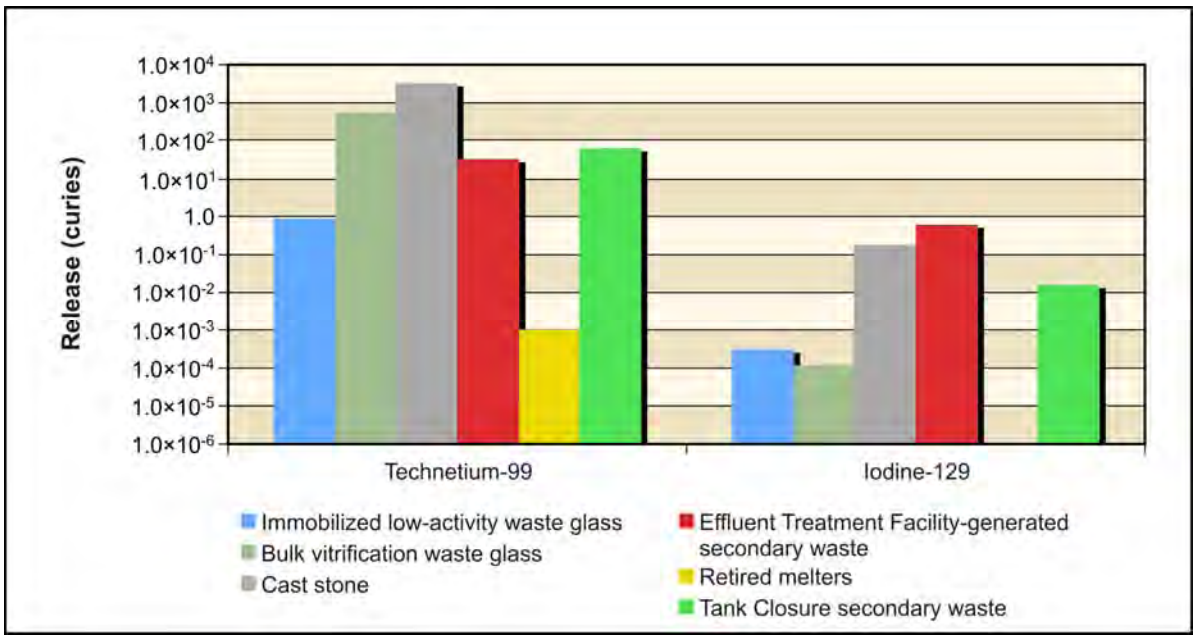


Figure 5–859. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

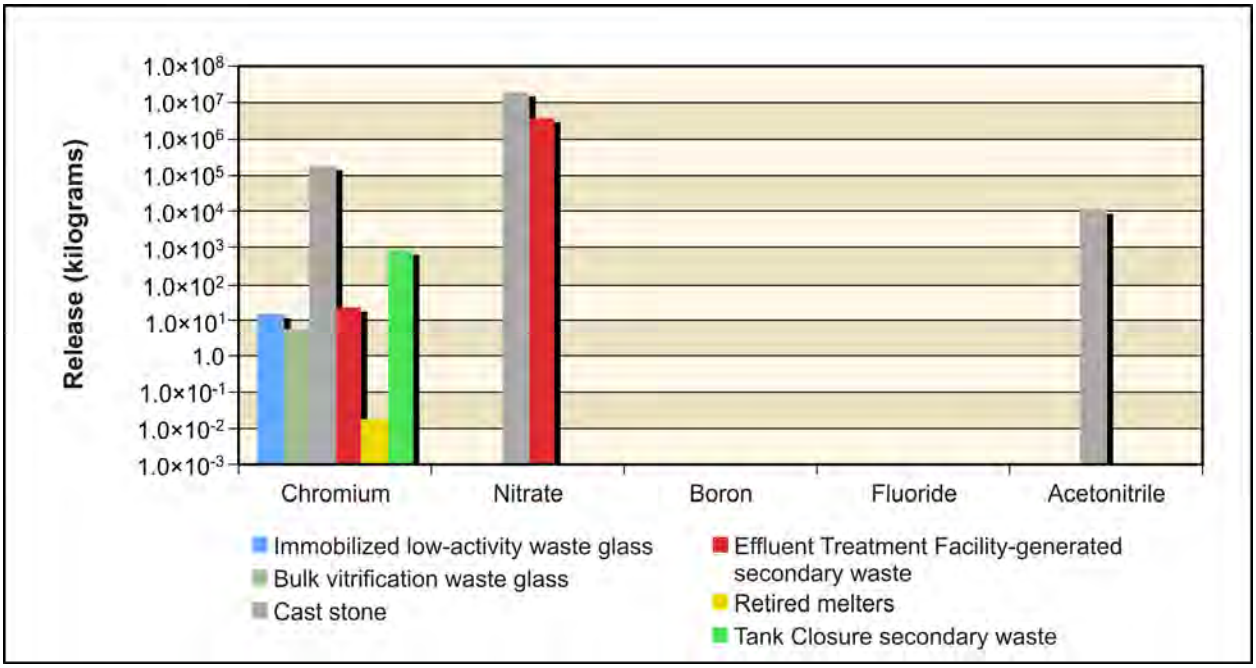


Figure 5–860. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases from FFTF Decommissioning Alternative 3 waste, waste management secondary, and onsite- and offsite-generated waste.

Figure 5–861 shows the release to the vadose zone for the radiological risk drivers and Figure 5–862, the chemical hazard drivers. The inventories in the three waste forms are a major factor in the release quantities to the vadose zone. Offsite-generated waste is the predominate source of the technetium-99 (greater than 99 percent) and iodine-129 (greater than 99 percent) released to the vadose zone. Essentially all (greater than 99 percent) of the nitrate, boron, and fluoride that is released to the vadose zone is from waste management secondary and onsite-generated waste. Chromium released to the vadose zone is from waste management secondary and onsite-generated waste, (66 percent) and offsite-generated waste (34 percent). No acetonitrile is released from IDF-West.

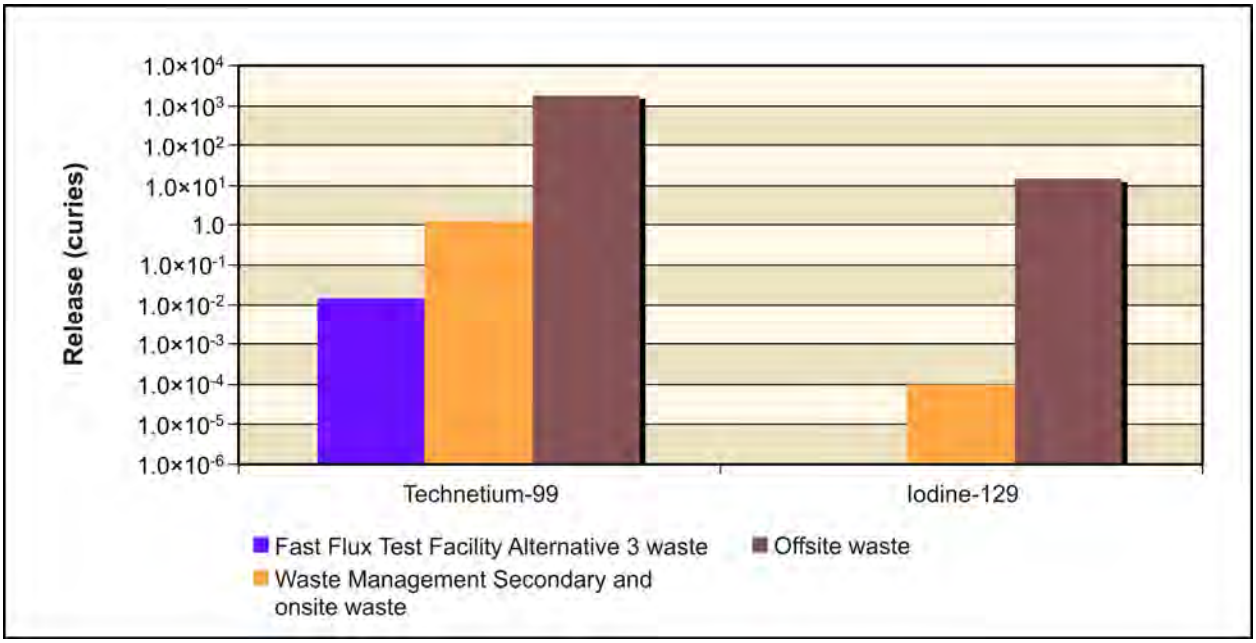


Figure 5–861. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

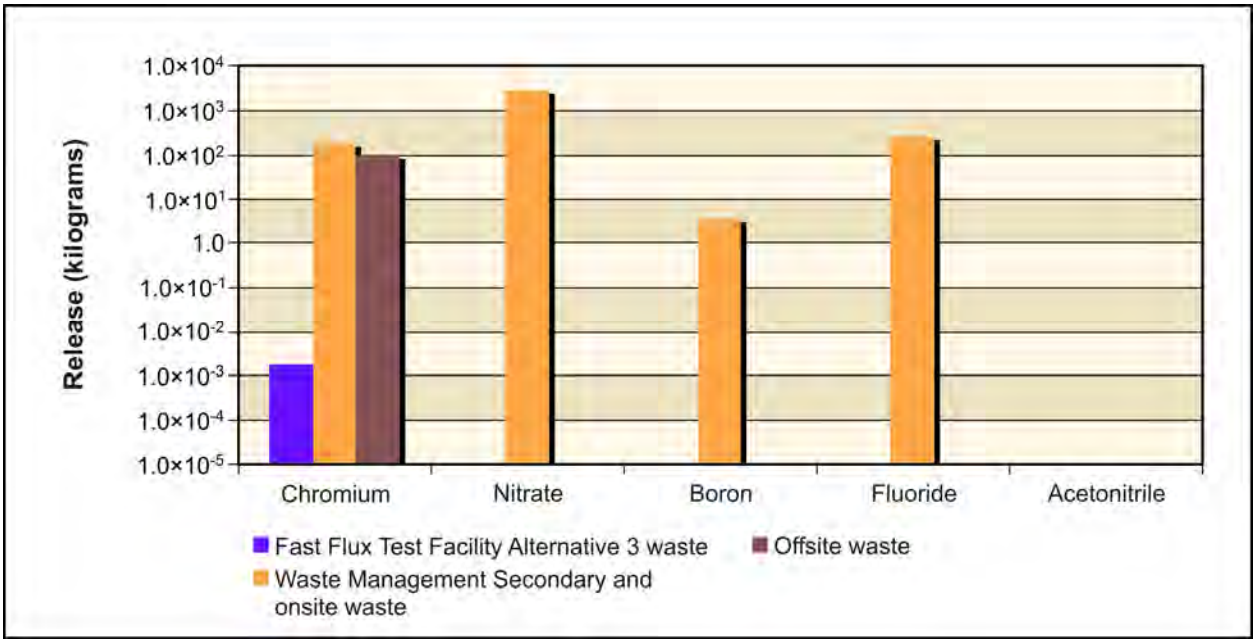


Figure 5–862. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–863 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–864, the chemical hazard drivers. In addition to the waste form inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Most of the IDF-West vadose zone technetium-99 (98 percent), iodine-129 (99 percent), chromium (99 percent), nitrate (greater than 99 percent), boron (greater than 99 percent), and fluoride (greater than 99 percent) are released to the groundwater during the period of analysis.

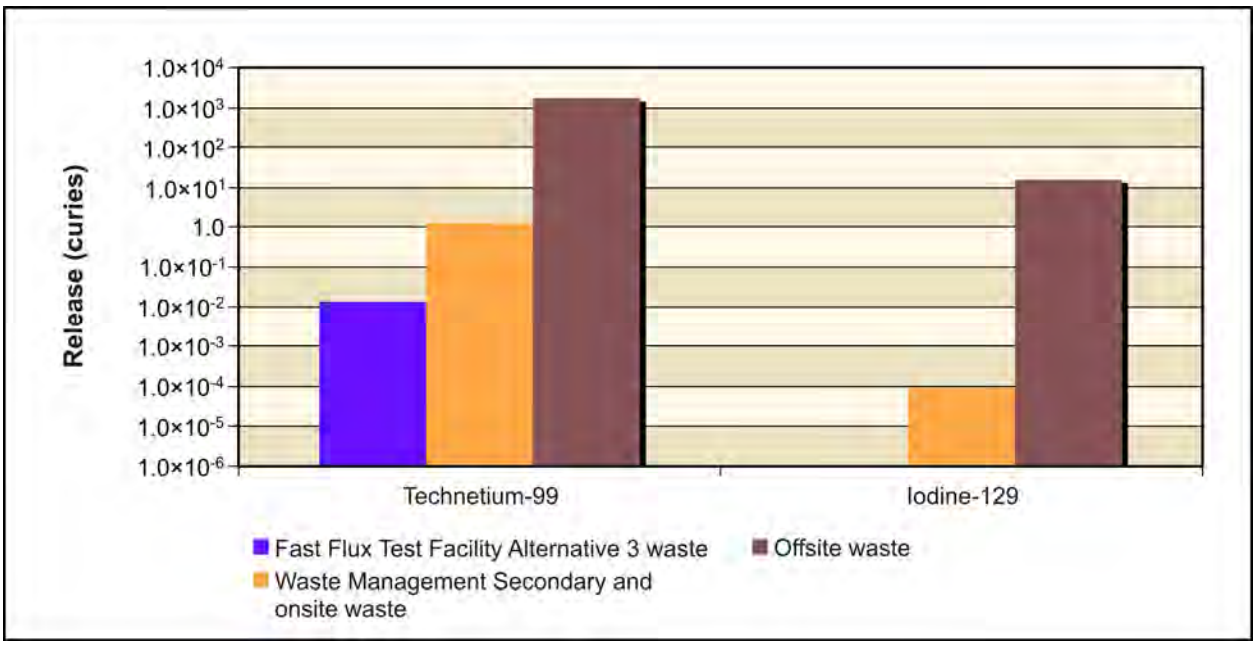


Figure 5–863. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

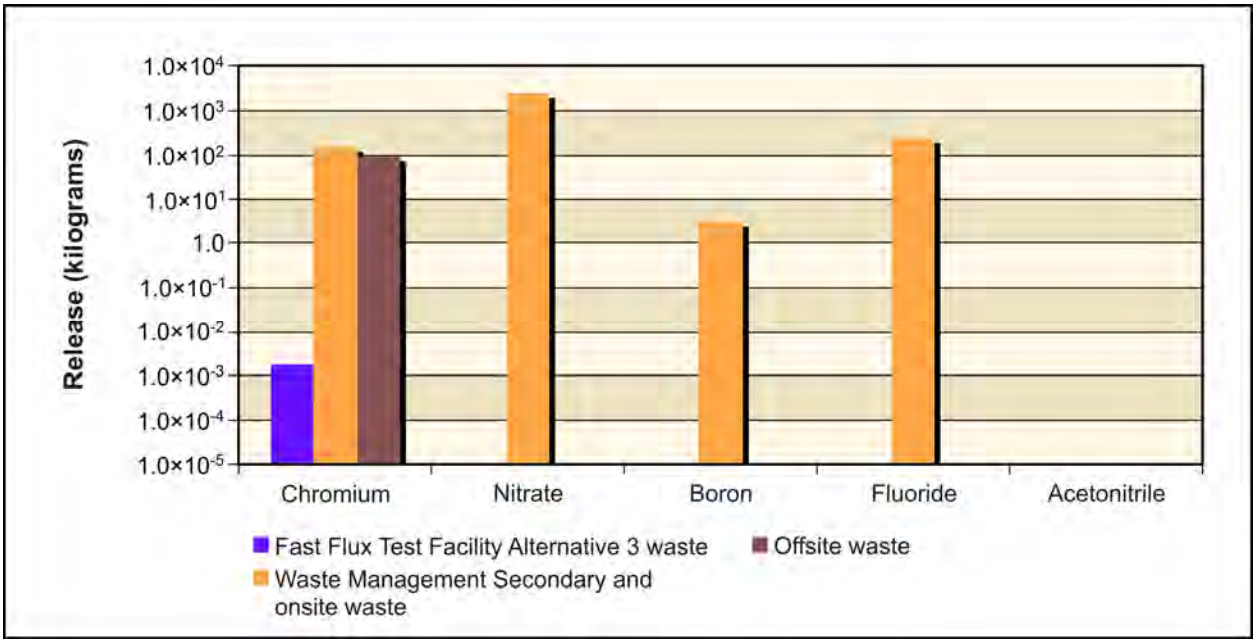


Figure 5–864. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–865 shows the estimated release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–866, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most (97–98 percent) of the IDF-West groundwater technetium-99, iodine-129, chromium, nitrate, boron, and fluoride are released to the Columbia River over the period of analysis.

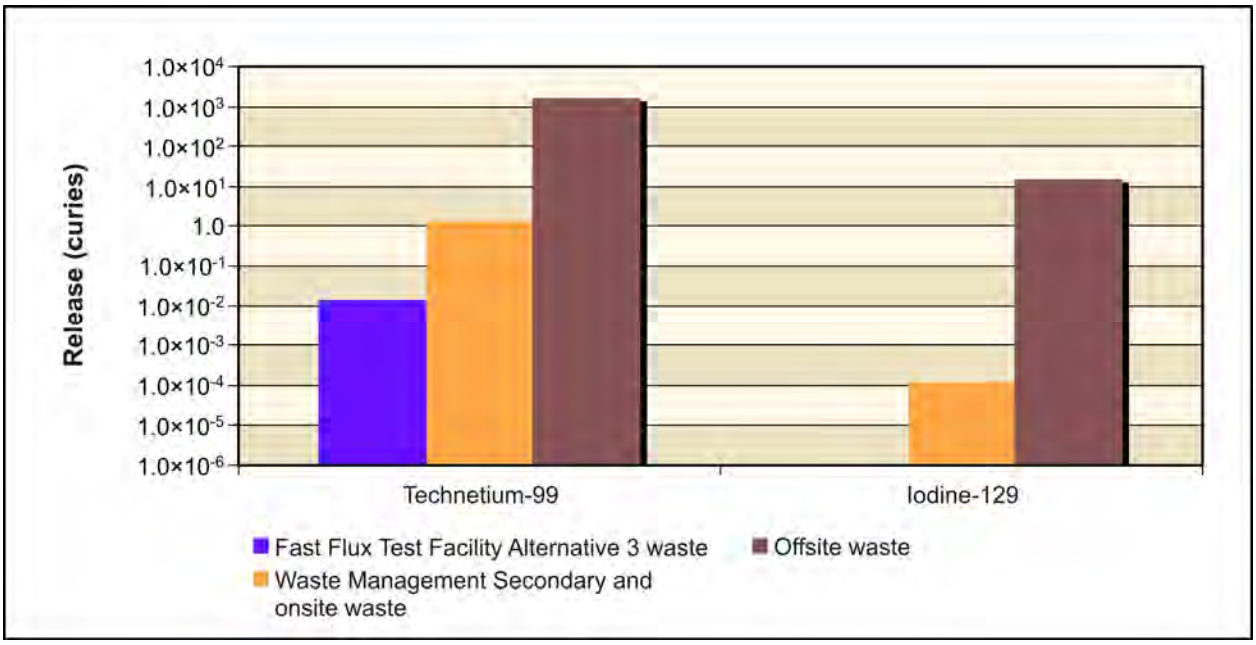


Figure 5–865. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

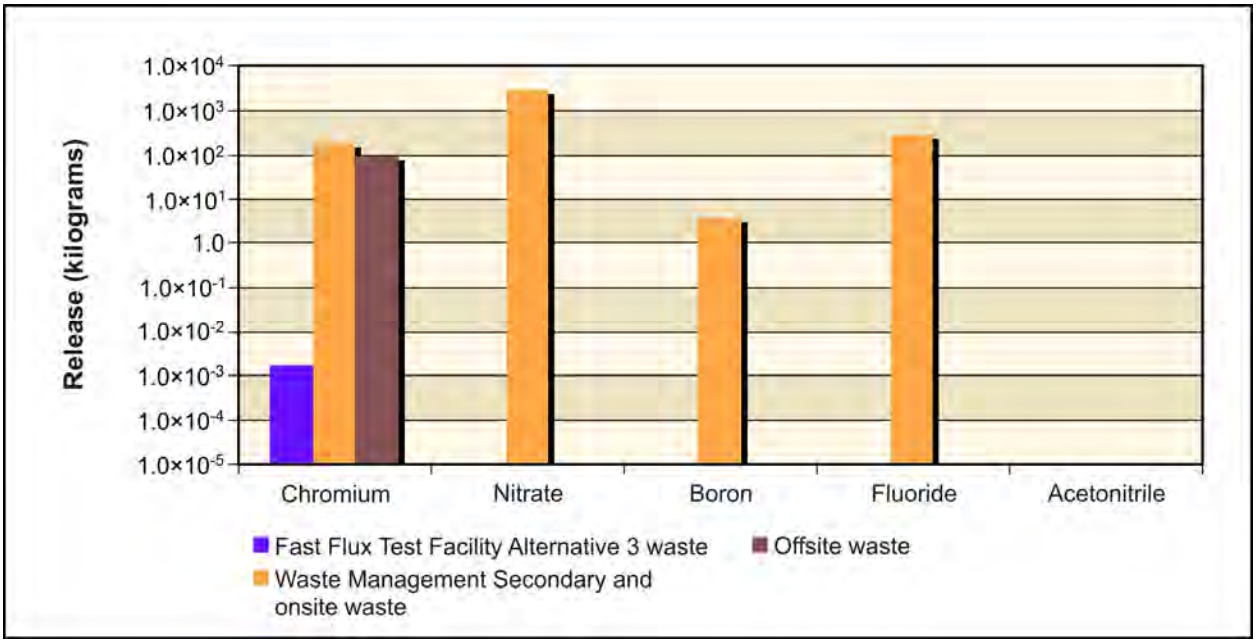


Figure 5–866. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

Overall, most (96-98 percent) of the IDF-West vadose zone technetium-99, iodine-129, chromium, nitrate, boron, and fluoride reach the Columbia River over the period of analysis.

River Protection Project Disposal Facility

Figure 5–867 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–868, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The vadose zone radiological sources from the RPPDF are technetium (largest) and iodine-129 (smallest). The chemical hazard sources from the RPPDF are nitrate (largest) and chromium (smallest). No fluoride, boron, or acetonitrile is released from the RPPDF.

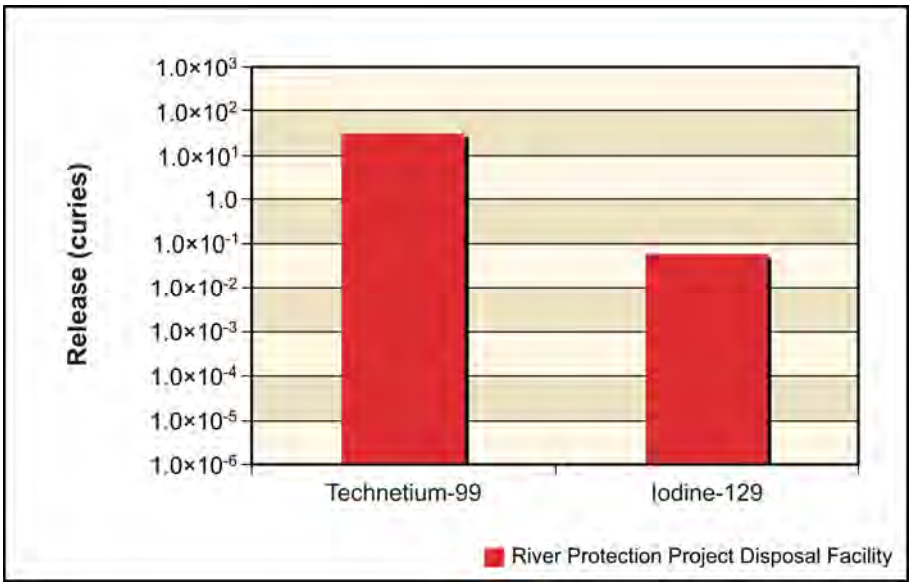


Figure 5–867. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

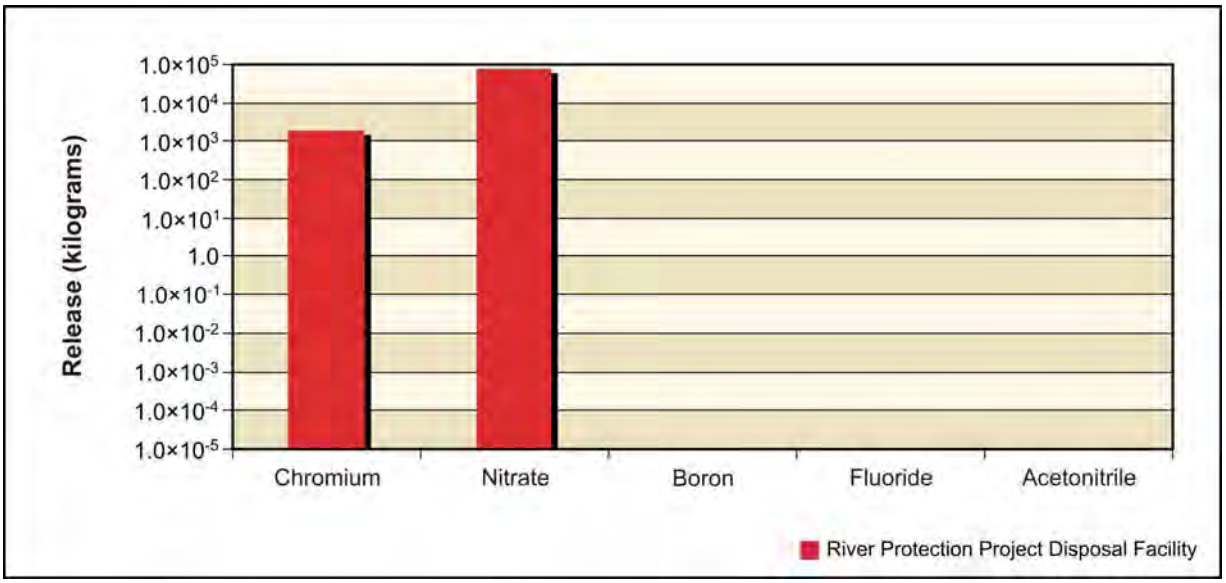


Figure 5–868. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–869 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–870, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Essentially all (99 percent) of the RPPDF vadose zone technetium-99, iodine-129, chromium, and nitrate are released to the groundwater.

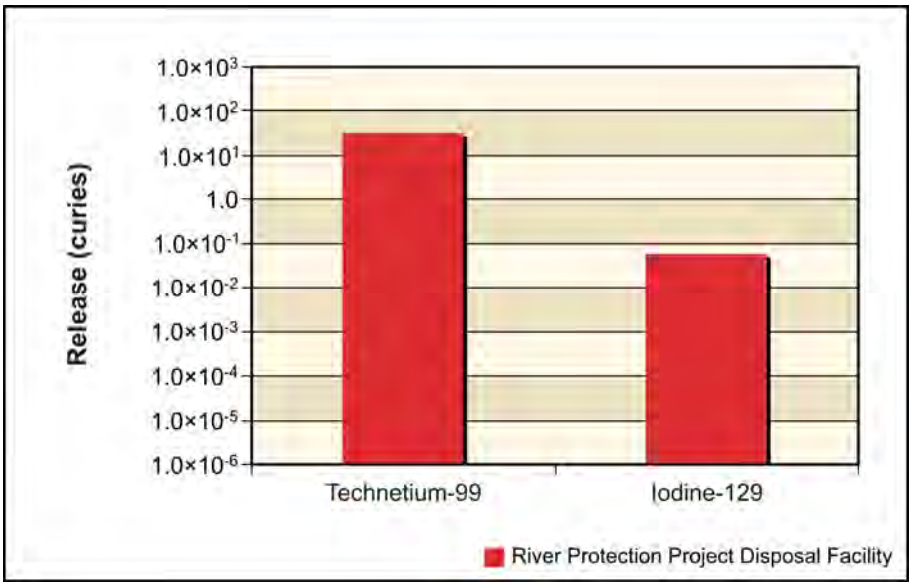


Figure 5–869. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at River Protection Project Disposal Facility to Groundwater

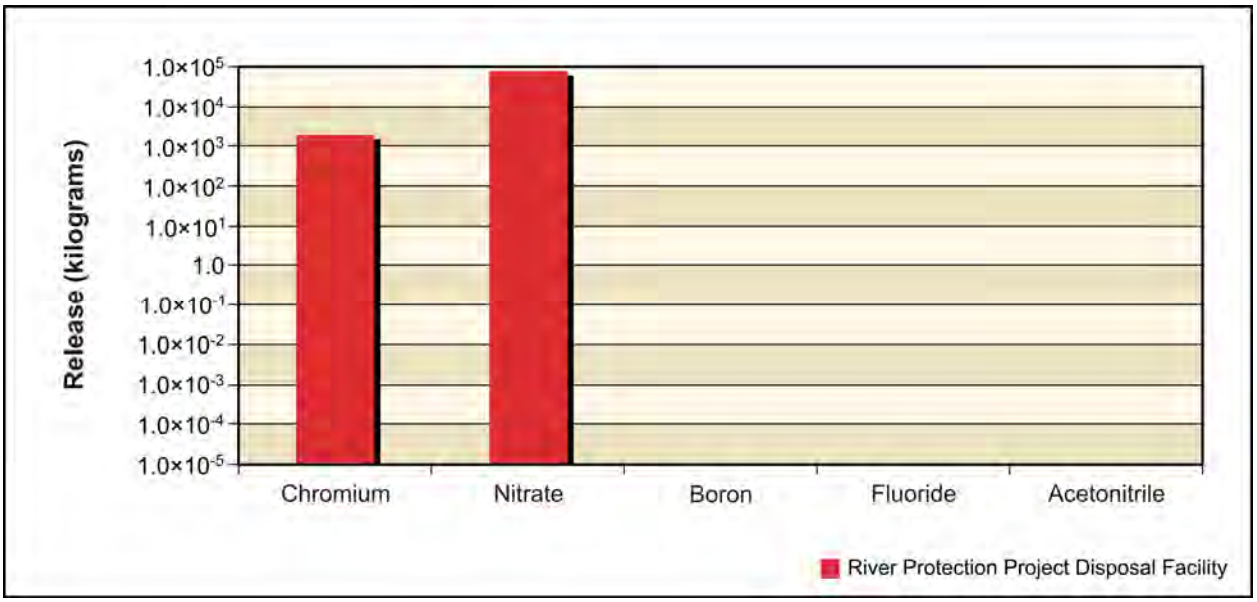


Figure 5–870. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–871 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–872, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most (96 percent) of the groundwater technetium-99, iodine-129, chromium, and nitrate are released to the Columbia River.

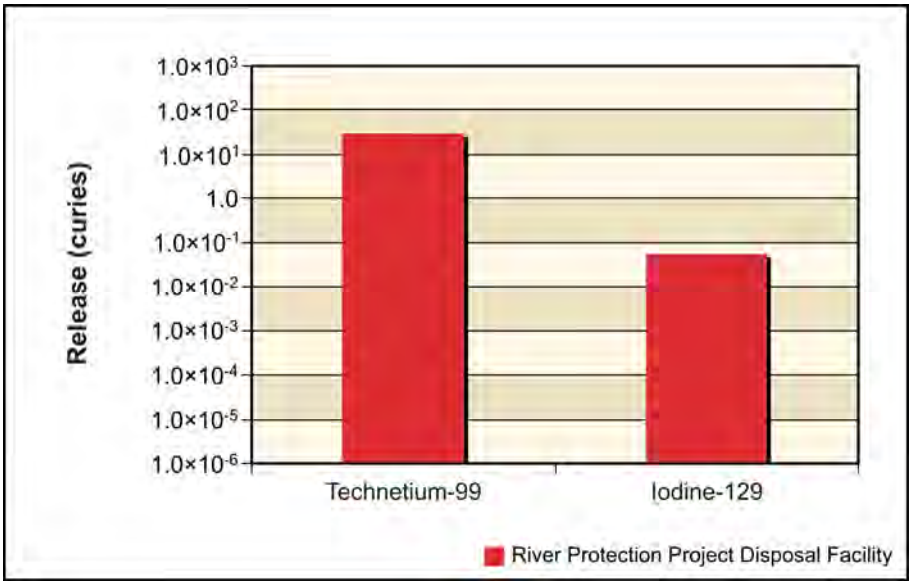


Figure 5–871. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at River Protection Project Disposal Facility to Columbia River

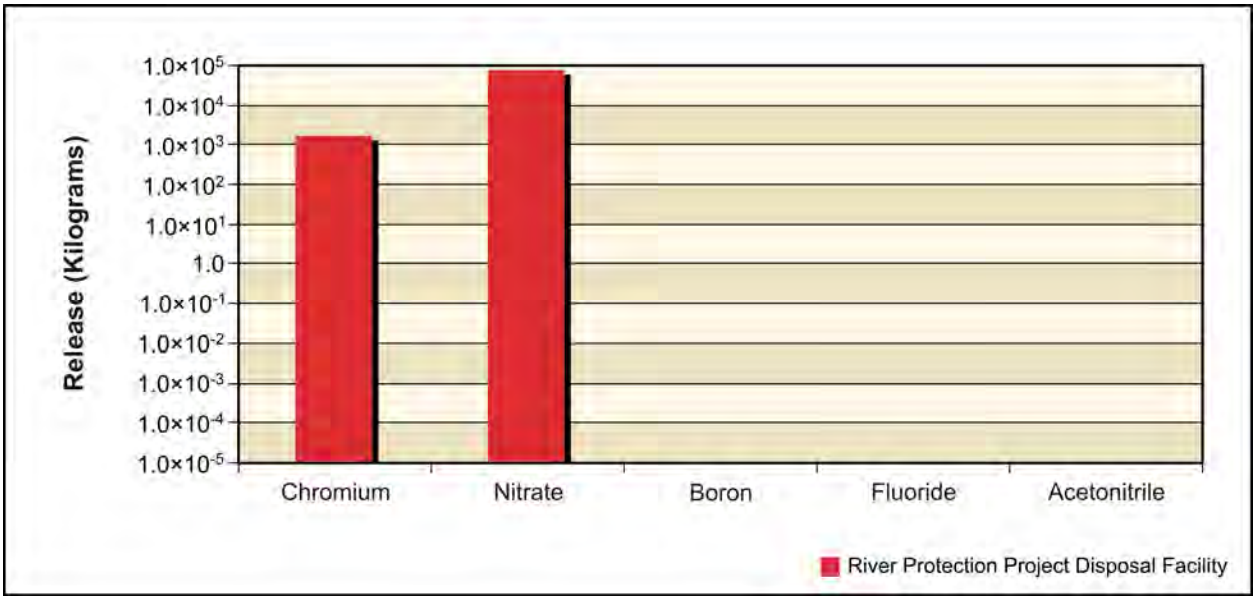


Figure 5–872. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at River Protection Project Disposal Facility to Columbia River

Overall, most (95–96 percent) of the RPPDF vadose zone technetium-99, iodine-129, chromium, and nitrate reached the Columbia River during the period of analysis.

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–93 shows the maximum concentrations in groundwater.

Table 5–93. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	**5,640**	**20,200**	103	**7,600**	**2,030**	900
	(9826)	(3713)	(3822)	(3690)	(8117)	
Iodine-129	**1**	**173**	0.2	**60**	**8**	1
	(11,228)	(3797)	(3940)	(3853)	(4728)	
Chemical in micrograms per liter						
Chromium	**223**	2	6	96	64	100
	(9069)	(3696)	(3804)	(8643)	(8079)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	29,000	17	229	13,900	6,380	45,000
	(9330)	(3703)	(4042)	(8994)	(8673)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–873 through 5–876 show concentration versus time for technetium-99, iodine-129, chromium, and nitrate, respectively. The releases of technetium-99 from IDF-East, IDF-West, and the RPPDF result in concentrations at the Core Zone Boundary and the Columbia River nearshore that exceed the technetium-99 benchmark concentration over part of the period of analysis (see Figure 5–873). There is a relatively narrow technetium-99 increase after the post-disposal period, when the Core Zone Boundary concentration exceeds the benchmark concentration for about 1,000 years. The peak, at about CY 3800, is less than one order of magnitude greater than the benchmark concentration. The Core Zone Boundary technetium-99 concentration then drops below the benchmark concentration to a level about equal to the Columbia River nearshore concentration. After a slight increase, both the Core Zone Boundary and the Columbia River nearshore technetium-99 concentrations remain at about the benchmark concentration level through the remainder of the period of analysis (CY 11,940).

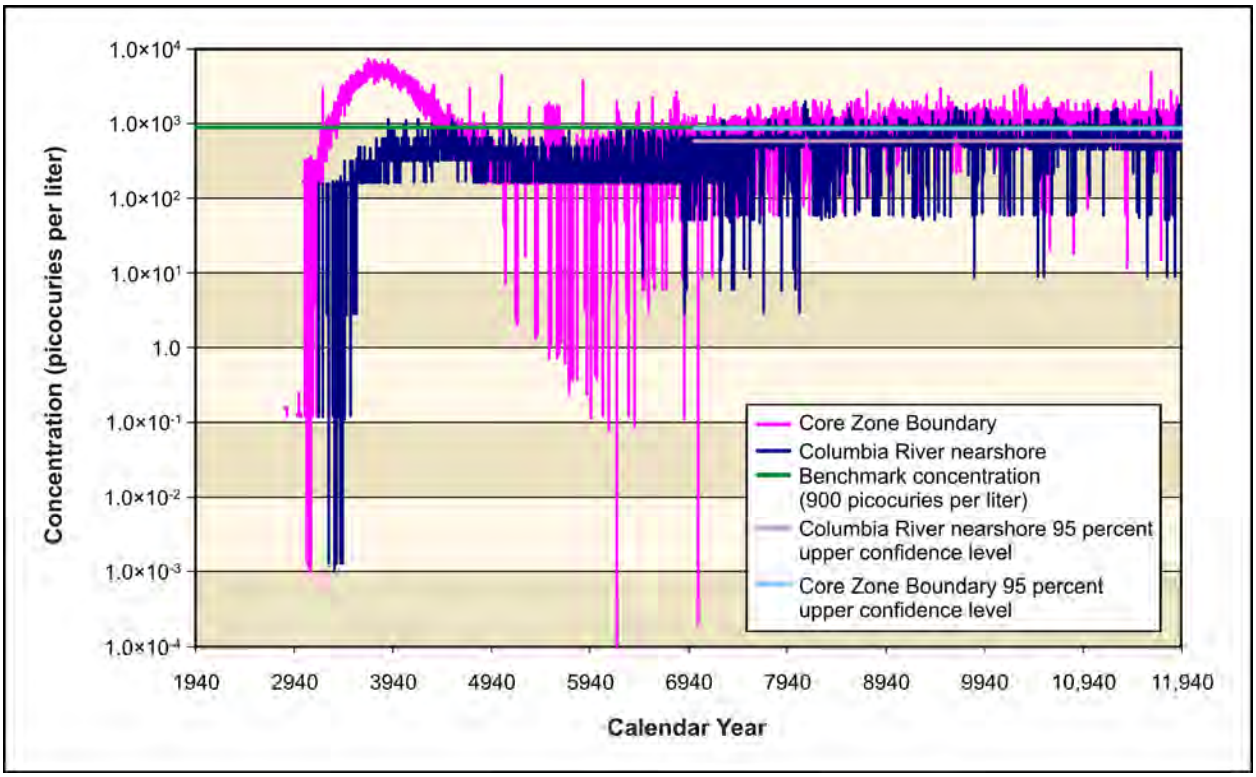


Figure 5–873. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Technetium-99 Concentration Versus Time

The iodine-129 concentration versus time (see Figure 5–874) shows a similar response at the Core Zone Boundary and the Columbia River nearshore. The iodine-129 peak at CY 3800 is less than two orders of magnitude greater than the benchmark concentration. The iodine-129 then decreases to the benchmark concentration level and remains at about the benchmark concentration level at both the Core Zone Boundary and Columbia River nearshore through the remainder of this period of analysis (CY 11,940).

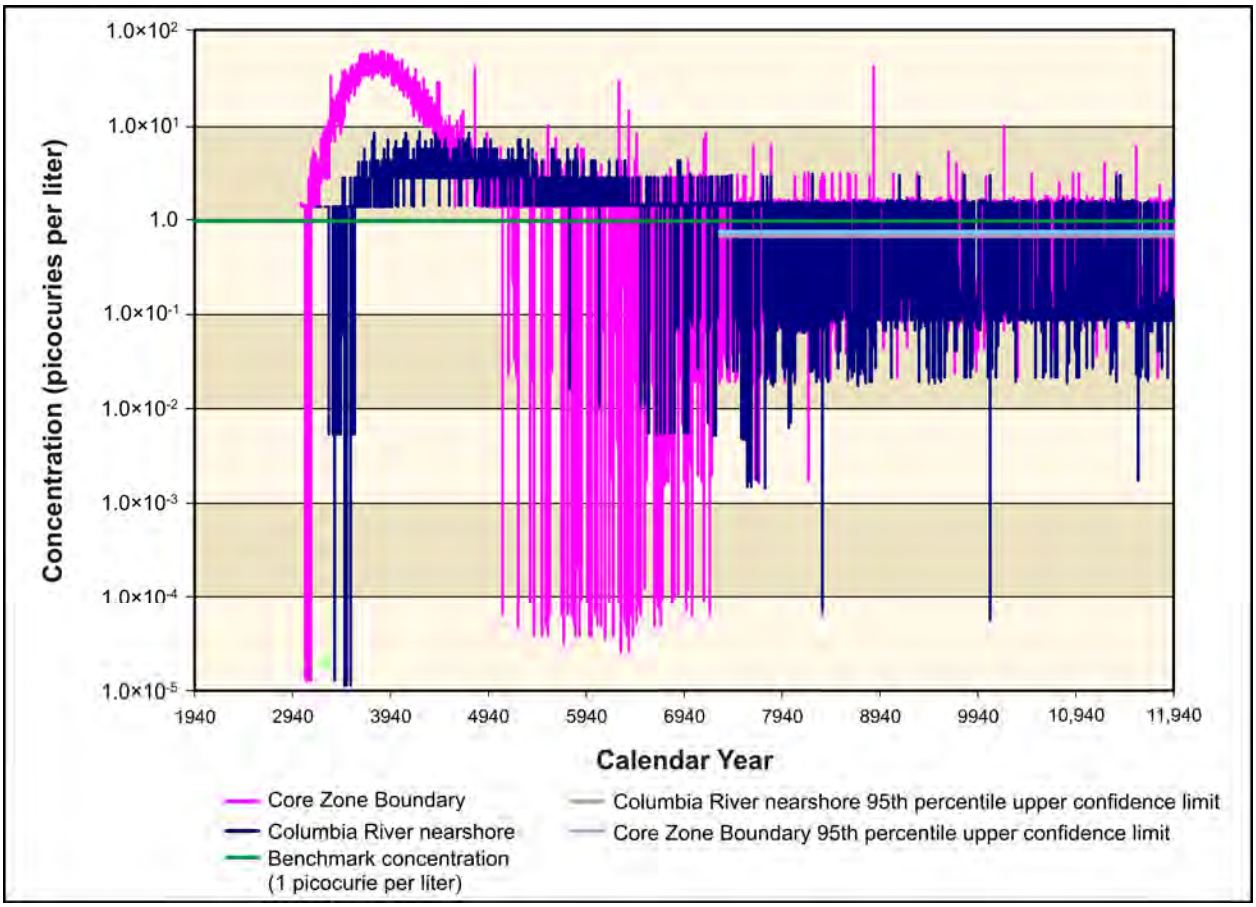


Figure 5–874. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Iodine-129 Concentration Versus Time

Figures 5–875 and 5–876 also show an initial increase in the Core Zone Boundary chromium and nitrate, followed by a second, broader increase period that peaks at about the two-thirds point of the analysis period. The chromium concentrations approach the benchmark concentration during the latter half of the analysis period, but then decline; the CY 11,940 concentrations are just under the benchmark concentration. The chromium concentrations are always less than the benchmark concentrations through the end of the analysis period. The nitrate concentration is always less than one order of magnitude from the benchmark concentration throughout the period of analysis at both the Core Zone Boundary and Columbia River nearshore.

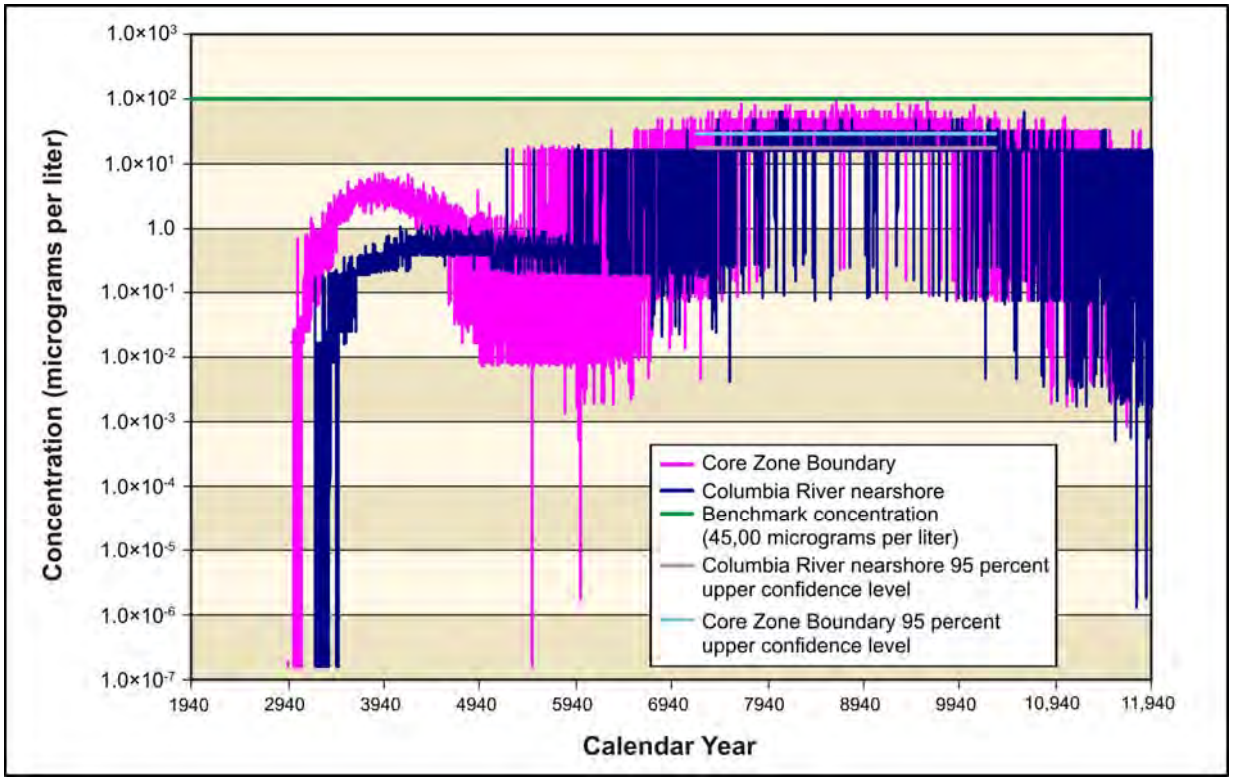


Figure 5–875. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chromium Concentration Versus Time

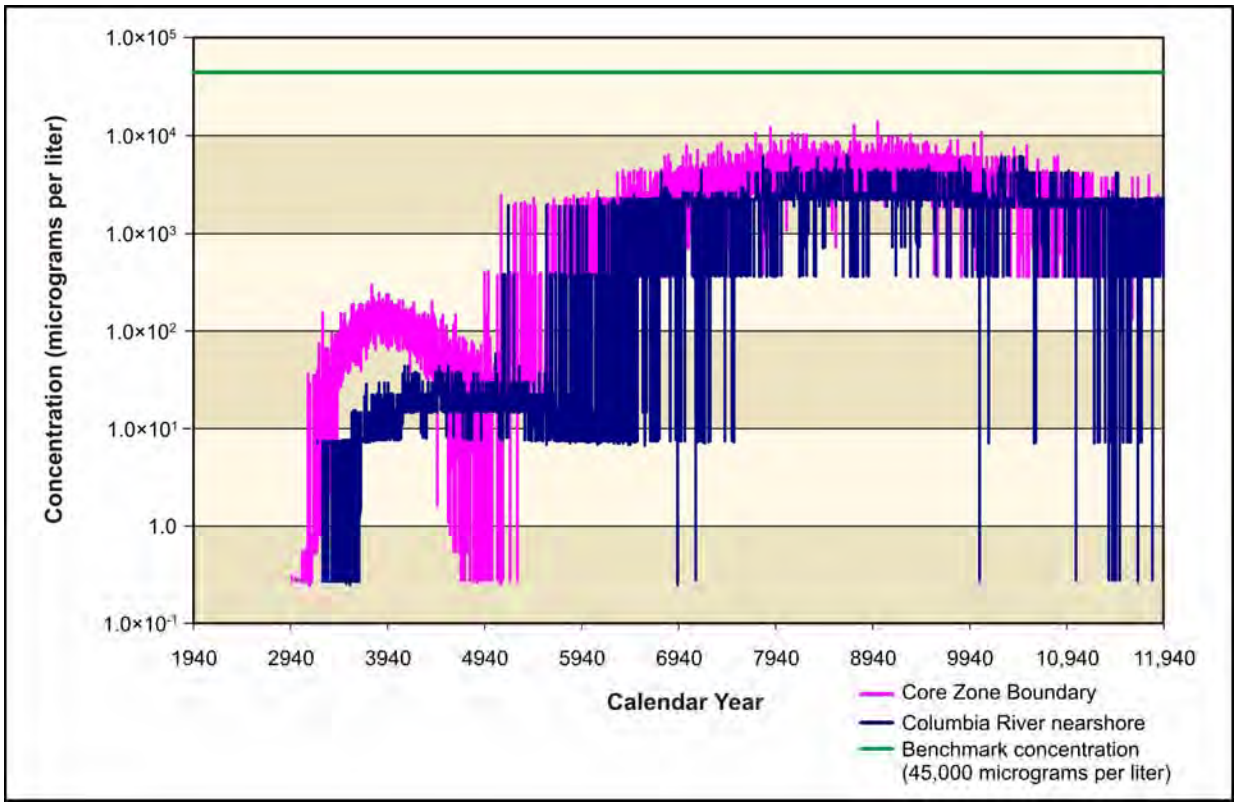


Figure 5–876. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Nitrate Concentration Versus Time

Figures 5–877 and 5–878 show concentration versus time for uranium-238 and total uranium, respectively. Because uranium-238 and total uranium move slowly through the vadose zone, releases from IDF-East, IDF-West, and the RPPDF result in groundwater concentrations at the Core Zone Boundary and the Columbia River nearshore that are always significantly lower than the benchmark concentrations. Toward the latter half of the period of analysis, both the uranium-238 (see Figure 5–877) and total uranium (see Figure 5–878) concentrations at the Core Zone Boundary and Columbia River nearshore increase. The Core Zone Boundary uranium-238 is at least two orders of magnitude less than the benchmark concentration at the end of the period of analysis (CY 11,940). The concentration at the Columbia River nearshore is even smaller (by about six orders of magnitude). The total uranium concentration at the Core Zone Boundary and the Columbia River nearshore shows a similar response, but the maximum levels of total uranium are always at least six orders of magnitude less than the total uranium benchmark concentration.

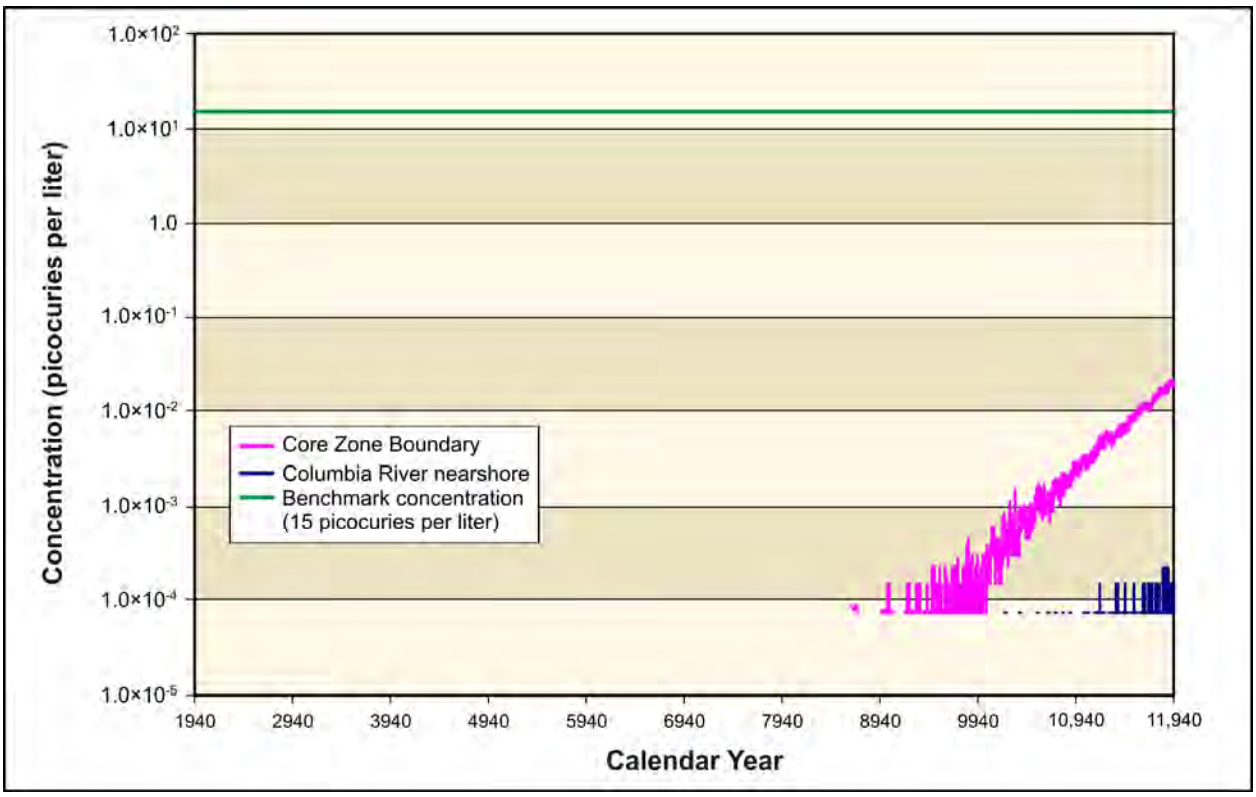


Figure 5–877. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Uranium-238 Concentration Versus Time

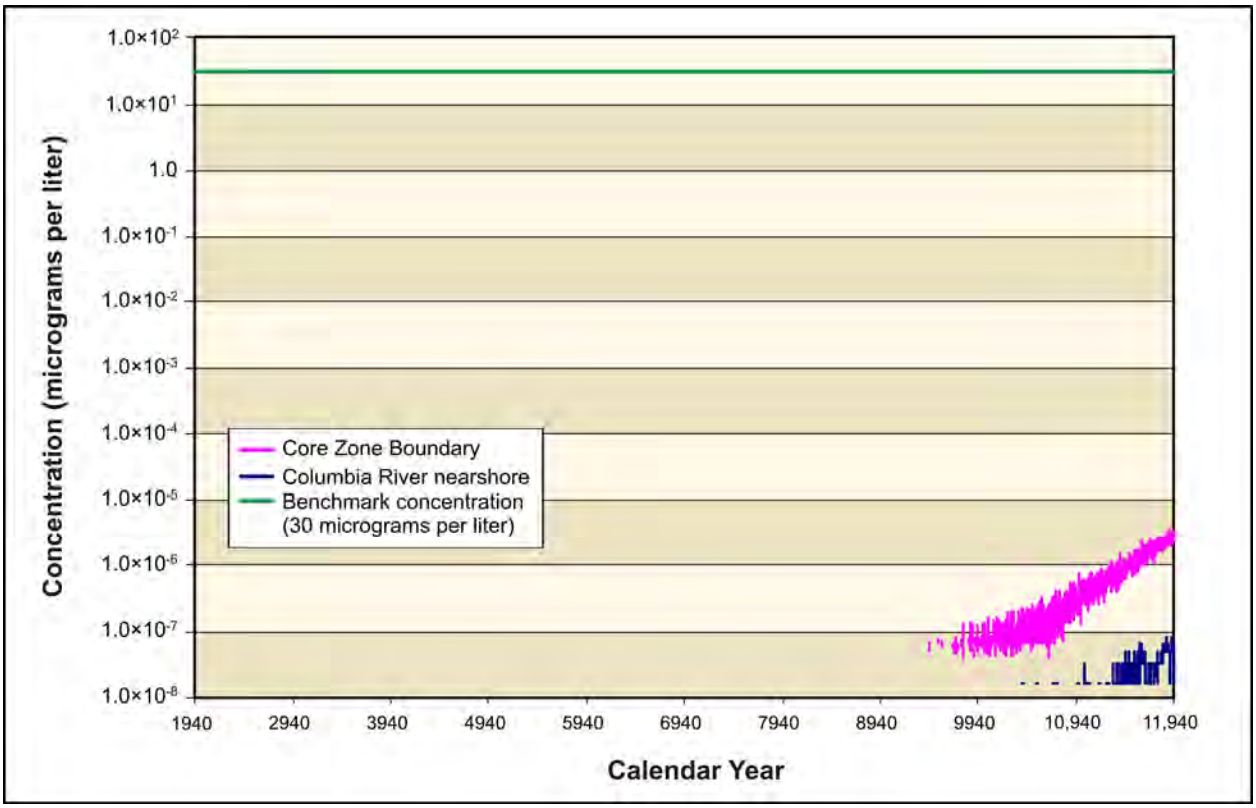


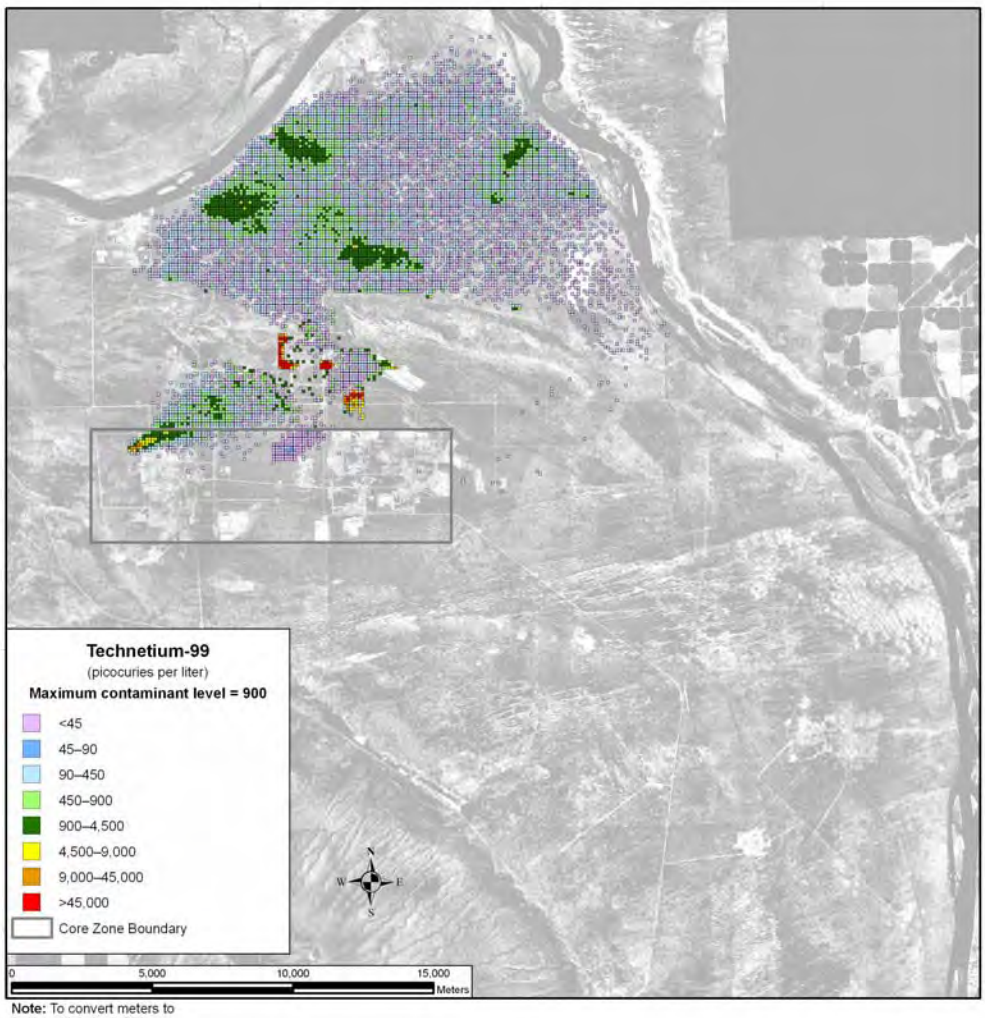
Figure 5–878. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

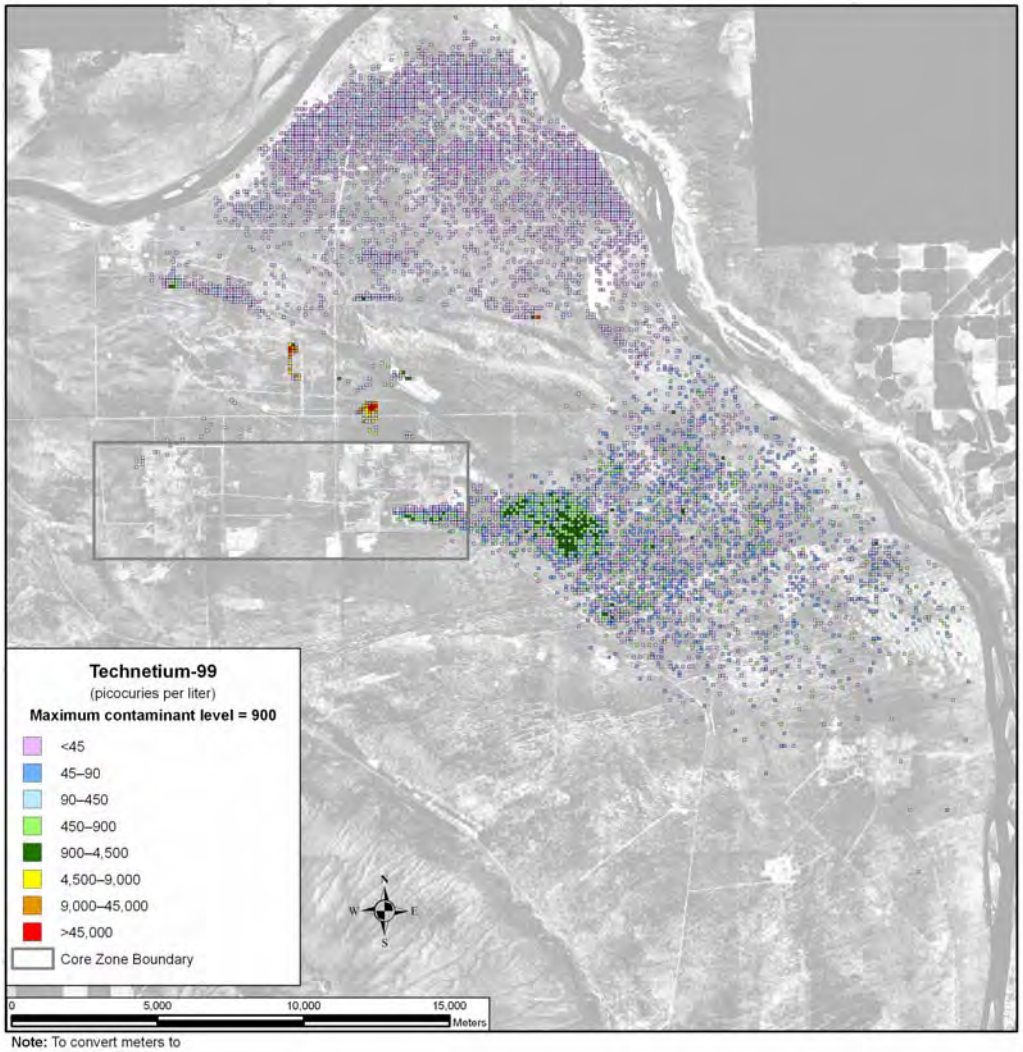
Figures 5–879 through 5–890 show concentration distributions at CYs 3890, 7140, and 11,885 for technetium-99, iodine-129, nitrate, and chromium. Figures 5–891 and 5–892 show the concentration distribution for uranium-238 and total uranium at CY 11,885. These data show the groundwater releases from the RPPDF and IFD-West that extend north from within the Core Zone to the Columbia River. These concentration distributions show that the releases of technetium-99, iodine-129, nitrate, and chromium occur significantly earlier at the RPPDF and IDF-West than the same releases at IDF-East. The RPPDF and IDF-West releases remain in a fairly narrow channel (Gable Gap) until about halfway to the Columbia River nearshore. The releases then spread out over the northern tip area of Hanford. The IDF-East releases remained in a relatively narrow channel until they reached about the one-quarter distance point to the Columbia River, where the releases spread out and continued to the Columbia River nearshore.

Figure 5–879 shows the technetium-99 release from IDF-West and the RPPDF in CY 3890. This spatial distribution shows that the technetium-99 exceeds the benchmark concentration within the Core Zone (due to the IDF-West release) and in several areas close to the Columbia River nearshore. There are several small areas with very high concentrations of technetium-99 (several orders of magnitude larger than the benchmark concentration) just north of the Core Zone Boundary. Figure 5–880 shows that the technetium-99 release from IDF-West and the RPPDF has dissipated by CY 7140 and only exists in areas close to the Columbia River nearshore at concentrations at least one order of magnitude lower than the benchmark concentration. This figure also shows a technetium-99 release distribution from IDF-East. This shows significant areas where the technetium-99 approaches or exceeds the benchmark concentration. Figure 5–881 shows the continued dissipation of the IDF-West and RPPDF groundwater technetium-99 in CY 11,885. In contrast, in CY 11,885, the IDF-East technetium-99 distribution has continued to spread toward the Columbia River. At CY 11,885, significant areas exist where the technetium-99 concentrations from the IDF-East release still exceed the benchmark concentration; levels are at least one order of magnitude larger than the benchmark concentration in parts of these areas.



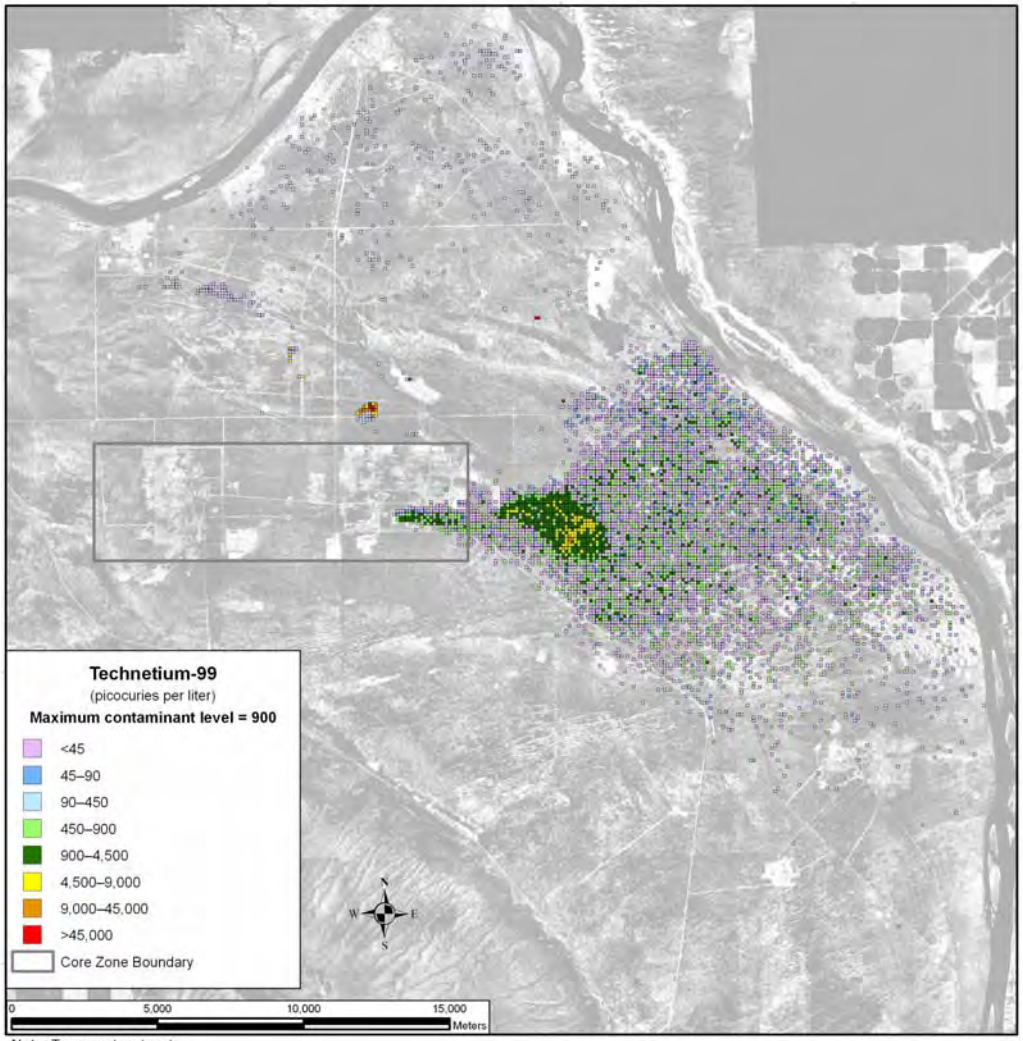
Note: To convert meters to feet, multiply by 3.281

Figure 5–879. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

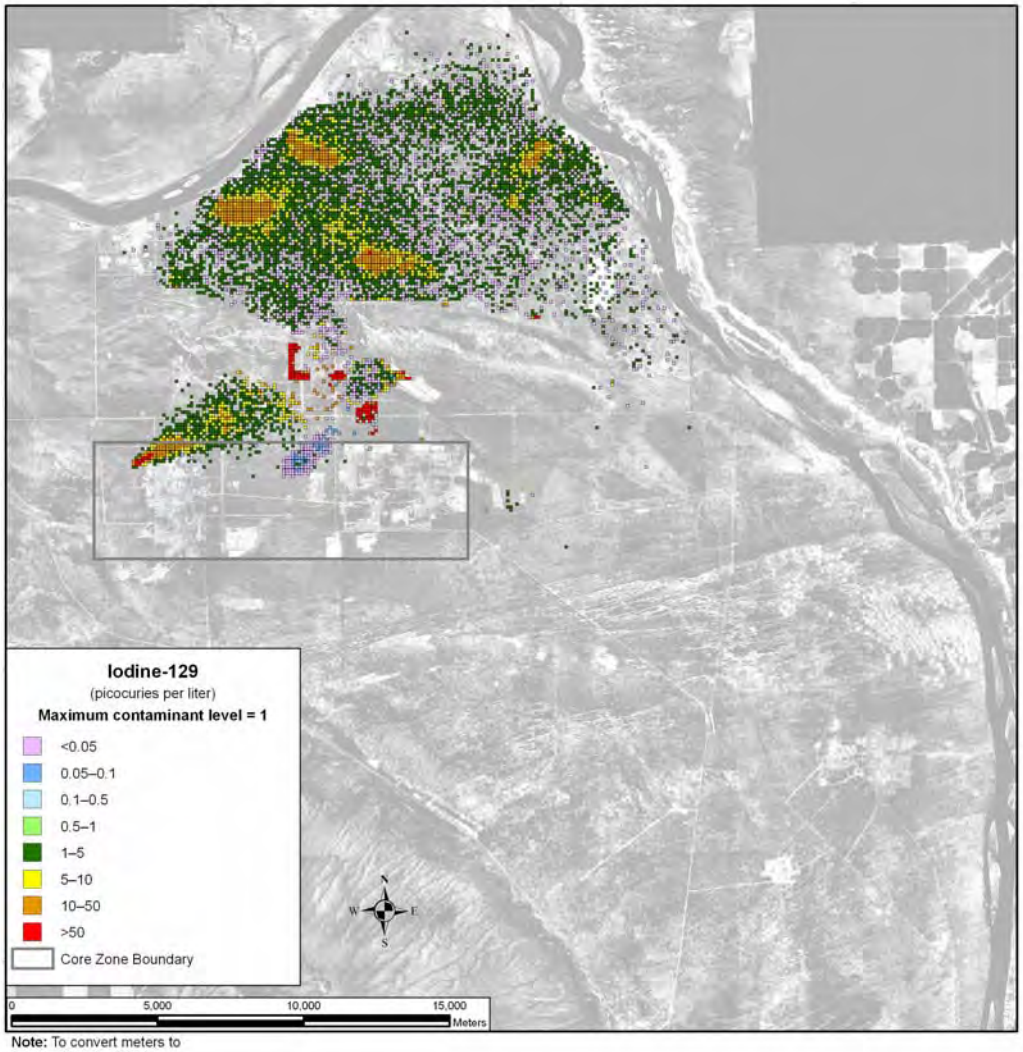
Figure 5–880. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

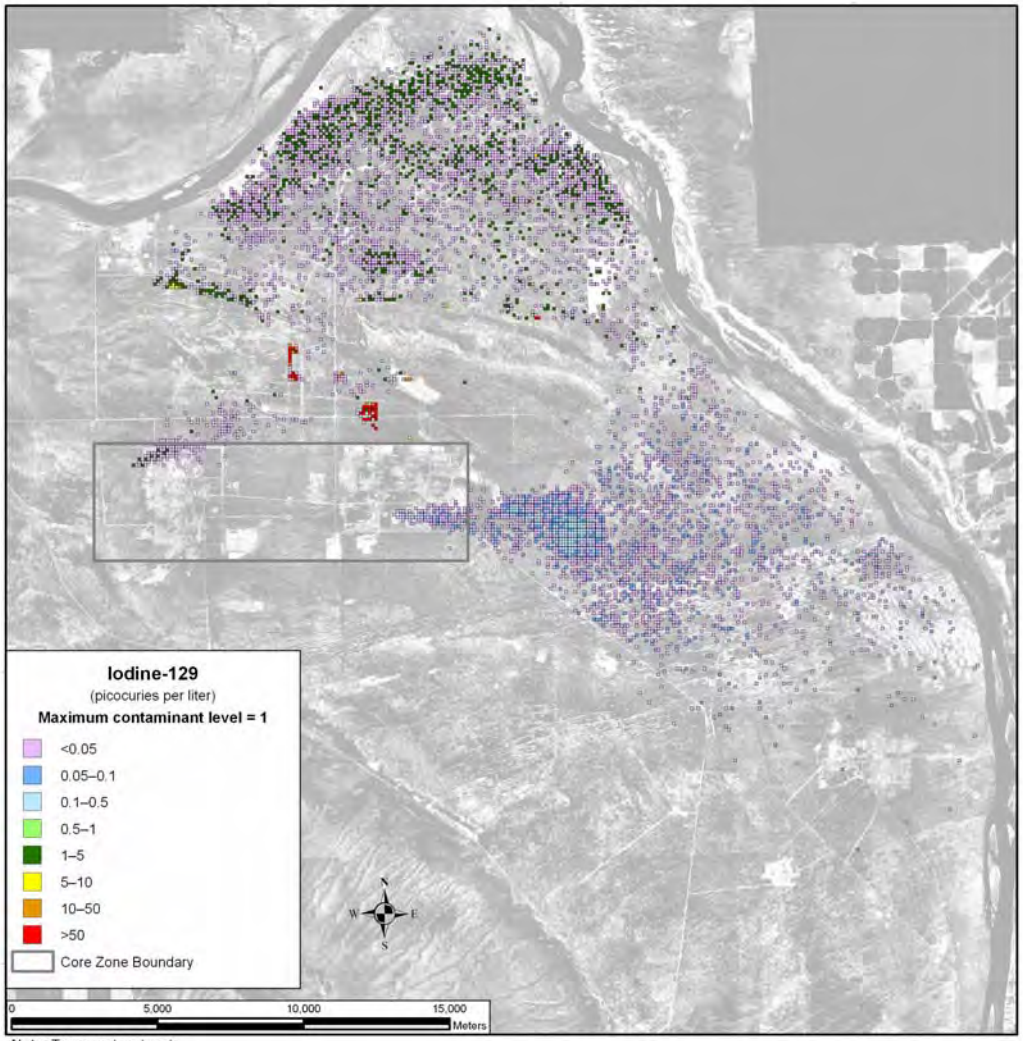
Figure 5–881. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

Figures 5–882 through 5–884 show iodine-129 released from IDF-East, IDF-West, and the RPPDF with a spatial distribution very similar to the technetium-99 release. However, the CY 3890 iodine-129 release (see Figure 5–882) shows higher relative concentrations (compared with the benchmark concentration) than the technetium-99 release. The areas of high concentrations are in the same locales, but these areas have levels that exceed the benchmark concentration by at least one order of magnitude. The iodine-129 released from IDF-West and the RPPDF has significantly dissipated by CY 7140 (see Figure 5–883). The IDF-West iodine-129 release shows less area in which concentrations are at or above the benchmark concentration than the technetium-99 release. The iodine-129 released from IDF-East in CY 11,885 (see Figure 5–884) shows the same relative spatial distribution as technetium-99, but the areas that approach or exceed the benchmark concentration are significantly smaller.



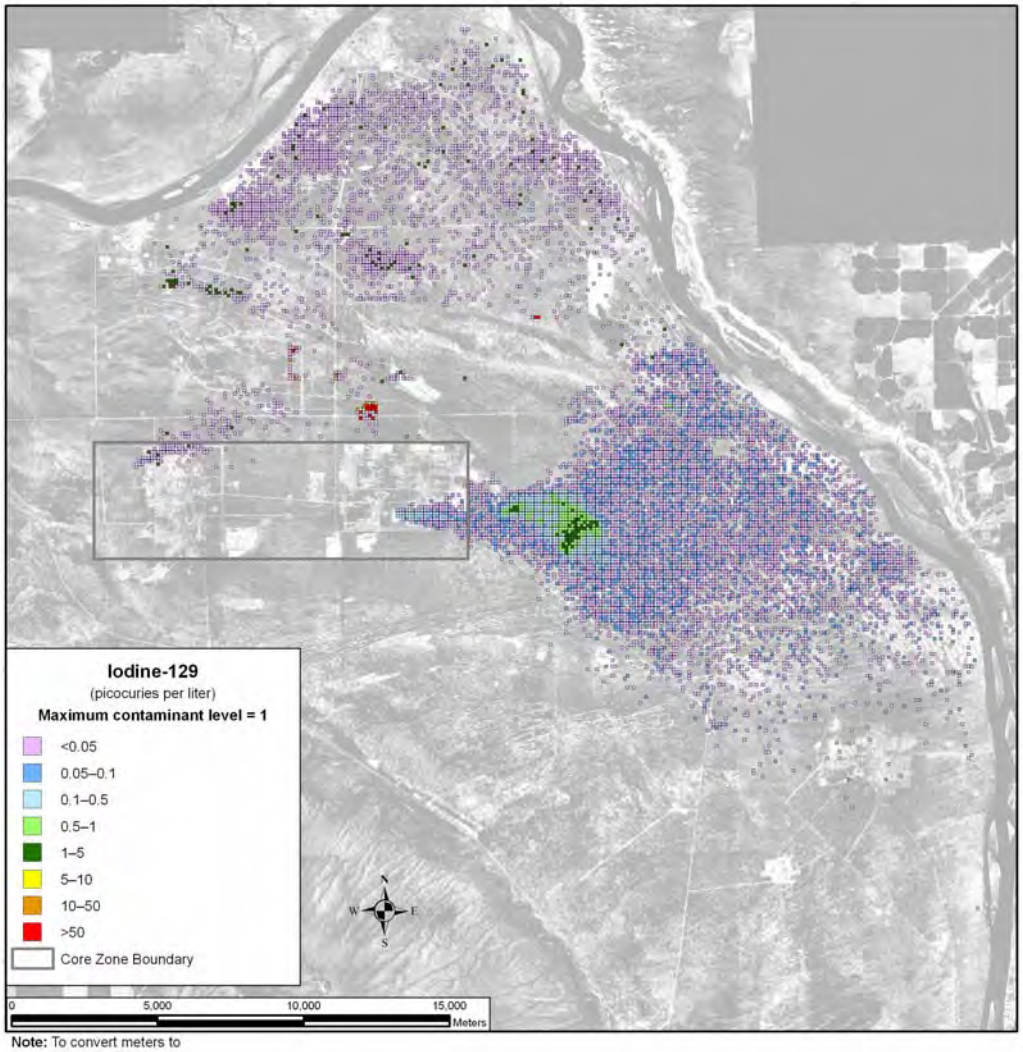
Note: To convert meters to feet, multiply by 3.281

Figure 5–882. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

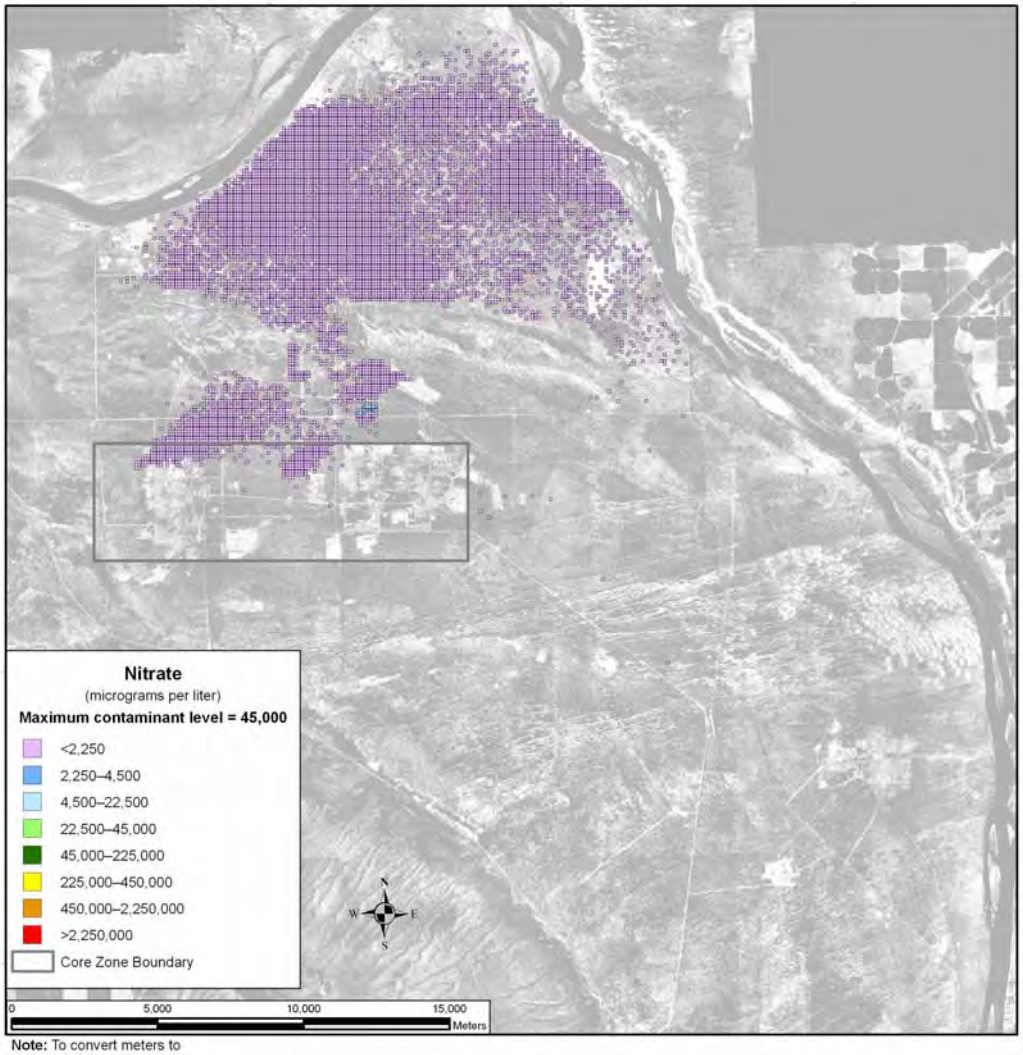
Figure 5–883. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

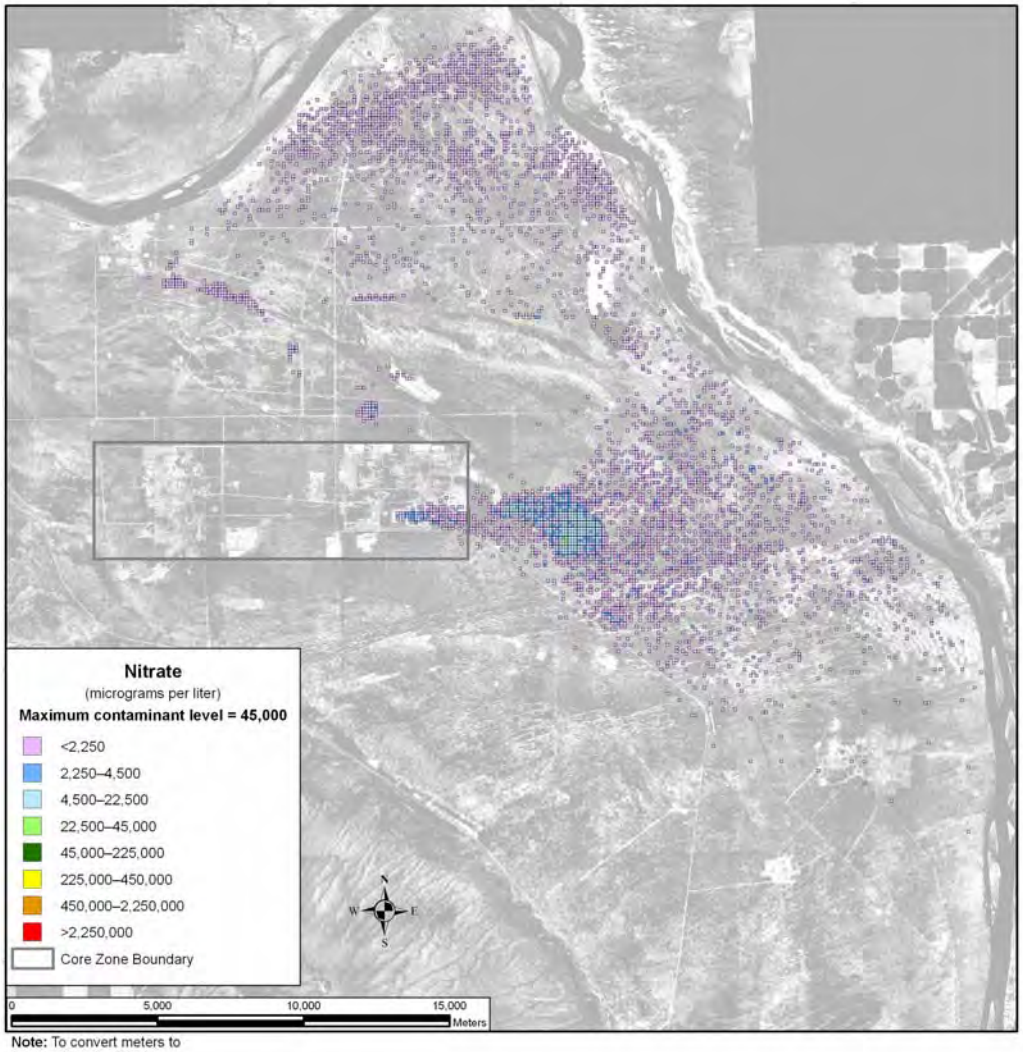
Figure 5–884. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

The IDF-East, IDF-West, and RPPDF nitrate releases, shown in Figures 5–885 through 5–887, show time and spatial distributions similar to the technetium-99 and iodine-129 releases. However, because the inventory of nitrate is lower than that of technetium-99 and iodine-129, concentrations of nitrate in these distributions are significantly less than the nitrate benchmark concentration. By CY 11,885, most of the groundwater nitrate has dissipated.



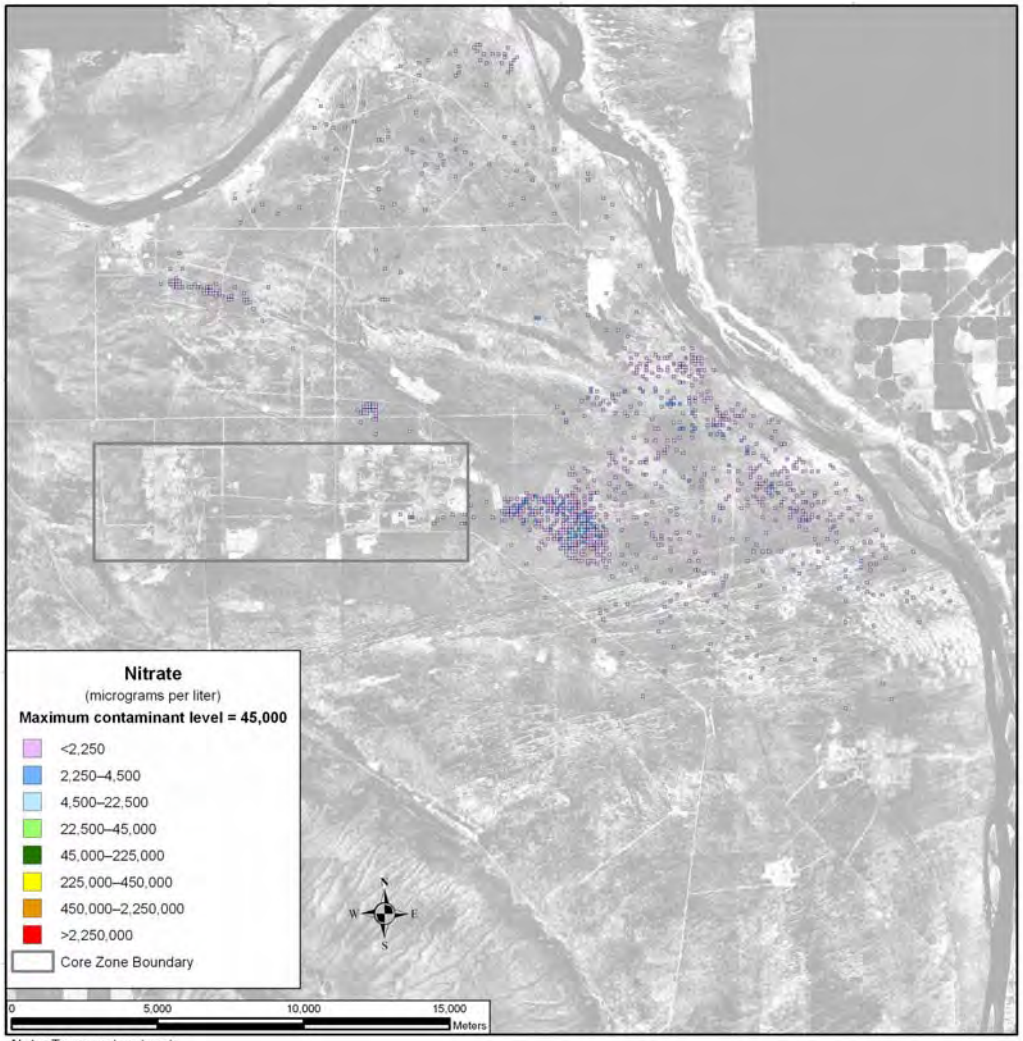
Note: To convert meters to feet, multiply by 3.281

Figure 5–885. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

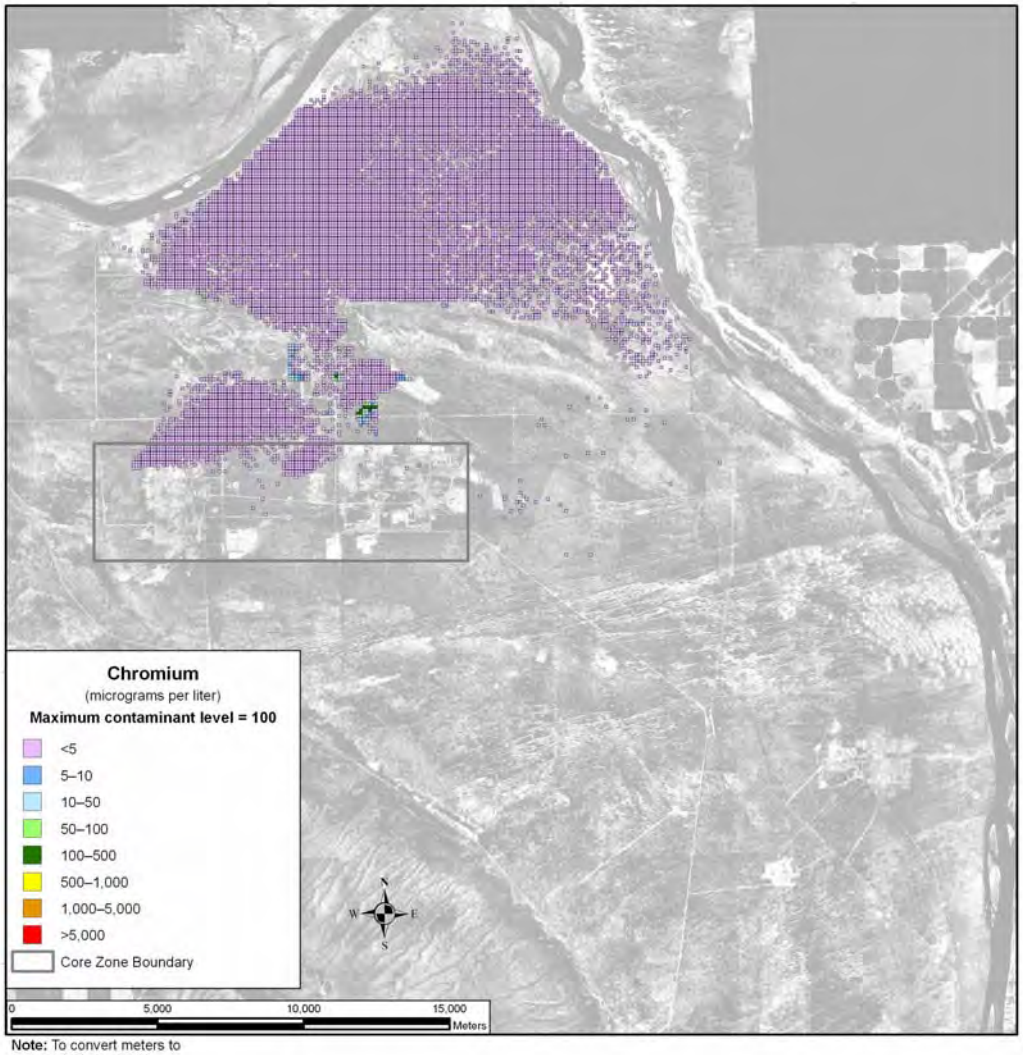
Figure 5–886. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

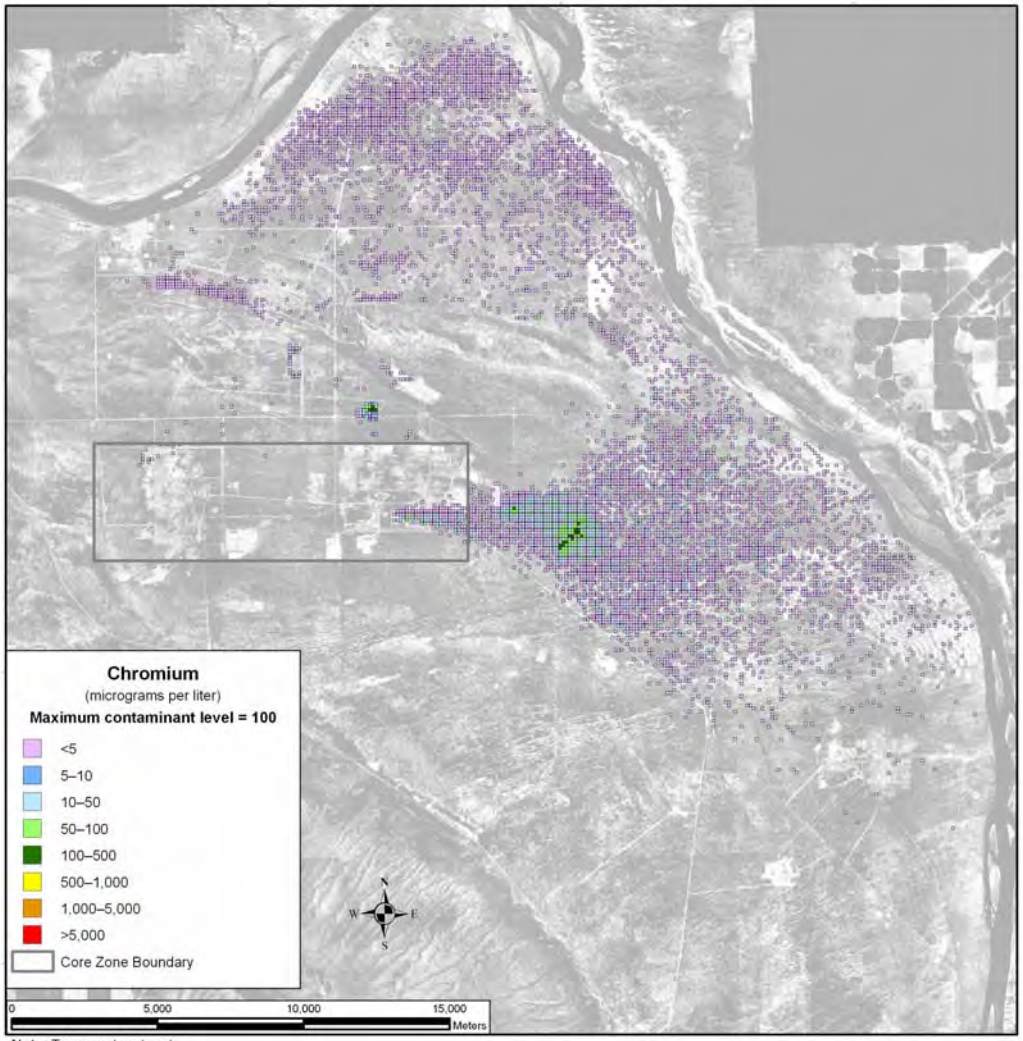
Figure 5–887. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

The initial chromium release time and spatial patterns in CY 3890 are nearly identical to the IDF-West and RPPDF nitrate releases (see Figure 5–888). There are several small areas where the chromium concentration approaches or exceeds its benchmark concentration. Most of the chromium released from IDF-West and the RPPDF has dissipated to the Columbia River by CY 7140 (see Figure 5–889). This also shows a significant chromium distribution from IDF-East with small areas that exceed benchmark concentrations. By CY 11,885 the IDF-West and RPPDF chromium is essentially dissipated (see Figure 5–890). However, there is a significant distribution of chromium that extends from the IDF-East release site to the Columbia River. Most of the distribution is well below benchmark concentrations.



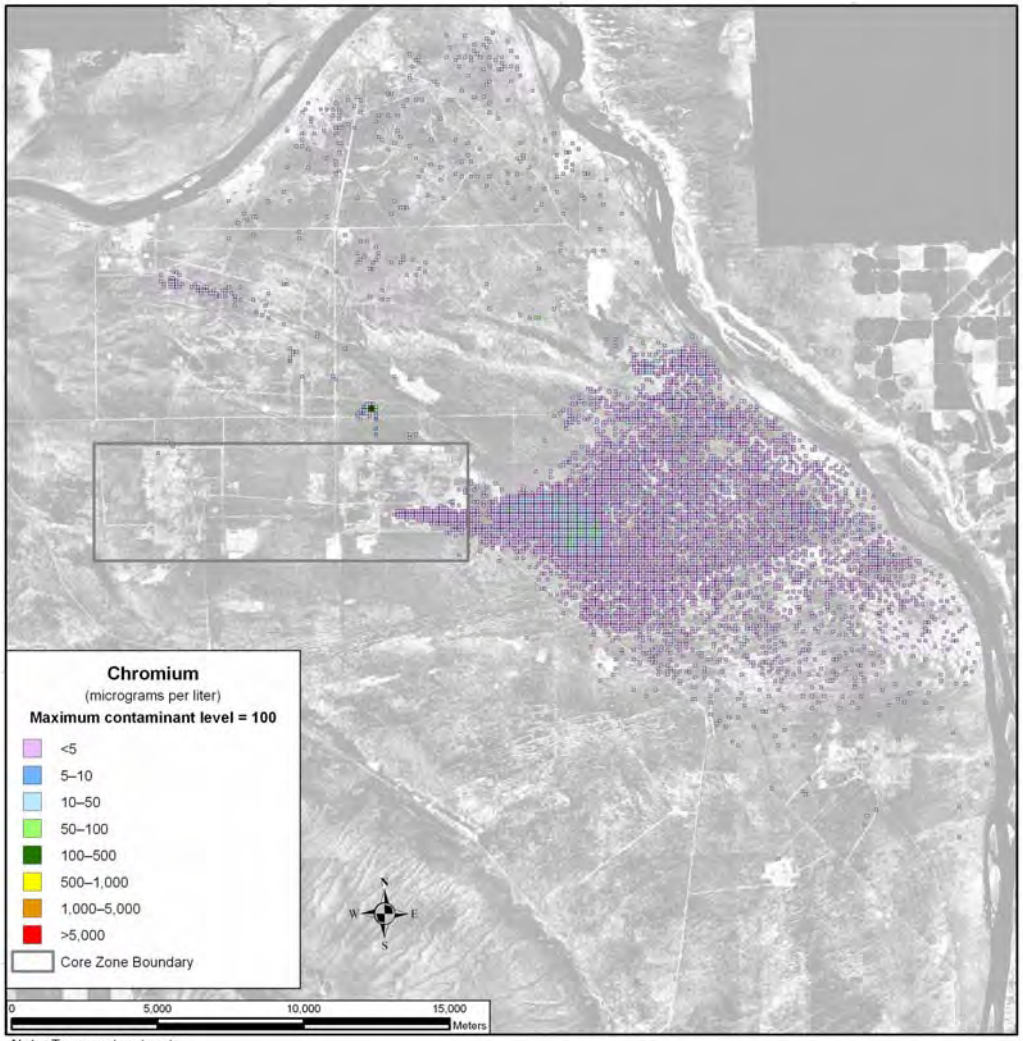
Note: To convert meters to feet, multiply by 3.281

Figure 5–888. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

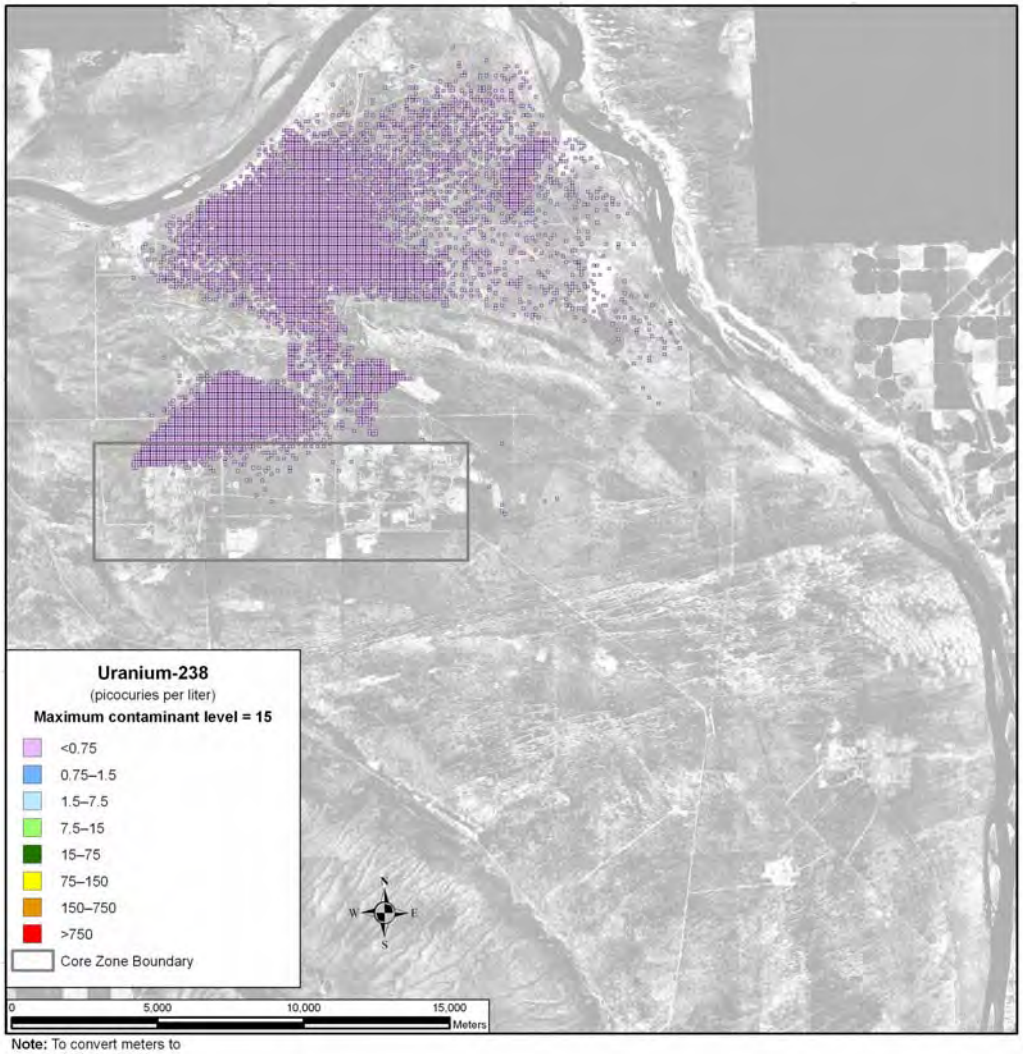
Figure 5–889. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

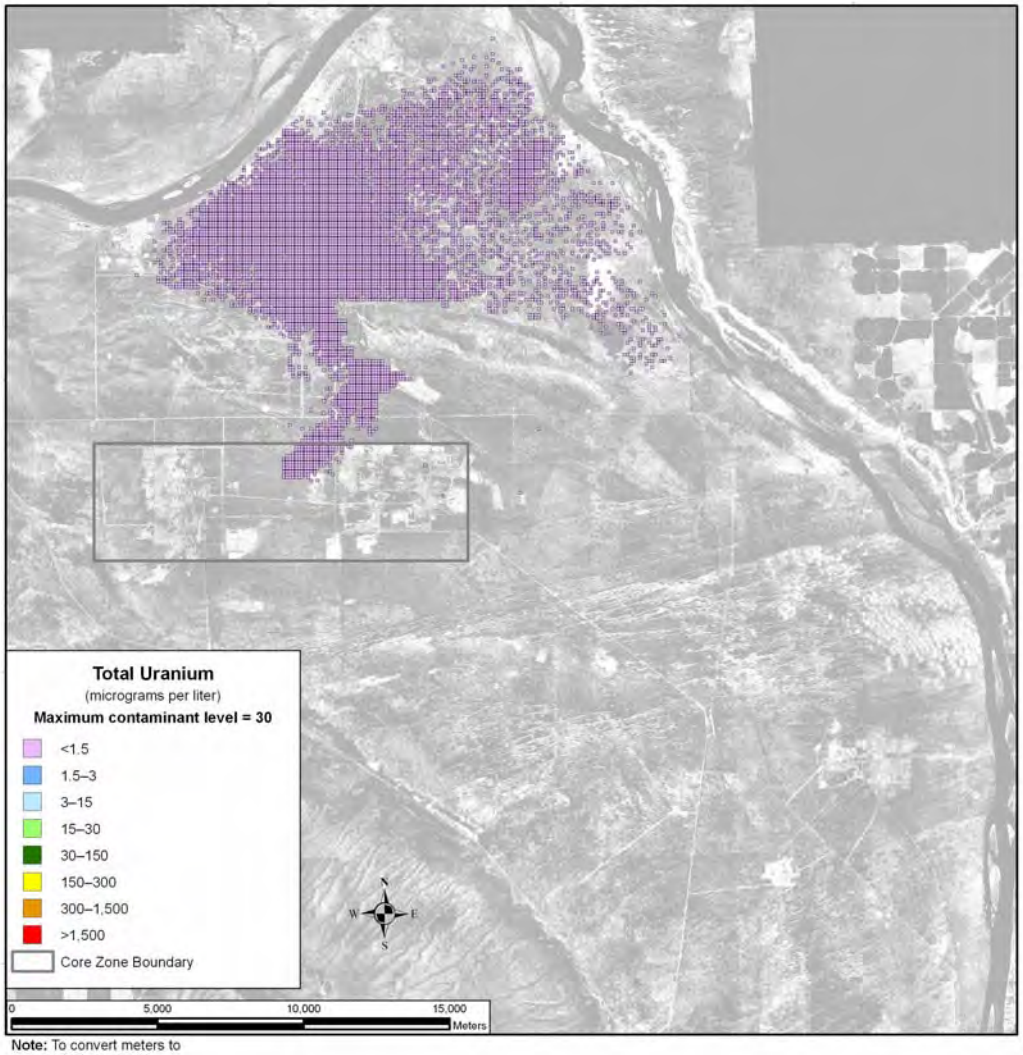
Figure 5–890. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

The uranium-238 and total uranium spatial distributions in Figures 5–891 and 5–892 (both CY 11,885) show a uranium-238 plume from IDF-West and a total uranium plume from the RPPDF. There are no uranium-238 or total uranium releases from IDF-East. The uranium-238 and total uranium concentrations in both releases remain well below their respective benchmark concentrations over the period of analysis. The data show uranium-238 and total uranium retardation with similar distributions and concentrations extending from the release sites to the Columbia River nearshore.



Note: To convert meters to feet, multiply by 3.281

Figure 5–891. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–892. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, in general, the inventories remaining at IDF-East, IDF-West, and the RPPDF, which are available for release to the environment at the start of the post-disposal period, are predominant contributors. The releases from IDF-West and the RPPDF occur earlier and dissipate earlier than releases from IDF-East.

By the end of this analysis period (CY 11,885), the chromium and nitrate distributions have largely dispersed below their benchmark concentrations. A significant spatial distribution of technetium-99 and iodine-129 remain. Most of the distribution area has concentrations below benchmark levels, but there are some small areas in which technetium-99 and iodine-129 concentrations exceed benchmark levels at CY 11,885. The released iodine-129, which occurs at higher concentration levels relative to its benchmark than technetium-99, dissipates much more quickly than technetium-99.

Uranium-238 and total uranium's relatively limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species do not exceed

their benchmark levels at the Core Zone Boundary or Columbia River nearshore over this period of analysis. However, the spatial distributions of both uranium-238 and total uranium exist through the end of the analysis period (CY 11,885). Although the concentrations of uranium-238 and total uranium are both two orders of magnitude smaller than either benchmark concentration during this analysis period, the trend appears to show a continuing increase through the end of the analysis period.

5.3.1.3.1.6 Disposal Group 1, Subgroup 1-F

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F covers disposal of waste generated under Tank Closure Alternative 5 and FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Tank closure waste would be converted to IHLW, ILAW glass, bulk vitrification glass, cast stone waste, and sulfate grout.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and IDF-West and continue through CY 2050, when the disposal facilities would be operationally closed. During the disposal period, the materials in these permitted, operational facilities would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2051 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East and IDF-West would become available for release to the environment. For the purpose of analyzing long-term groundwater impacts, IDF-East and IDF-West are assumed to be covered by a barrier that limits infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F. Full results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, nitrate, and acetonitrile.

The COPC drivers for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, nitrite, and acetonitrile) are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone

Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F (IDF-East, and IDF-West releases), in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies, chemicals in kilograms. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–893 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–894, the chemical hazard drivers. The inventories in the seven waste forms are a major factor in the release quantities to the vadose zone. Cast stone waste is the predominant vadose zone source for technetium (83 percent), with the remainder coming largely from bulk vitrification glass (12 percent) and some from tank closure secondary waste (4 percent) and ETF-generated secondary waste (1 percent). The vadose zone iodine-129 is from the ETF-generated secondary waste (90 percent) and cast stone waste (7 percent) with some from tank closure secondary waste (3 percent). Sulfate grout is the predominant vadose zone source of chromium (78 percent) with some from cast stone (22 percent). Acetonitrile (greater than 99 percent) is from cast stone waste. The nitrate is from ETF-generated secondary waste (57 percent) and cast stone waste (43 percent). No boron or fluoride is released from IDF-East.

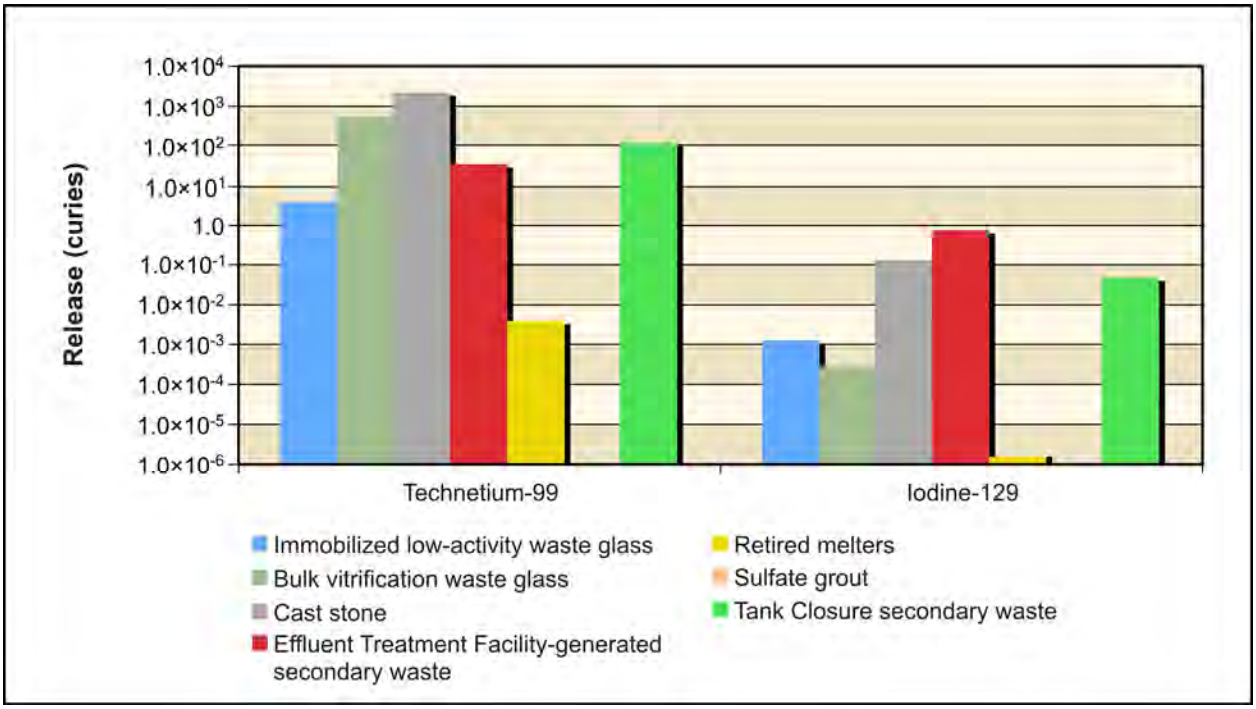


Figure 5–893. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

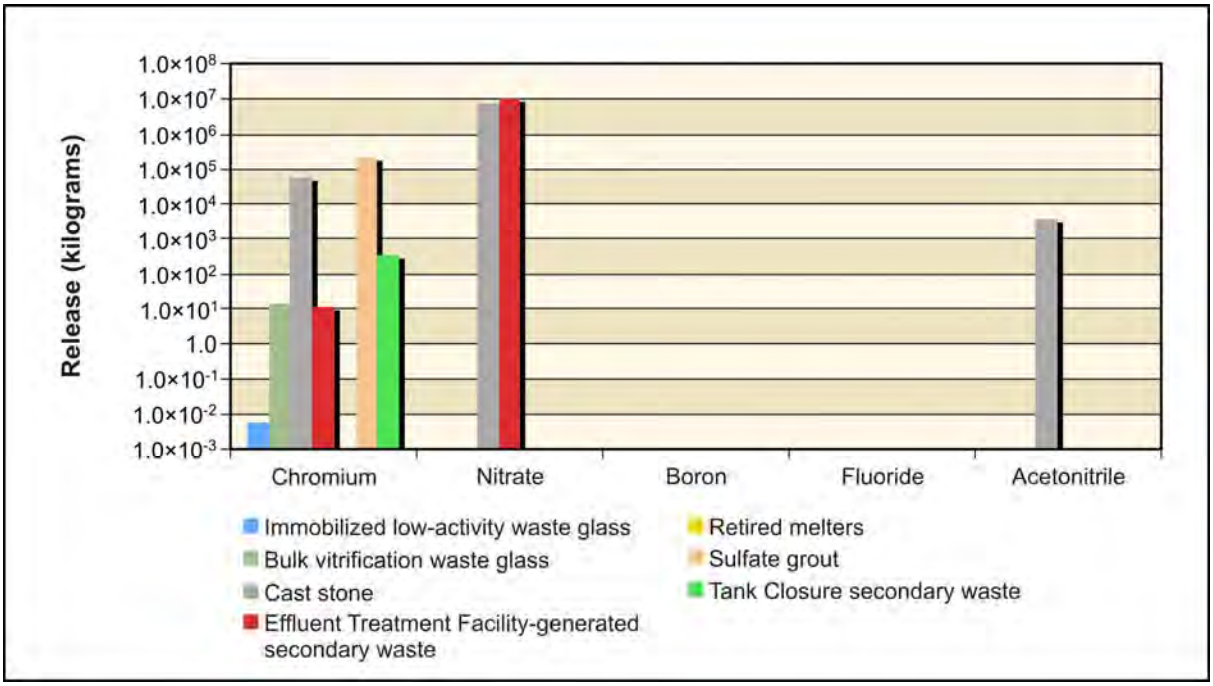


Figure 5–894. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–895 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–896, the chemical hazard drivers. In addition to the waste form inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. The vadose zone releases some technetium-99 (50 percent) and iodine-129 (43 percent) to the groundwater. Nearly all (99 percent) of the vadose zone chromium, nitrate, and acetonitrile are released to the groundwater.

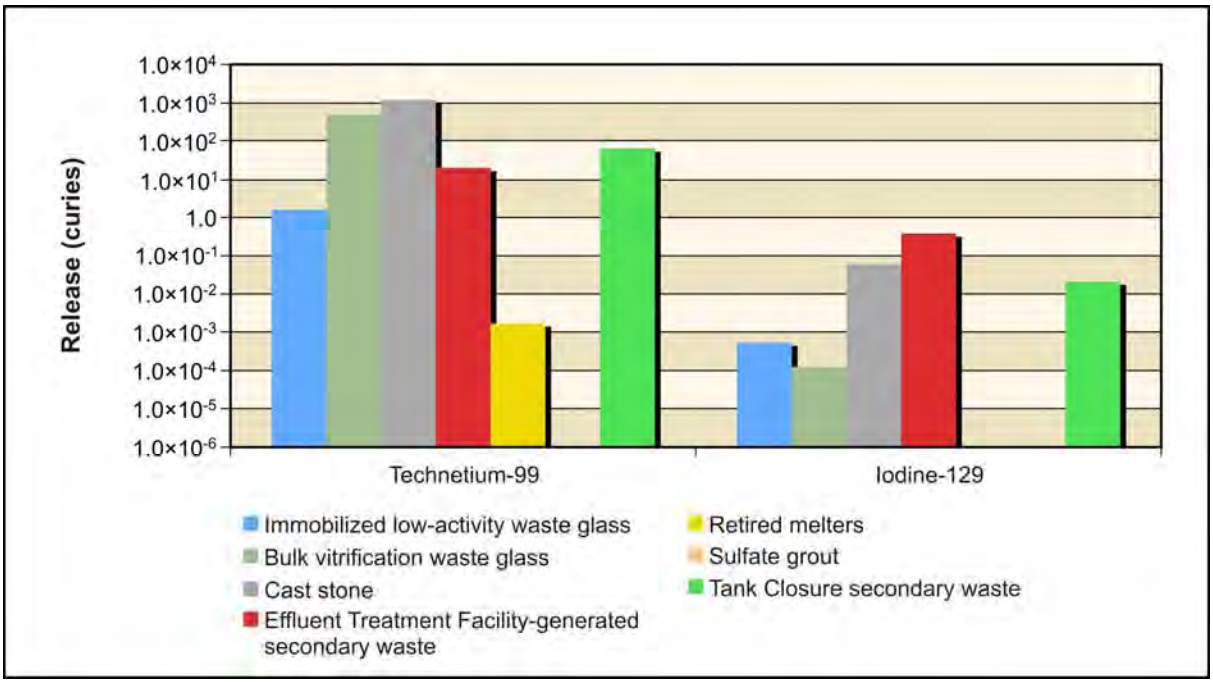


Figure 5–895. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

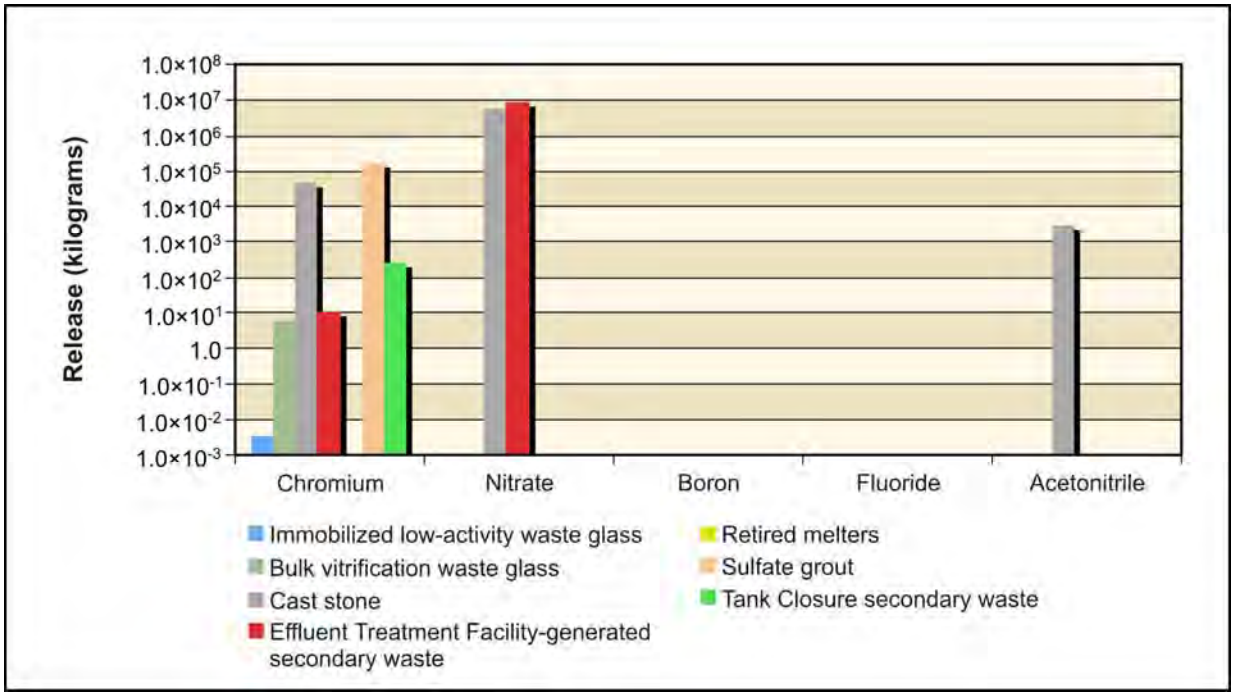


Figure 5–896. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–897 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–898, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. The groundwater releases most of its technetium-99 (92 percent), iodine-129 (90 percent), chromium (96 percent), nitrate (97 percent), and acetonitrile (96 percent) to the Columbia River.

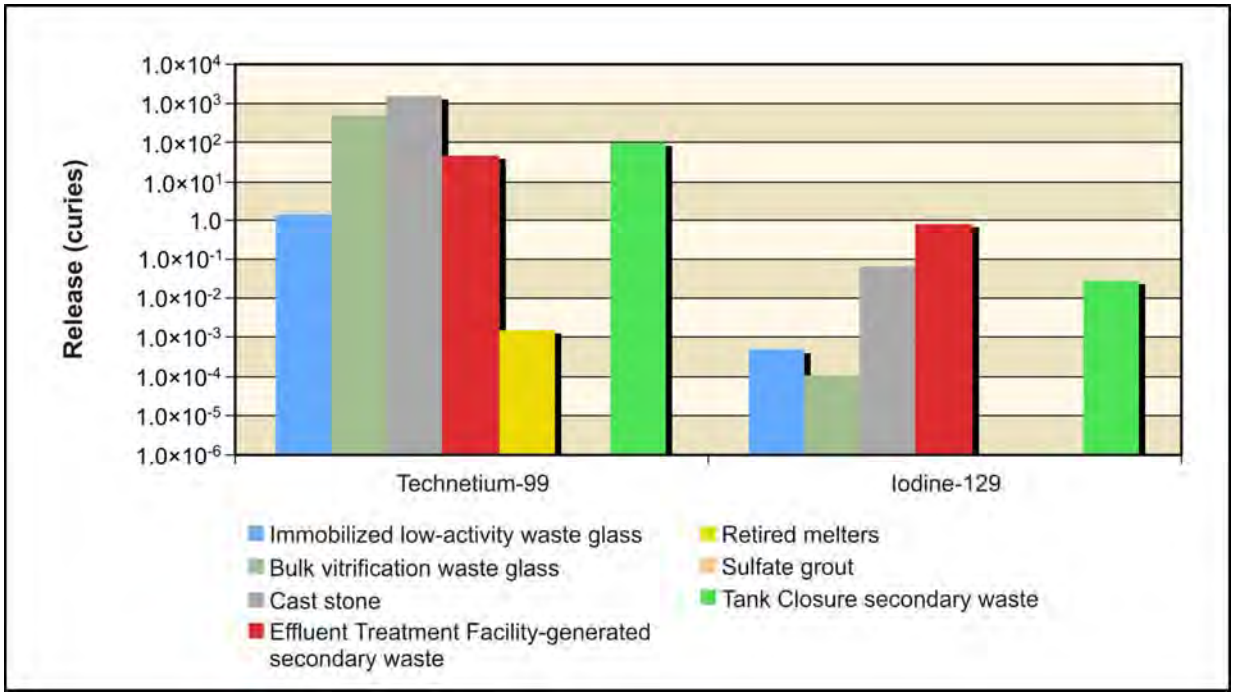


Figure 5–897. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

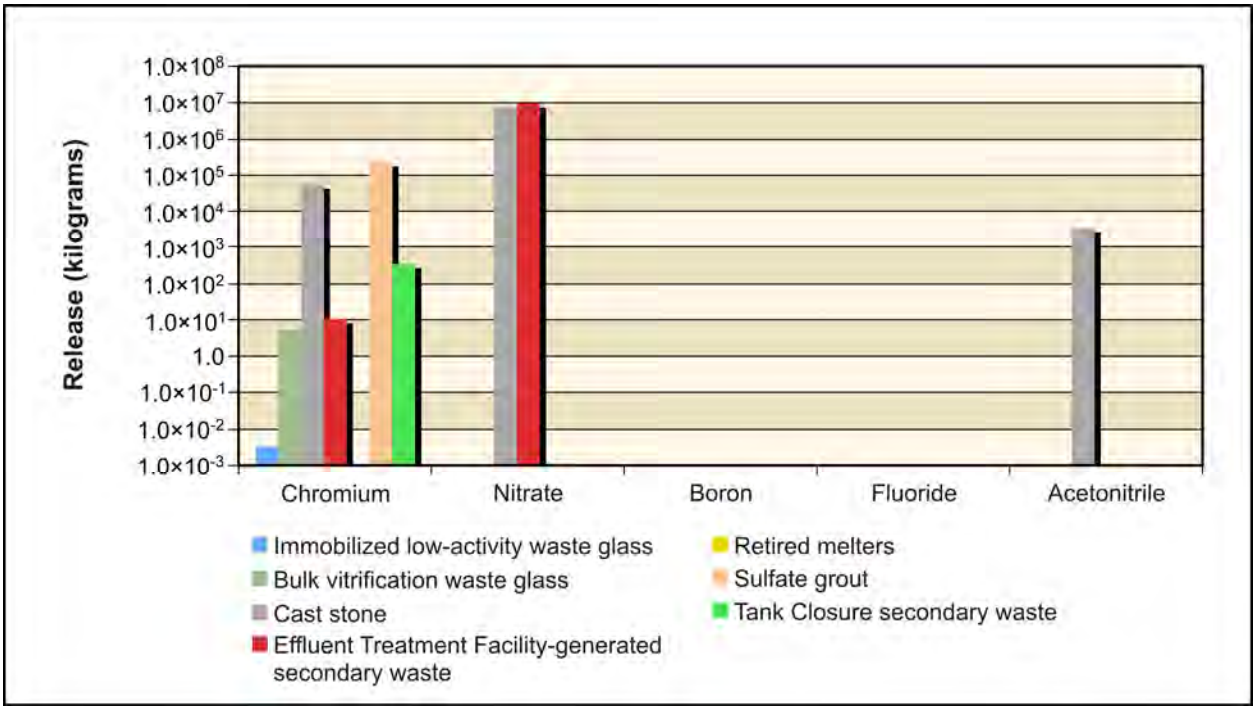


Figure 5–898. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

Overall, almost all of the IDF-East vadose zone chromium (96 percent), nitrate (97 percent), and acetonitrile (96 percent), as well as some of the vadose zone technetium-99 (46 percent) and iodine-129 (39 percent), reached the Columbia River over the period of analysis.

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases of FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste.

Figure 5–899 shows the estimated release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–900, the chemical hazard drivers. The inventories in the three waste forms are a major factor in the release quantities to the vadose zone. The predominant source of technetium-99 (greater than 99 percent) and iodine-129 (greater than 99 percent) released to the vadose zone is offsite-generated waste. Essentially all (greater than 99 percent) of the nitrate, boron, and fluoride that are released to the vadose zone are from waste management secondary and onsite-generated waste. The chromium released to the vadose zone is from waste management secondary and onsite-generated waste (66 percent) and offsite-generated waste (34 percent). No acetonitrile is released from IDF-West.

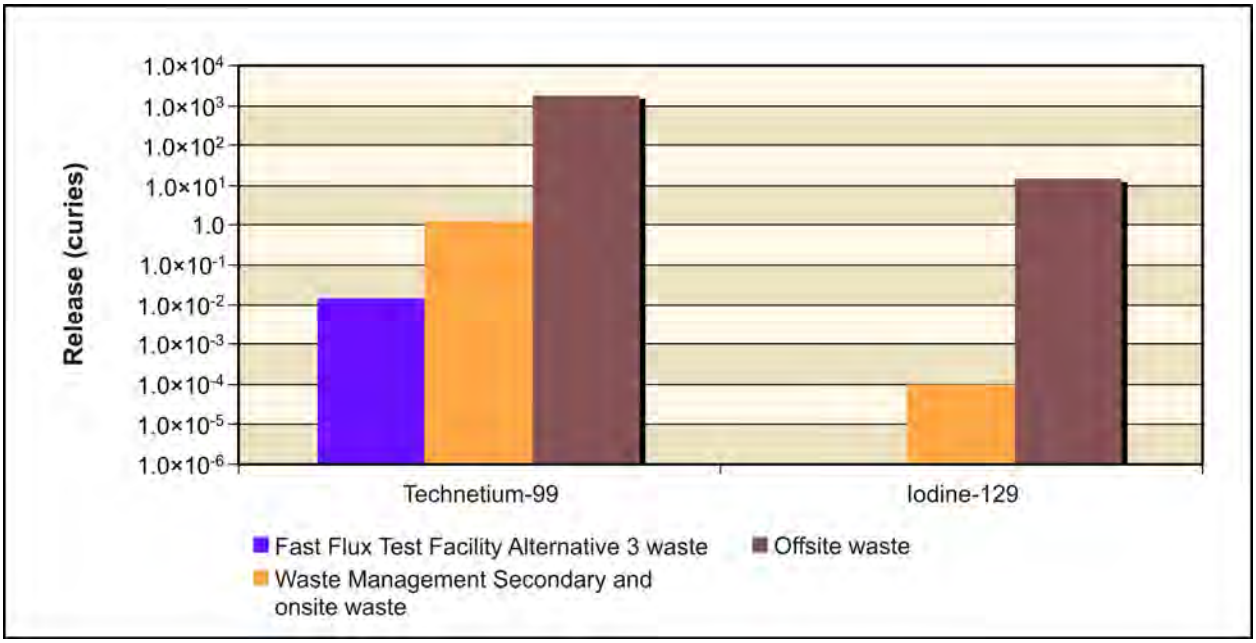


Figure 5–899. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

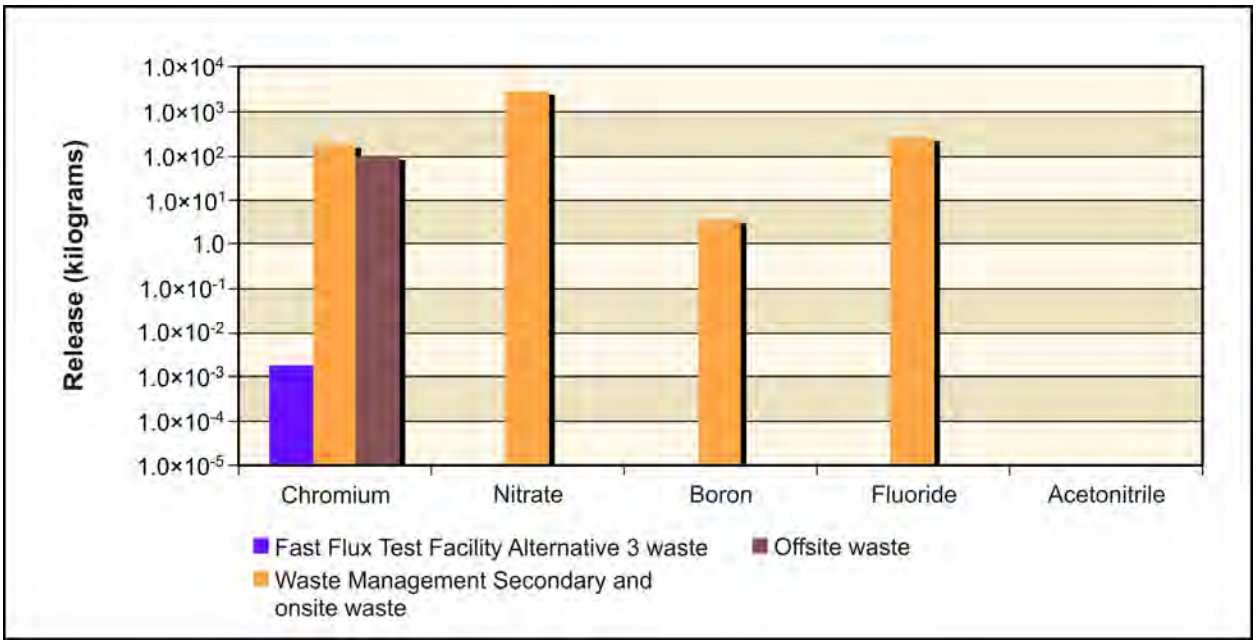


Figure 5–900. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–901 shows the estimated release at IDF-West to groundwater for the radiological risk drivers and Figure 5–902, the chemical hazard drivers. In addition to the waste form inventory, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Most of the IDF-West vadose zone technetium-99 (98 percent), iodine-129 (99 percent), chromium (99 percent), nitrate (greater than 99 percent), boron (greater than 99 percent), and fluoride (greater than 99 percent) are released to the groundwater during the period of analysis.

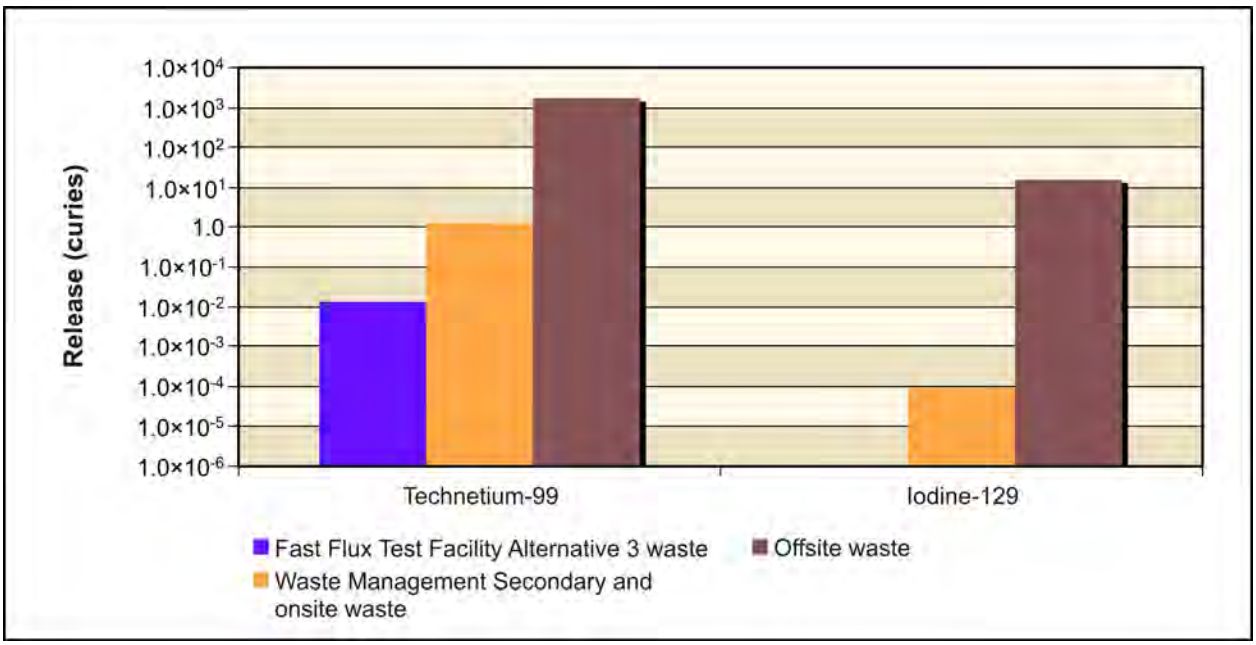


Figure 5–901. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

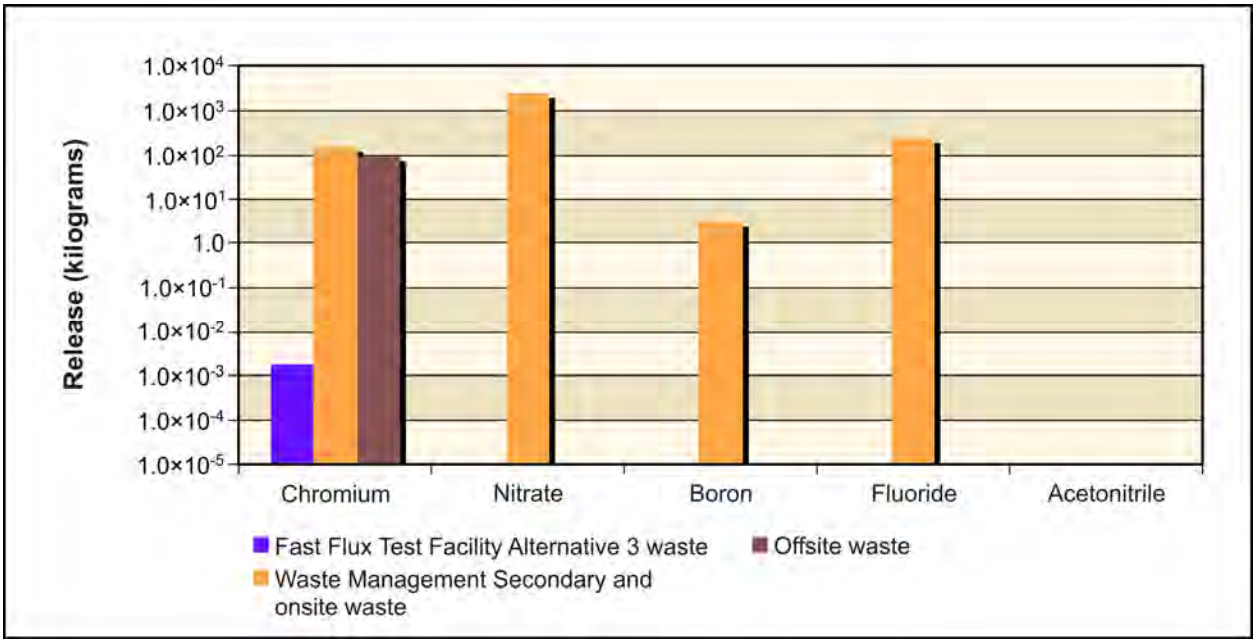


Figure 5–902. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–903 shows the estimated release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–904, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most (97–98 percent) of the IDF-West groundwater technetium-99, iodine-129, chromium, nitrate, boron, and fluoride are released to the Columbia River over the period of analysis.

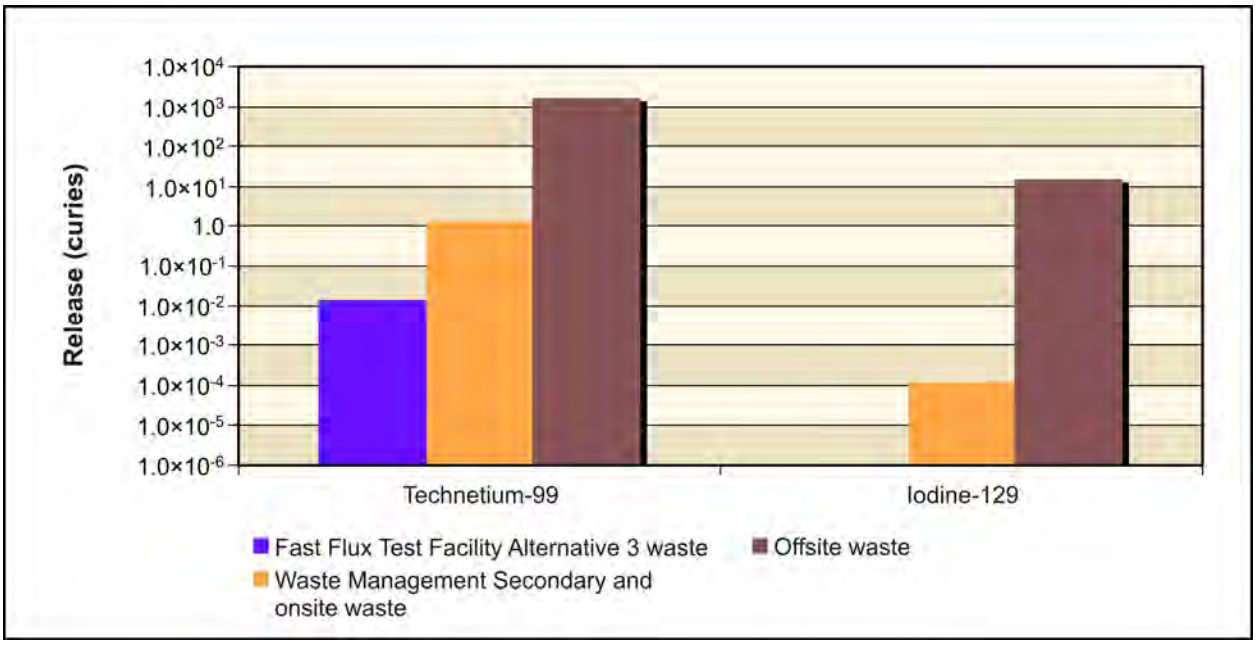


Figure 5–903. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

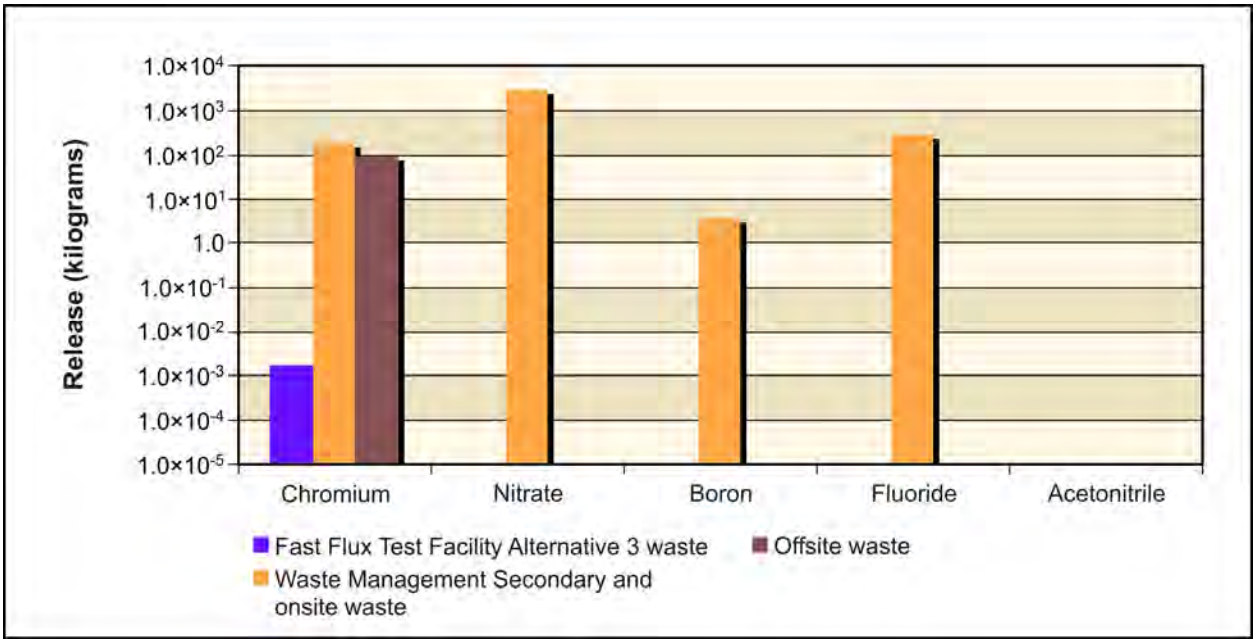


Figure 5–904. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

Overall, most (96–98 percent) of the IDF-West vadose zone technetium-99, iodine-129, chromium, nitrate, boron, and fluoride reached the Columbia River over the period of analysis.

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. Table 5–94 shows maximum concentrations in groundwater.

Table 5–94. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide picocuries per liter						
Technetium-99	**2,390**	**20,200**	N/A	**7,540**	**1,130**	900
	(9701)	(3713)		(3690)	(4528)	
Iodine-129	**1**	**173**	N/A	**60**	**8**	1
	(11,711)	(3797)		(3853)	(4729)	
Chemical in microgram per liter						
Acetonitrile	5	0	N/A	2	1	100
	(8475)	(1940)		(9519)	(8575)	
Chromium	**335**	2	N/A	**148**	**110**	100
	(8735)	(3696)		(8764)	(8819)	
Fluoride	0	1	N/A	1	0	4,000
	(1940)	(3684)		(3907)	(4555)	
Nitrate	21,400	17	N/A	7,420	4,560	45,000
	(8448)	(3703)		(8887)	(8787)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; N/A=not applicable; RPPDF=River Protection Project Disposal Facility.

Figures 5–905 through 5–908 show concentration versus time for technetium-99, iodine-129, chromium, and nitrate. Figure 5–905 shows that, at the onset of the releases from IDF-East and IDF-West, there is a technetium-99 release peak (lasting 1,000 years) at the Core Zone Boundary. The Core Zone Boundary technetium-99 concentration then decreases below the benchmark concentration to a level coincident with the Columbia River nearshore concentration. The Columbia River nearshore technetium-99 concentration never exceeds the benchmark concentration. Both the Core Zone Boundary and the Columbia River nearshore continue with concentrations below the benchmark level (within one order of magnitude) through the end of this analysis period (CY 11,940).

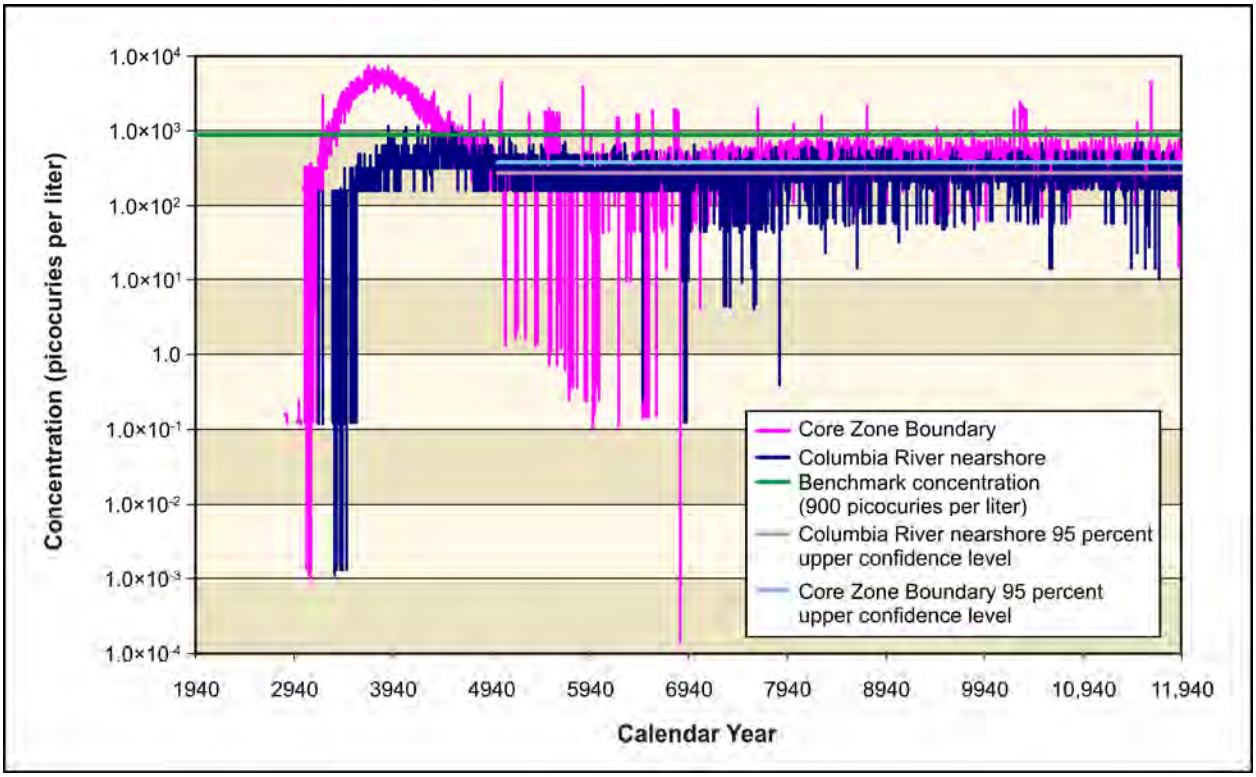


Figure 5–905. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Technetium-99 Concentration Versus Time

The Core Zone Boundary and the Columbia River nearshore both show similar concentration peaks at the onset of the iodine-129 release (see Figure 5–906). The Core Zone Boundary concentration peaks between one and two orders of magnitude above the benchmark concentration. The Columbia River nearshore concentration peaks just above the benchmark concentration, but below one order of magnitude. Both concentrations then continue on a slow decline that brings them nearly coincident with the benchmark concentration for the last half of the analysis period.

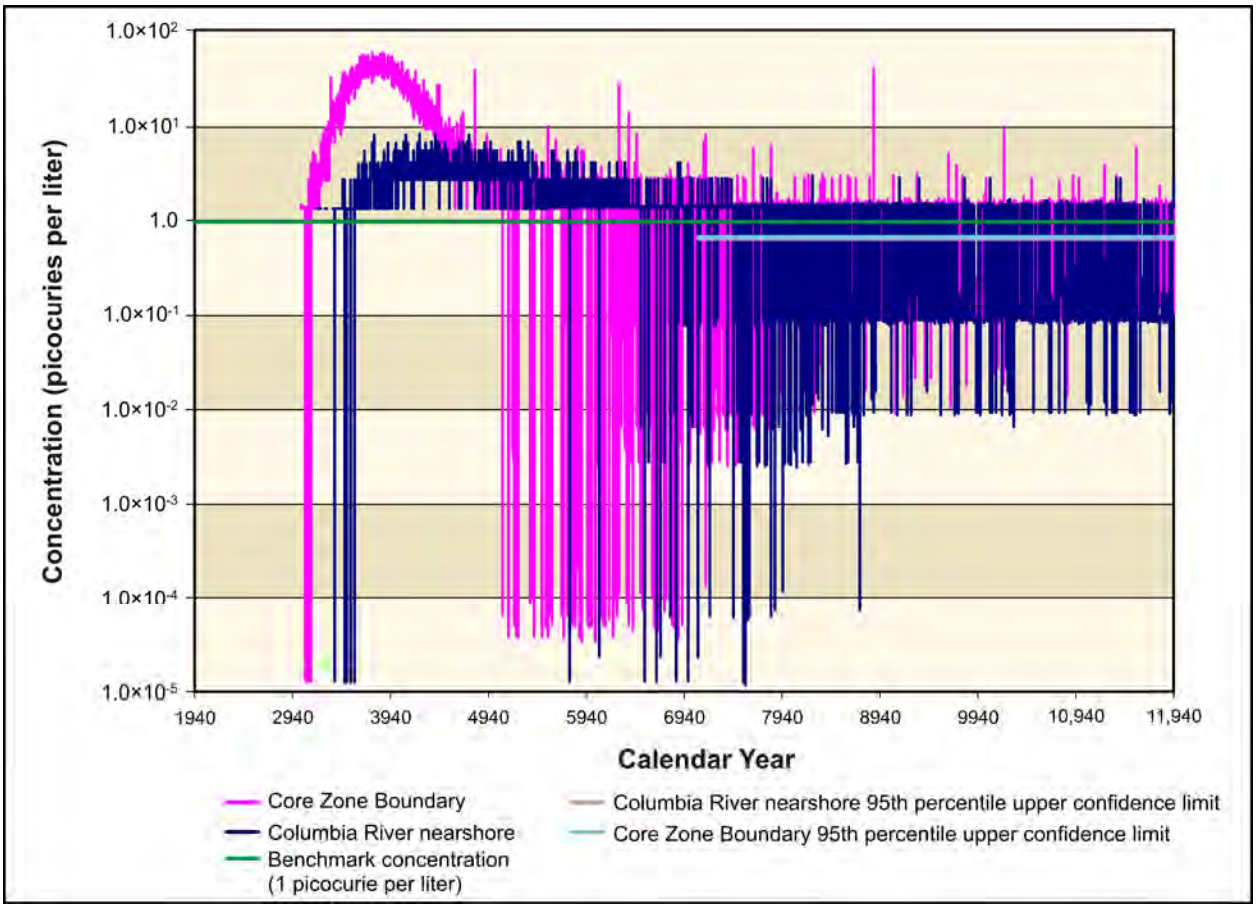


Figure 5–906. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Iodine-129 Concentration Versus Time

Figures 5–907 and 5–908 also show an initial increase in the Core Zone Boundary chromium and nitrate, followed by a second, broader increase that extends over about two-thirds of the analysis period. The nitrate concentrations are always less than one order of magnitude from the benchmark concentration. The chromium concentrations (at the Core Zone Boundary and Columbia River nearshore) approach within one order of magnitude of the benchmark concentration for most of the analysis period. Note that the actual time periods of exceedance associated with the peak values (listed in Table 5–94) are extremely limited and the 95th percentile upper confidence limit on chromium concentrations are within an order of magnitude below the benchmark concentrations.

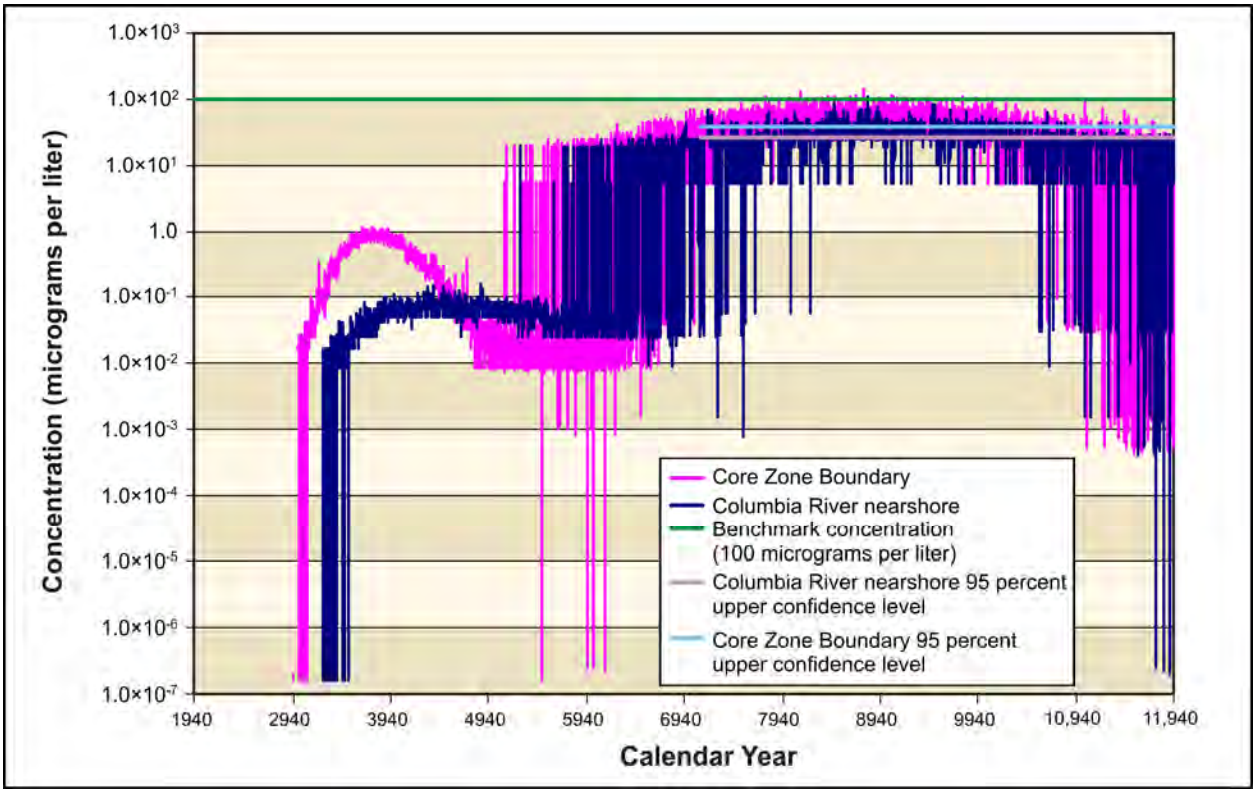


Figure 5–907. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chromium Concentration Versus Time

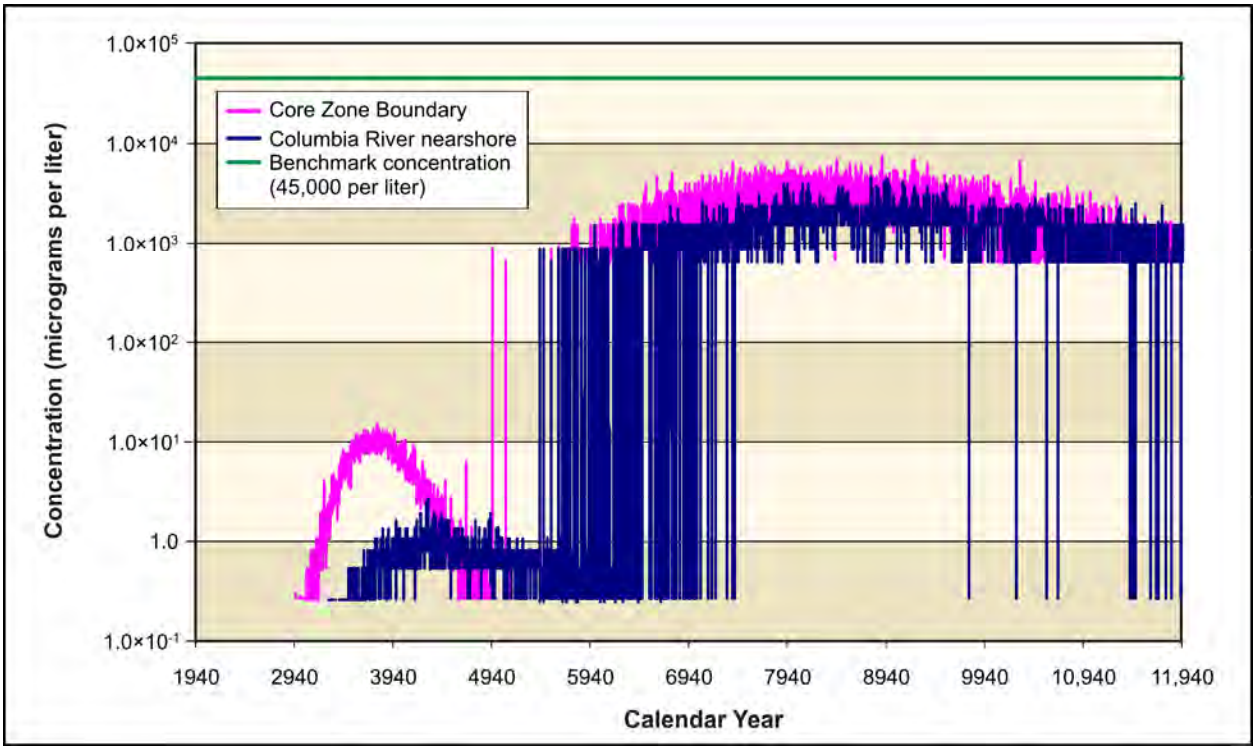


Figure 5–908. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Nitrate Concentration Versus Time

Figure 5–909 shows Core Zone Boundary and Columbia River nearshore concentrations versus time for uranium-238. There is no significant total uranium release. The data show that total uranium never approaches within nine orders of magnitude of the total uranium benchmark concentration. Figure 5–909 shows that, during the latter third of the analysis period, the uranium-238 concentrations at both the Core Zone Boundary and the Columbia River nearshore are increasing. The concentration at the Core Zone Boundary is at least three orders of magnitude below the benchmark concentration at the end of the analysis period. The concentration at the Columbia River nearshore is even smaller. The data do show that this uranium-238 rate of increase is significant and that it extends through the end of the analysis period (CY 11,885).

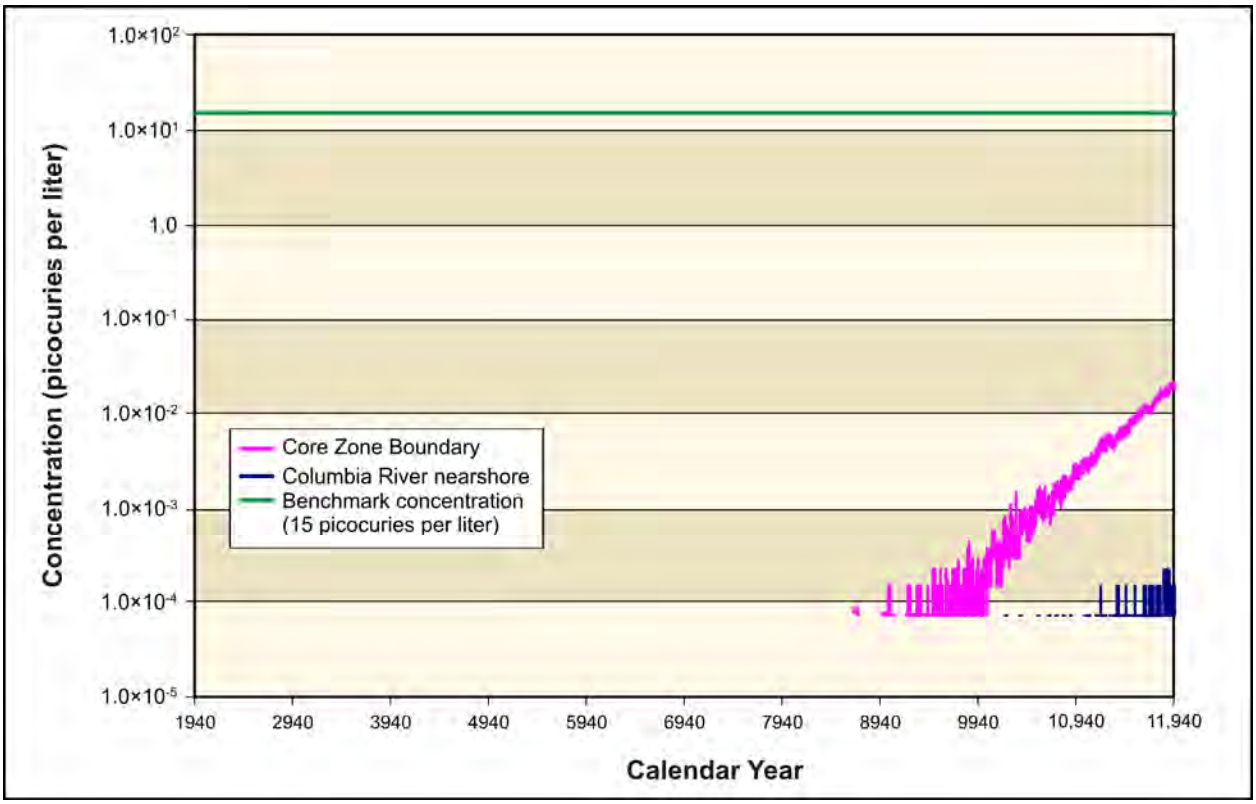


Figure 5–909. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Uranium-238 Concentration Versus Time

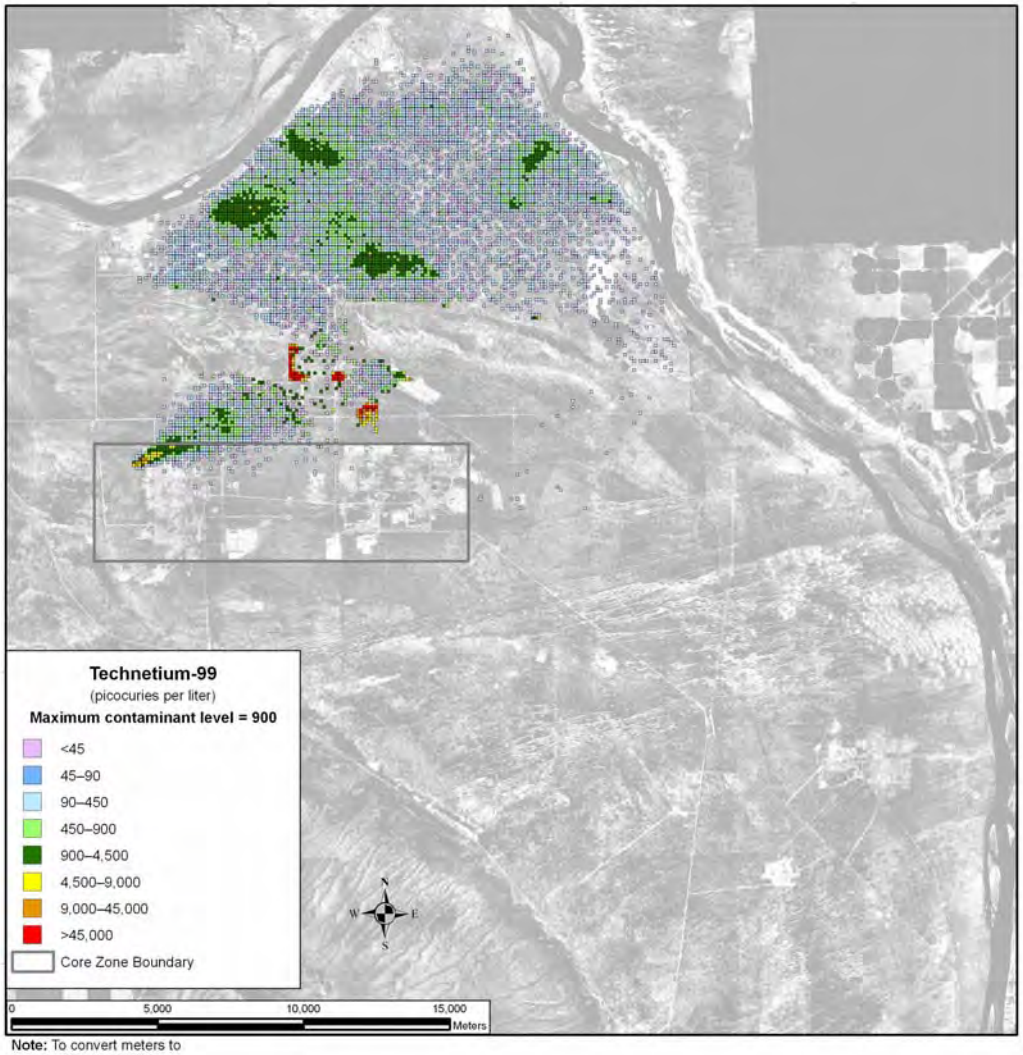
ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated the by faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figures 5–910 through 5–921 show concentration distributions at CYs 3890, 7140, and 11,885 for technetium-99, iodine-129, nitrate, and chromium. The groundwater releases from IDF-West extend north from the release site within the Core Zone to the Columbia River nearshore, with the distribution

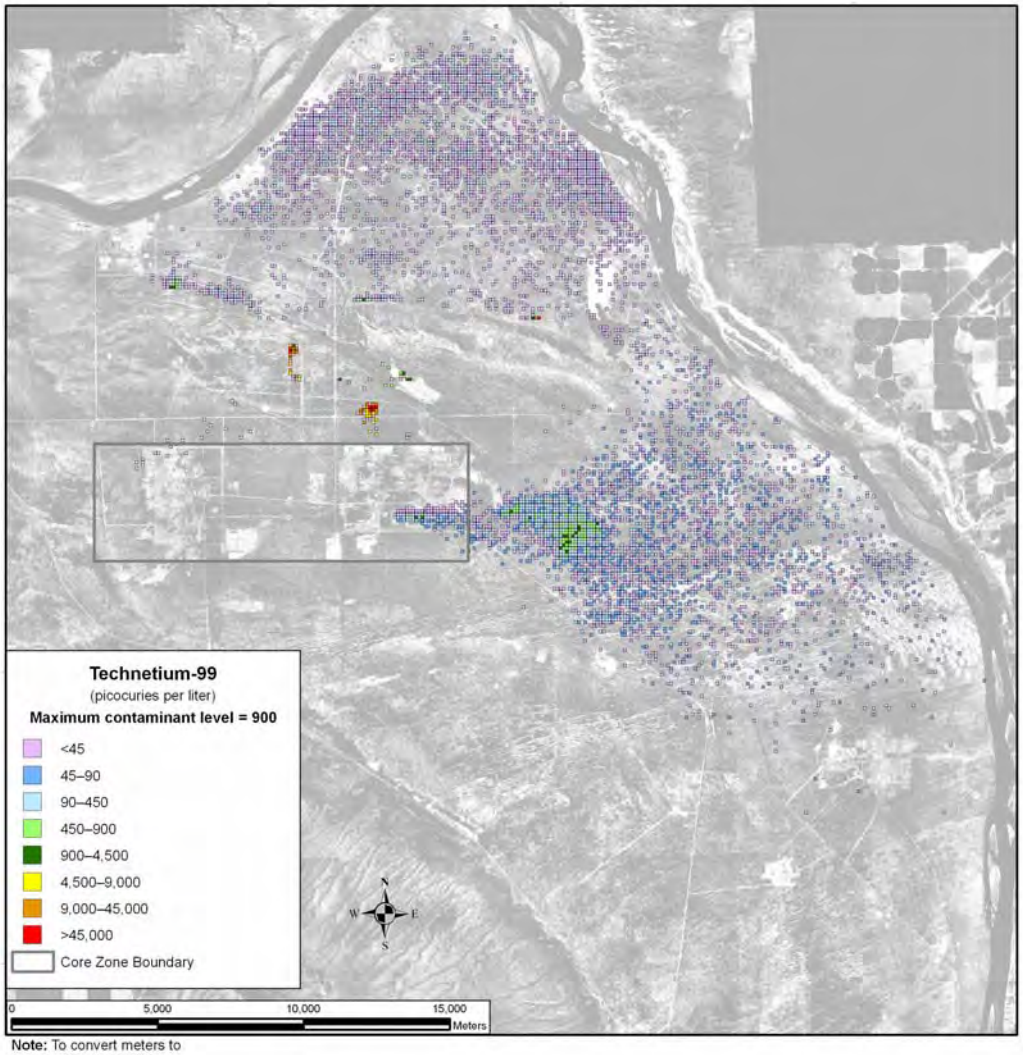
remaining in a fairly narrow channel (Gable Gap) until about halfway to the Columbia River nearshore. The IDF-East releases remained in a relatively narrow channel until they reached about the one-quarter distance point to the Columbia River, where they broadened and continued to the Columbia River nearshore. For technetium-99, iodine-129, nitrate, and chromium, the IDF-West releases occur earlier and dissipate sooner than those from IDF-East. Figure 5–922 shows the concentration distribution for IDF-East uranium-238 at CY 11,885 which creates a similar release distribution.

Figure 5–910 shows that the technetium-99 release from IDF-West exceeds its benchmark concentration within the Core Zone and in several areas near to the Columbia River nearshore in CY 3890. There are also several small areas with very high technetium-99 concentrations (several orders of magnitude larger than the benchmark) just north of the Core Zone Boundary. This figure shows no technetium-99 from IDF-East at this time. Figure 5–911 shows that the IDF-West technetium-99 has mostly dissipated by CY 7140 with the exception of several small pockets north of the Core Zone Boundary where the technetium-99 concentration is greater than the benchmark concentration. The technetium-99 IDF-East release is shown with concentrations that are mostly lower than the technetium-99 benchmark concentration. Figure 5–912 shows that the IDF-West groundwater technetium-99 continues to dissipate in CY 11,885, in contrast to the IDF-East technetium-99 distribution, which continues to spread toward the Columbia River with peak concentrations that approach or exceed benchmark concentrations in an area east of the Core Zone Boundary. Most of the technetium-99 distribution is at least one order of magnitude below its benchmark concentration between IDF-East and the Columbia River nearshore.



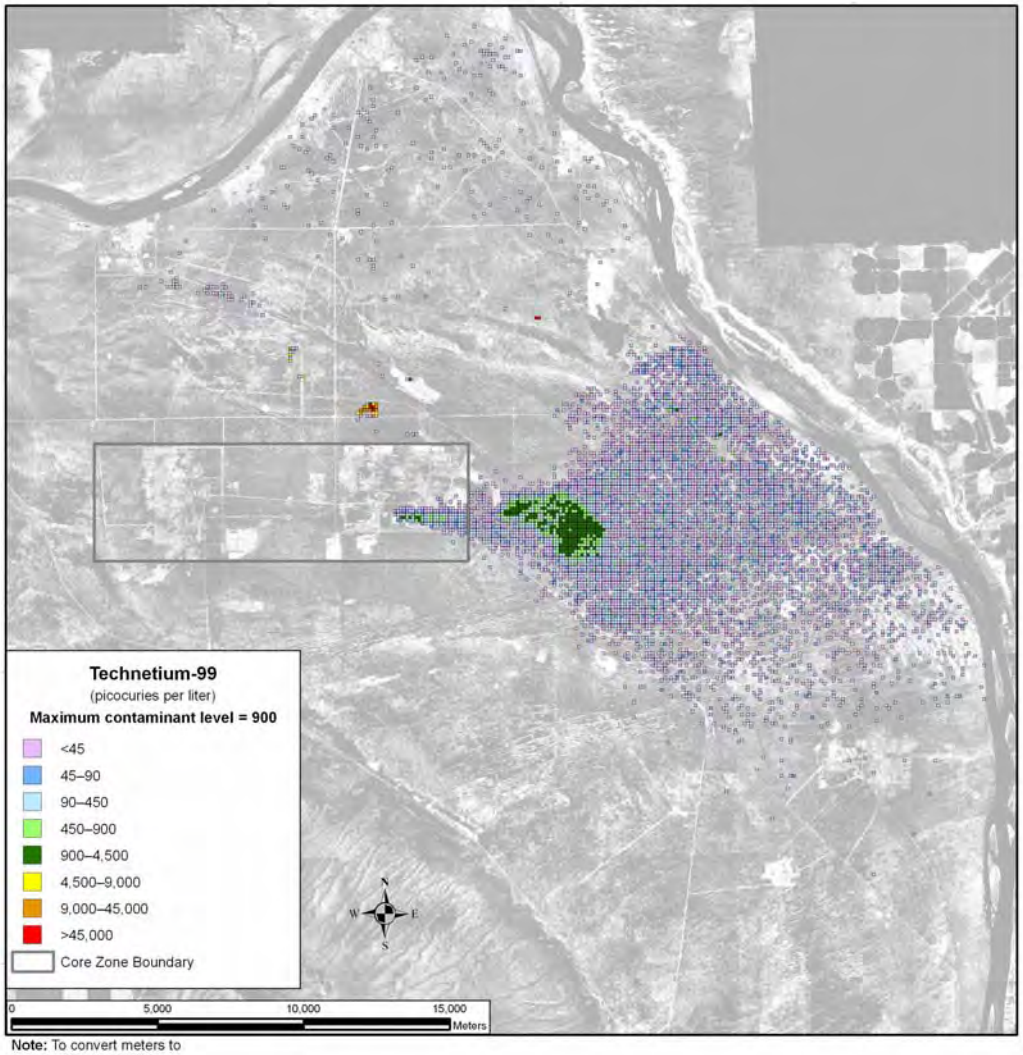
Note: To convert meters to feet, multiply by 3.281

Figure 5–910. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

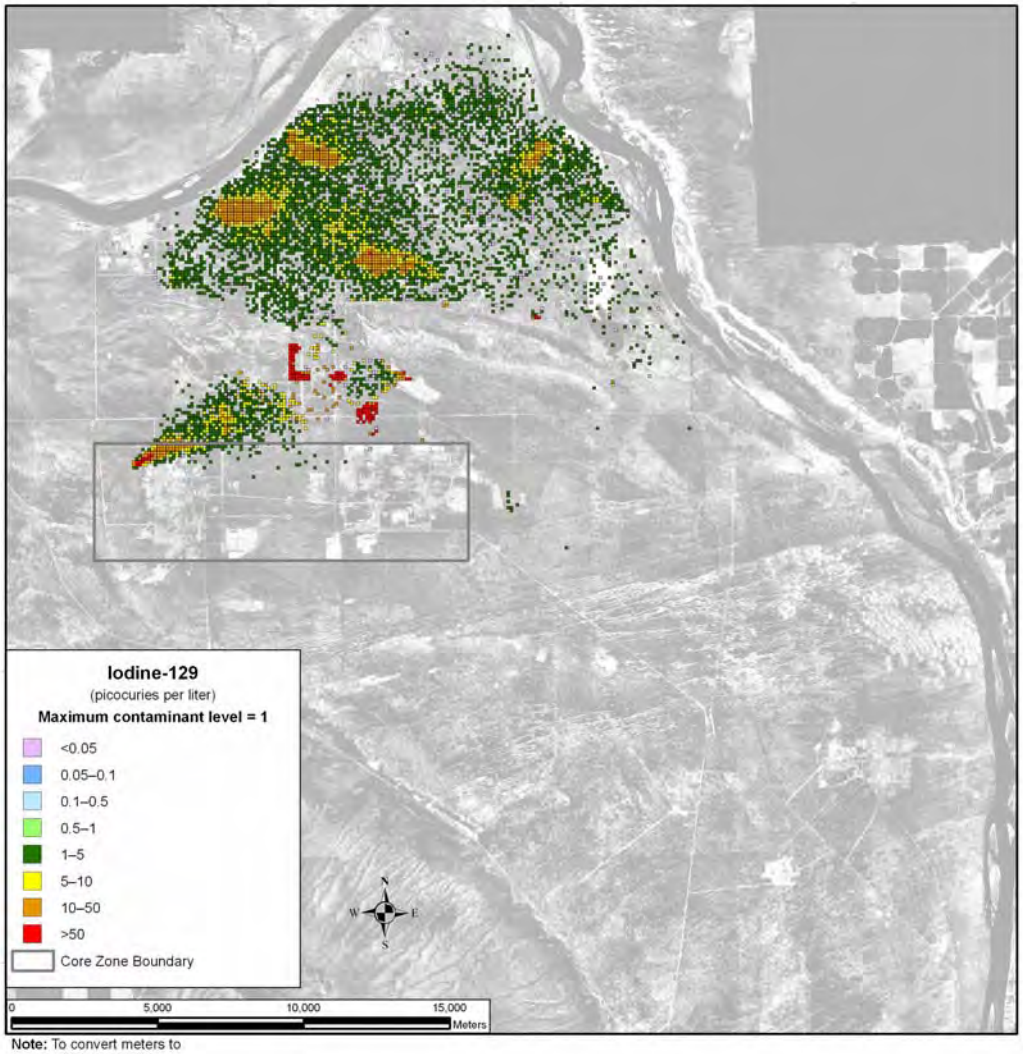
Figure 5–911. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

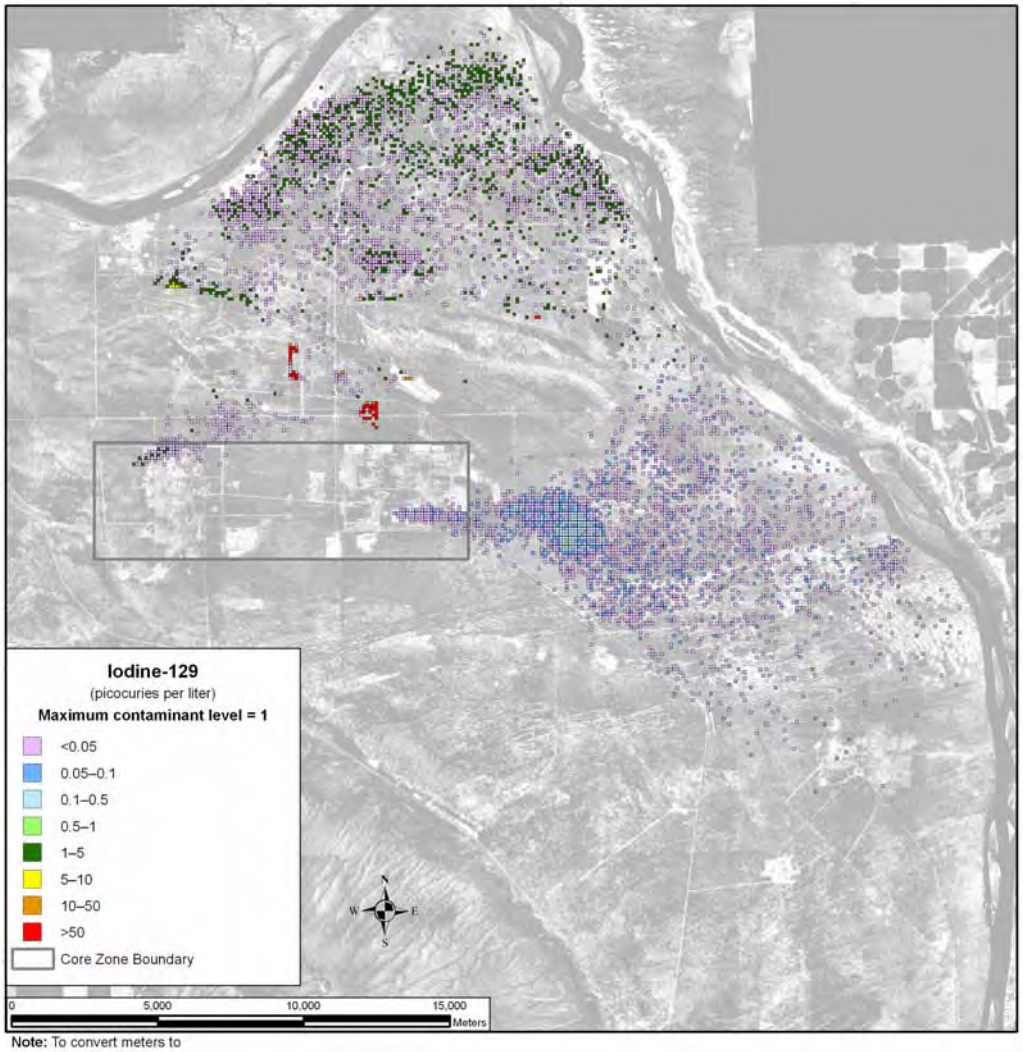
Figure 5–912. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

Figures 5–913 through 5–915 show iodine-129 released from IDF-East and IDF-West with a spatial distribution very similar to the technetium-99 release. However, the CY 3890 iodine-129 release (see Figure 5–913) shows higher relative concentrations (compared with the benchmark concentration) than the technetium-99 release. The areas of high concentrations are in the same locales, but these areas have levels that exceed the benchmark concentration by at least one order of magnitude. No iodine-129 is released from IDF-East at this time. By CY 7140, the IDF-West iodine-129 release has significantly dissipated (see Figure 5–914); only small areas remain where iodine-129 is at or above its benchmark concentration. This shows the onset of the IDF-East iodine-129 release. By CY 11,885 (see Figure 5–915), the IDF-East iodine-129 distribution has significantly increased in size and concentration. Several small areas east of the Core Zone Boundary show concentrations at or above benchmark levels.



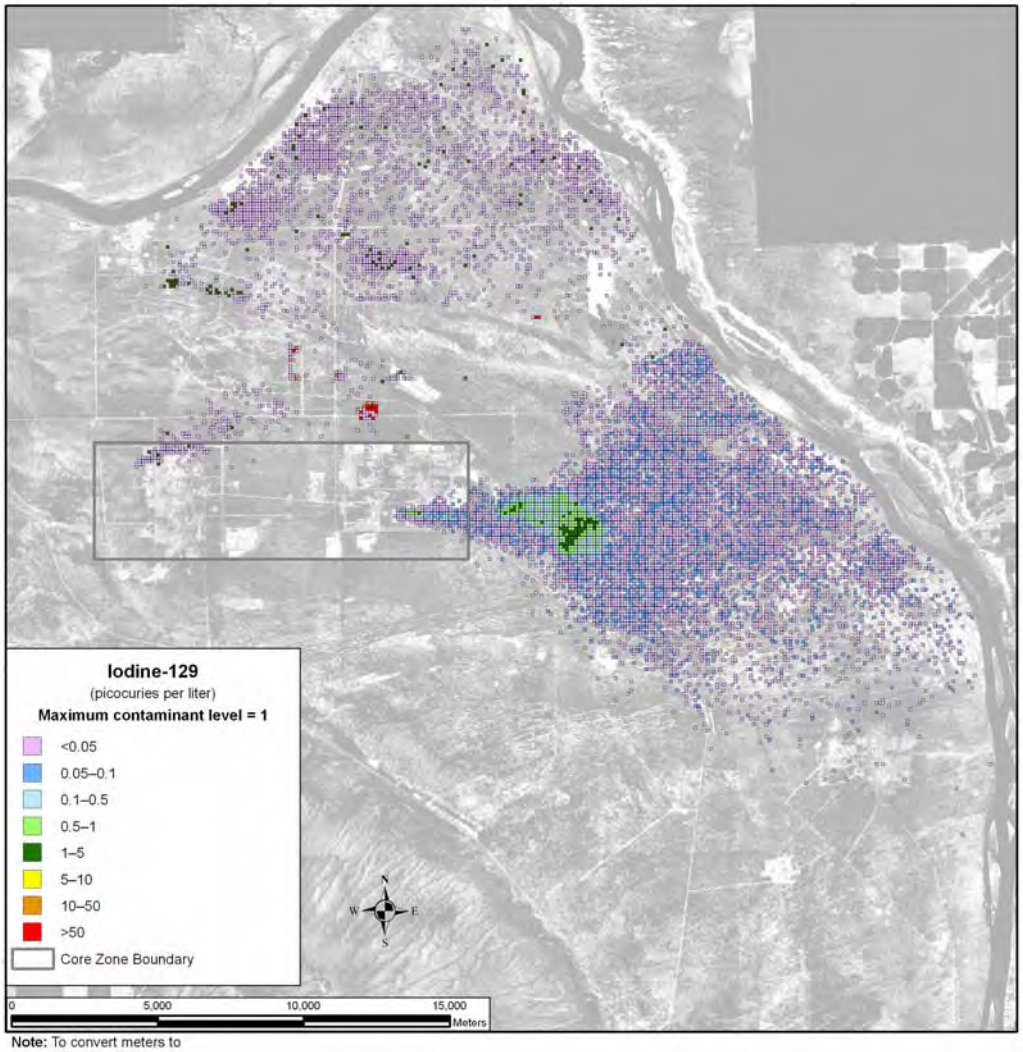
Note: To convert meters to feet, multiply by 3.281

Figure 5–913. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

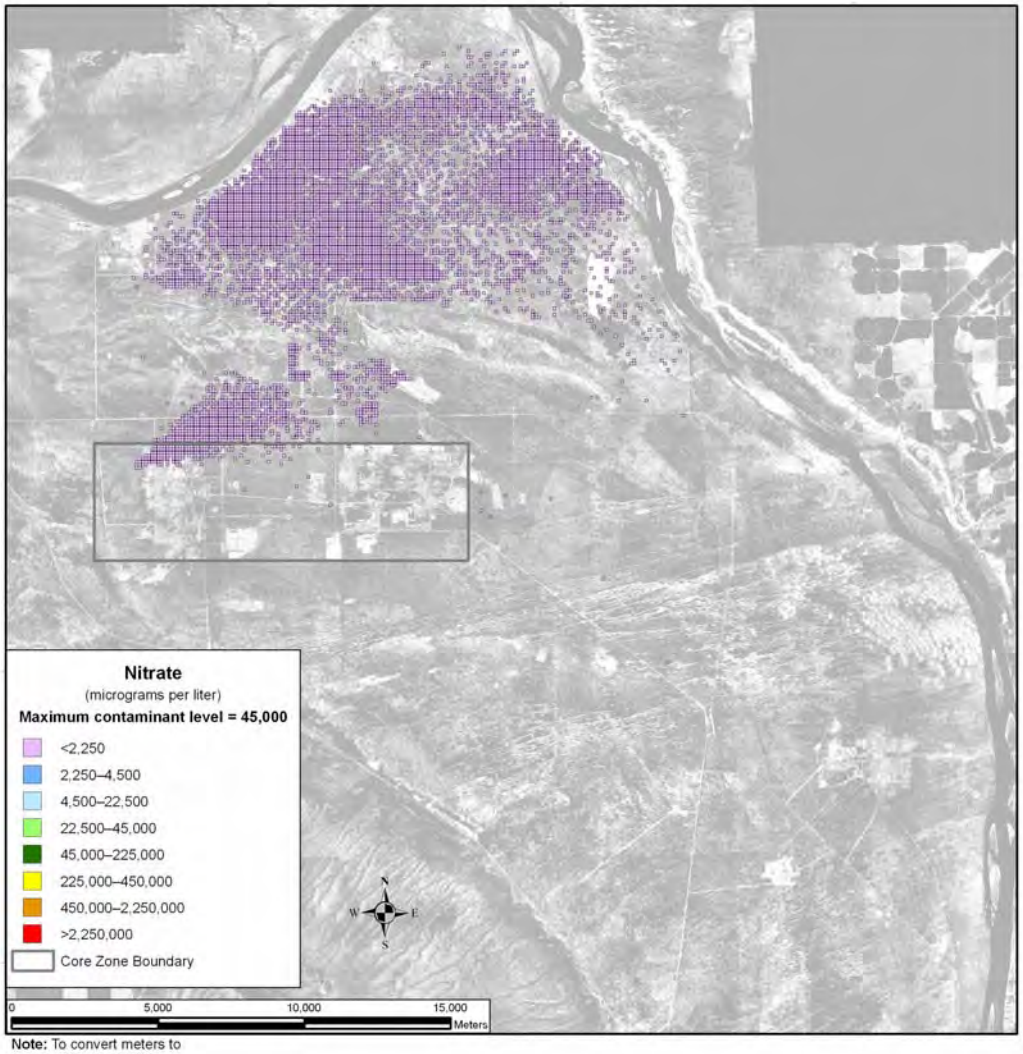
Figure 5–914. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

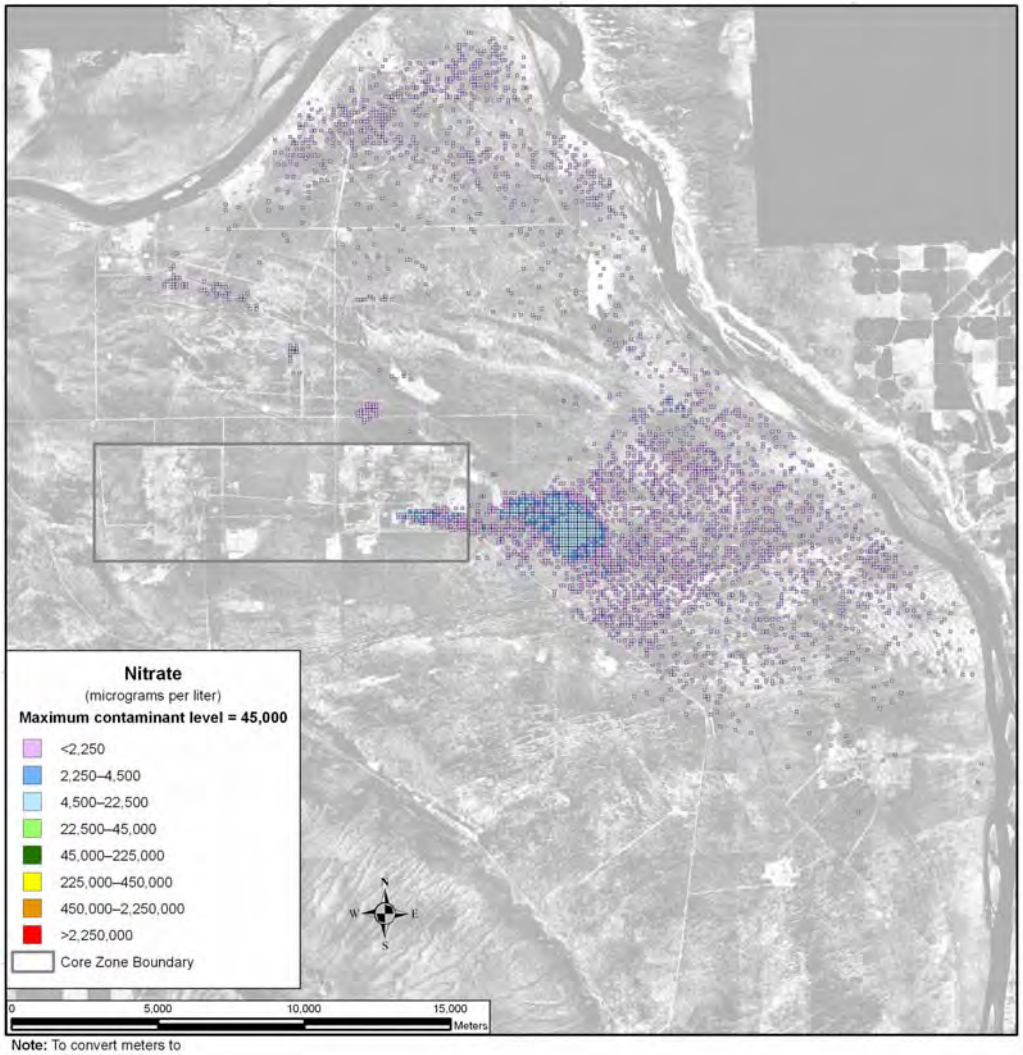
Figure 5–915. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

The IDF-East and IDF-West nitrate releases, shown in Figures 5–916 through 5–918, show time and spatial distributions similar to the technetium-99 and iodine-129 released. However, the IDF-East nitrate release never approaches benchmark concentrations and dissipates significantly by CY 7140 (almost nothing is showing at CY 11,885). The IDF-East nitrate release occurs later and does not appear in the CY 3890 data (see Figure 5–916). By CY 7140 (see Figure 5–917), the IDF-East nitrate release has reached the Columbia River. By CY 11,885 (see Figure 5–918), the nitrate has dissipated significantly and concentrations have fallen well below the benchmark concentration.



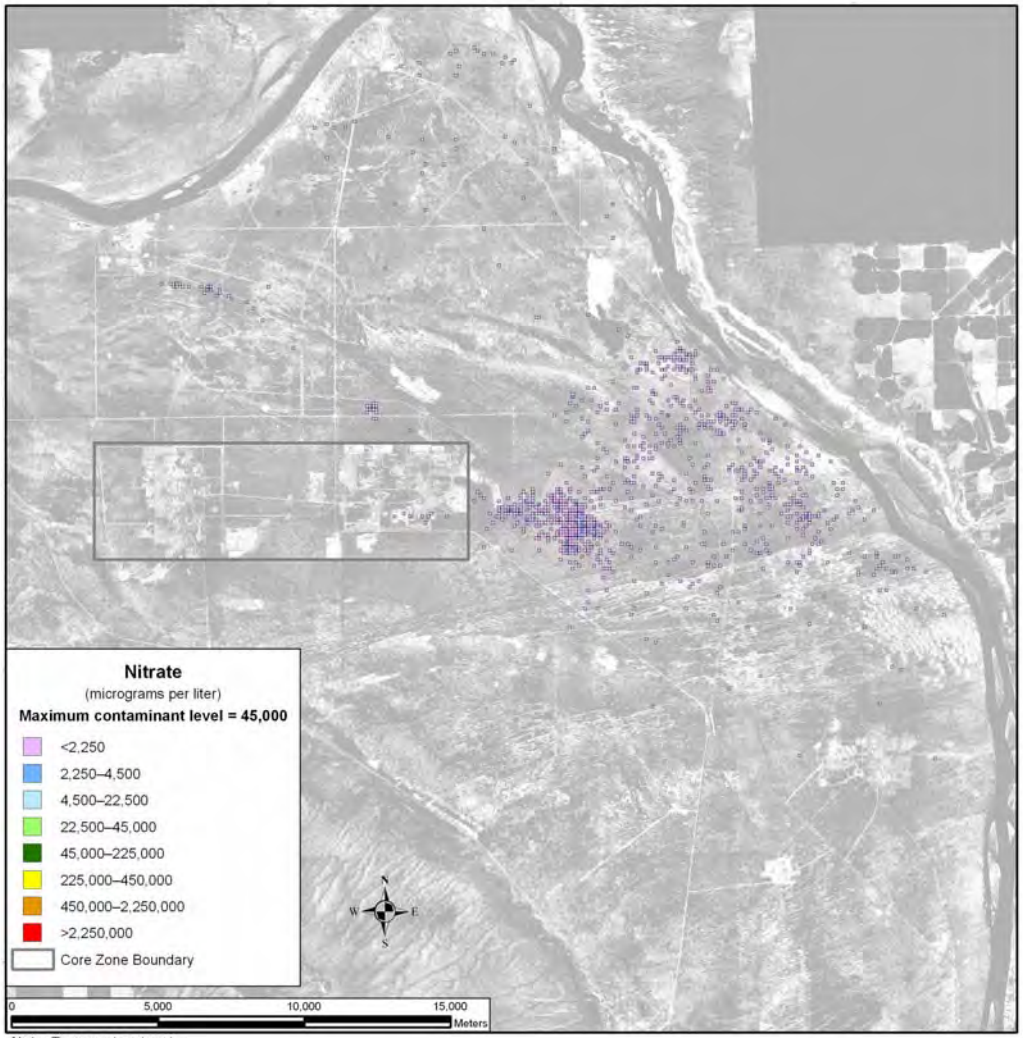
Note: To convert meters to feet, multiply by 3.281

Figure 5–916. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

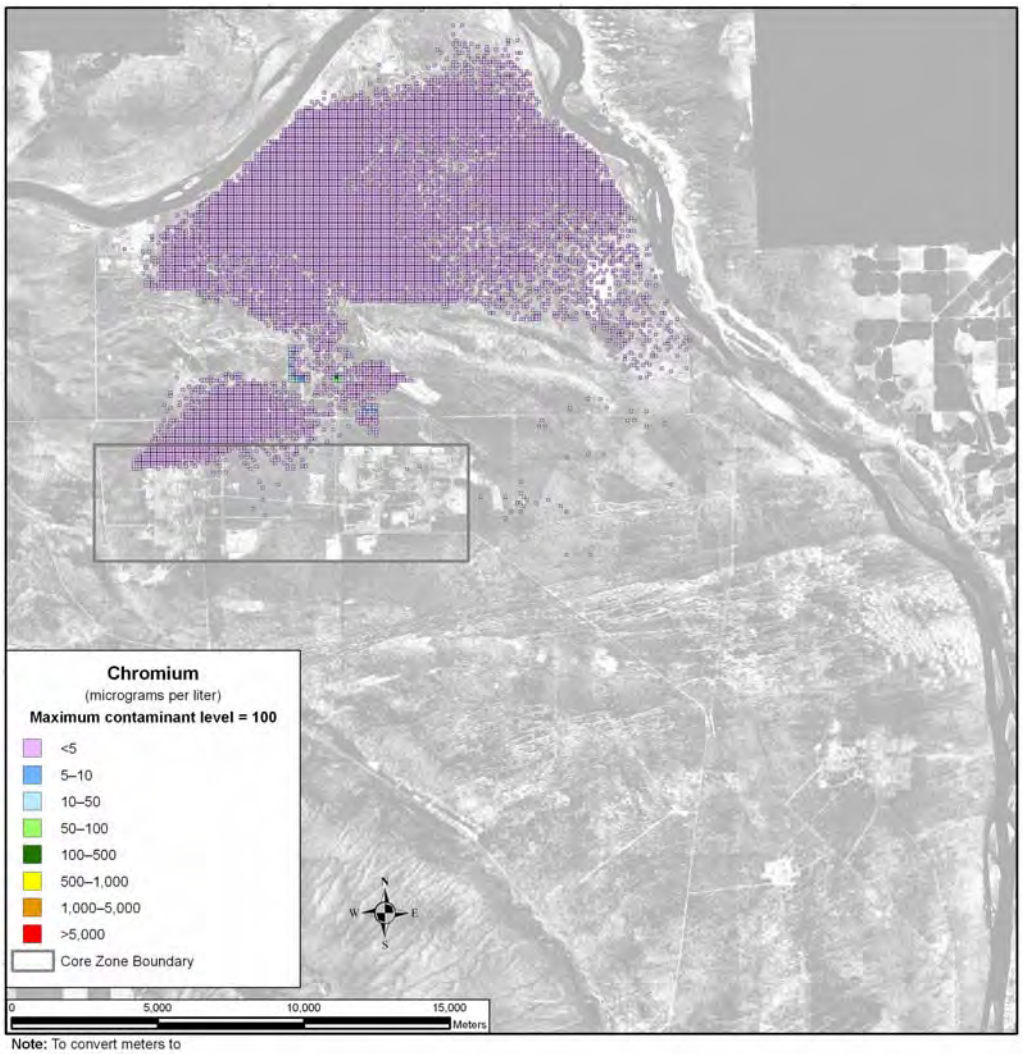
Figure 5–917. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

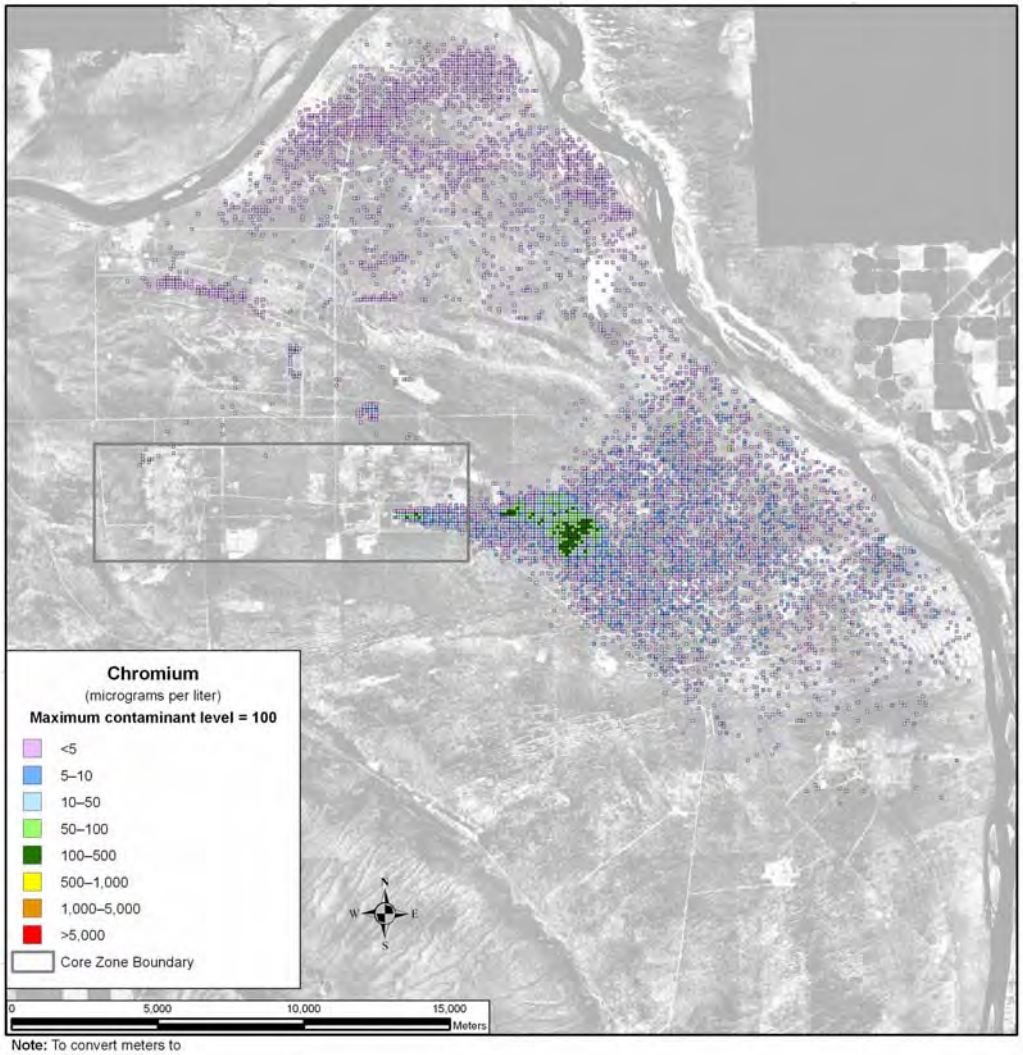
Figure 5–918. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

The initial chromium release time and spatial patterns at CY 3890 in (see Figure 5–919) are nearly identical to the IDF-West nitrate release. The chromium concentrations at CY 3890 are several orders of magnitude below the benchmark level. By CY 7140, most of this low-concentration IDF-West chromium has dissipated to the Columbia River (see Figure 5–920). By CY 7140, there is a significant chromium distribution from IDF-East, with small areas that exceed benchmark concentrations. By CY 11,885 (see Figure 5–921), the IDF-West chromium is essentially dissipated. The IDF-East chromium release extends from the release site to the Columbia River, but with concentrations that are well below the chromium benchmark concentration.



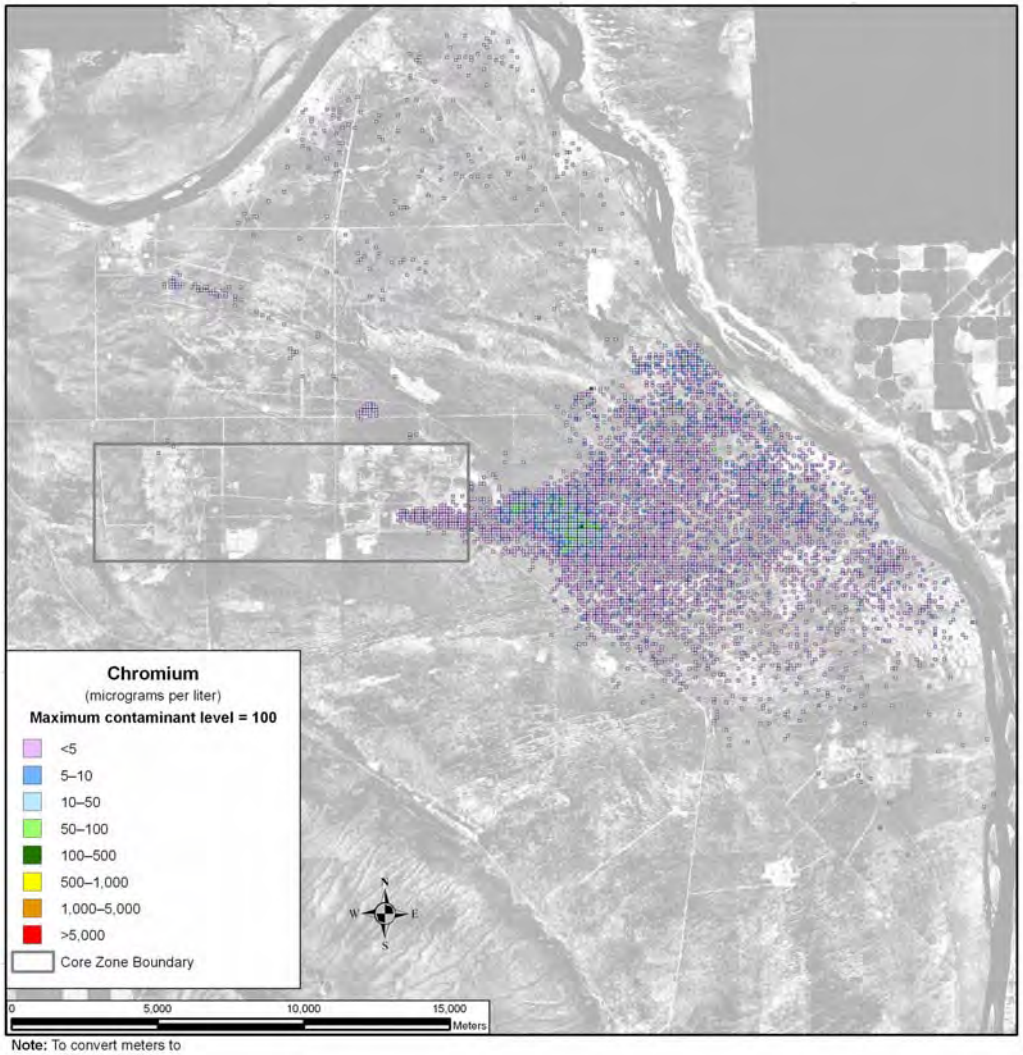
Note: To convert meters to feet, multiply by 3.281

Figure 5–919. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

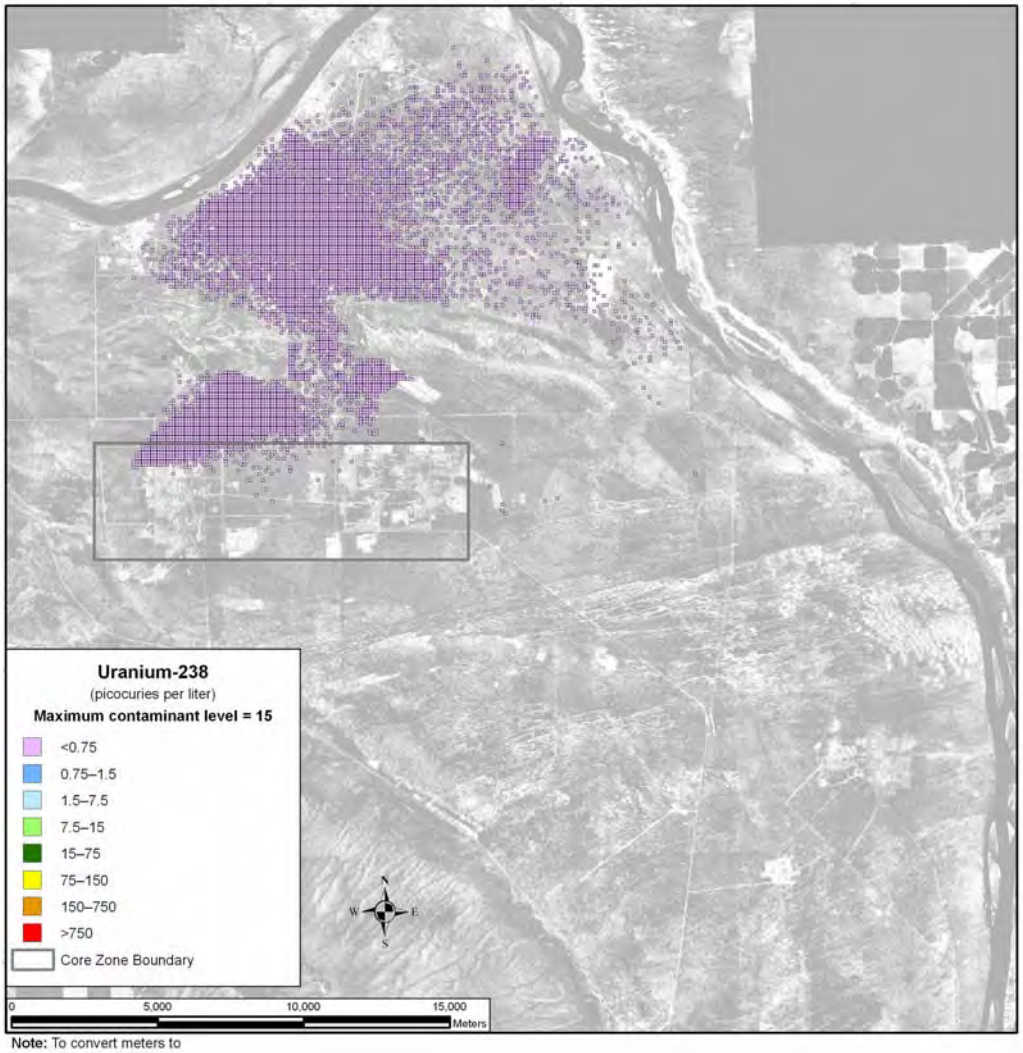
Figure 5–920. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–921. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

Figure 5–922 shows an IDF-West uranium-238 release at CY 11,885. No uranium-238 is released from IDF-East. The uranium-238 concentration in the distribution is well below its benchmark concentration. The data show retardation that resulted in a fairly homogenous concentration extending from the release site to the Columbia River nearshore.



Note: To convert meters to feet, multiply by 3.281

Figure 5–922. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, in general, the inventory remaining at IDF-East, IDF-West, and the RPPDF, that are available for release to the environment at the start of the post-disposal period are predominant contributors. The releases from IDF-West and the RPPDF are earlier and dissipate earlier than releases from IDF-East.

By the end of this analysis period (CY 11,885), the chromium and nitrate distributions have largely dispersed below their benchmark concentrations. A significant spatial distribution of technetium-99 and iodine-129 remains. Most of the distribution area has concentrations below benchmark levels, but there are some small areas in which technetium-99 and iodine-129 concentrations exceed benchmark levels at

CY 11,885. The released iodine-129, which occurs at higher concentration levels relative to its benchmark than technetium-99, dissipates much quicker than technetium-99.

Uranium-238's relatively limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of this retarded species do not exceed the benchmark levels at the Core Zone Boundary or Columbia River nearshore over this period of analysis. However, the spatial distributions of uranium-238 exist through the end of the analysis period (CY 11,885). Although the concentrations of uranium-238 are two orders of magnitude smaller than its benchmark concentration during this analysis period, the trend appears to show a continuing increase in concentrations through the end of the analysis period.

5.3.1.3.1.7 Disposal Group 1, Subgroup 1-G

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G covers disposal of wastes generated during Tank Closure Alternative 6C, FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste. Tank closure waste would be converted to IHLW and ILAW glass. The ILAW glass would be stored on site as HLW pending disposition.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continues through CY 2050, when the disposal facilities will be operationally closed. During the disposal period the materials in these permitted, operational facilities are not available for release to the environment.

- The post-disposal period starts in CY 2051 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G. Full results for all 40 COPCs are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, then selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contribution to risk and hazard are not dominant during the year of peak risk or hazard, they become major contributors toward the end of the period of analysis. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk.

The chemical hazard drivers above account for 100 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G.

The COPC drivers that are discussed in detail in this section fall into two categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. Uranium-238 and total uranium are long-lived or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, in terms of total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over six orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–923 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–924, the chemical hazard drivers. Two subtotals are plotted, representing releases from ETF-generated secondary waste and tank closure secondary waste. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). The predominant source for technetium-99 and chromium is tank closure secondary waste. ETF-generated secondary waste is the predominant source for iodine-129 and nitrate.

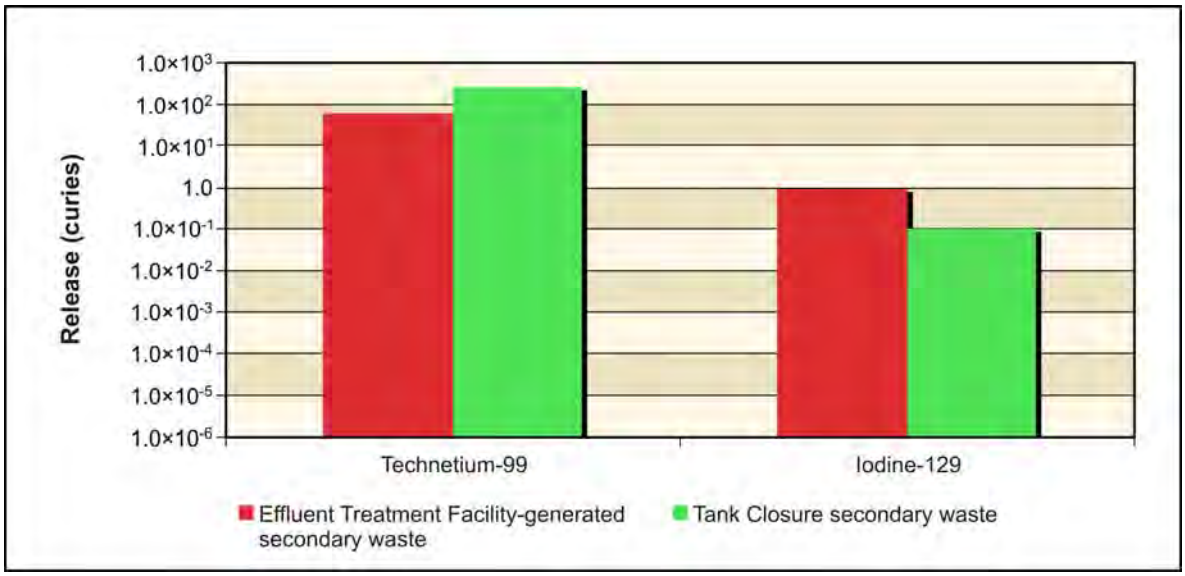


Figure 5–923. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

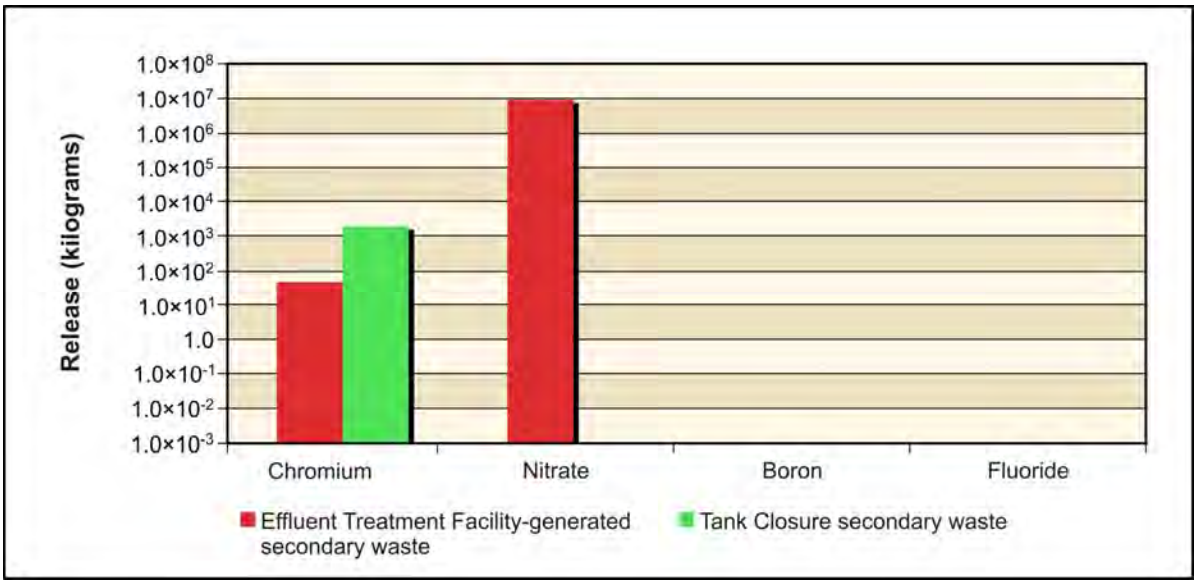


Figure 5–924. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–925 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–926, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. With the exception of technetium-99 released from ETF-generated secondary waste, of which nearly all released to the vadose zone reaches groundwater, only 40 to 50 percent of the technetium-99 and iodine-129 released to the vadose zone reaches groundwater. Nearly all chromium and nitrate released to the vadose zone reaches groundwater.

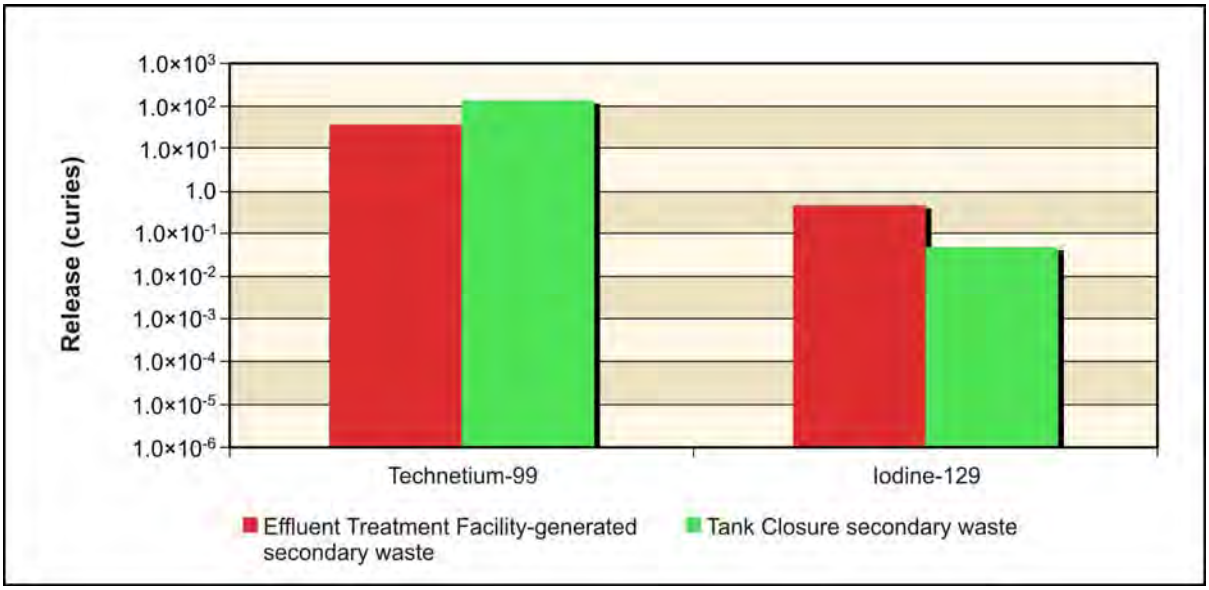


Figure 5–925. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

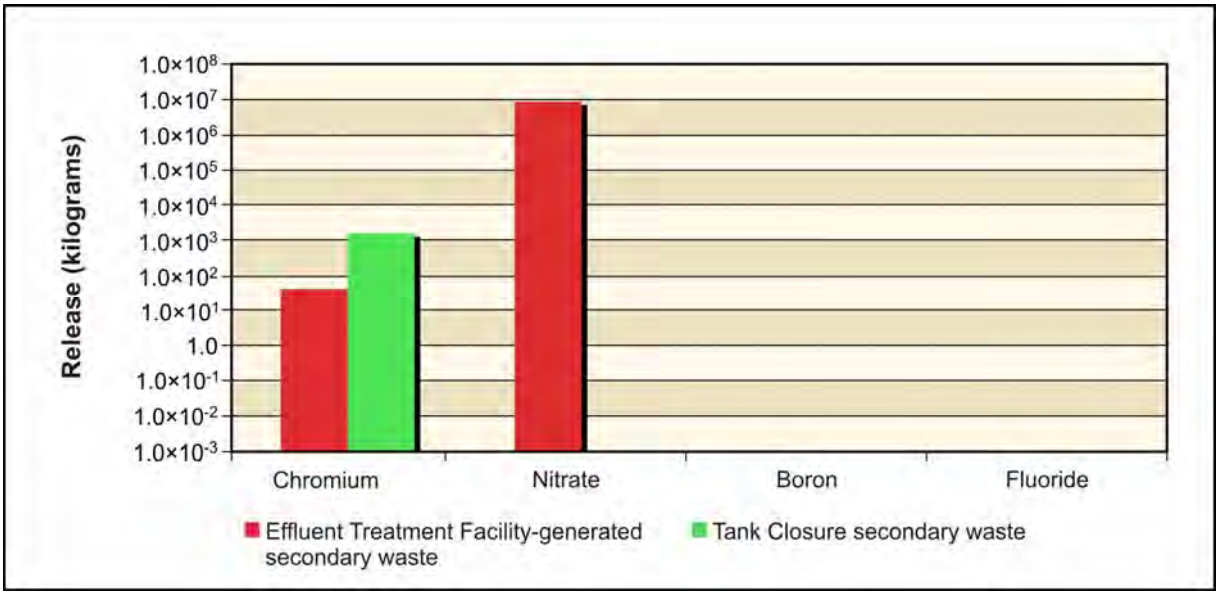


Figure 5–926. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–927 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–928, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. In all cases between 90 and 100 percent of the amount released to groundwater reached the Columbia River.

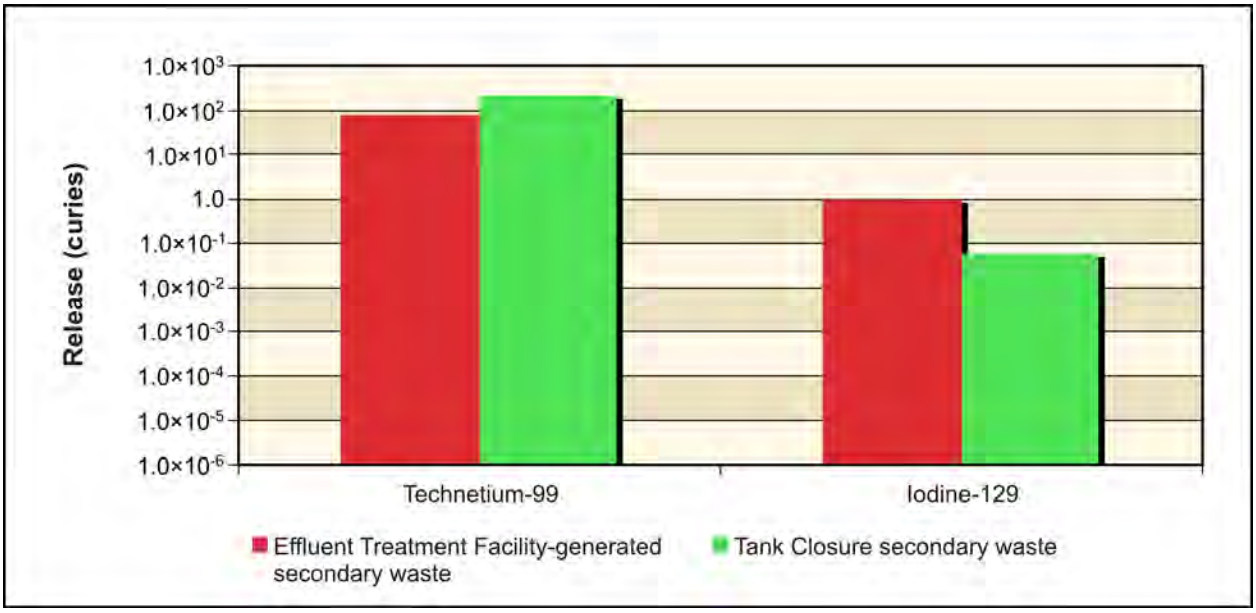


Figure 5–927. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

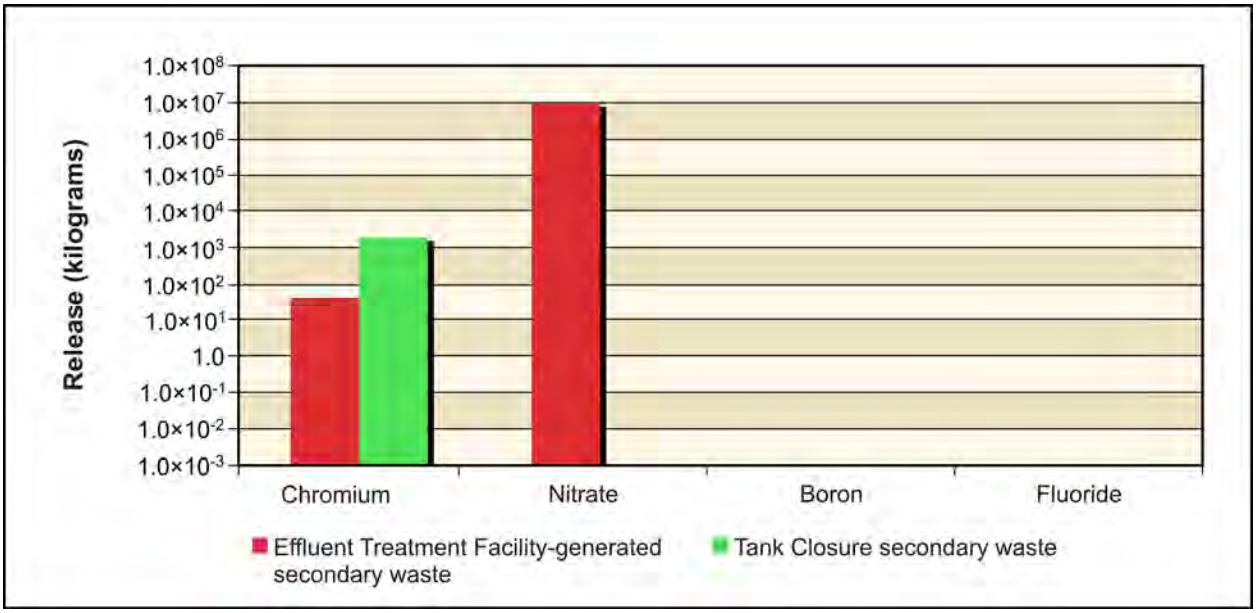


Figure 5–928. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases from FFTF Decommissioning Alternative 3 waste, waste management secondary and onsite- and offsite-generated waste. Figure 5–929 shows the estimated release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–930, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, boron, chromium, fluoride, and nitrate are all present at IDF-West.

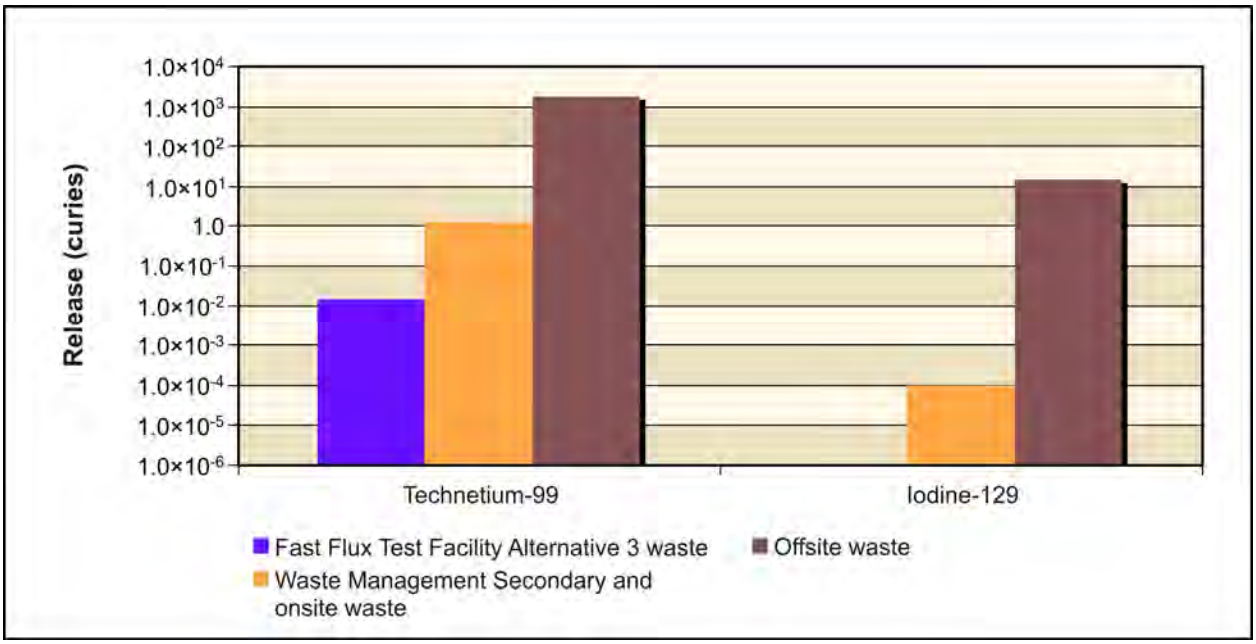


Figure 5–929. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

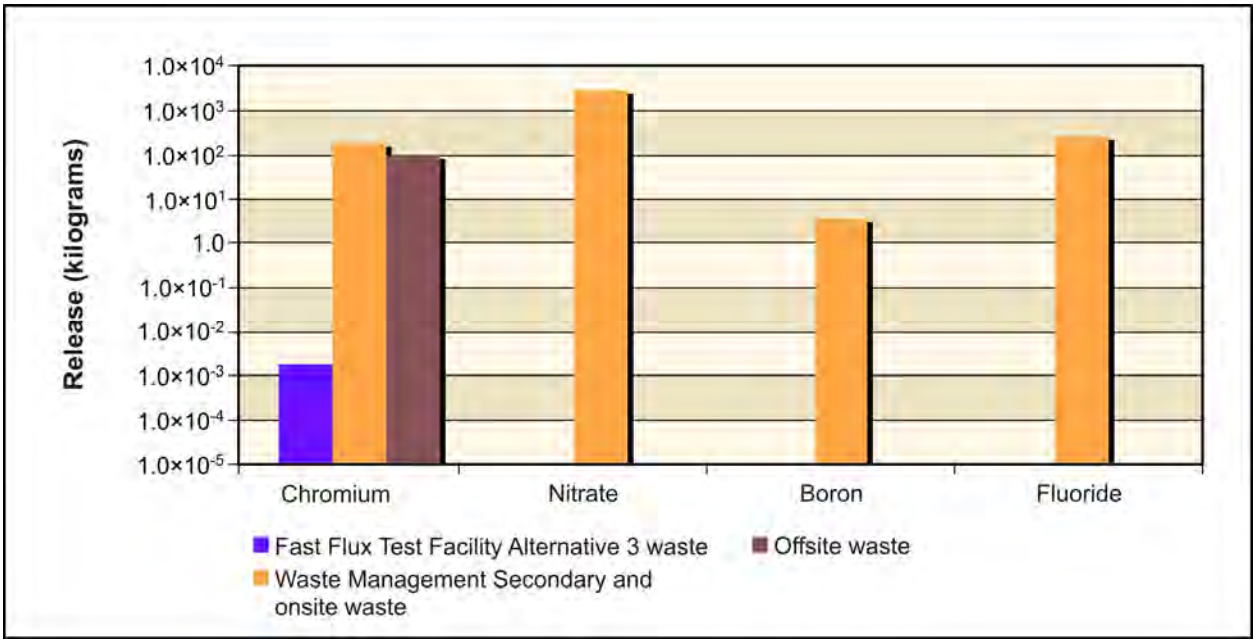


Figure 5–930. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–931 shows the estimated release at IDF-West to groundwater for the radiological risk drivers and Figure 5–932, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present at IDF-West behave as conservative tracers, with essentially all of the mass released to the vadose zone reaching groundwater.

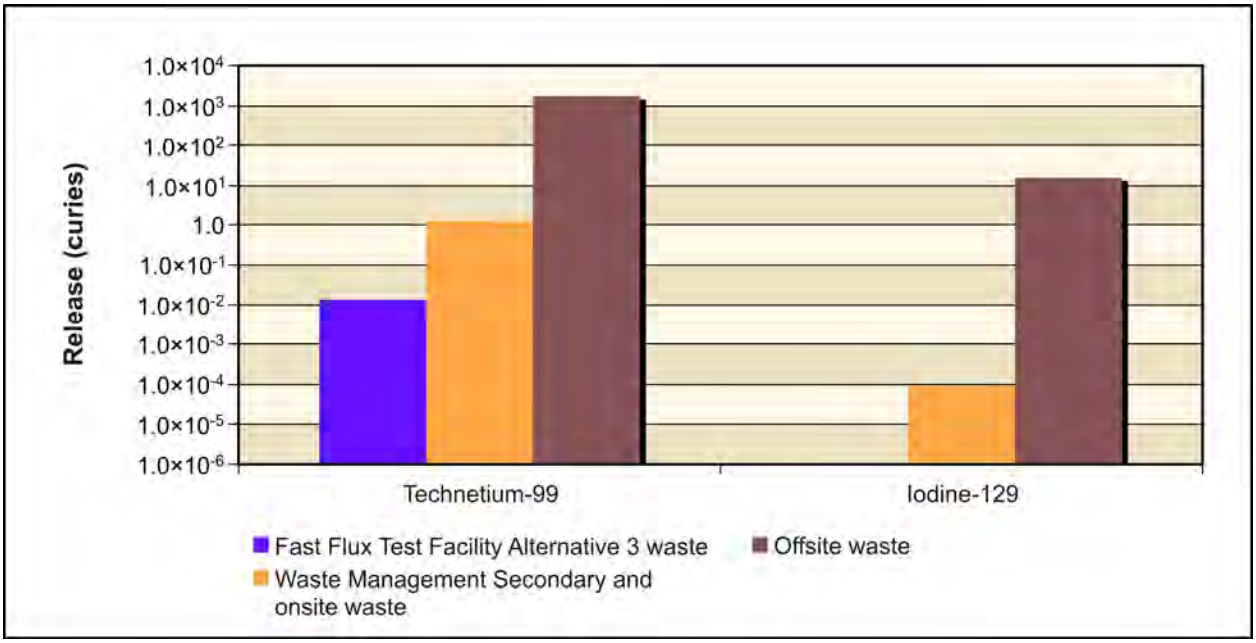


Figure 5–931. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

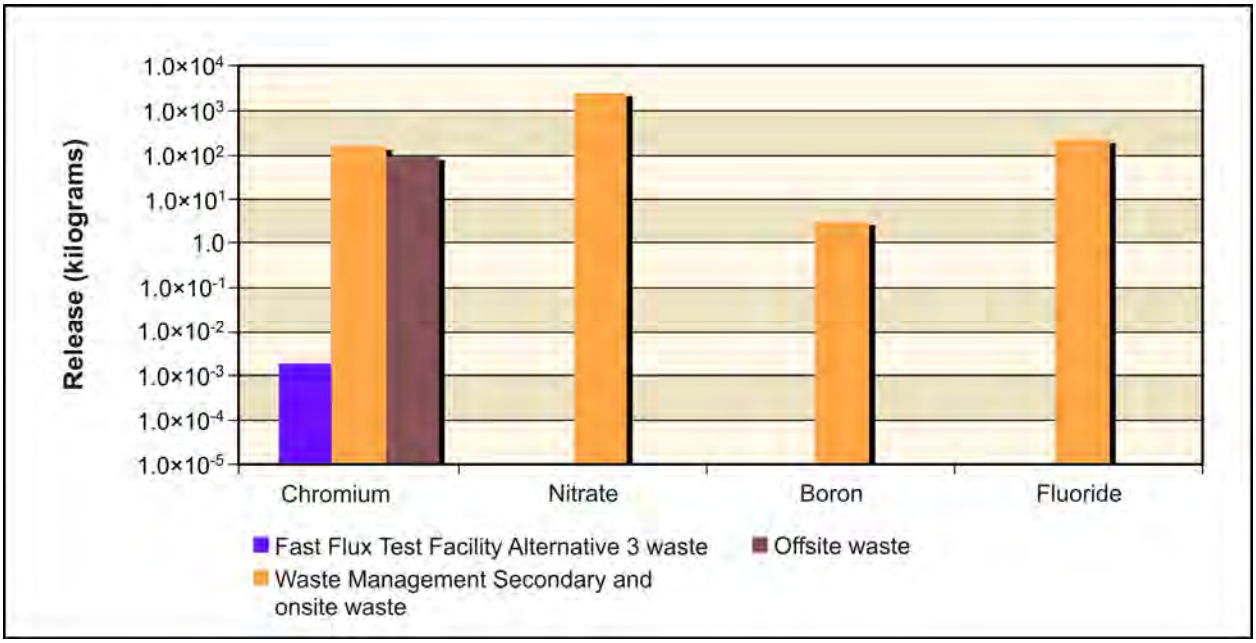


Figure 5–932. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–933 shows the estimated release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–934, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Essentially everything released to groundwater reached the Columbia River for all COPC drivers present.

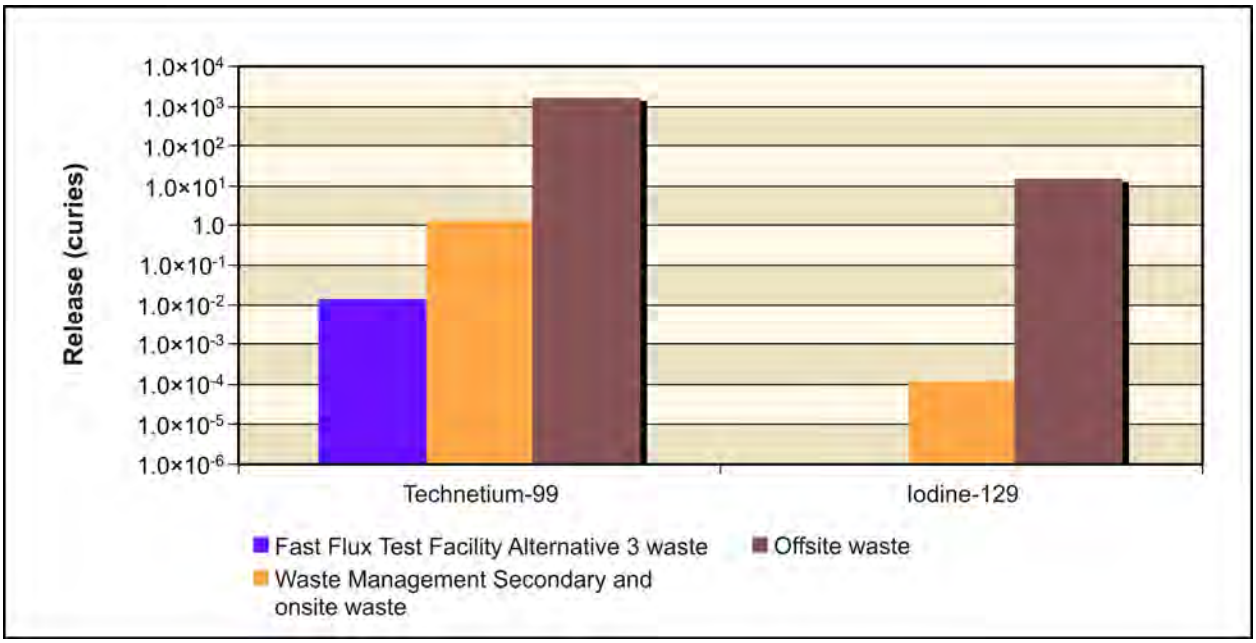


Figure 5–933. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

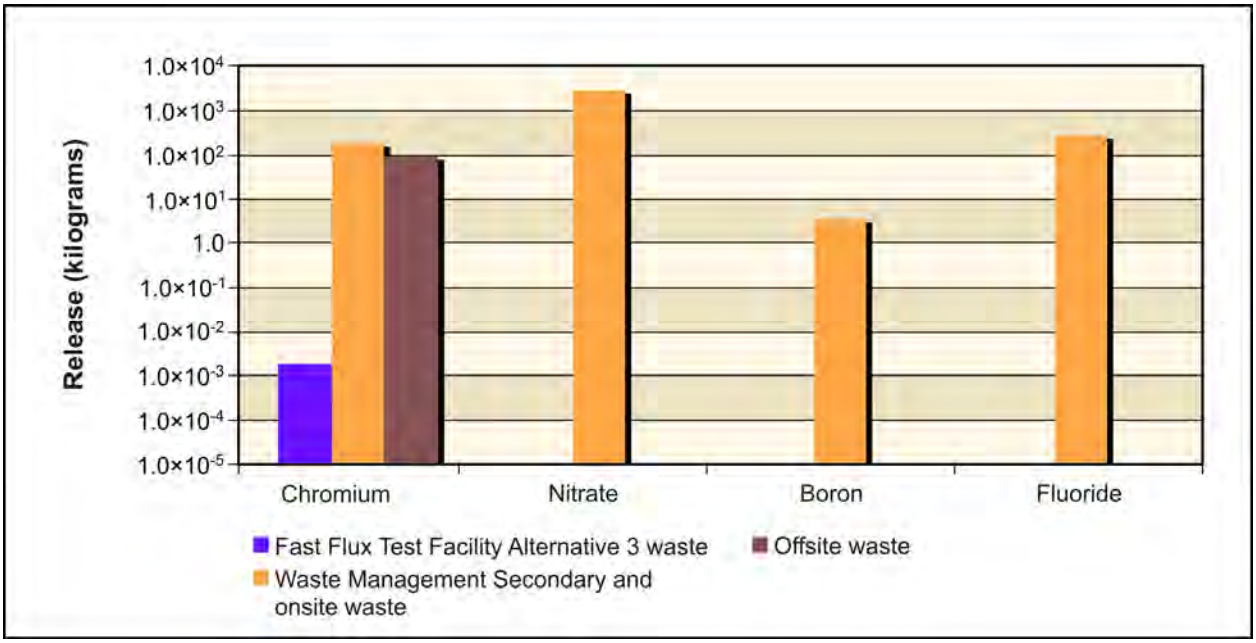


Figure 5–934. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

The RPPDF would receive lightly contaminated equipment and soils resulting from tank farm closure activities. Figure 5–935 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–936, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, chromium, and nitrate are all present at the RPPDF.

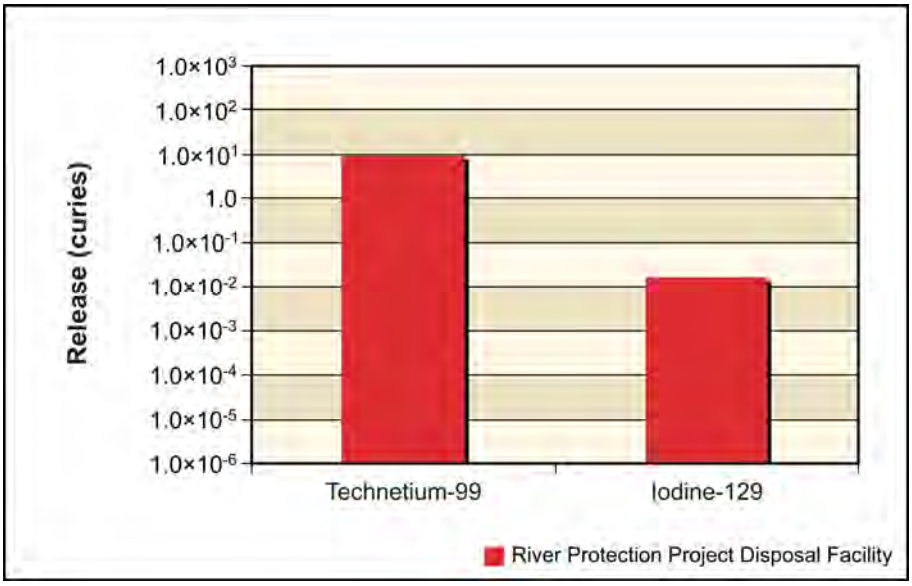


Figure 5–935. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

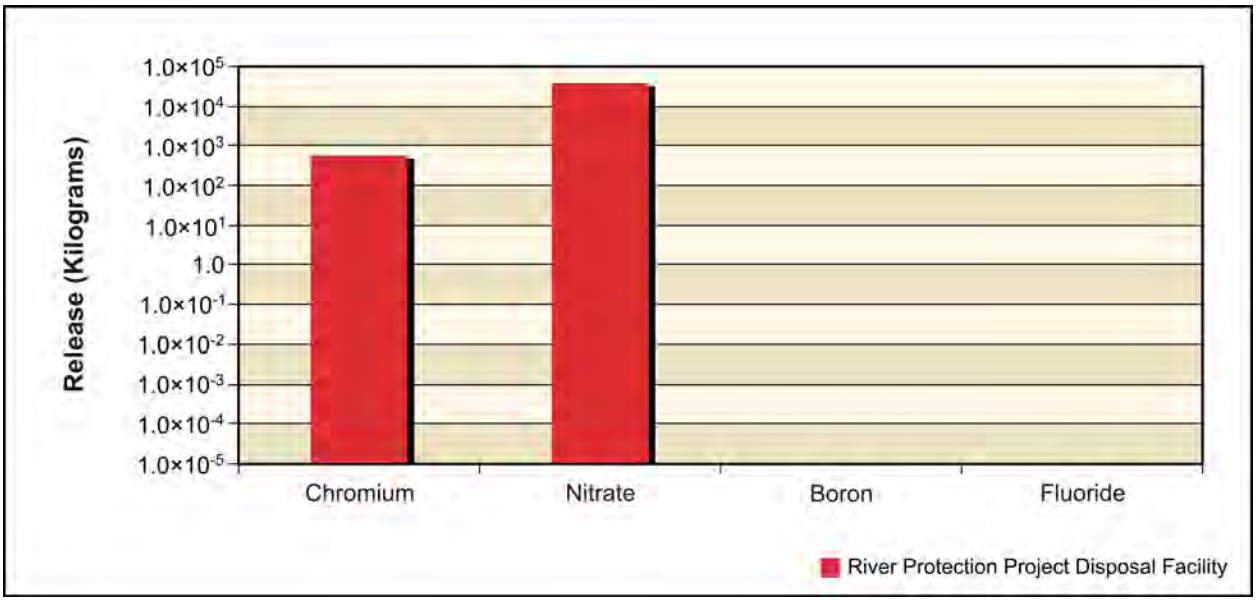


Figure 5–936. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–937 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–938, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present at the RPPDF behave as conservative tracers, with essentially all of the mass released to the vadose zone reaching groundwater.

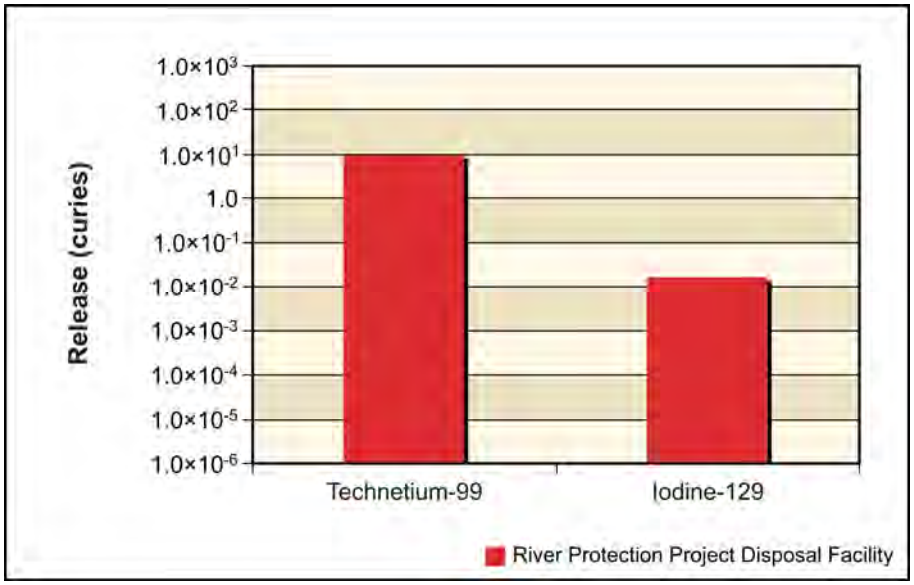


Figure 5–937. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at River Protection Project Disposal Facility to Groundwater

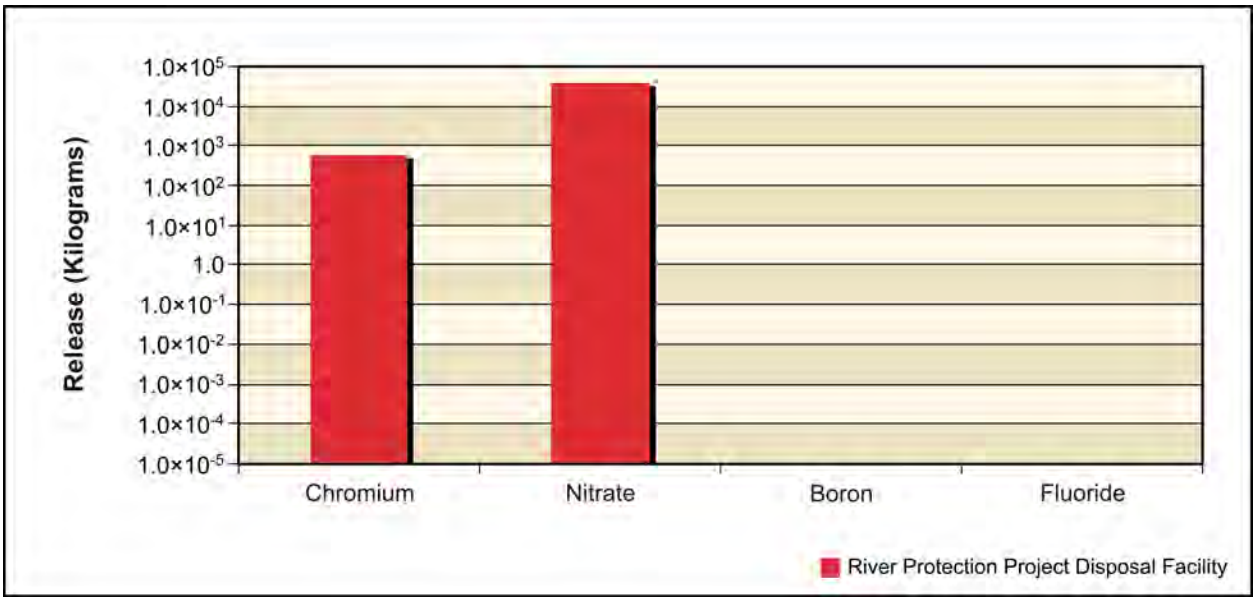


Figure 5–938. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–939 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–940, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Essentially everything released to groundwater reached the Columbia River for all COPC drivers present.

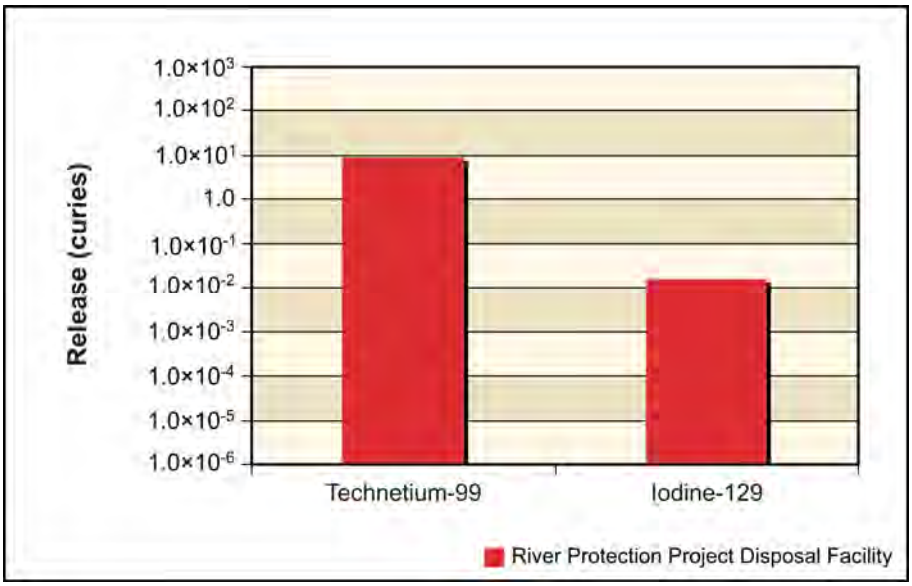


Figure 5–939. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at River Protection Project Disposal Facility to Columbia River

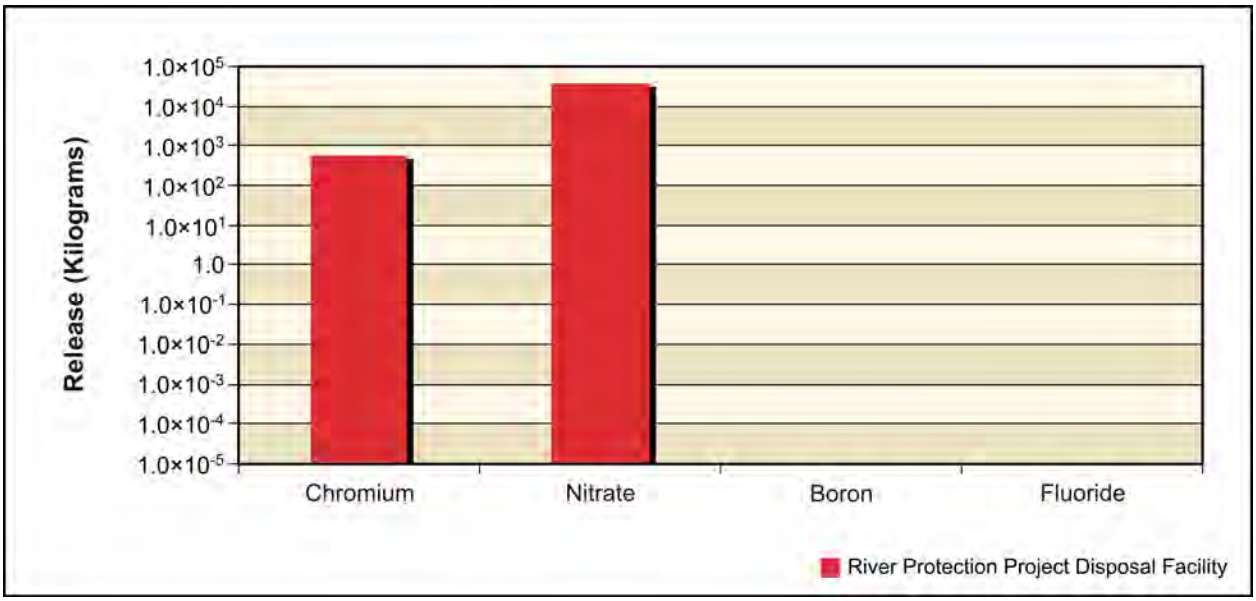


Figure 5–940. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude. Table 5–95 shows the maximum concentrations in groundwater.

Table 5–95. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	414	**20,200**	33	**7,560**	**1,130**	900
	(10032)	(3713)	(3825)	(3690)	(4528)	
Iodine-129	**1**	**173**	0.1	**60**	**8**	1
	(11,243)	(3797)	(3772)	(3853)	(4729)	
Chemical in microgram per liter						
Chromium	4	2	2	3	1	100
	(8618)	(3696)	(3856)	(3628)	(8204)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	14,200	17	149	5,630	2,440	45,000
	(8522)	(3703)	(3811)	(9653)	(8043)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–941 through 5–944 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). For technetium-99, concentrations rise early in the simulation, reaching a peak around CY 3940 at about an order of magnitude above the benchmark concentration. Concentrations drop until around CY 7940, when they begin to stabilize nearly an order of magnitude below the benchmark. Iodine-129 follows a similar pattern, stabilizing slightly below the benchmark after peaking at nearly two orders of magnitude above the benchmark. Chromium concentrations at the Core Zone Boundary peak nearly two orders of magnitude below the benchmark before concentrations drop sharply. Around CY 5400, concentrations begin rising again, with a peak over two orders of magnitude below the benchmark. Nitrate has a similar two-peaked pattern, with the first peak remaining three orders of magnitude below the benchmark at the Core Zone Boundary, while the second peak is only one order of magnitude below the benchmark at the Core Zone Boundary.

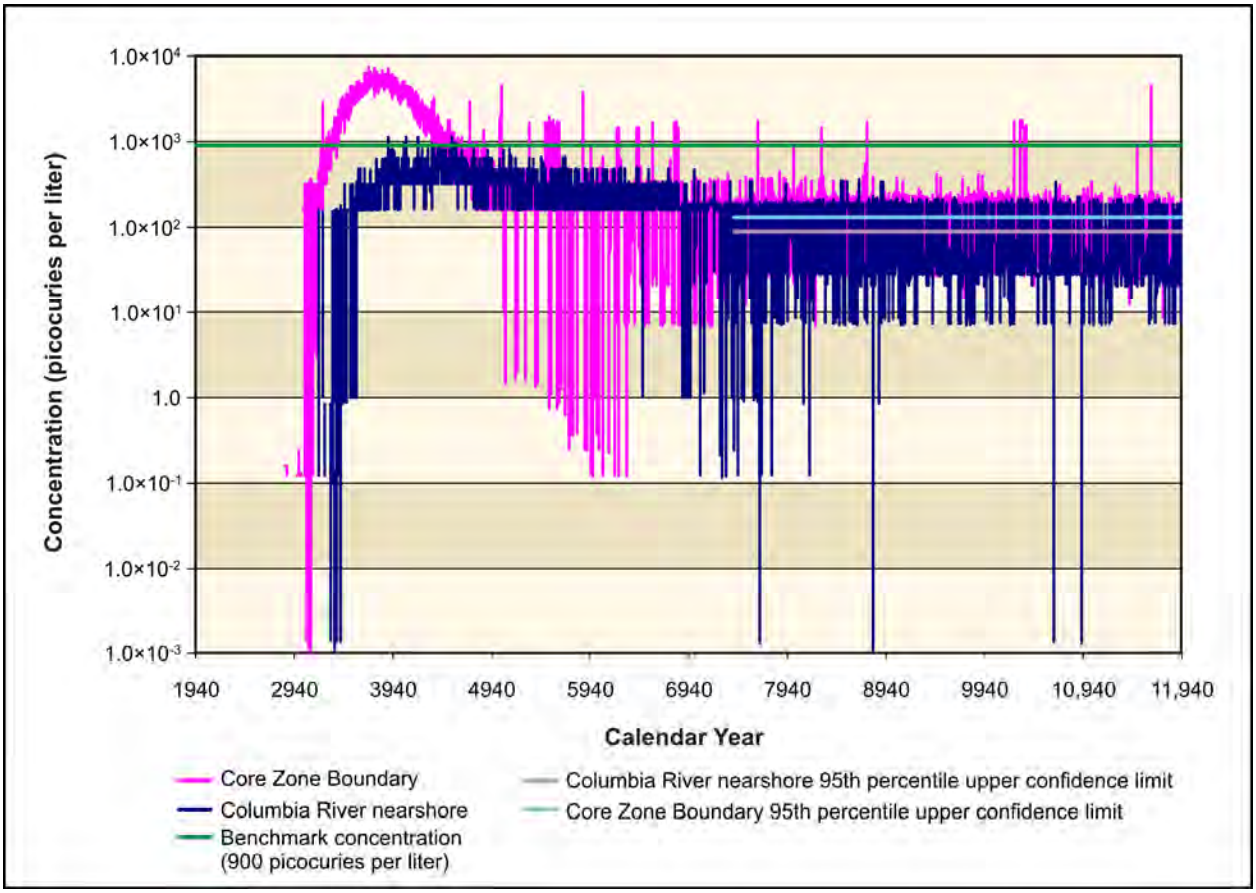


Figure 5–941. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Technetium-99 Concentration Versus Time

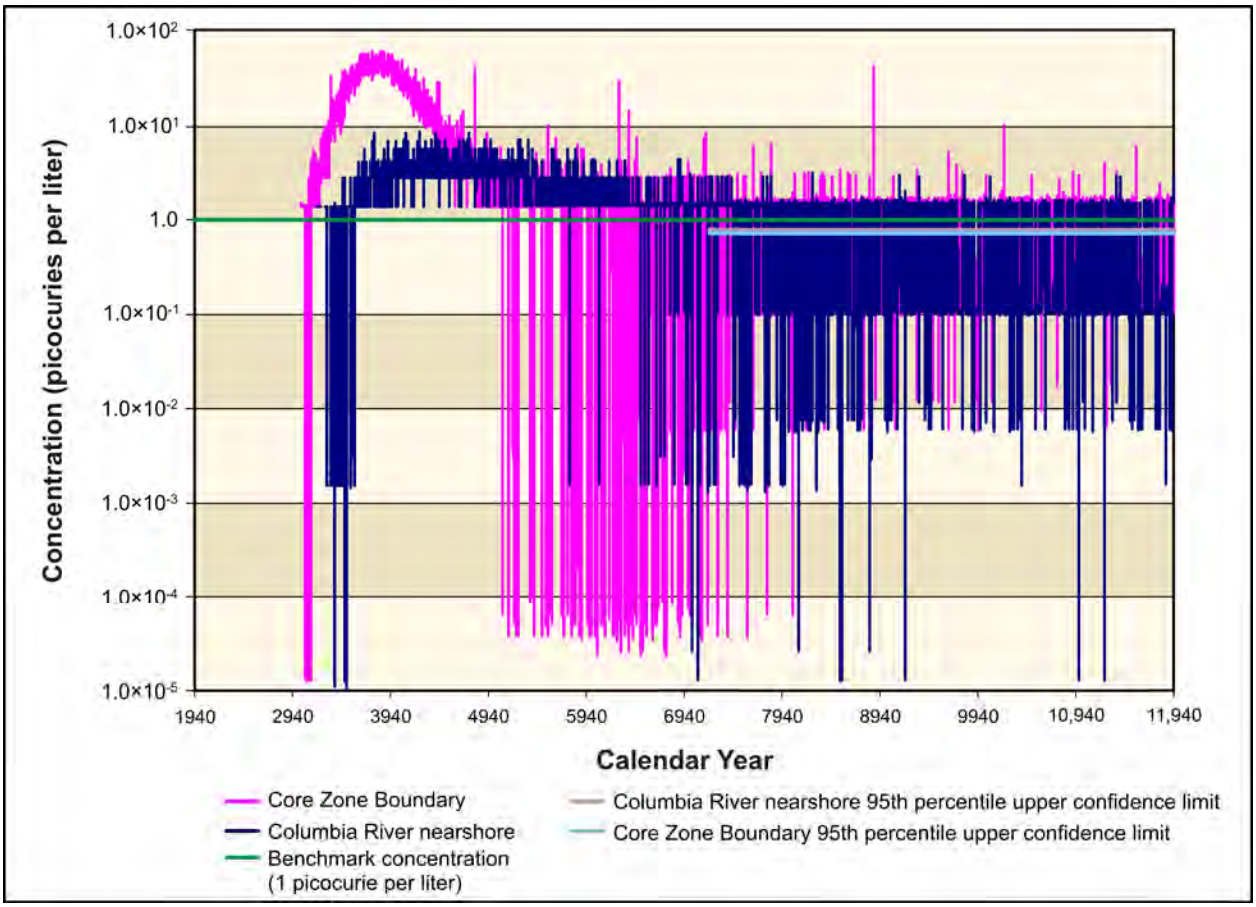


Figure 5–942. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Iodine-129 Concentration Versus Time

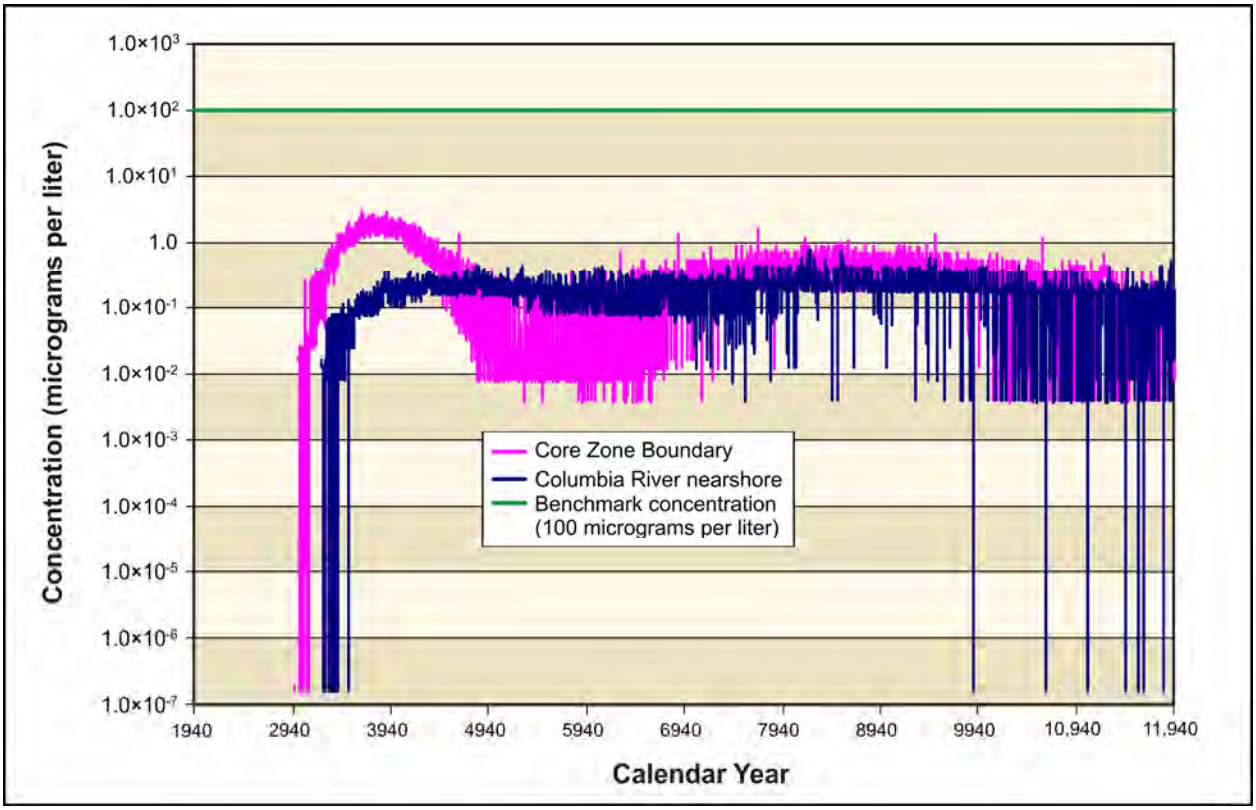


Figure 5–943. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chromium Concentration Versus Time

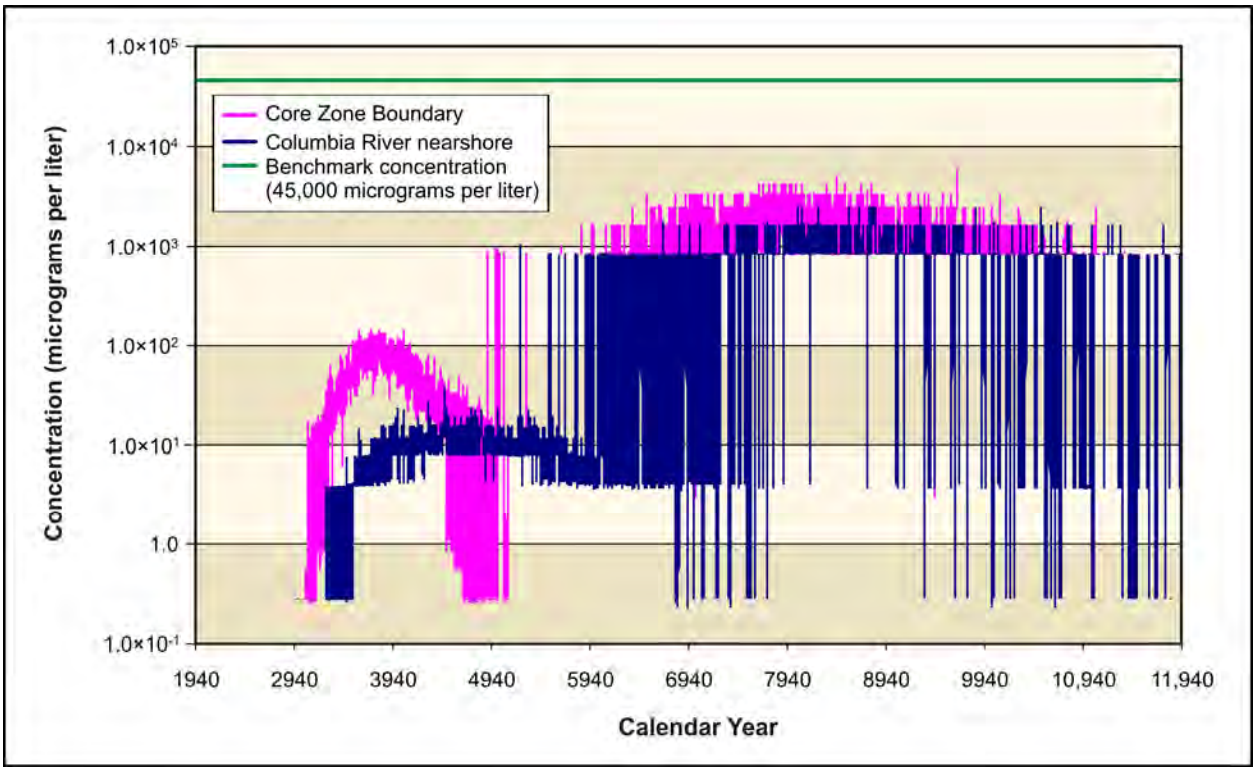


Figure 5–944. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Nitrate Concentration Versus Time

Figures 5–945 and 5–946 show concentration versus time for uranium-238 and total uranium. Because of the high retardation of uranium, no contamination appears until CY 8940, when uranium-238 concentrations at the Core Zone Boundary first surpass 1.0×10^{-8} micrograms per liter. Uranium-238 remains three orders of magnitude below the benchmark throughout the simulation. Total uranium remains over seven orders of magnitude below the benchmark concentration at the Core Zone Boundary throughout the simulation.

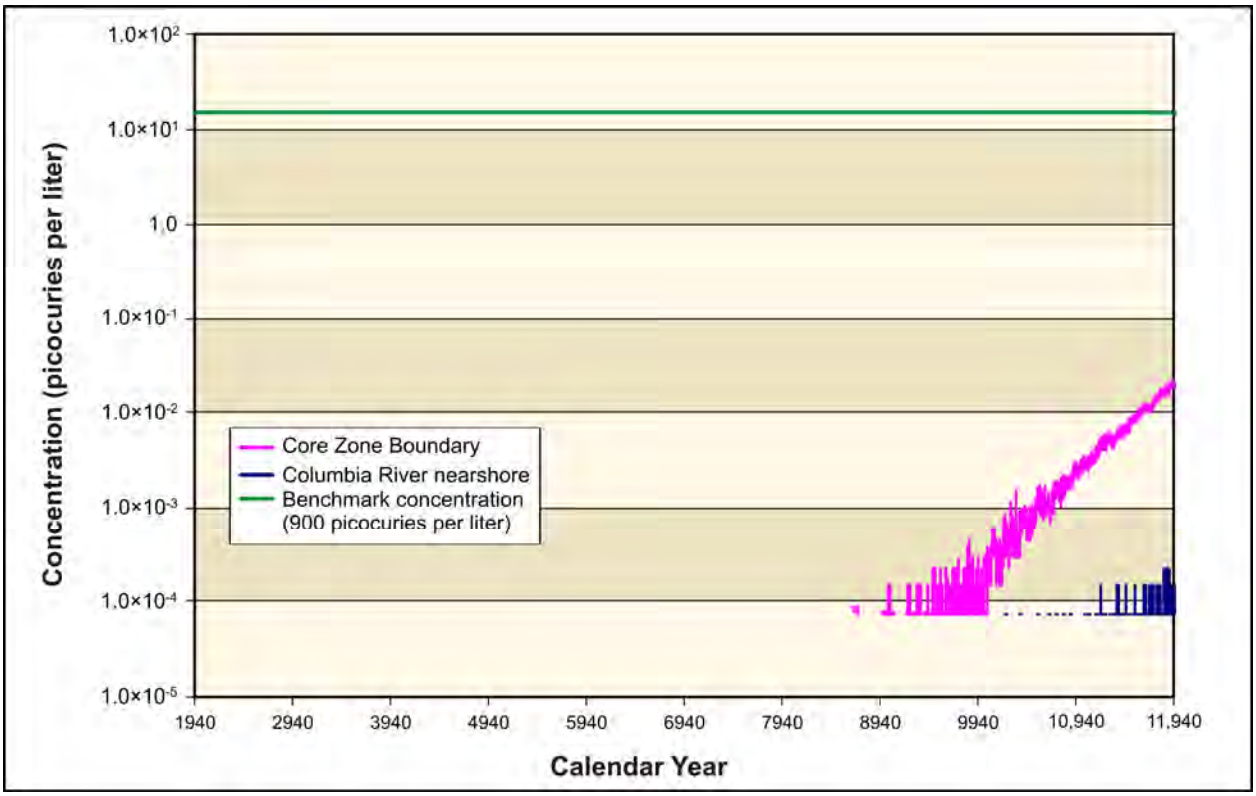


Figure 5–945. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Uranium-238 Concentration Versus Time

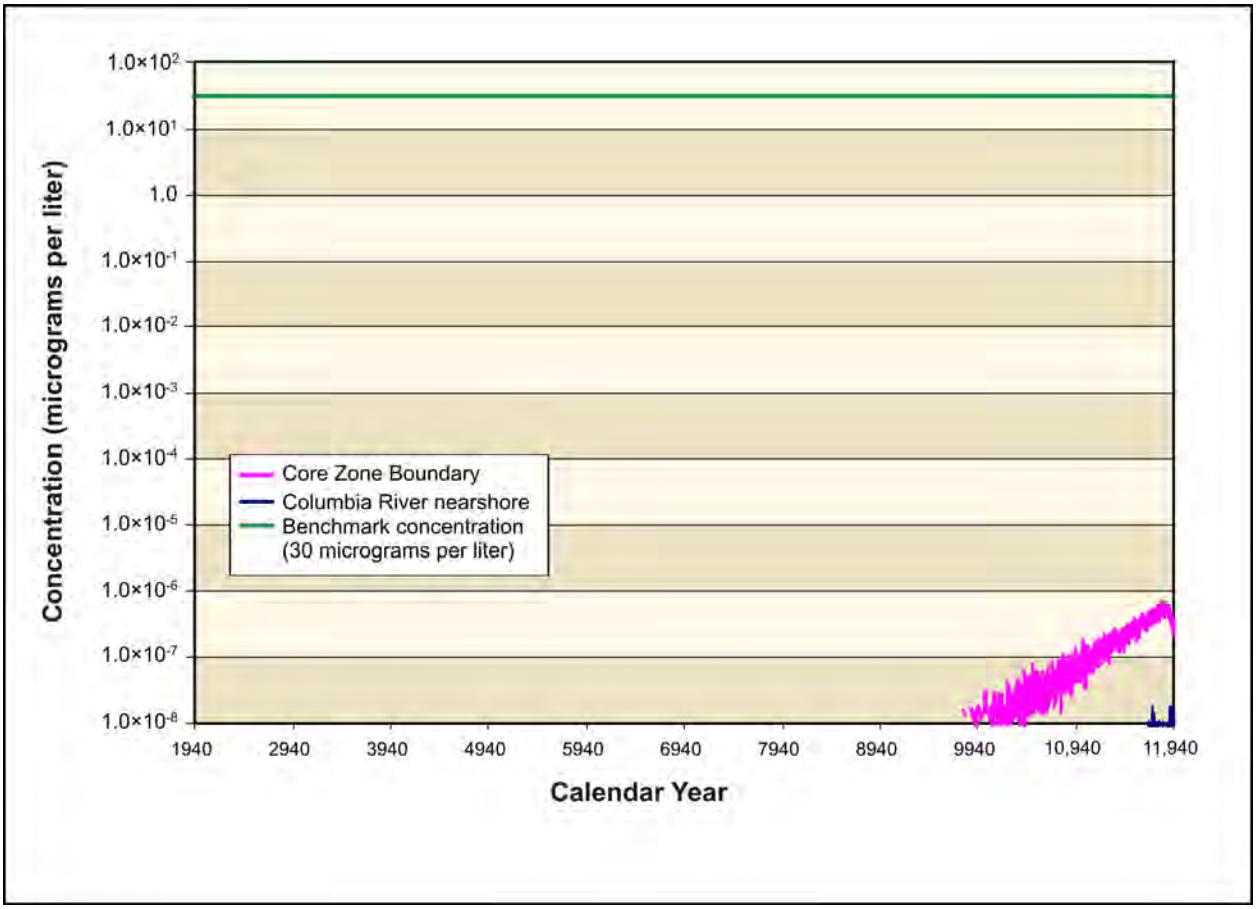


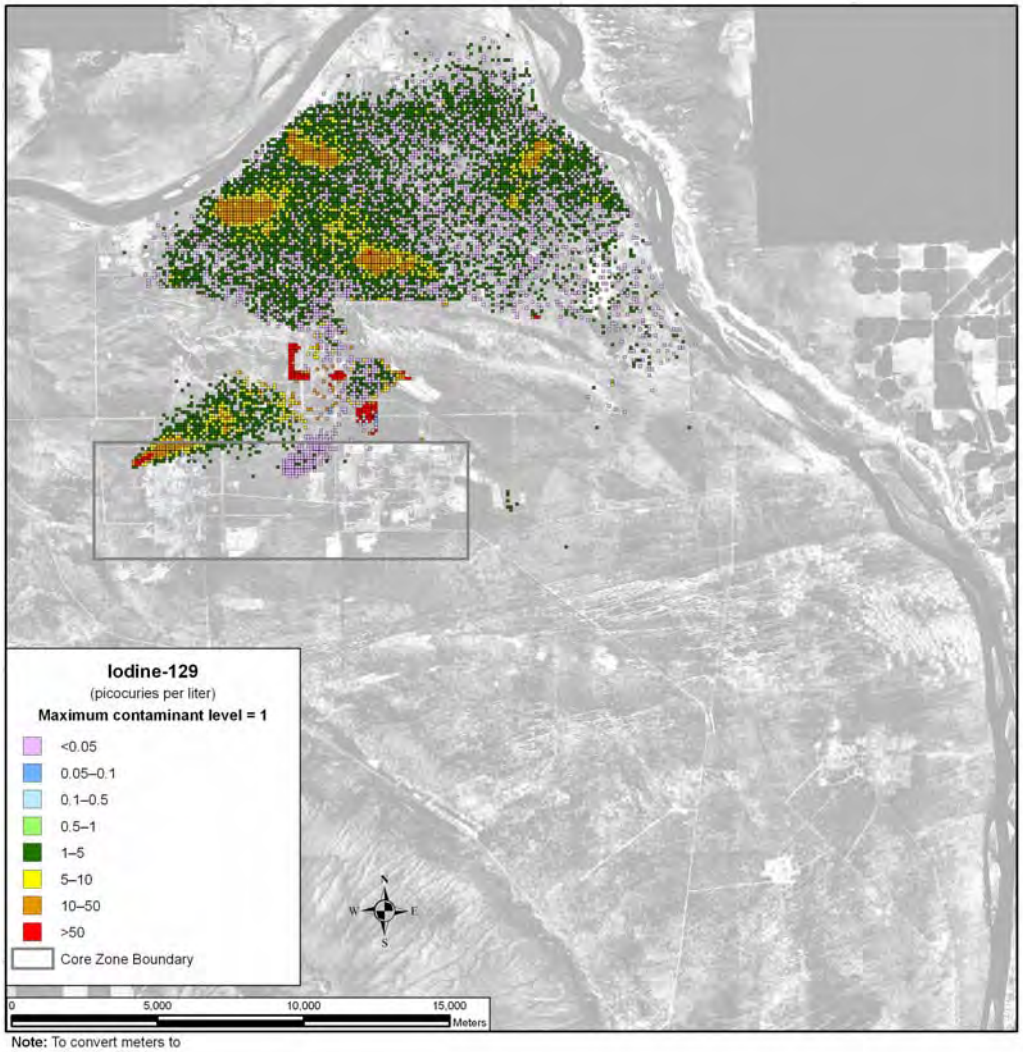
Figure 5–946. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale indicative of the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations lower than the benchmark, by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentrations ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

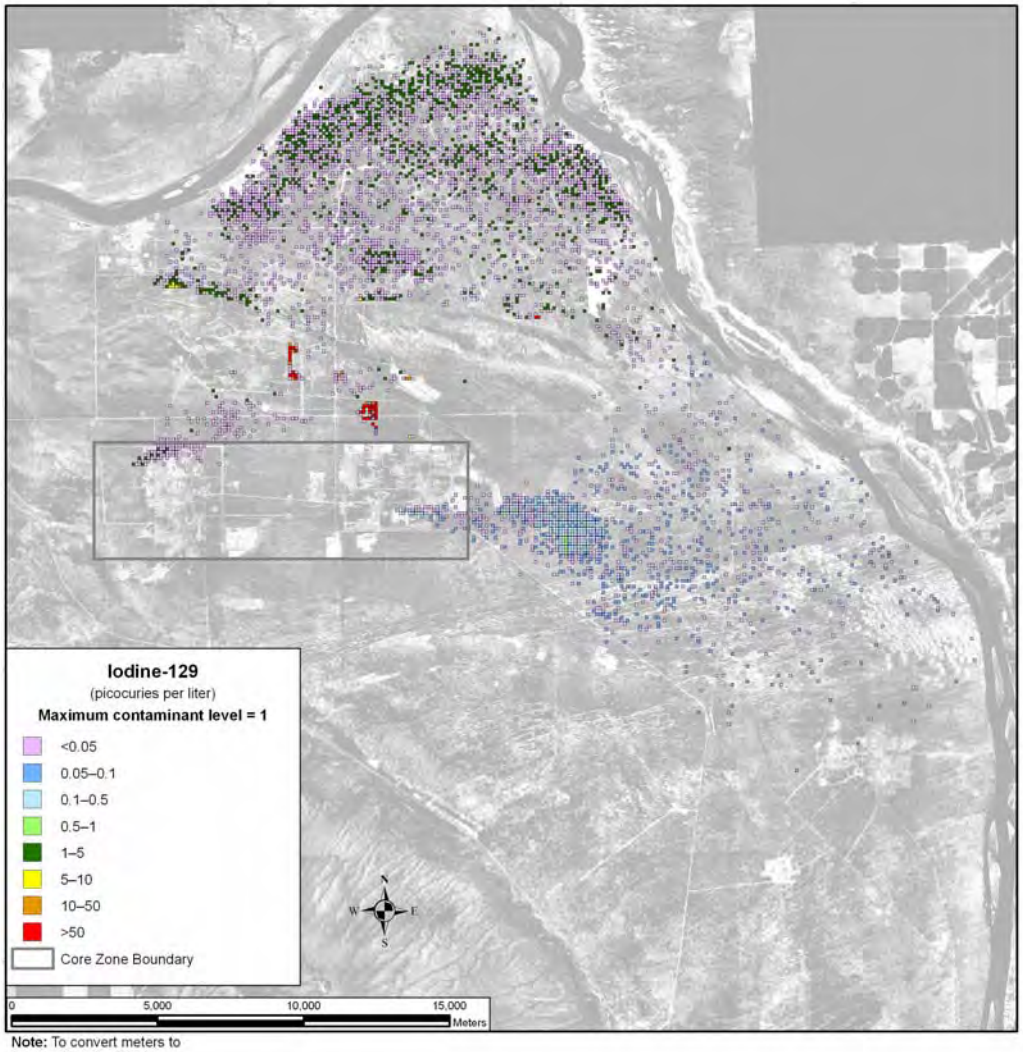
At CY 3890 (see Figure 5–947), there is a high-concentration plume of iodine-129 stretching northeast of IDF-West, and a low-concentration plume that stretches north from the RPPDF through Gable Gap. Four separate high-concentration areas have also formed north of Gable Mountain and Gable Butte. By CY 7140 (see Figure 5–948), the plumes from IDF-West and the RPPDF have dissipated, but a new plume has formed, traveling east from IDF-East. Concentrations in this plume remain close to the benchmark. Figure 5–949 shows the spatial concentration for iodine-129 during CY 11,885. Technetium-99 (see Figures 5–950 through 5–952) shows a similar spatial distribution, but has lower concentrations. Nitrate (see Figures 5–953 through 5–955) shows similar spatial distributions at selected times, but has consistently lower concentrations, well below the benchmark. Chromium (see Figures 5–956 through 5–958) has low-concentration plumes originating at IDF-East and the

RPPDF, but no contamination originating at IDF-West. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).



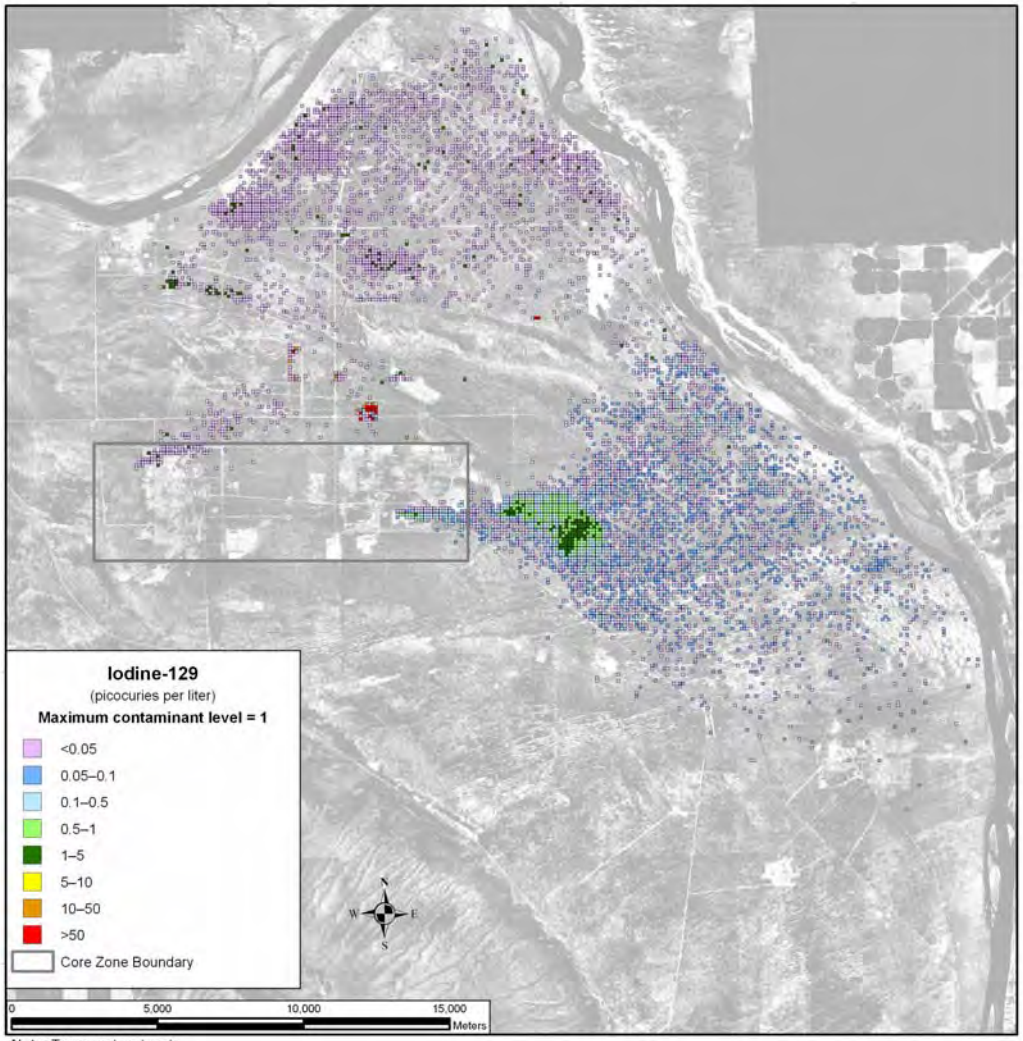
Note: To convert meters to feet, multiply by 3.281

Figure 5–947. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



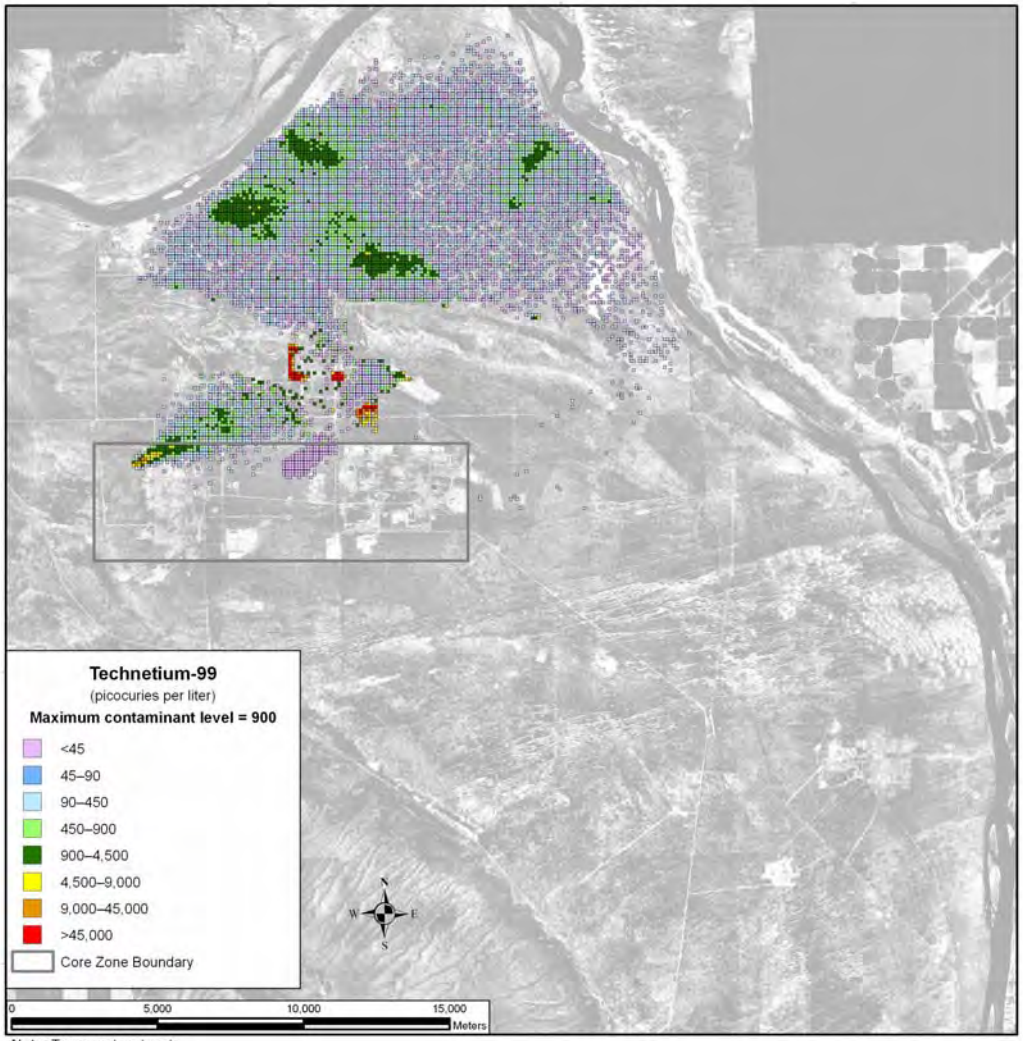
Note: To convert meters to feet, multiply by 3.281

Figure 5–948. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



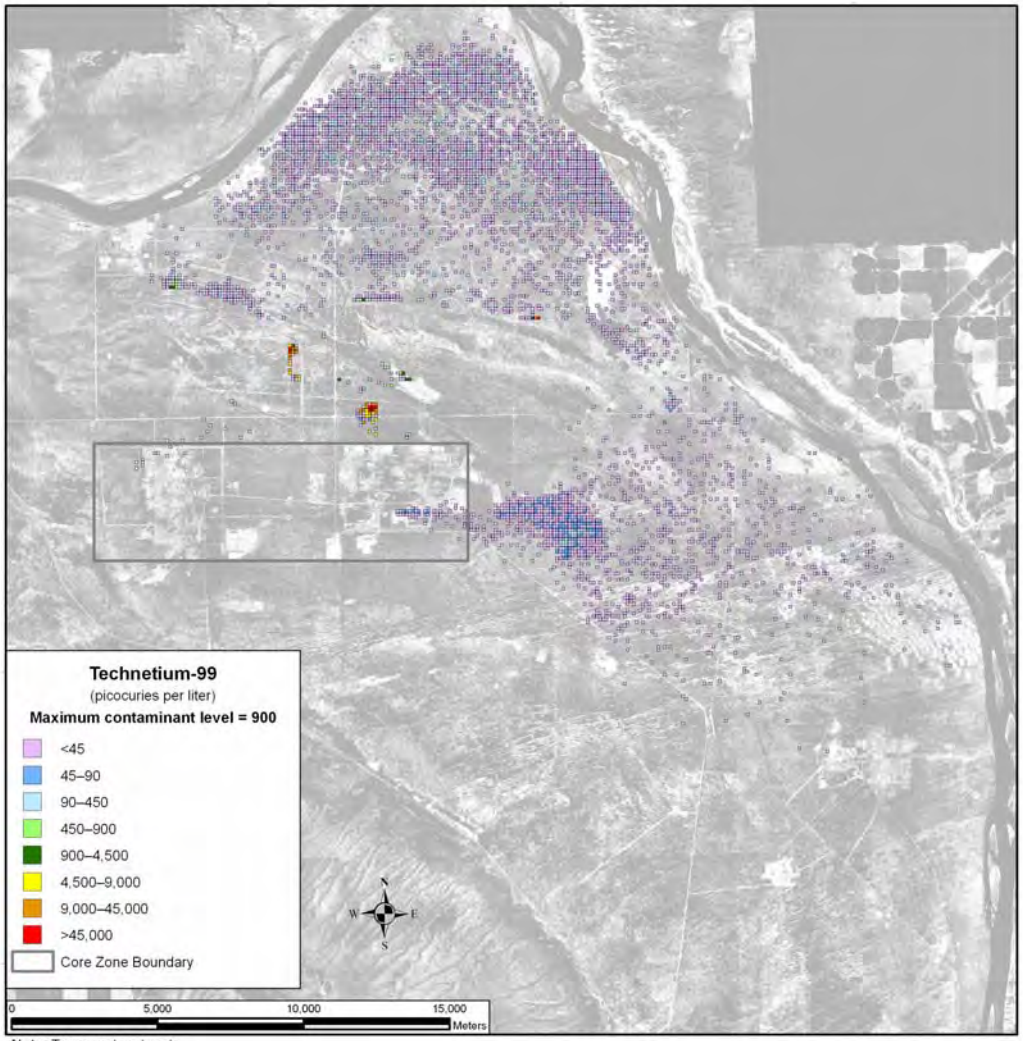
Note: To convert meters to feet, multiply by 3.281

Figure 5–949. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



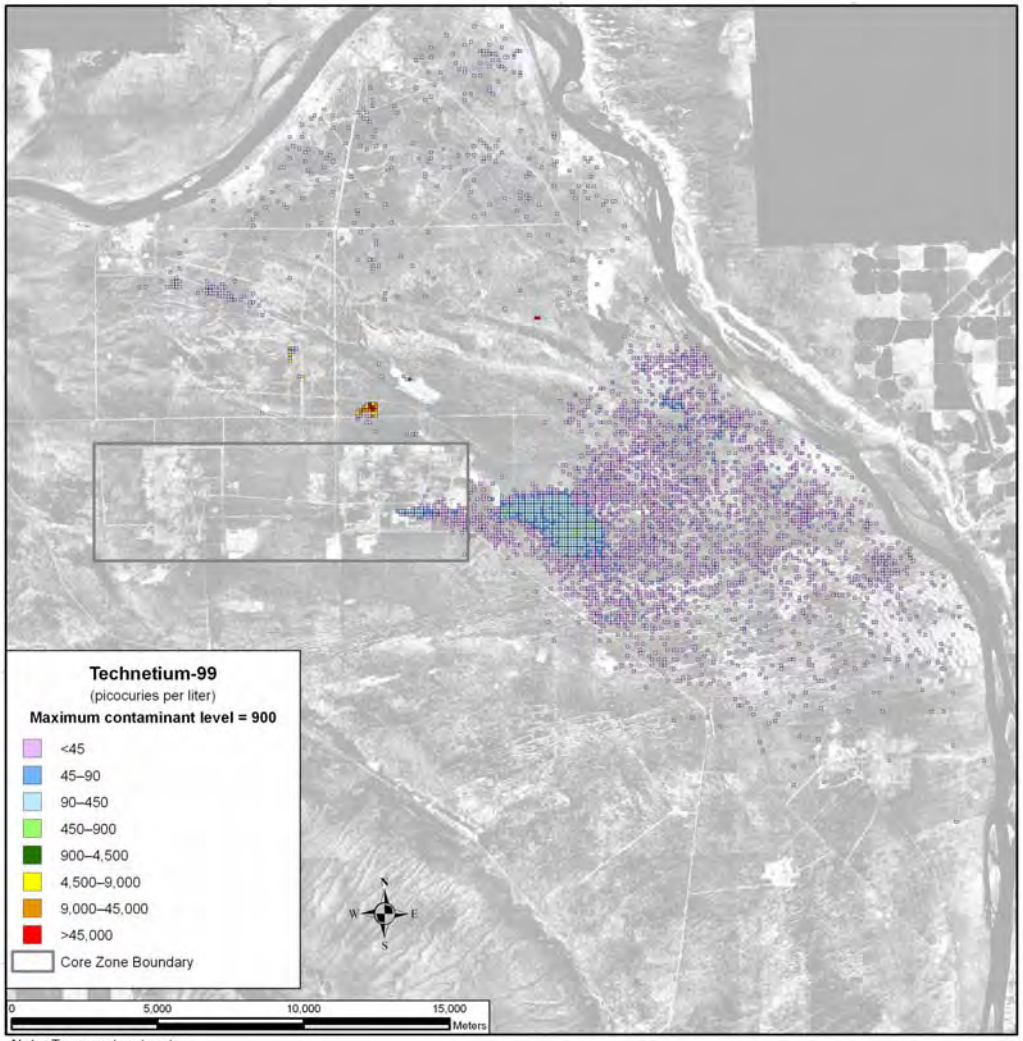
Note: To convert meters to feet, multiply by 3.281

Figure 5–950. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



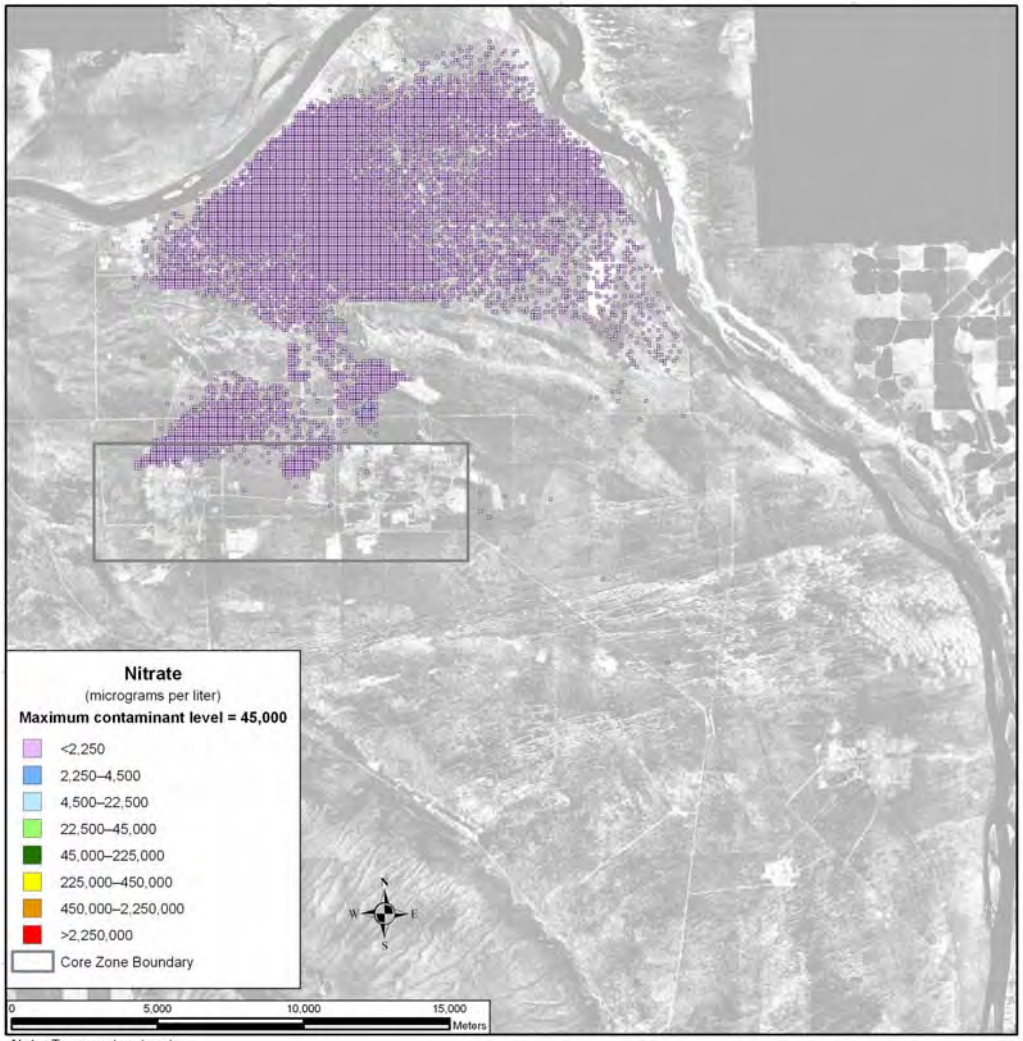
Note: To convert meters to feet, multiply by 3.281

Figure 5–951. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



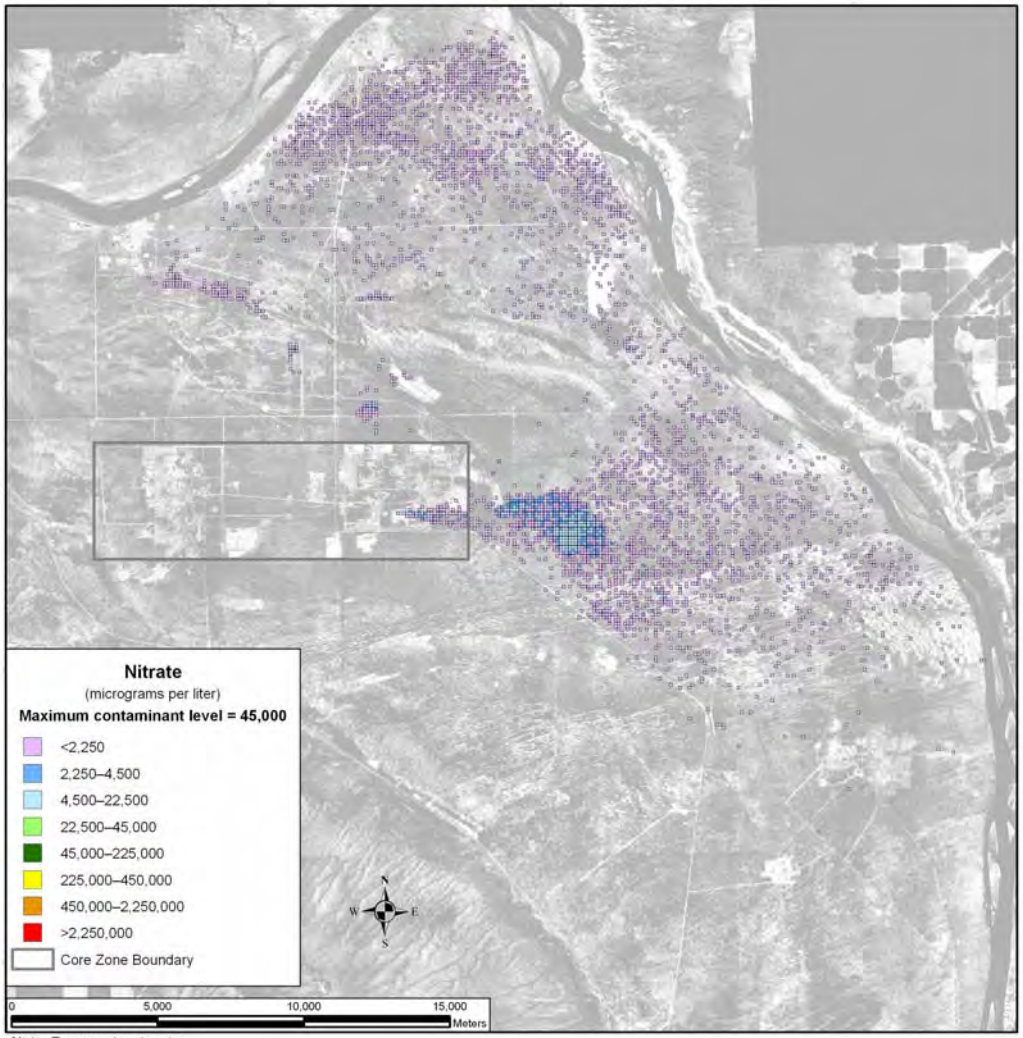
Note: To convert meters to feet, multiply by 3.281

Figure 5–952. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



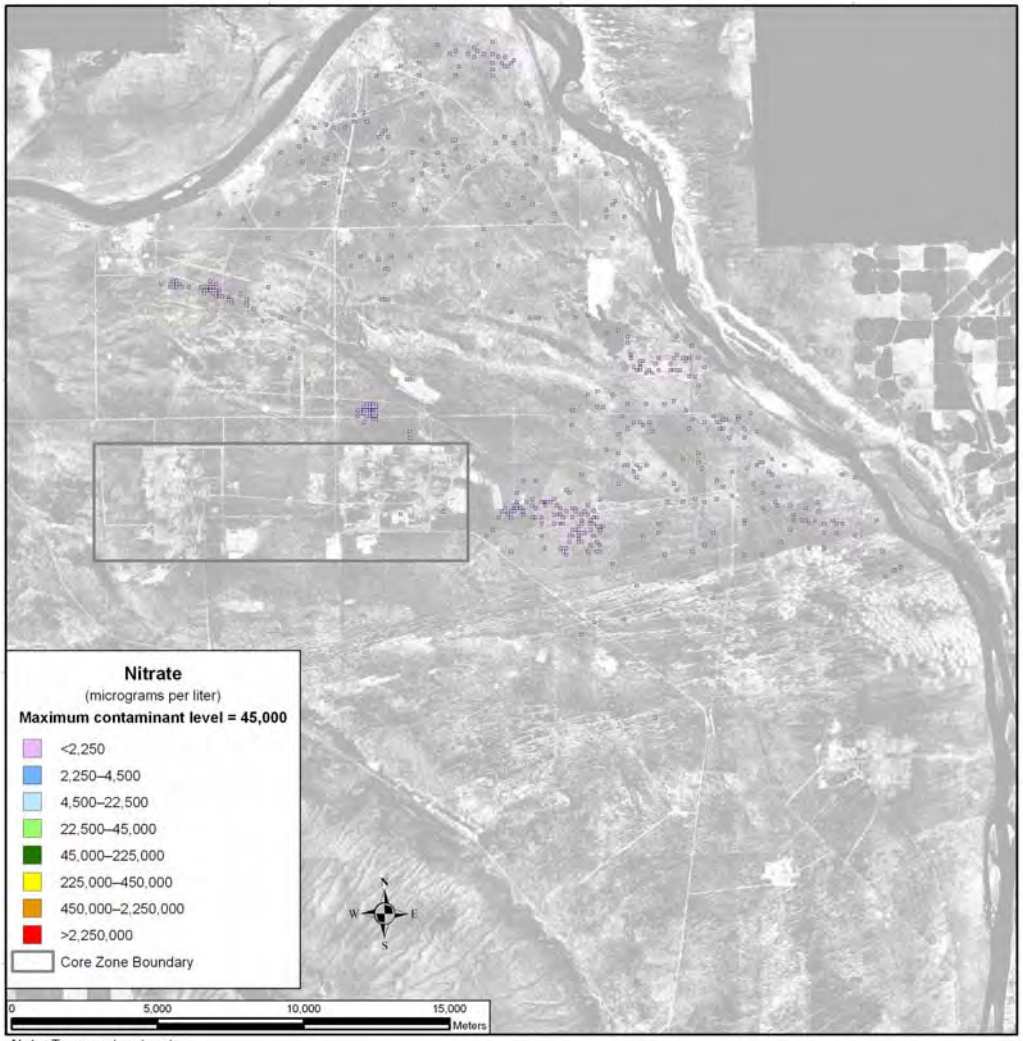
Note: To convert meters to feet, multiply by 3.281

Figure 5–953. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



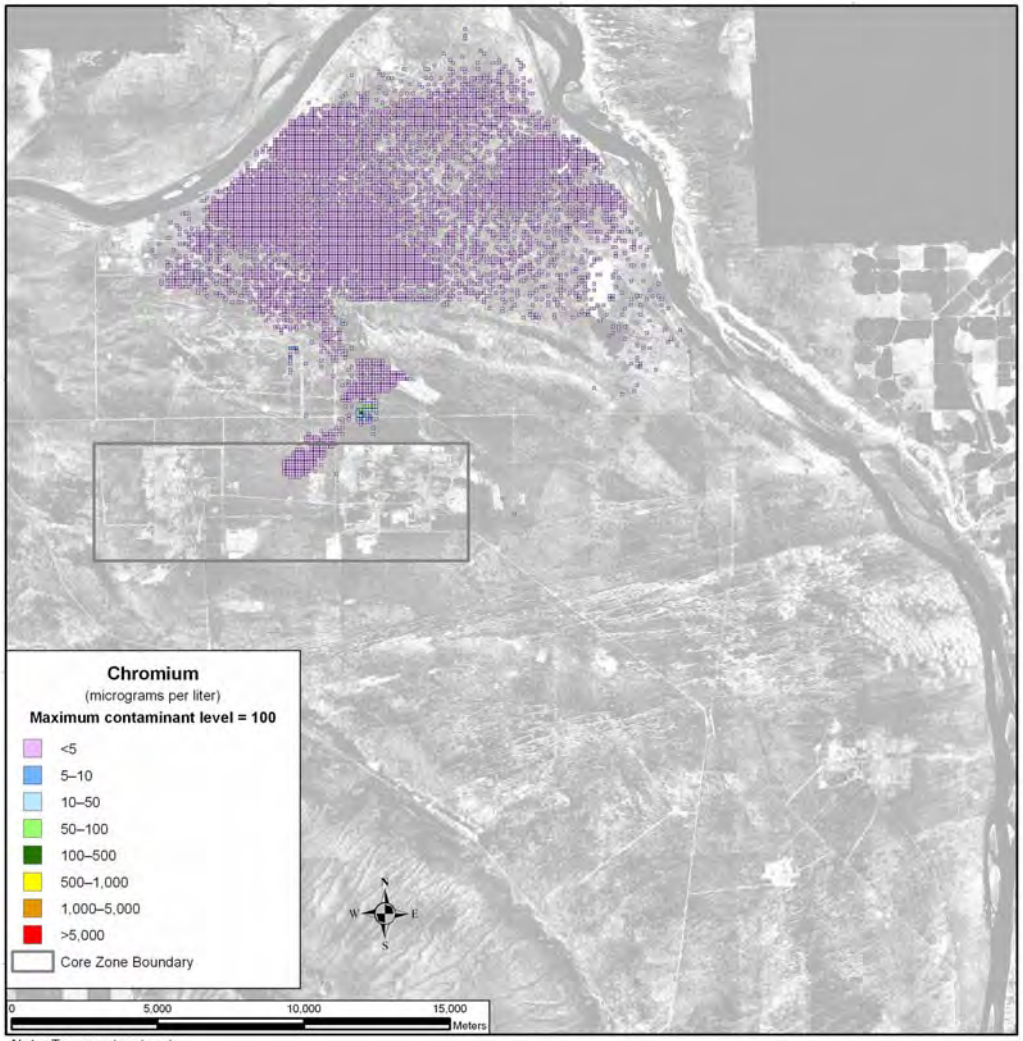
Note: To convert meters to feet, multiply by 3.281

Figure 5–954. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



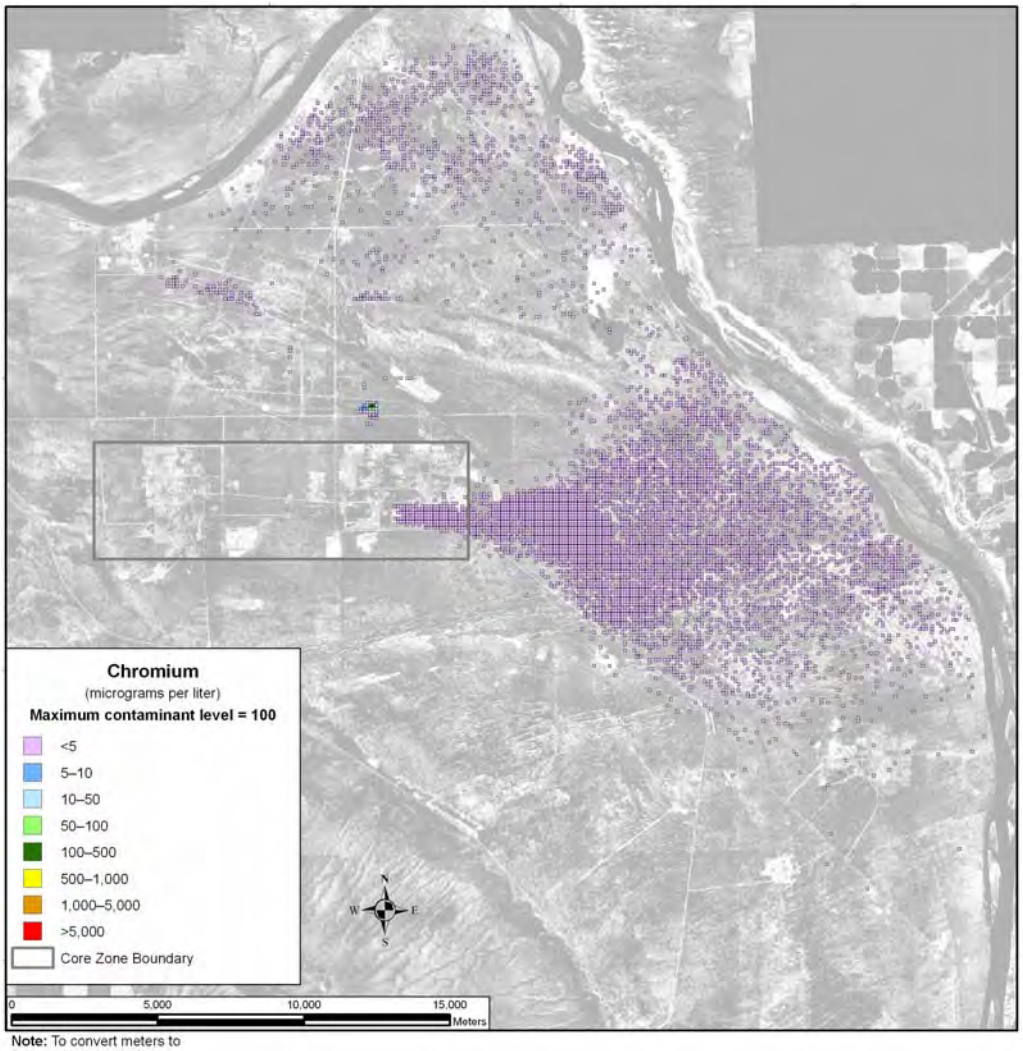
Note: To convert meters to feet, multiply by 3.281

Figure 5–955. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885



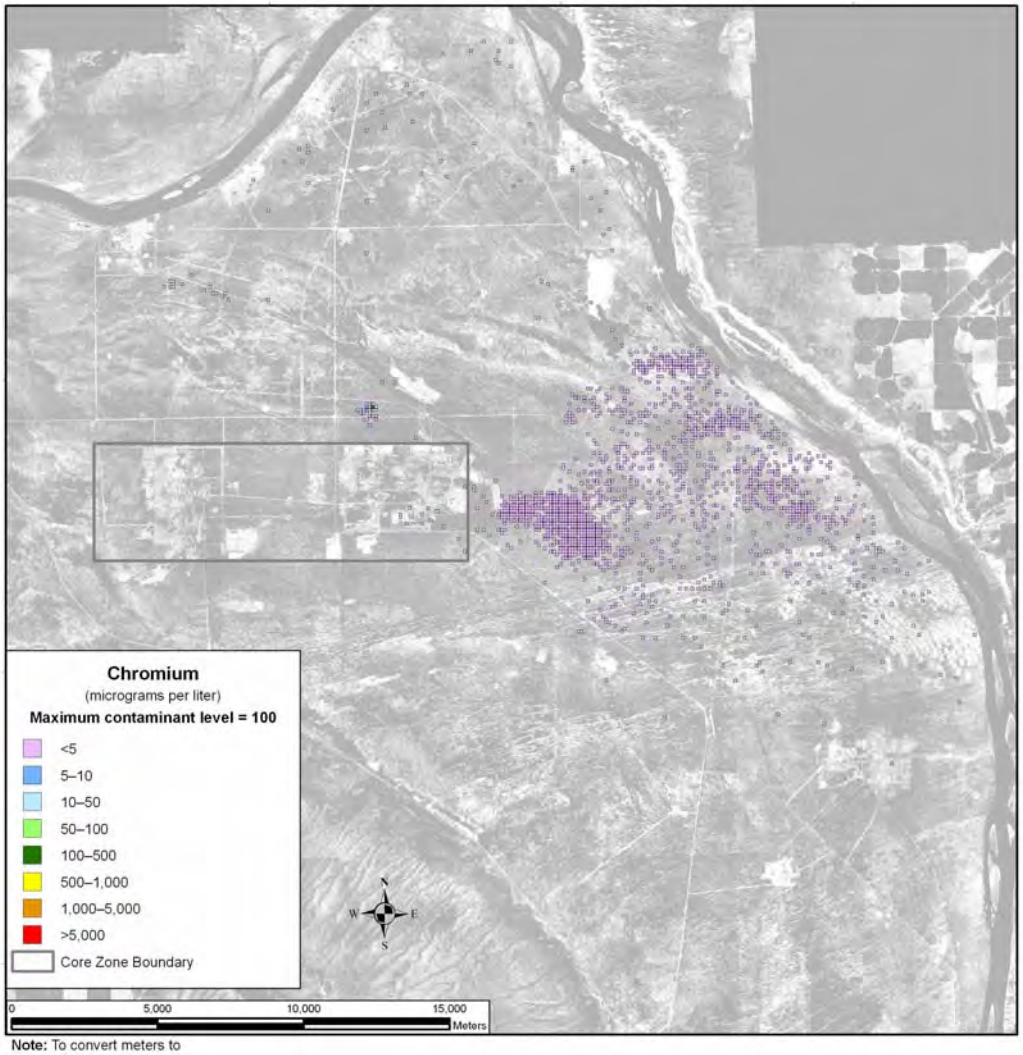
Note: To convert meters to feet, multiply by 3.281

Figure 5–956. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

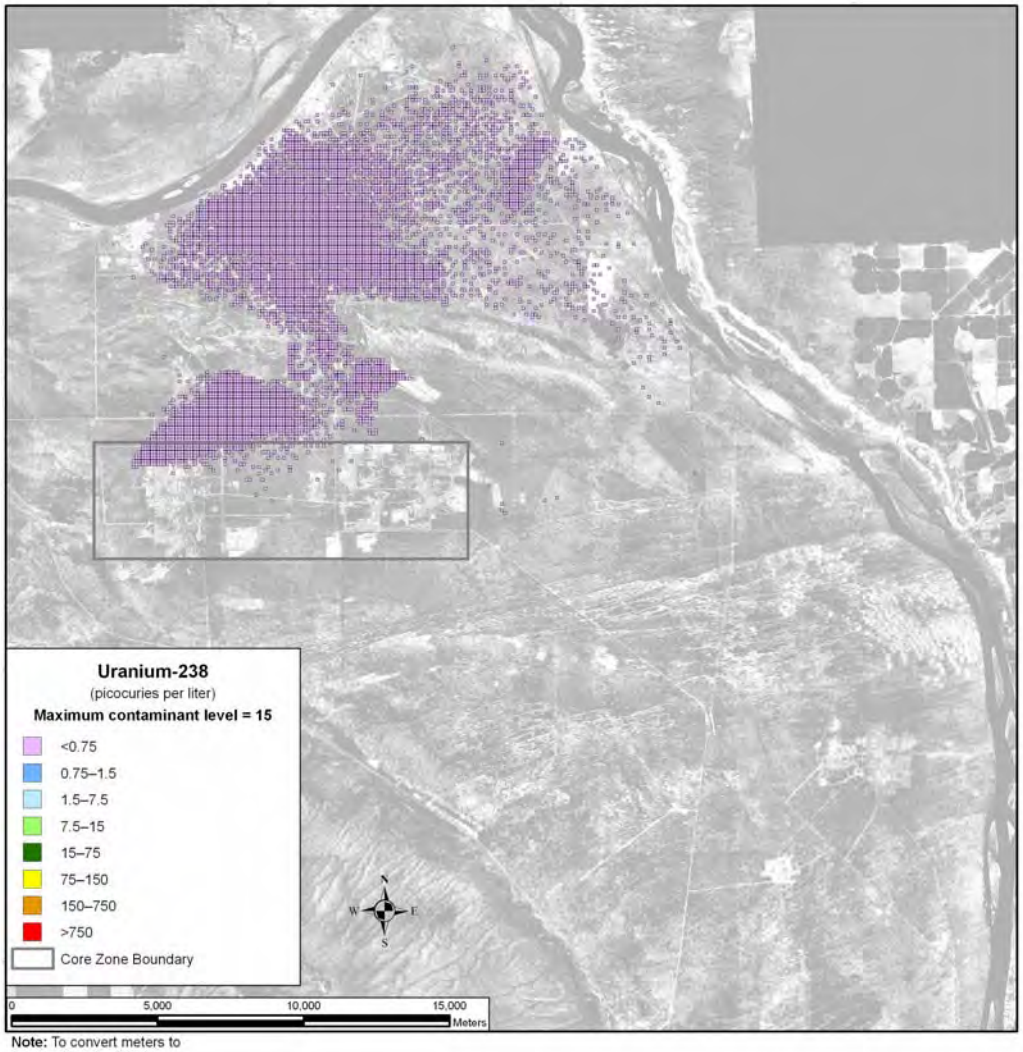
Figure 5–957. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–958. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

Total uranium and uranium-238 show a different spatial distribution over time. They are not as mobile as the COPCs discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. By CY 11,885, a uranium-238 plume extends northeast from IDF-West through Gable Gap (see Figure 5–959). Concentrations in all areas of the plumes remain below one-twentieth of the benchmark.



Note: To convert meters to feet, multiply by 3.281

Figure 5–959. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, in general, discharges from IDF-West are the predominant contributors. IDF-East and the RPPDF are secondary contributors.

Concentrations of iodine-129 and technetium-99 show a sharp rise and fall between CY 2940 and CY 4940 that exceeds the benchmark by an order of magnitude or slightly more. Concentrations of these COPCs stabilize near the benchmark concentration around CY 7940. Chromium shows a similar rise and fall but remains about two orders of magnitude below the benchmark. Nitrate has a similar rise and fall in concentrations between CY 2940 and CY 4940, followed by another rise in concentrations. This rise in concentration stabilizes around CY 6940 and is about an order of magnitude greater than the first peak, but an order of magnitude below the benchmark concentration.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species remain well below the

benchmark at the Core Zone Boundary and the Columbia River nearshore throughout the simulation. The peak intensity and area of the contamination plume are near the end of the period of analysis.

5.3.1.3.2 Disposal Group 2

Disposal Group 2 is characterized by operational completion dates of CY 2100 for IDF-East and the RPPDF, and CY 2050 for IDF-West. In Disposal Group 2, IDF-West has a large capacity (90,000 cubic meters [117,720 cubic yards]), IDF-East has a larger capacity (325,000 cubic meters [425,100 cubic yards]), and the RPPDF has an even larger capacity (8,370,000 cubic meters[10,947,960 cubic yards]). These capacities were designed to meet the waste generation volumes associated with Tank Closure Alternative 2A or 6B, FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste.

5.3.1.3.2.1 Disposal Group 2, Subgroup 2-A

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, includes Tank Closure Alternative 2A, FFTF Decommissioning Alternative 2 or 3, and onsite and offsite waste.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009 and continues through CY 2050 for IDF-West and CY 2100 for IDF-East when the disposal facilities will be operationally closed. During the disposal period, the materials in this permitted, operational facility are not available for release to the environment.

- The post-disposal period starts in CY 2101 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East and IDF-West become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, IDF-East and IDF-West are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, then selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above accounts for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, boron, chromium, fluoride, nitrate) are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A (IDF-East and IDF-West), in terms of total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

IDF-East has four subtotals plotted representing releases from ILAW glass, ETF-generated secondary waste, retired melters, and tank closure secondary waste.

Figure 5–960 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–961, the chemical hazard drivers. For all four types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source for technetium-99 and chromium is tank closure secondary waste. Iodine-129 and nitrate have ETF-generated secondary waste as the predominant source. Boron and fluoride do not exist at IDF-East.

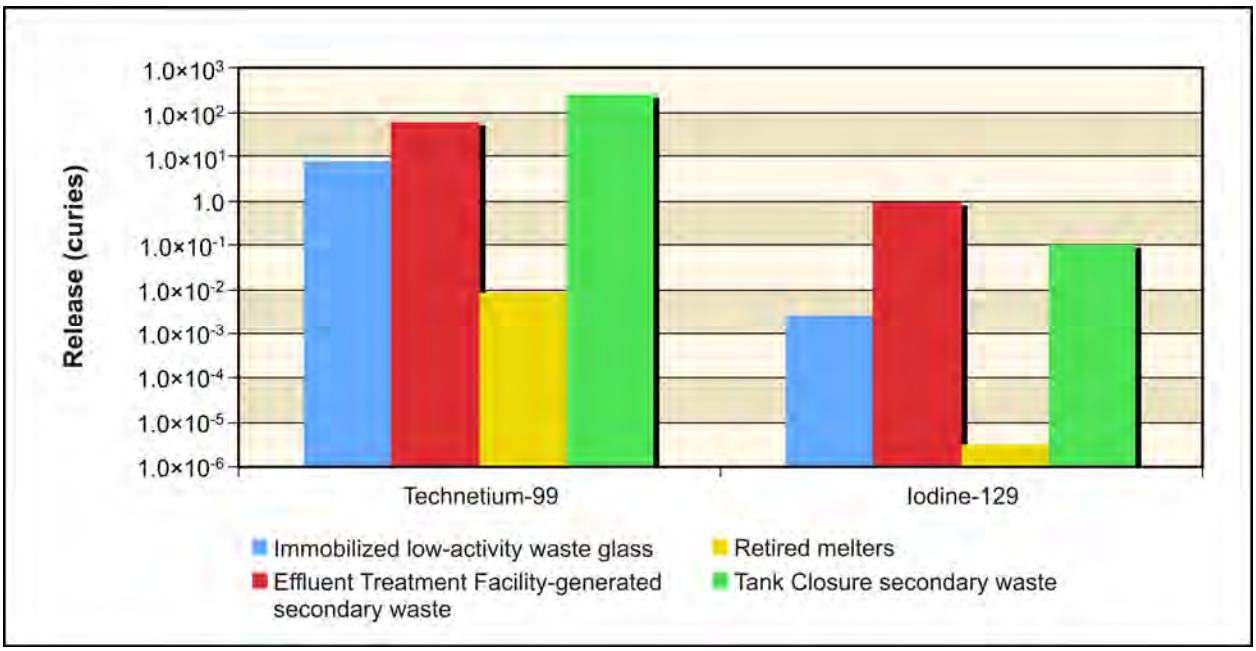


Figure 5–960. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

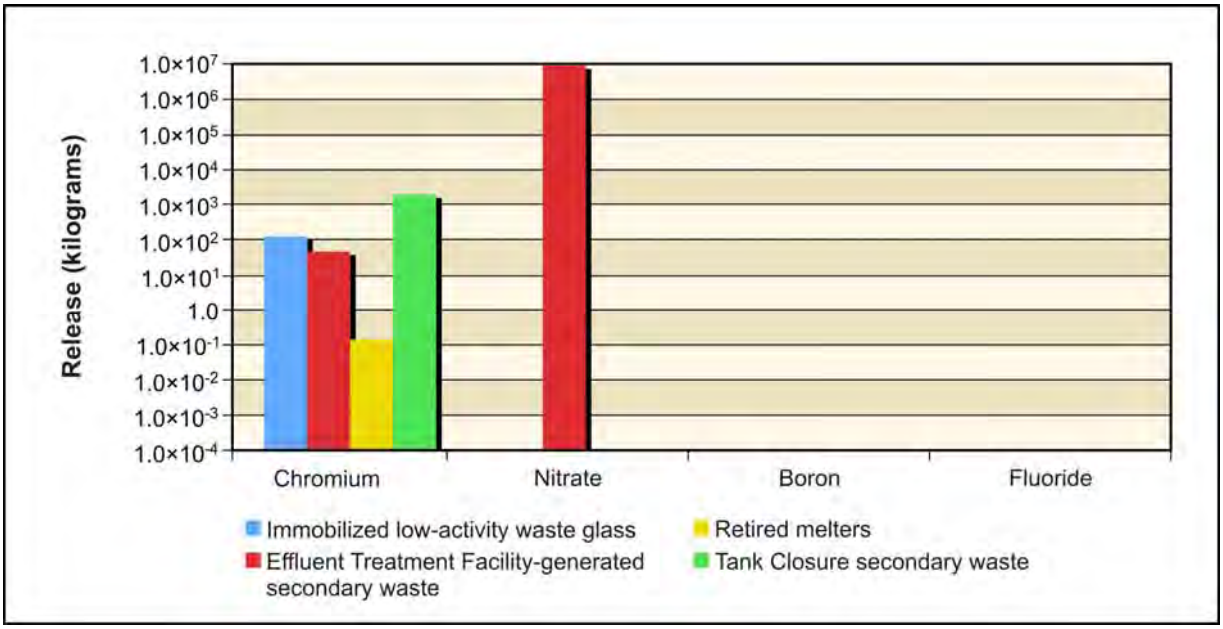


Figure 5–961. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–962 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–963, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. "Essentially equal" means that there is a difference of less than one order of magnitude. Overall, about 58 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reaches the groundwater, while approximately 100 percent of the chemical quantity (kilograms) released to the vadose zone during the period of analysis reaches the groundwater.

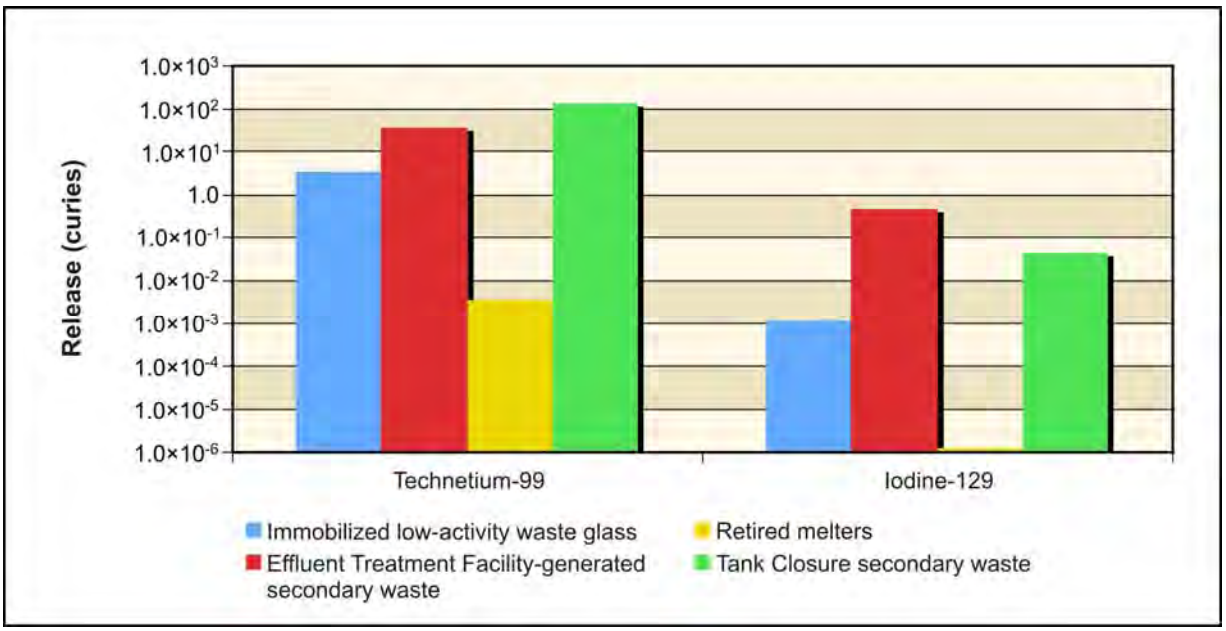


Figure 5–962. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

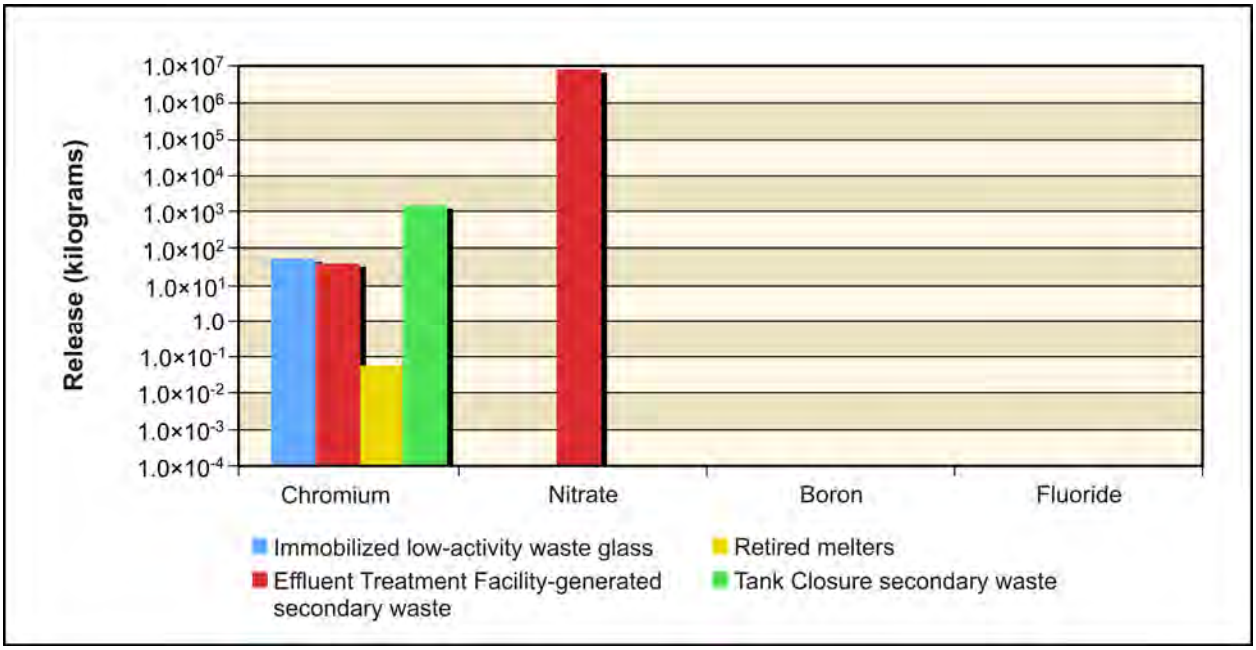


Figure 5–963. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–964 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–965, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, iodine-129, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 91 percent of the radionuclide amount (curies) released to the groundwater during the period of analysis reaches the river, while approximately 98 percent of the chemical quantity (kilograms) released to the groundwater during the period of analysis reaches the river.

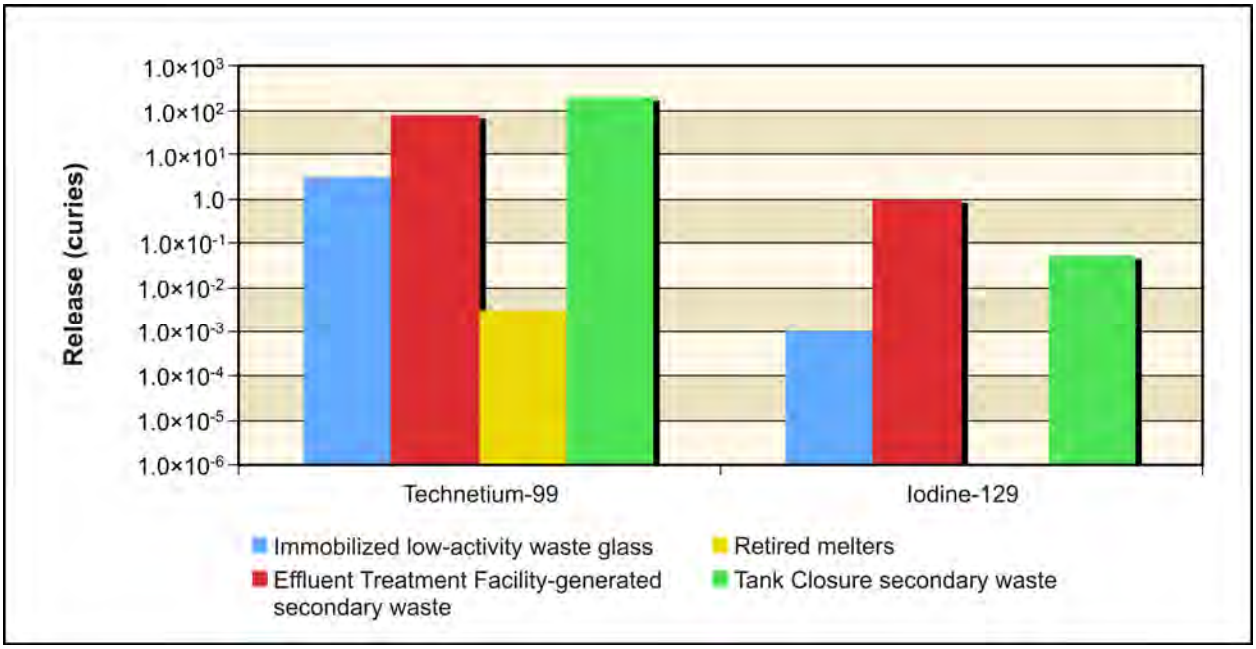


Figure 5–964. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

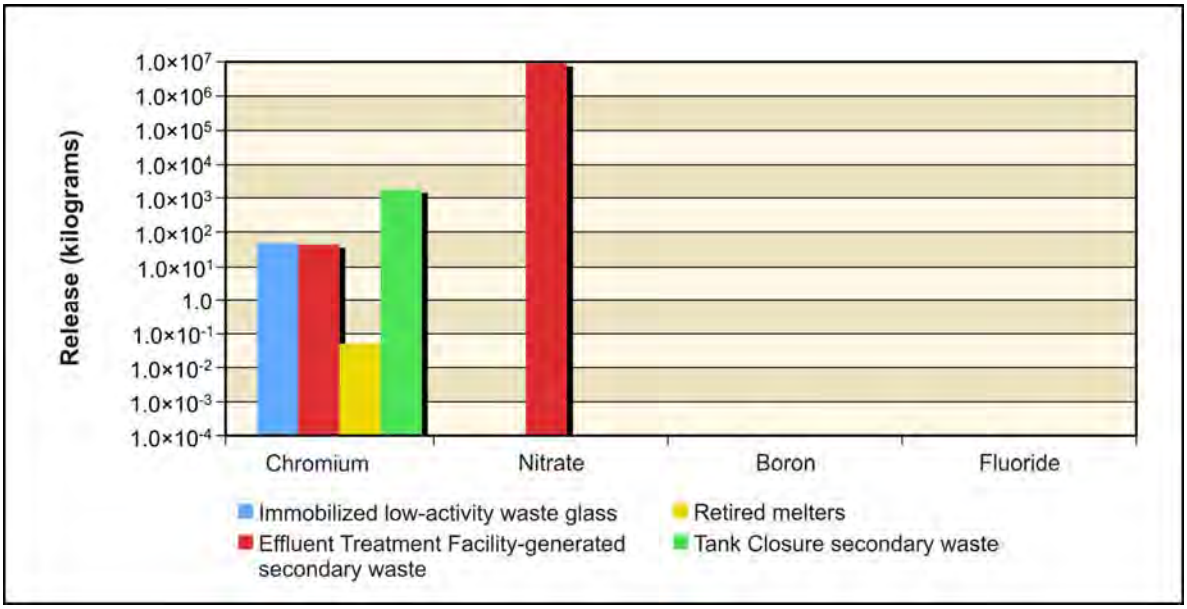


Figure 5–965. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases from FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste.

Figure 5–966 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–967, the chemical hazard drivers. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source for technetium-99 and iodine-129 is offsite waste. For chromium, nitrate, boron, and fluoride, the predominant source is waste management secondary waste and onsite-generated waste.

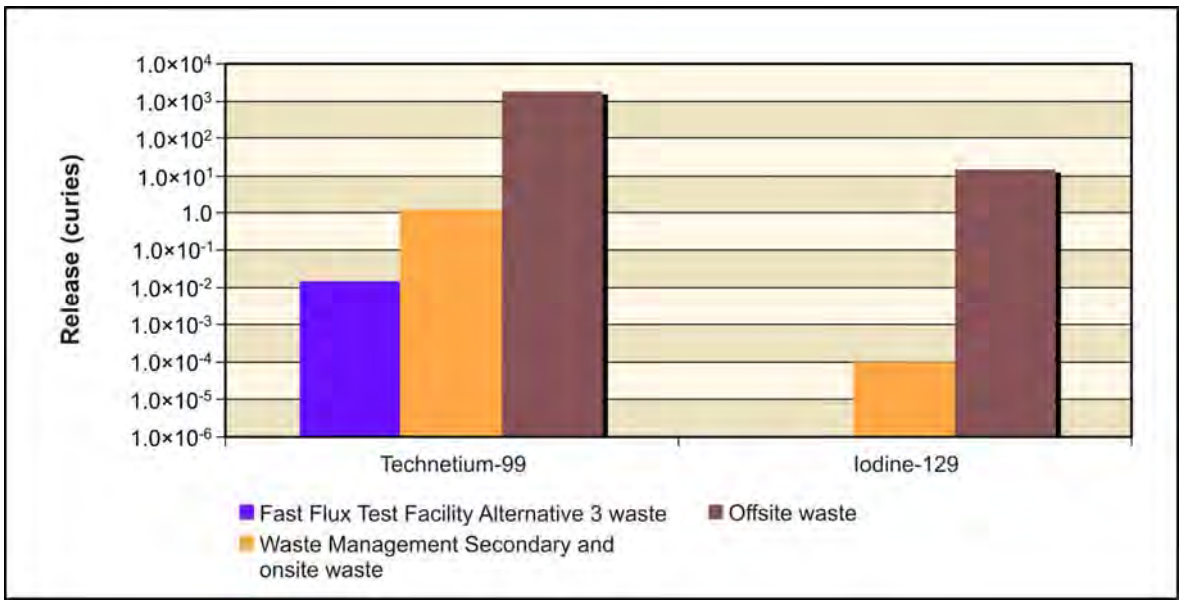


Figure 5–966. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

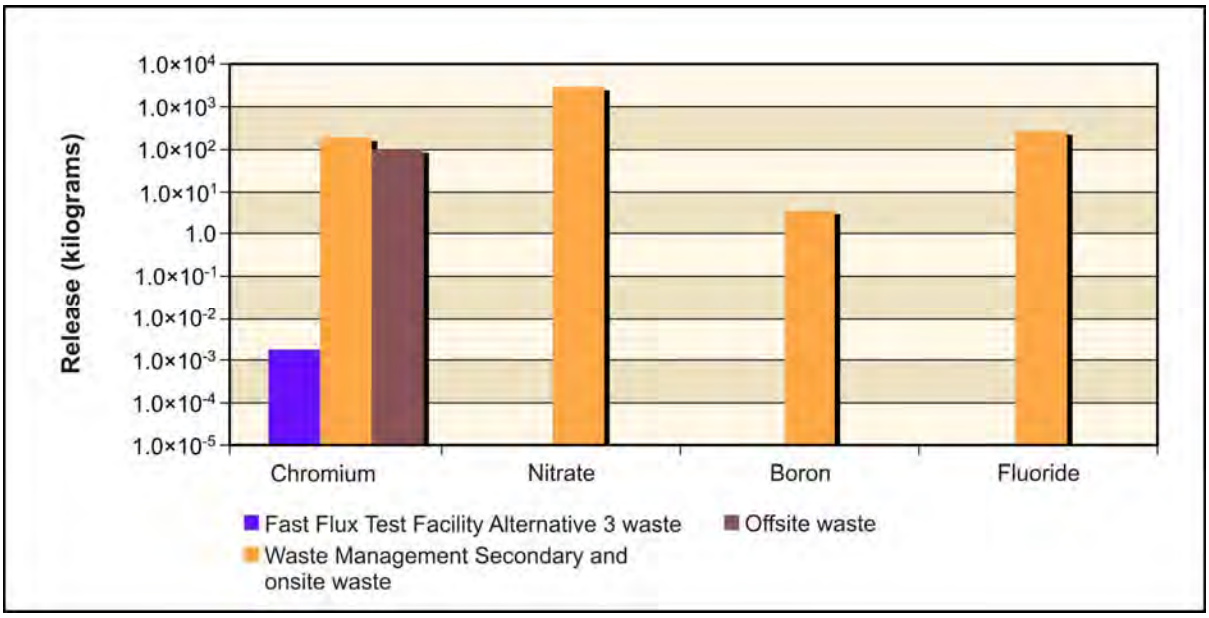


Figure 5–967. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–968 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–969, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, nitrate, boron, and fluoride, the amount released to groundwater is essentially equal to the amount released to the vadose zone. "Approximately equal" means that there is a difference of less than one order of magnitude. Overall, about 98 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reaches groundwater, while approximately 100 percent of the chemical quantity (kilograms) released to the vadose zone during the period of analysis reaches groundwater.

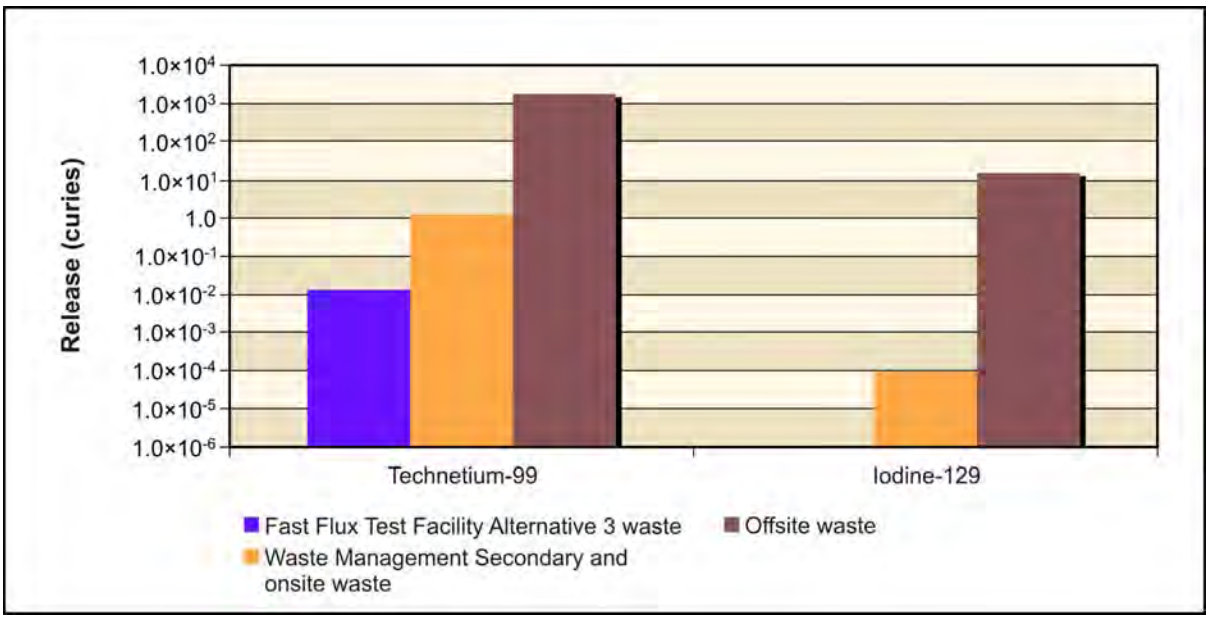


Figure 5–968. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

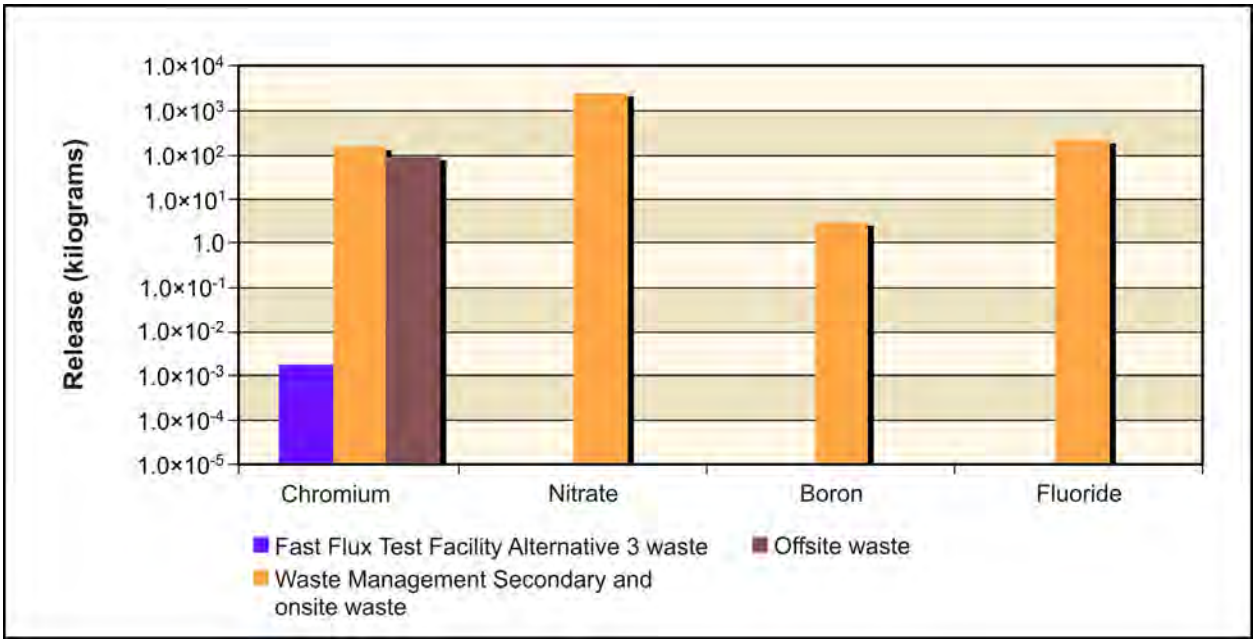


Figure 5–969. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–970 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–971, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, iodine-129, chromium, nitrate, boron, and fluoride, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 97 percent of the radionuclide amount (curies) released to groundwater during the period of analysis reaches the river while approximately 98 percent of the chemical quantity (kilograms) released to groundwater during the period of analysis reaches the river.

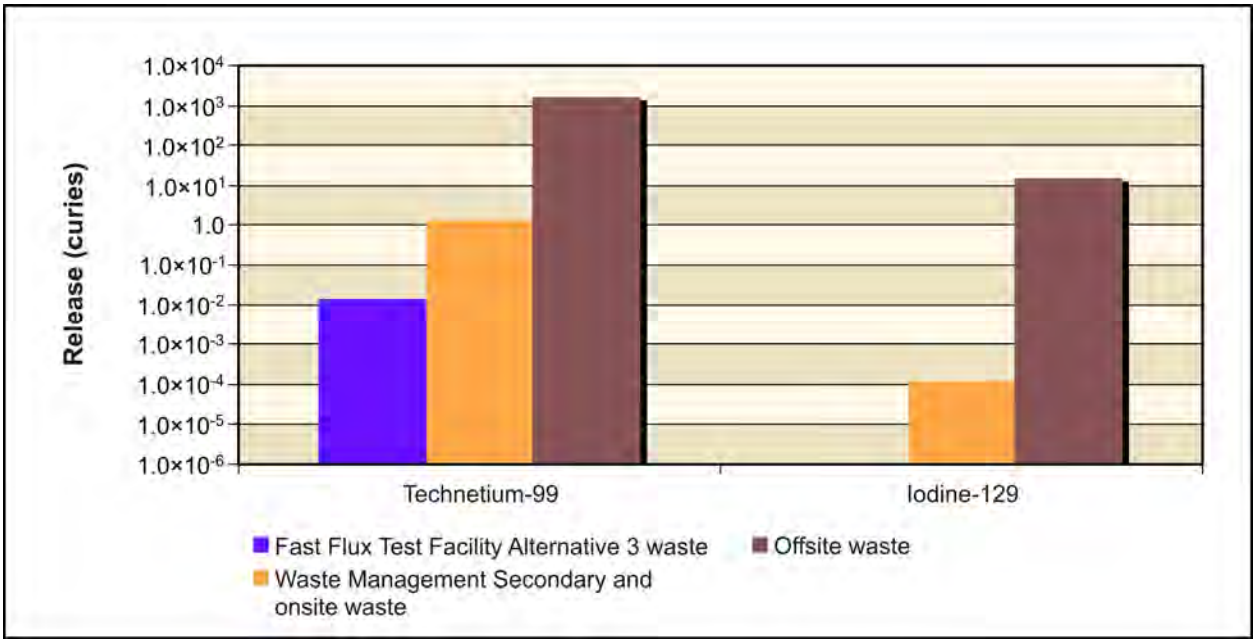


Figure 5–970. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

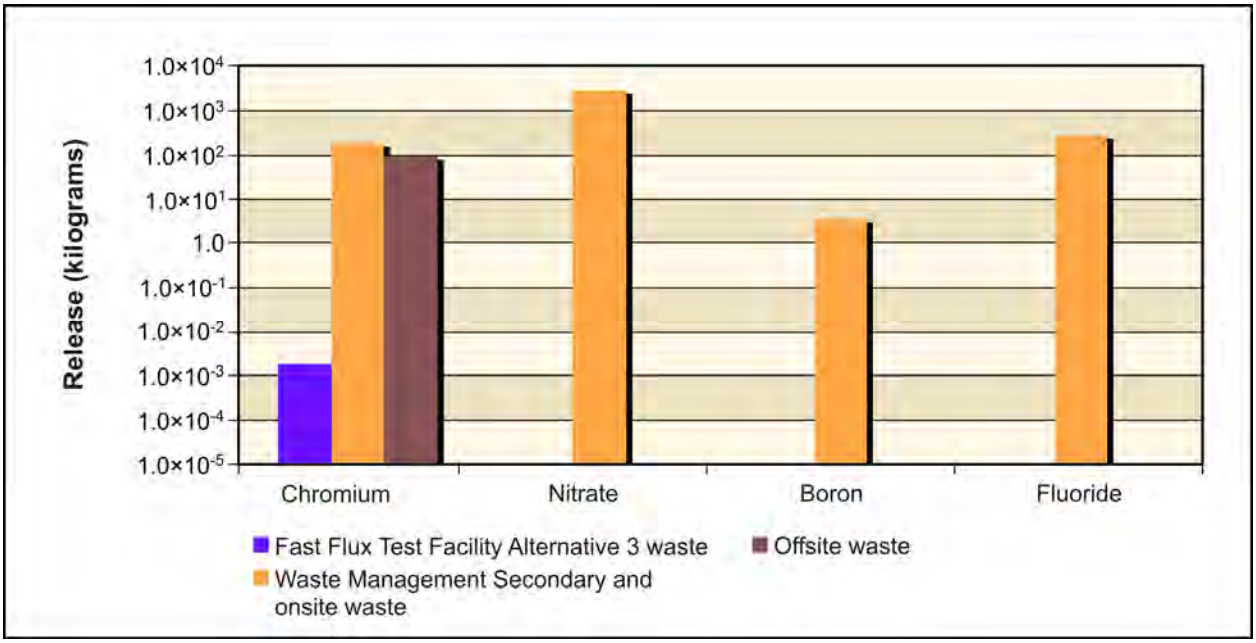


Figure 5–971. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration for each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations.

Figures 5–972 through Figure 5–975 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. Releases from IDF-East and IDF-West cause groundwater concentrations of iodine-129 to exceed benchmark concentrations at the Core Zone Boundary and Columbia River nearshore by approximately one order of magnitude. Iodine-129 concentration exceeds the benchmark in the earlier part of the period of analysis. Technetium-99 has one peak at the Core Zone Boundary that exceeds the benchmark by one order of magnitude. This peak only lasts for approximately 10 percent of the period of analysis. Technetium-99 sporadically exceeds the benchmark at the Columbia River nearshore, and the 95th percentile upper confidence limit is within an order of magnitude below the benchmark for most of the period of analysis. Nitrate and chromium do not exceed benchmark concentrations at the Core Zone Boundary or Columbia River nearshore. Table 5–96 shows the maximum concentrations in groundwater.

Table 5–96. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	334	**20,200**	N/A	**7,540**	**1,130**	900
	(9823)	(3713)		(3690)	(4528)	
Iodine-129	**2**	**173**	N/A	**60**	**8**	1
	(10,498)	(3797)		(3853)	(4729)	
Chemical in micrograms per liter						
Chromium	3	2	N/A	2	1	100
	(9308)	(3696)		(8982)	(8353)	
Fluoride	0	1	N/A	1	0	4,000
	(1940)	(3684)		(3907)	(4555)	
Nitrate	15,500	17	N/A	5,700	4,070	45,000
	(7977)	(3703)		(7905)	(8056)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are identified in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; N/A=not applicable; RPPDF=River Protection Project Disposal Facility.

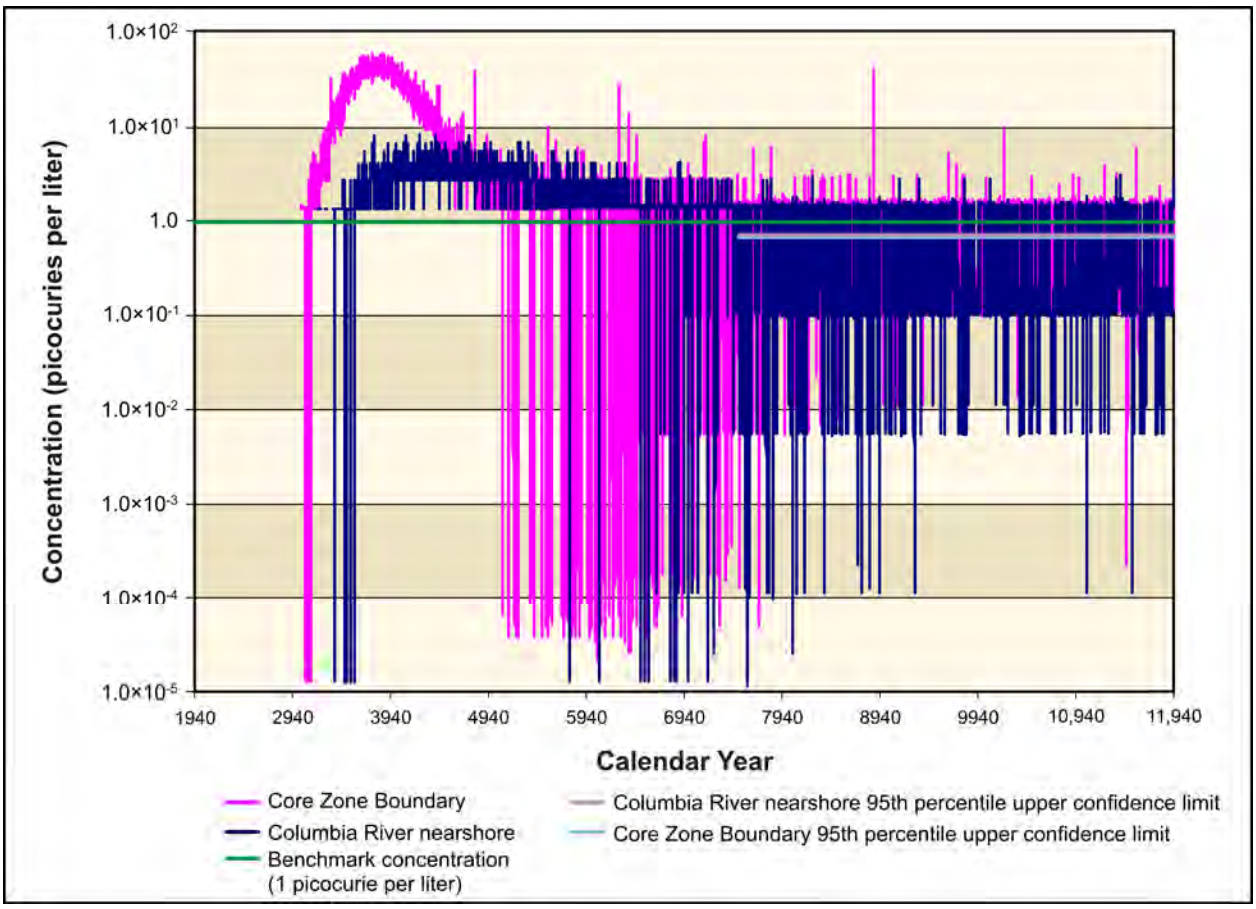


Figure 5–972. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Iodine-129 Concentration Versus Time

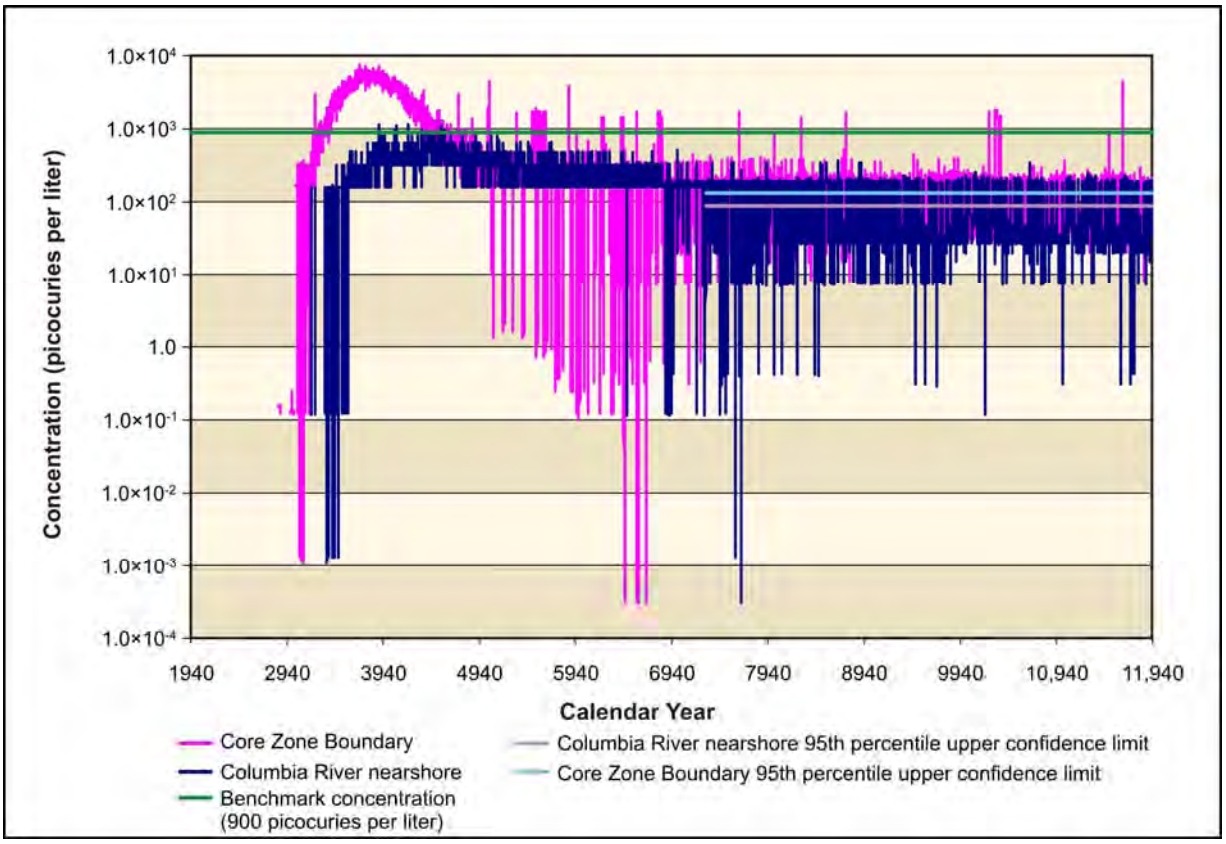


Figure 5–973. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Technetium-99 Concentration Versus Time

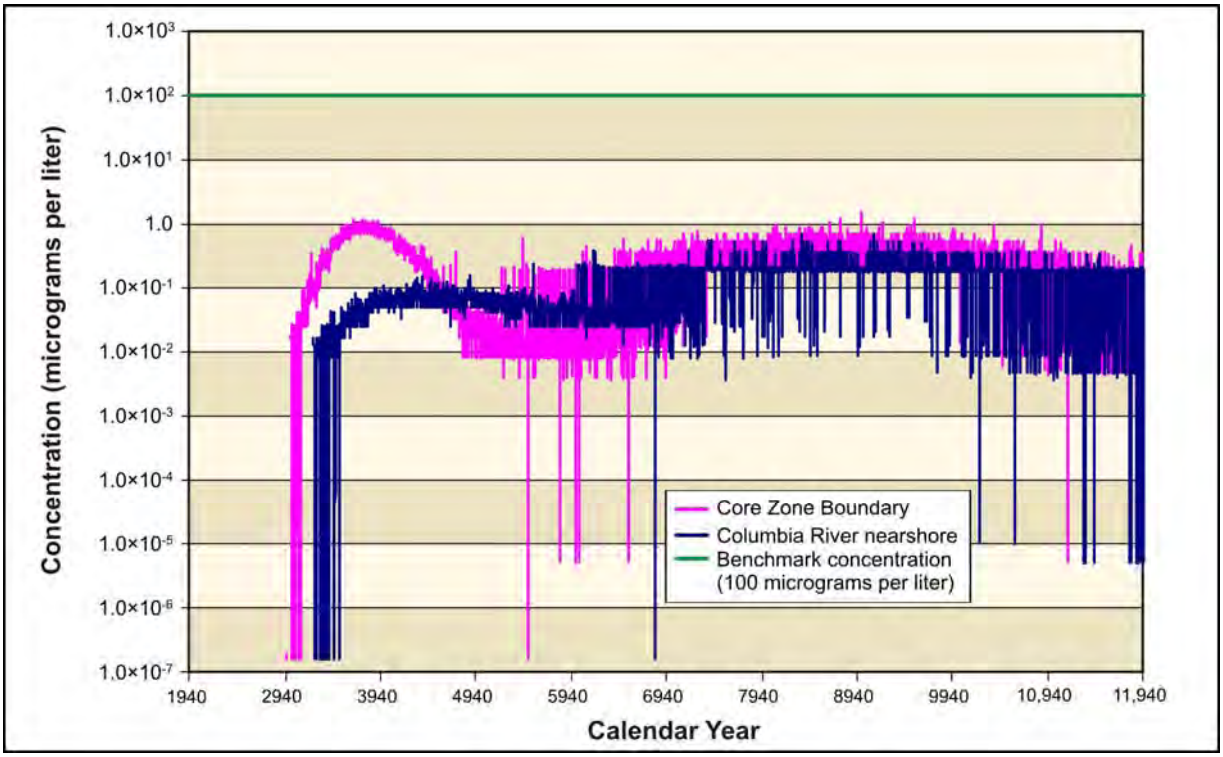


Figure 5–974. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chromium Concentration Versus Time

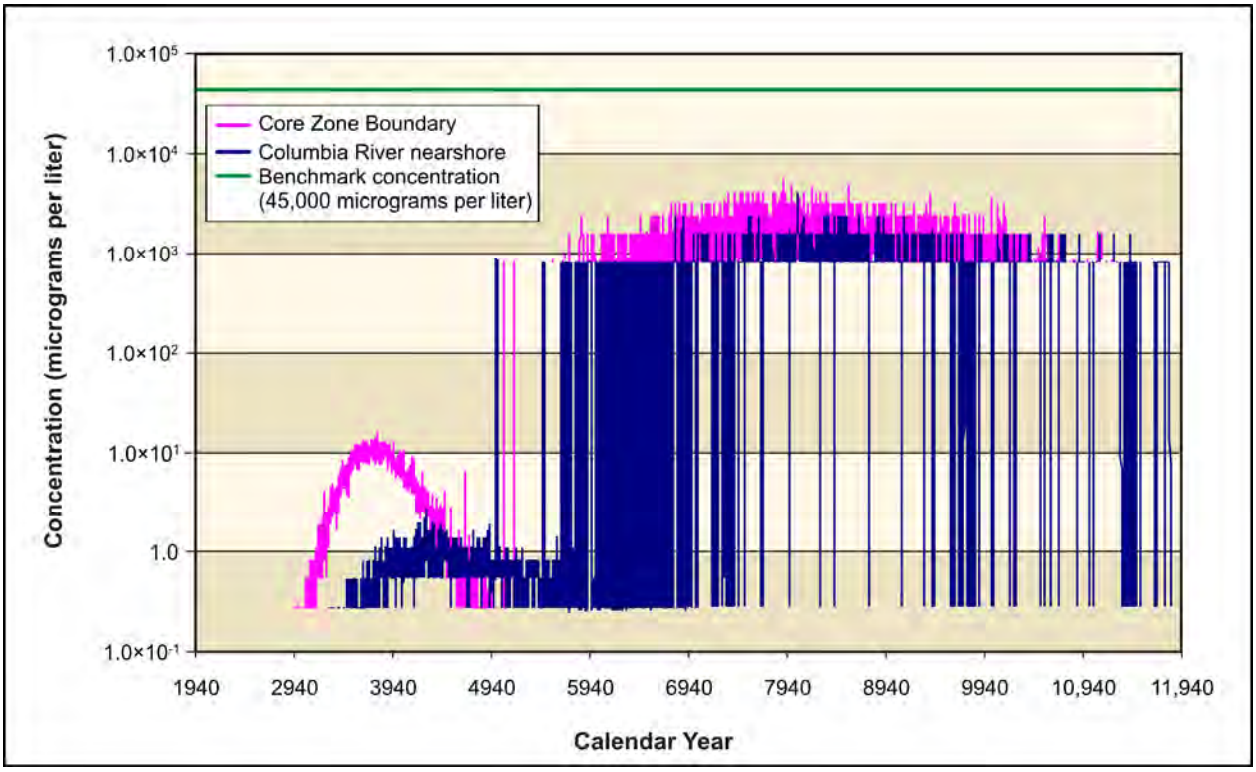


Figure 5–975. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Nitrate Concentration Versus Time

Figure 5–976 shows concentration versus time for uranium-238. Because uranium-238 moves slowly through the vadose zone, releases from IDF-East and IDF-West result in groundwater concentrations that are several orders of magnitude lower than benchmark concentrations. Uranium-238 concentrations, while very minimal, continue to rise throughout the period of analysis, but never get closer than three orders of magnitude of exceeding benchmark concentrations by the end of the period of analysis. There is no significant total uranium concentration.

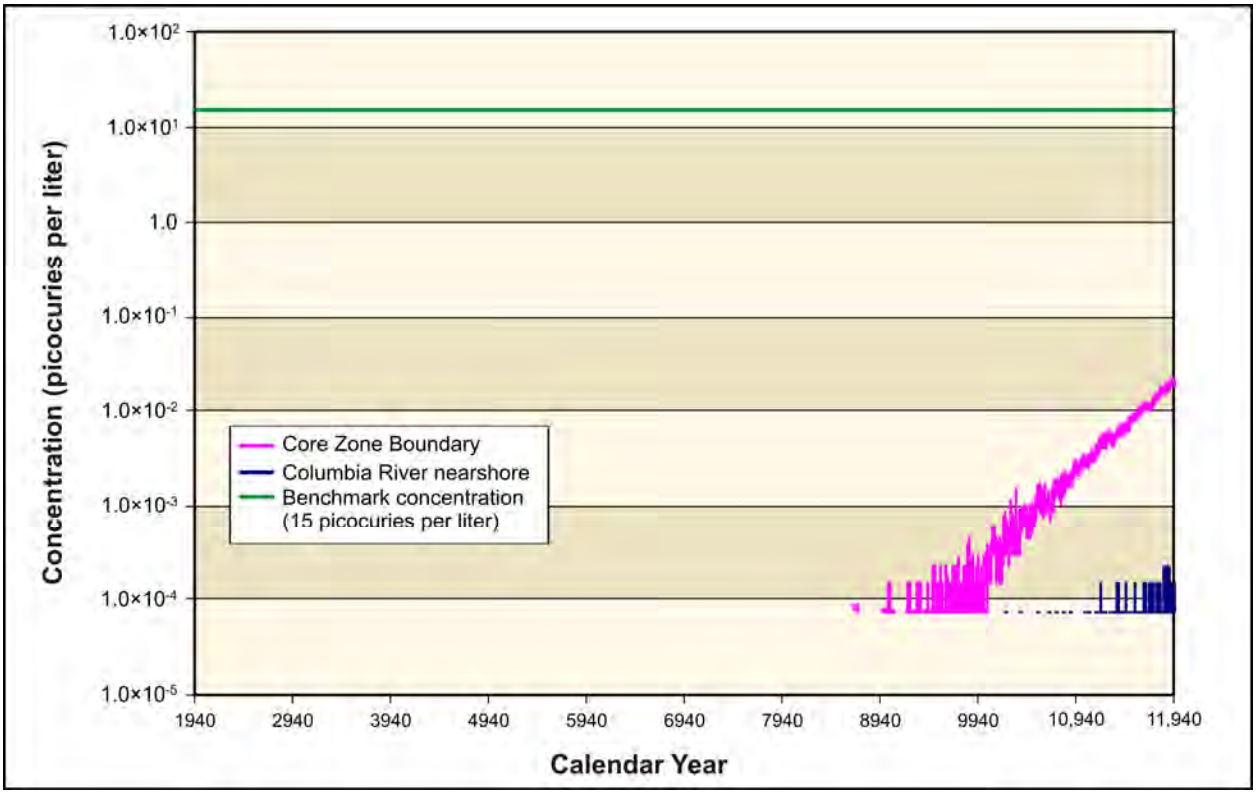
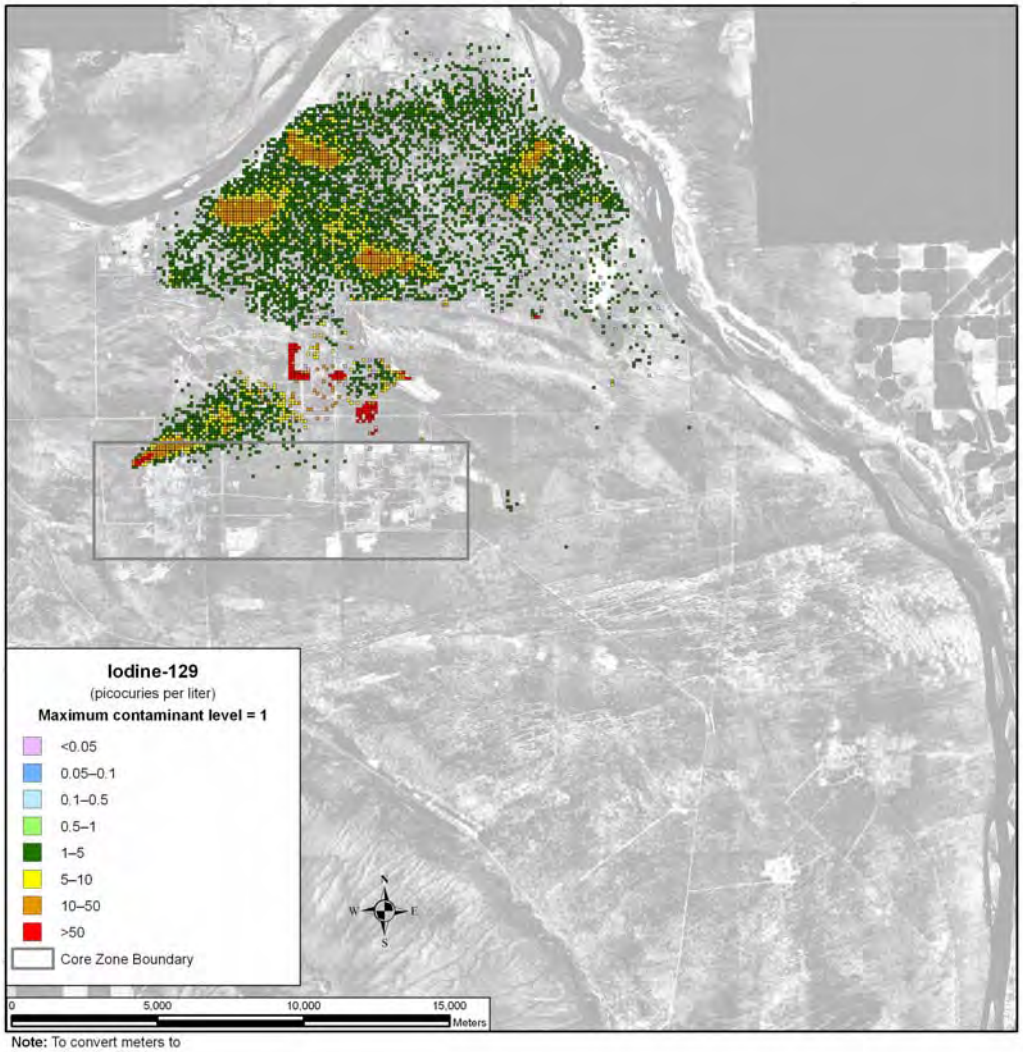


Figure 5–976. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Uranium-238 Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

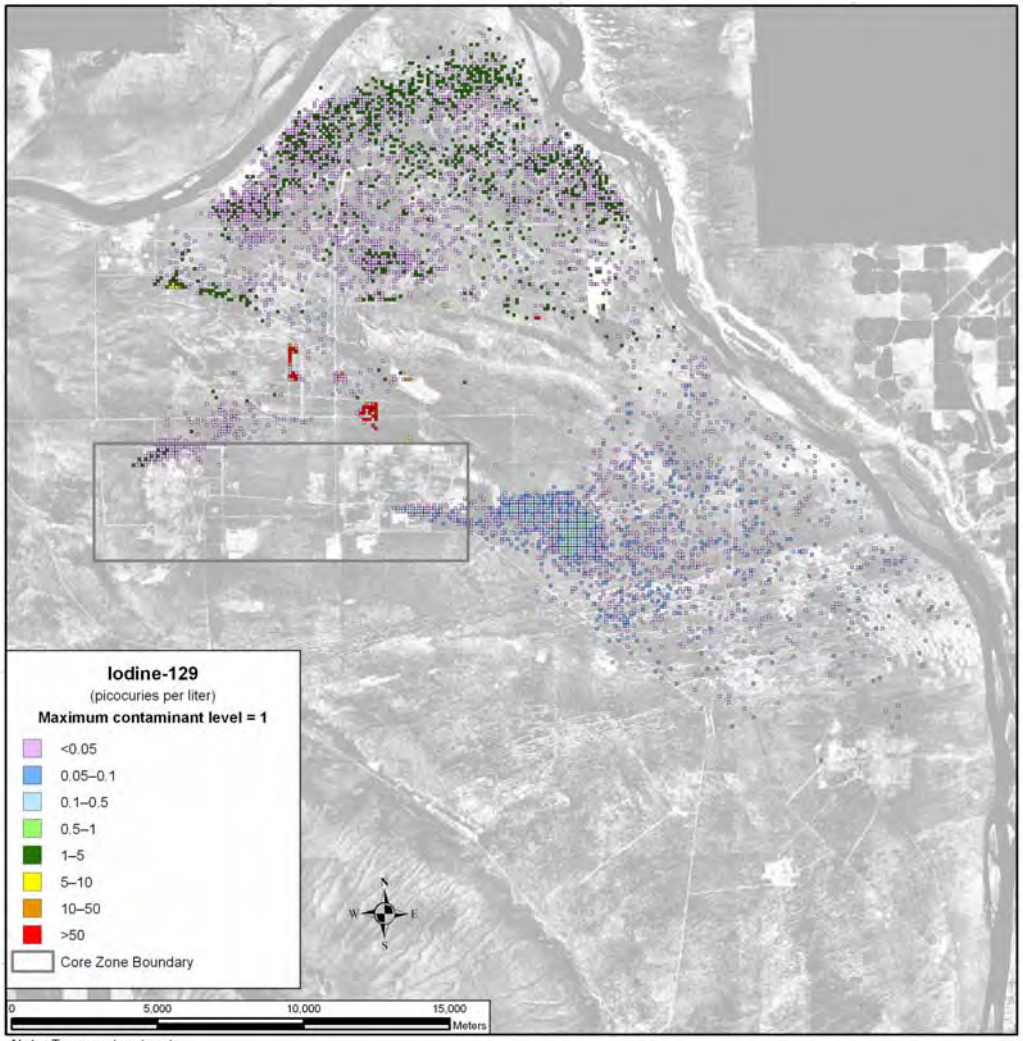
This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale indicative of the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations lower than the benchmark, by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figure 5–977 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890. Releases from IDF-West result in a groundwater plume starting in the Core Zone and heading north through Gable Mountain. This plume exceeds the benchmark concentration at the Core Zone Boundary and north of the Core Zone Boundary by one to two orders of magnitude. During CY 7140, releases from IDF-East create a groundwater plume, not exceeding the benchmark, extending from the 200-East Area eastward toward the Columbia River (see Figure 5–978). Also by CY 7140, most of the IDF-West plume continues to move north and reaches the Columbia River. By CY 11,885, most of the mass in the IDF-East plume is still moving eastward toward the Columbia River, with only small isolated pockets of concentration exceeding the benchmark (see Figure 5–979). Technetium-99 (see Figures 5–980 through 5–982) shows similar spatial distributions at selected times and exceeds the benchmark concentrations at approximately the same time and locations. Chromium (see Figures 5–983 through 5–985), and nitrate (see Figures 5–986 through 5–988) show similar spatial distributions at selected times, except none of them exceed the benchmark concentrations. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).



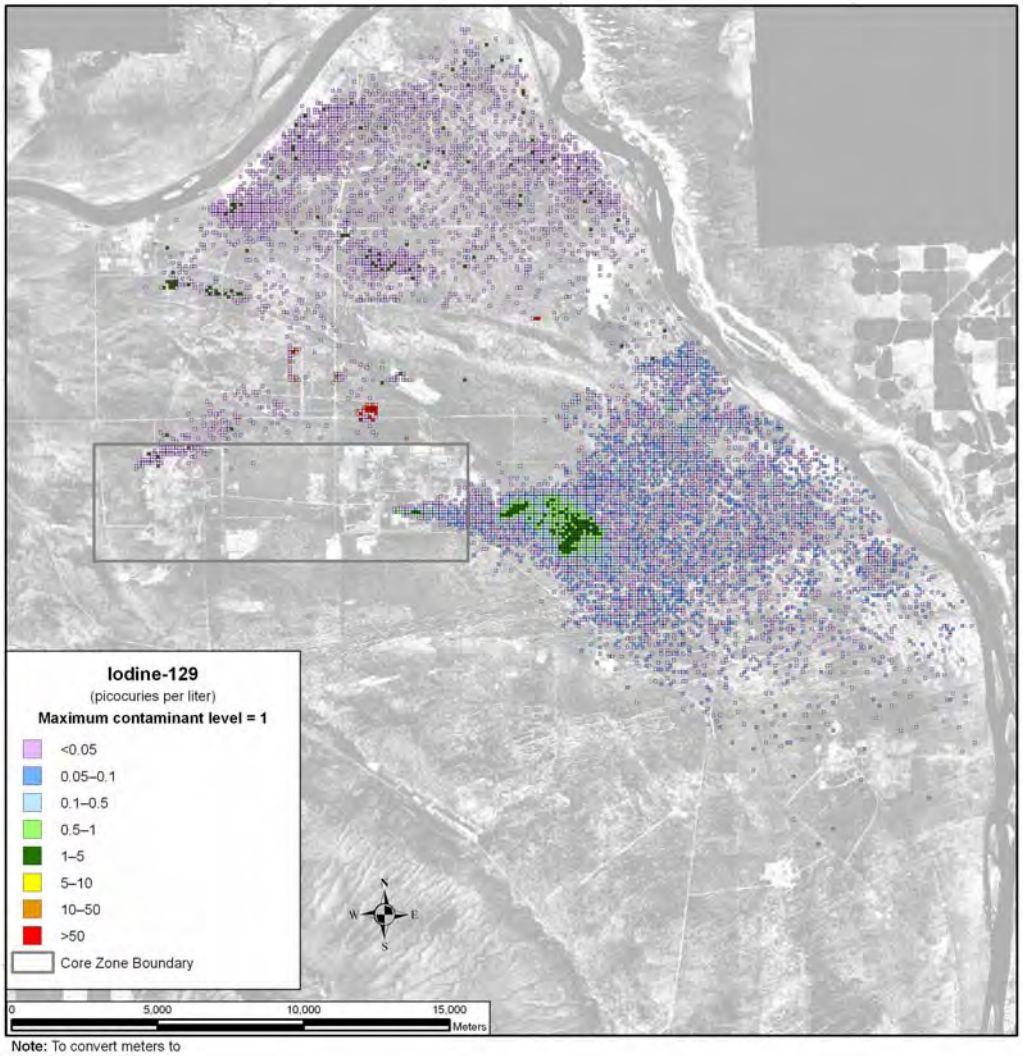
Note: To convert meters to feet, multiply by 3.281

Figure 5–977. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



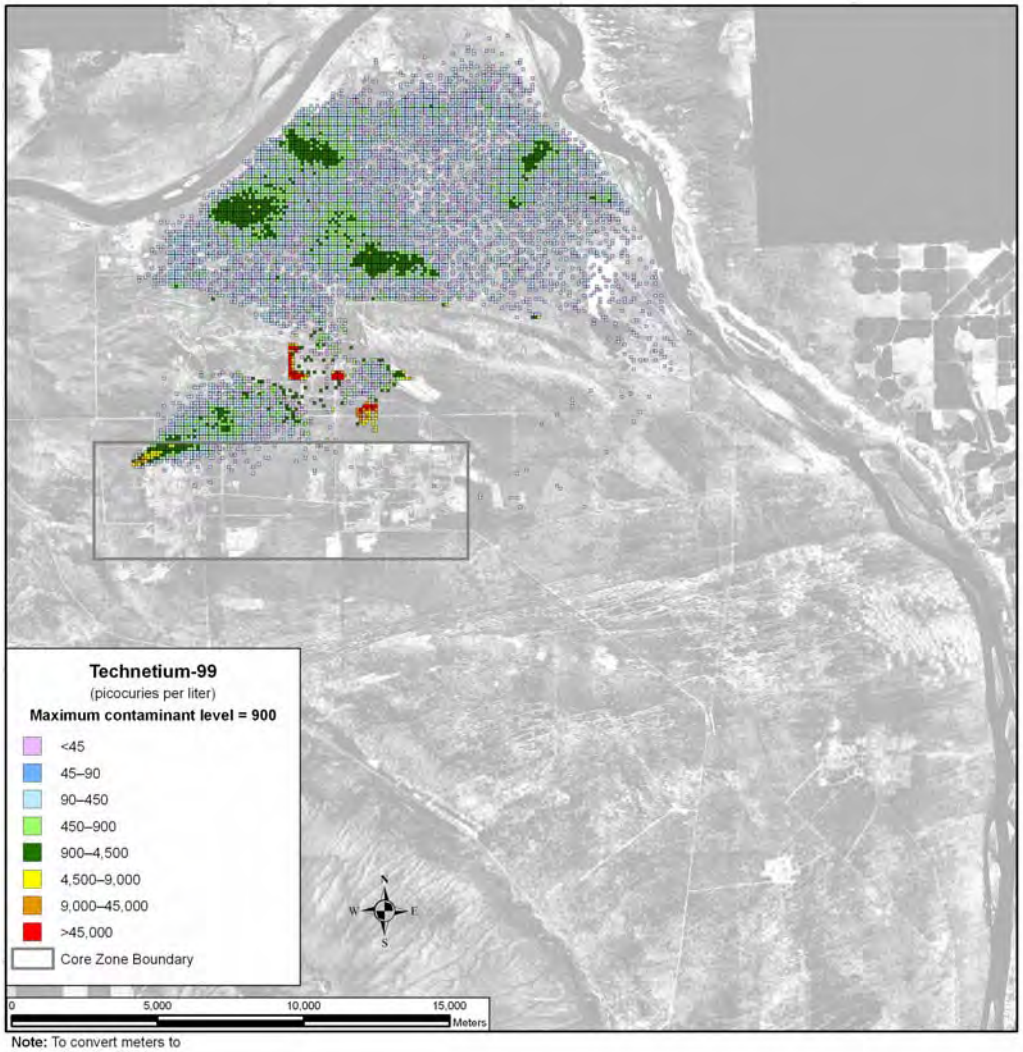
Note: To convert meters to feet, multiply by 3.281

Figure 5–978. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



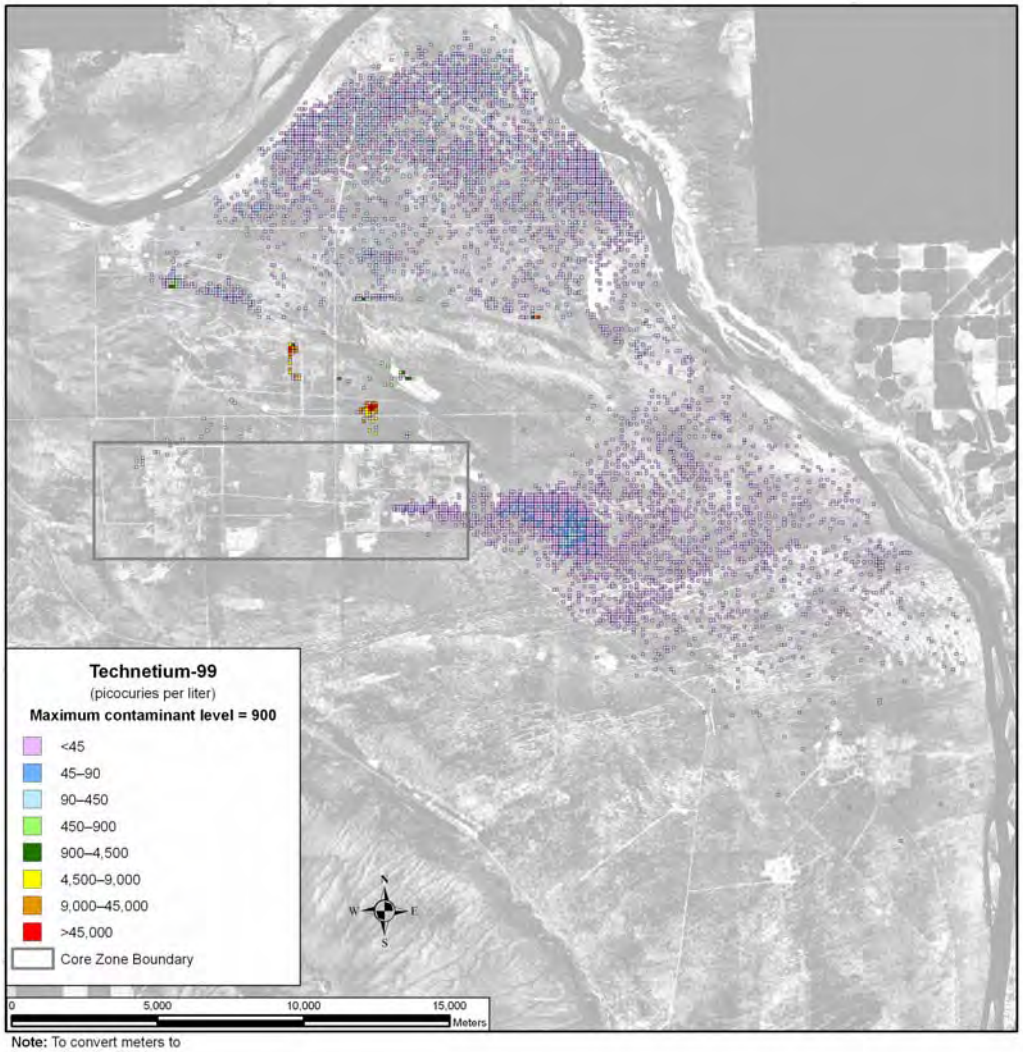
Note: To convert meters to feet, multiply by 3.281

Figure 5–979. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



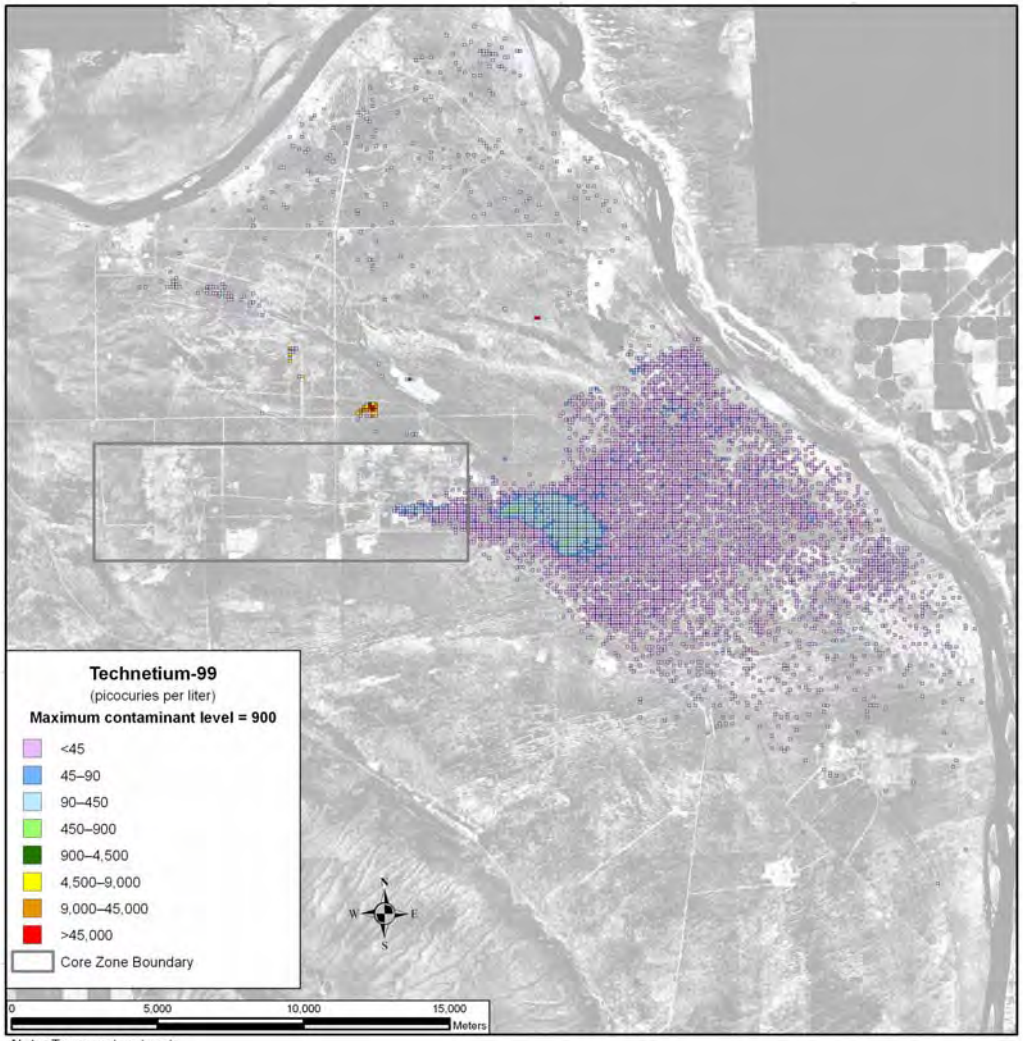
Note: To convert meters to feet, multiply by 3.281

Figure 5–980. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



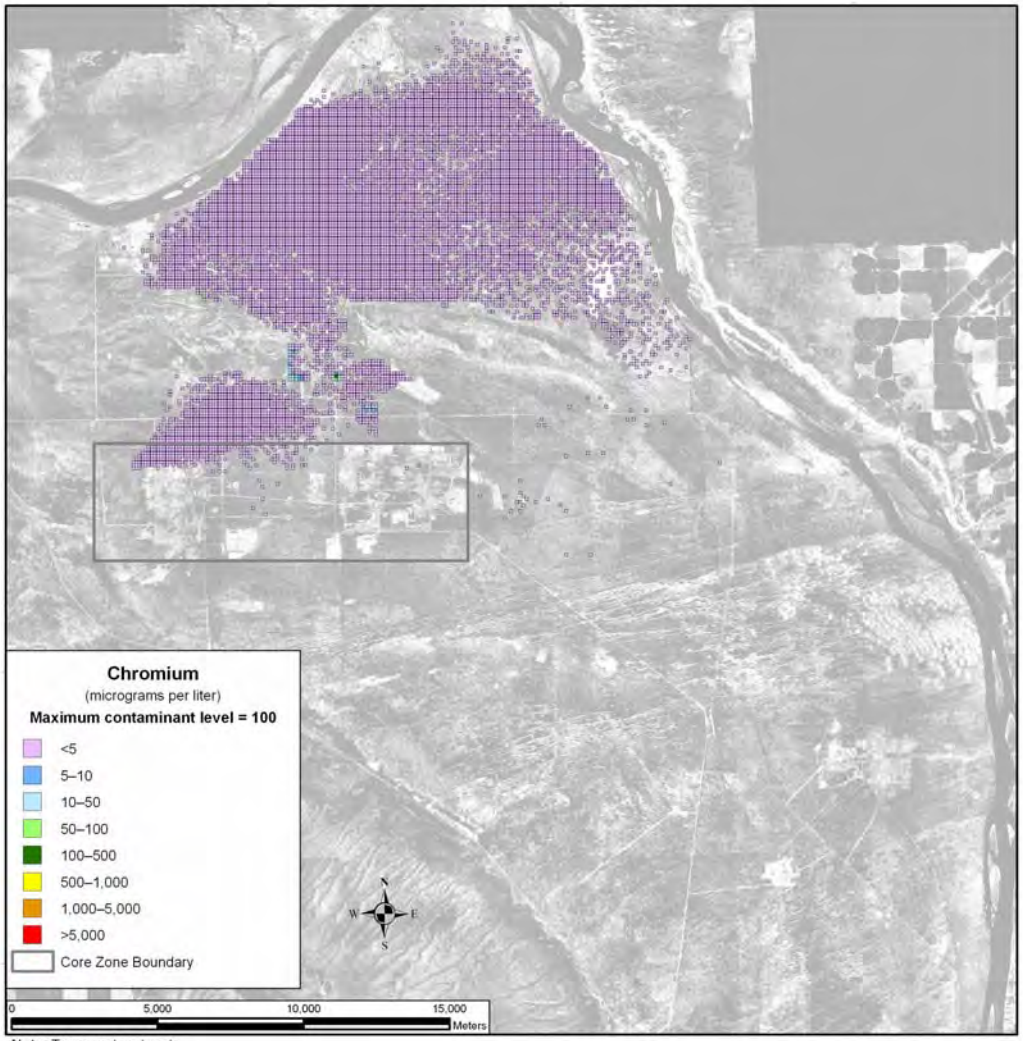
Note: To convert meters to feet, multiply by 3.281

Figure 5–981. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



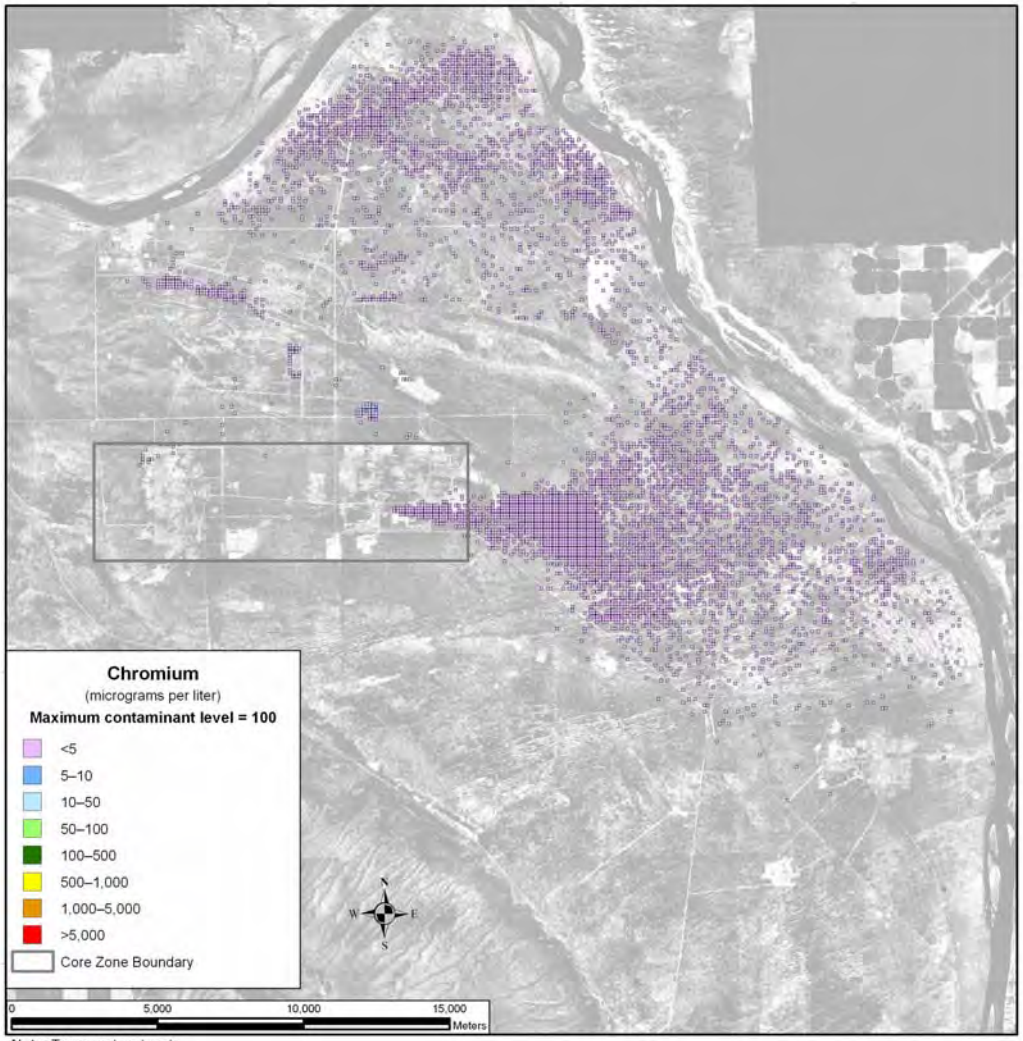
Note: To convert meters to feet, multiply by 3.281

Figure 5–982. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



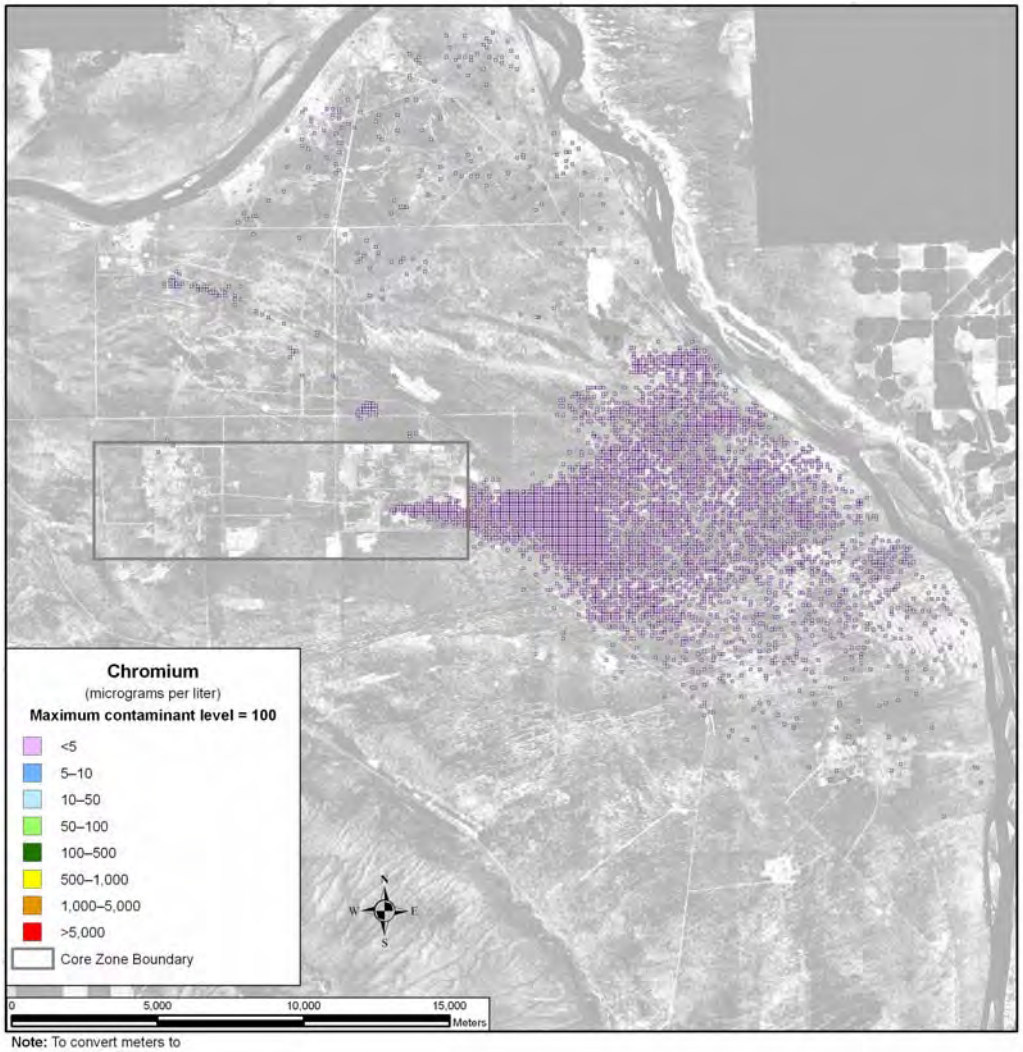
Note: To convert meters to feet, multiply by 3.281

Figure 5–983. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



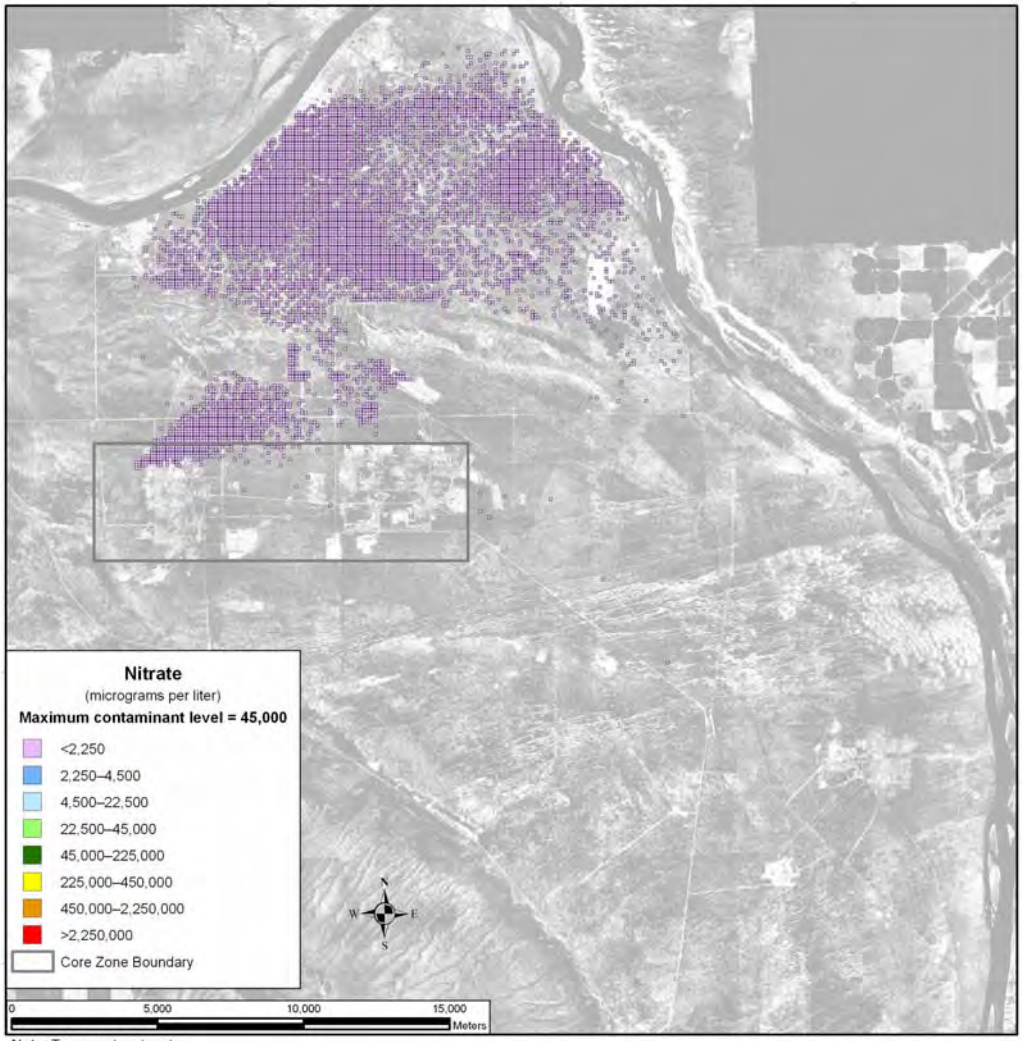
Note: To convert meters to feet, multiply by 3.281

Figure 5–984. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



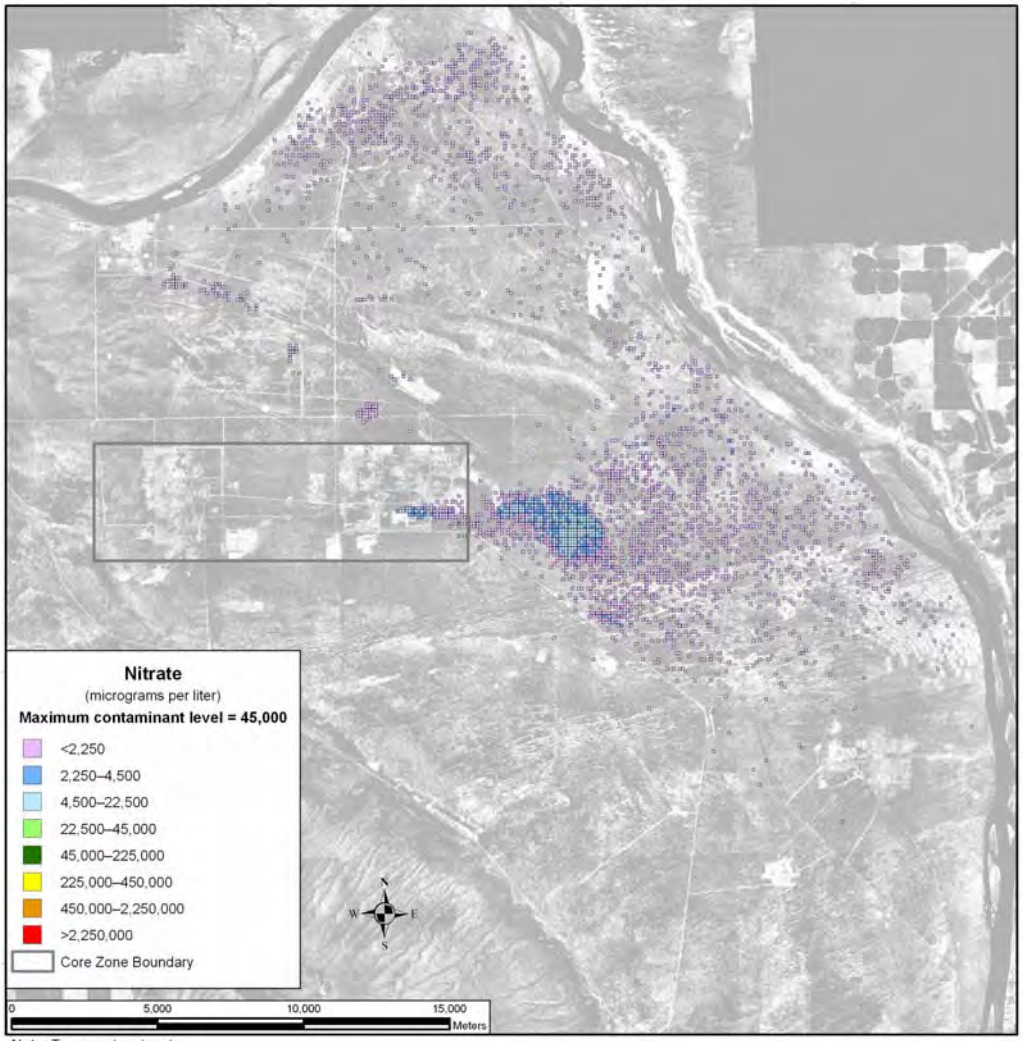
Note: To convert meters to feet, multiply by 3.281

Figure 5–985. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



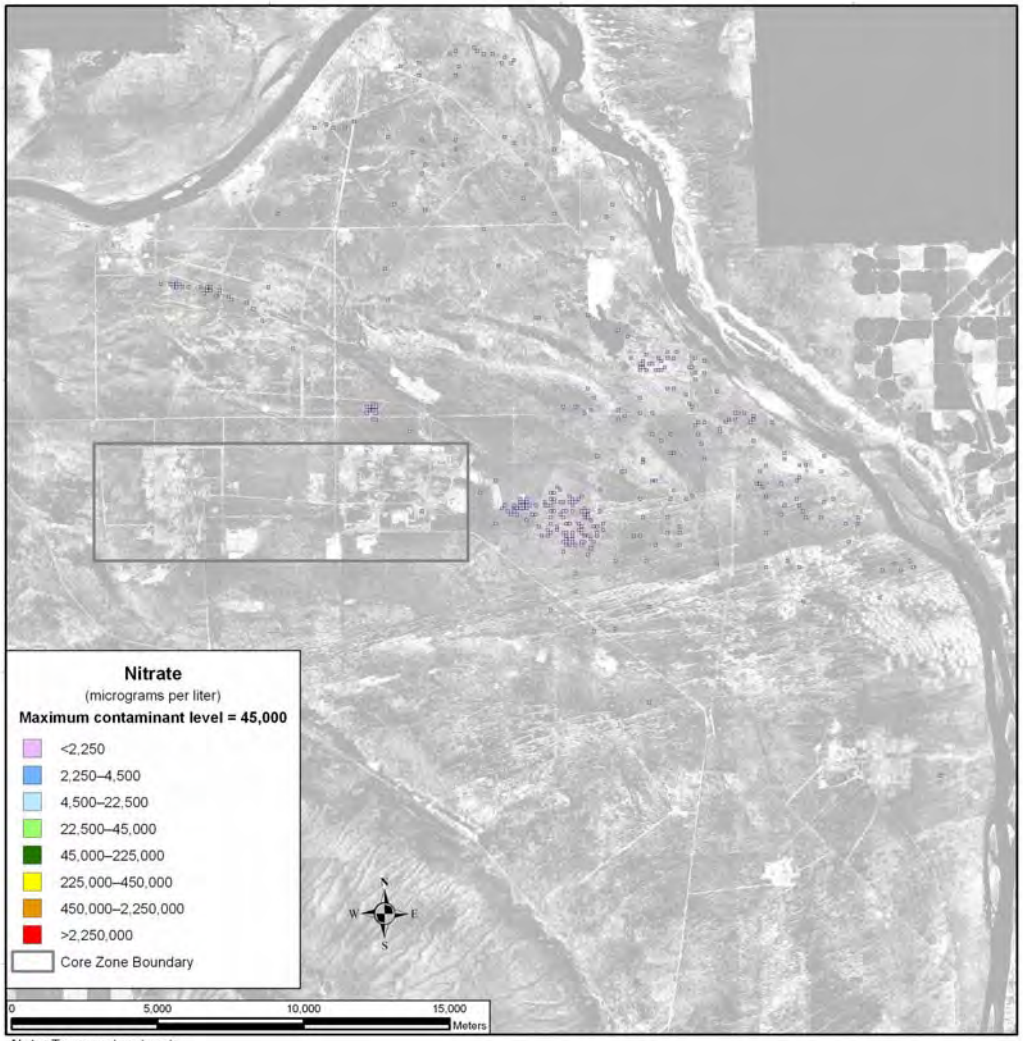
Note: To convert meters to feet, multiply by 3.281

Figure 5–986. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

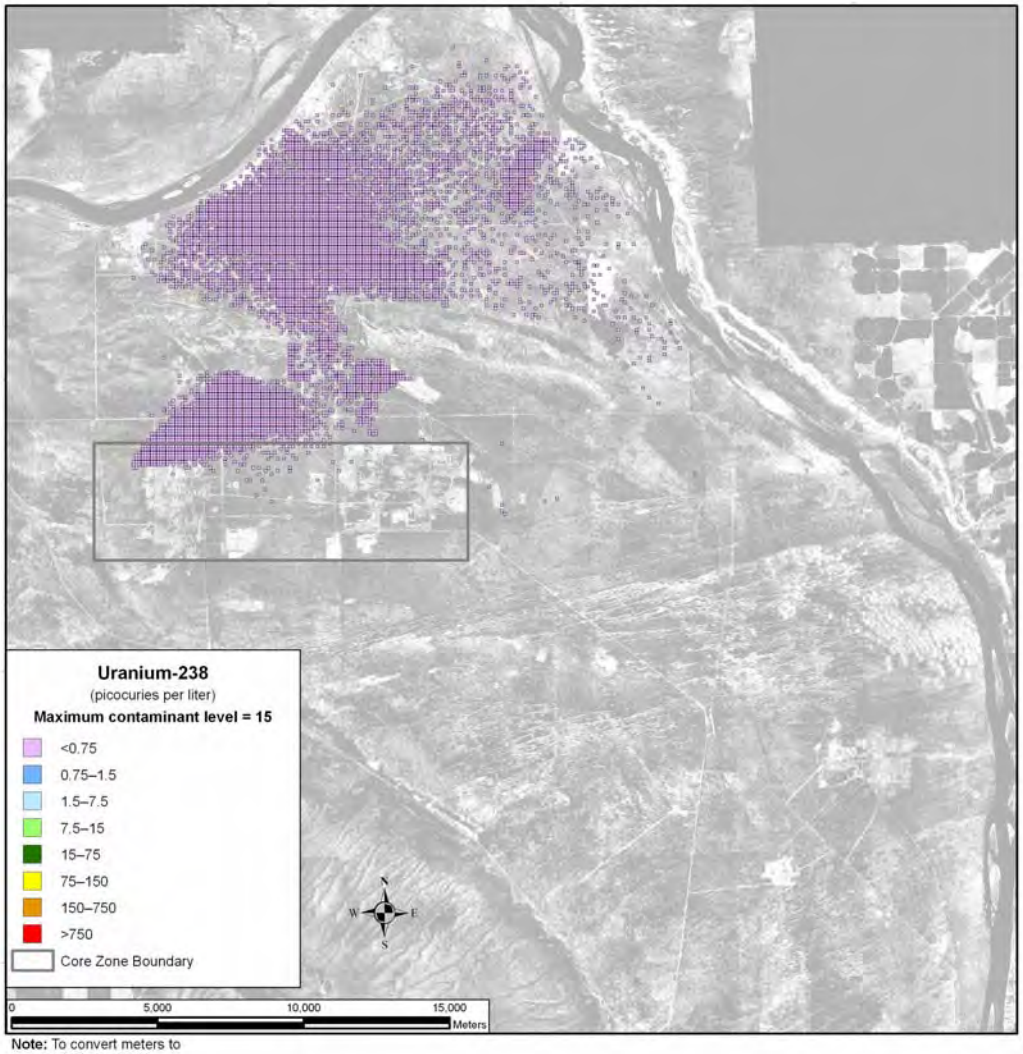
Figure 5–987. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–988. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Uranium-238 shows a different spatial distribution over time. This COPC is not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–989 shows the distribution of uranium-238 during CY 11,885. Releases from IDF-West result in a groundwater plume that starts in the Core Zone and moves north through Gable Mountain. However, this plume does not exceed the benchmark concentration during the period of analysis.



Note: To convert meters to feet, multiply by 3.281

Figure 5–989. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, in general, the inventory remaining at IDF-East and IDF-West which are available for release to the environment at the start of the post-disposal period are predominant contributors.

For the conservative tracers, concentrations slightly outside the Core Zone Boundary exceed benchmark standards by one to two orders of magnitude during most of the period of analysis. The concentration at

the Columbia River nearshore is about one to two orders of magnitude lower. The intensities and areas of these groundwater plumes peak between CY 3890 and CY 7140.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframe and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or the Columbia River nearshore.

5.3.1.3.2.2 Disposal Group 2, Subgroup 2-B, Base Case

Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, is designed to show the impacts of waste disposal on IDF-East, IDF-West, and the RPPDF.

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, covers the disposal of wastes generated during Tank Closure Alternative 6B, FFTF Decommissioning Alternatives 2 or 3, and onsite- and offsite-generated waste.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009, RPPDF in CY 2022 and continues through CY 2050 for IDF-West and CY 2100 for IDF-East and the RPPDF, when the disposal facilities will be operationally closed. During the disposal period, the materials in this permitted, operational facility are not available for release to the environment.

- The post-disposal period starts in CY 2101 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East and IDF-West become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case (i.e., Tank Closure Alternative 6B, Base Case; FFTF Decommissioning Alternatives 2 and 3; and onsite- and offsite-generated waste), is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: acetonitrile, boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, then selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, acetonitrile, chromium, and nitrate) are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, in terms of total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Subtotals are plotted as releases from three disposal facilities: IDF-West (FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- waste, and offsite-generated waste); IDF-East (PPF glass, ETF-generated secondary waste, retired melters, and tank closure secondary waste); and the RRPDF. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over more than 10 orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–990 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–991, the chemical hazard drivers. The release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period of analysis). For the radiological COPCs (technetium-99 and iodine-129), the releases range over five orders of magnitude depending on the source of both radionuclides. ETF-generated secondary waste and tank closure secondary waste account for most of the releases. The release of nitrate in IDF-East is all associated with ETF-generated secondary waste. Sources of chromium include tank closure secondary waste, PPF glass, and retired melters.

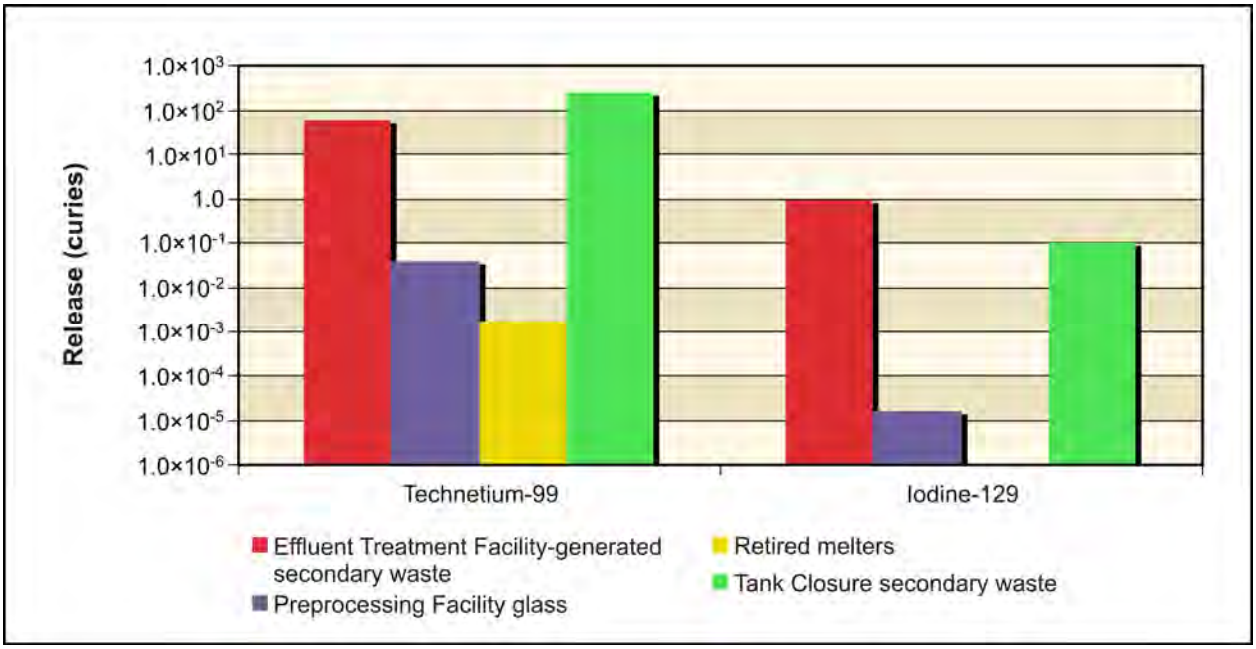


Figure 5–990. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

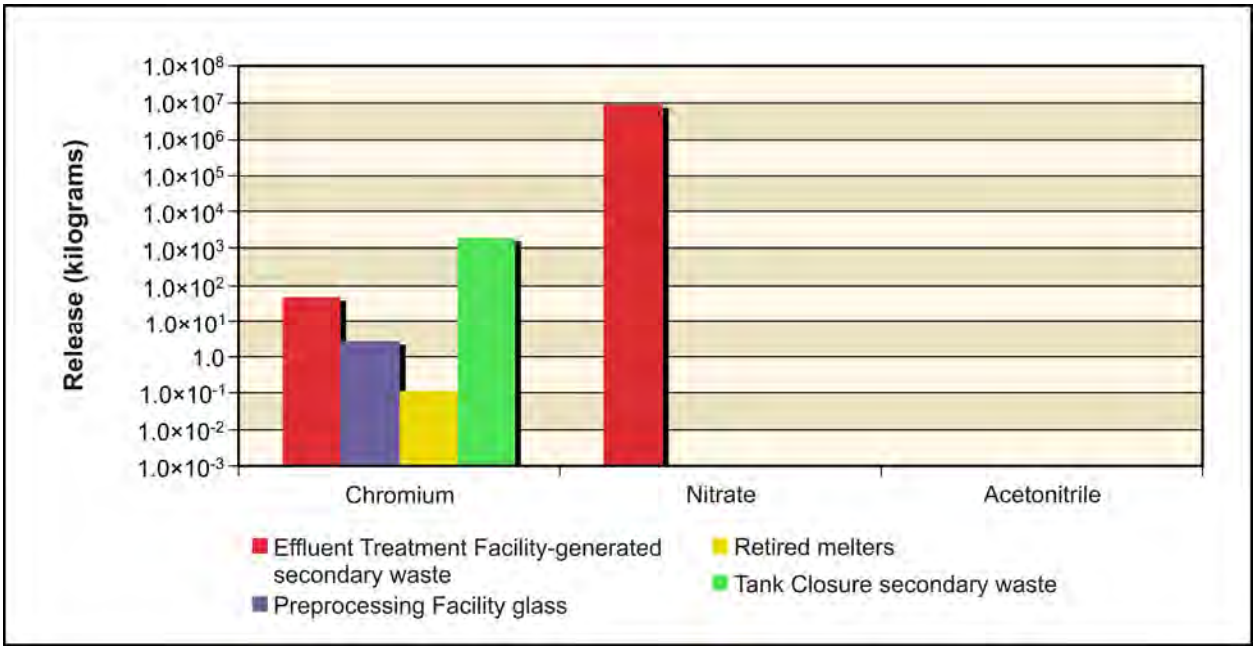


Figure 5–991. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–992 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–993, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate) the amount released to groundwater is essentially equal to the amount released to the vadose zone.

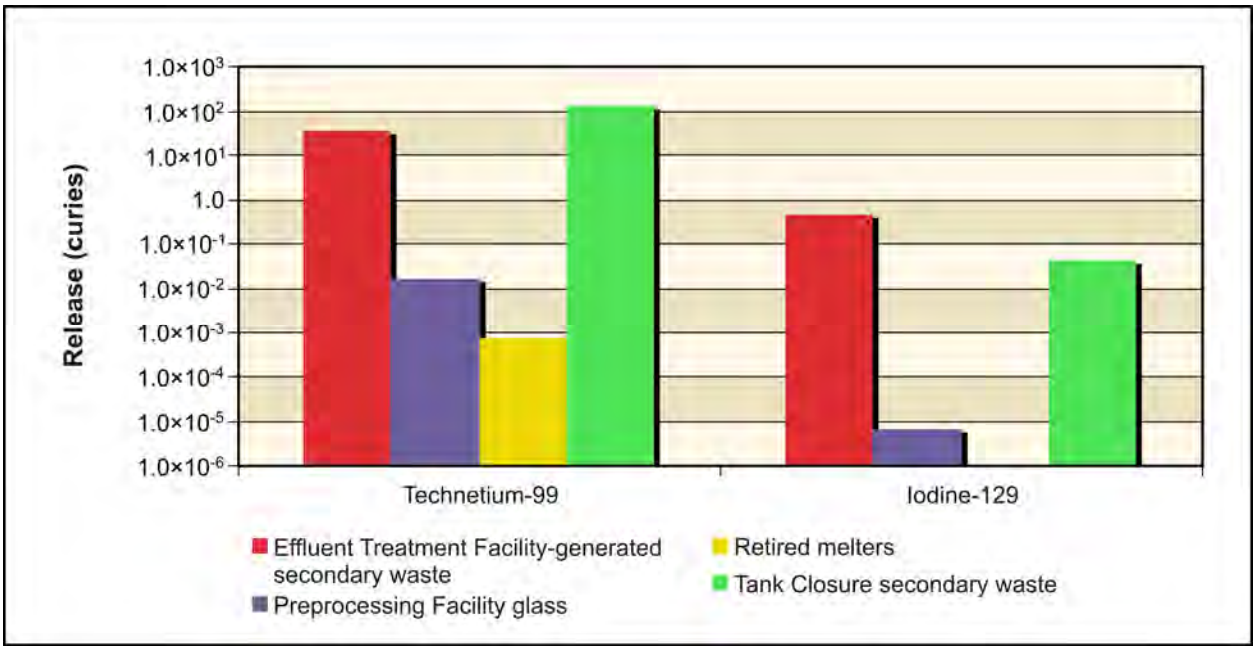


Figure 5–992. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

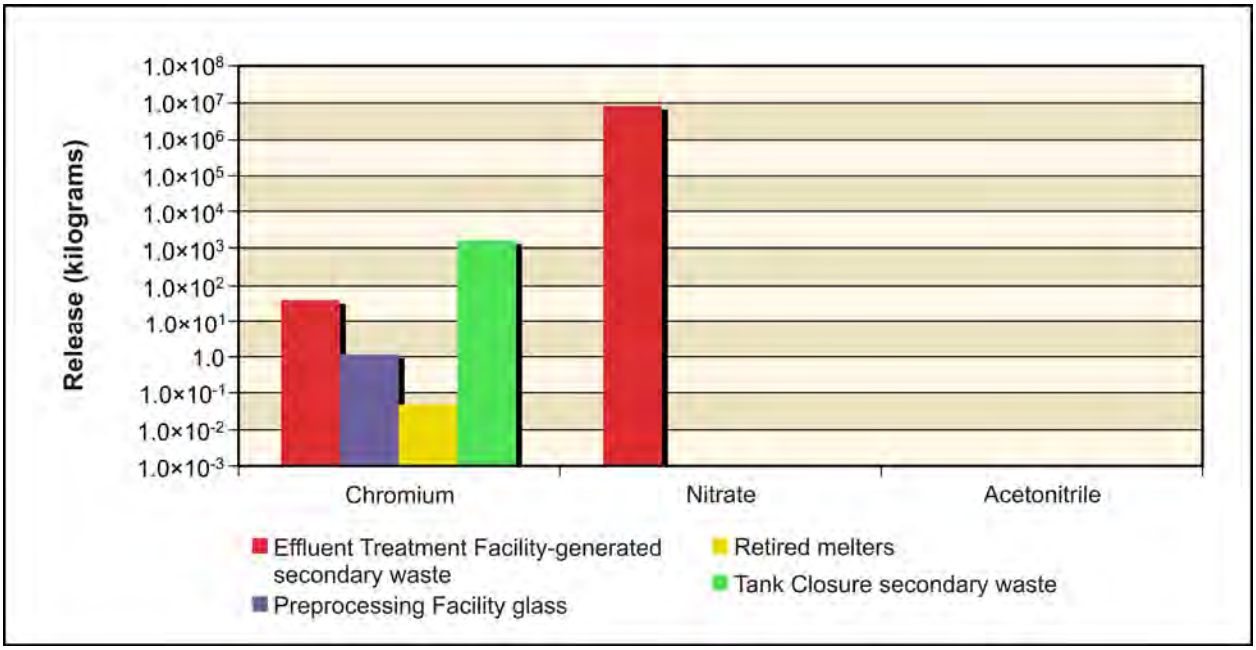


Figure 5–993. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–994 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–995, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate) the amount released to the Columbia River is essentially equal to the amount released to groundwater.

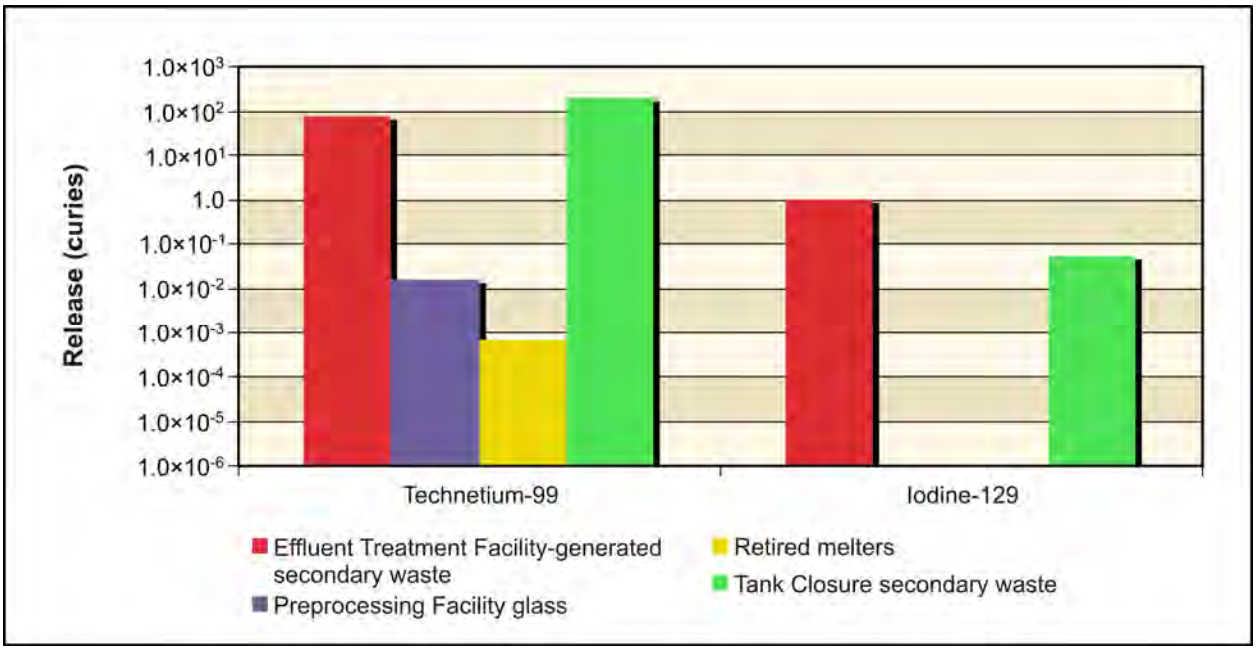


Figure 5–994. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

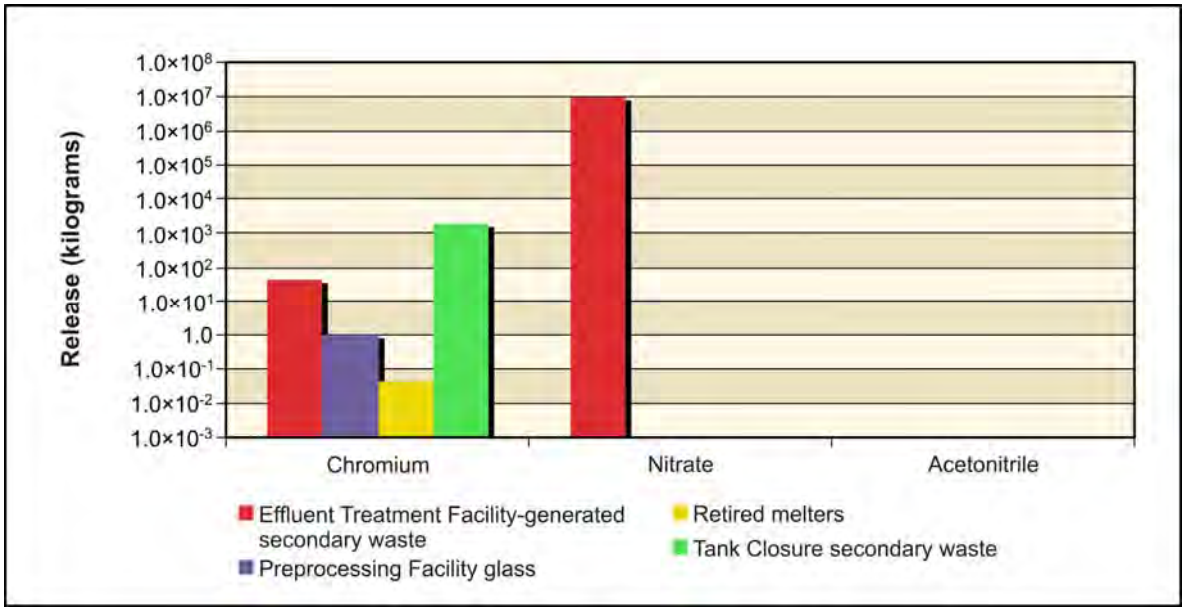


Figure 5–995. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

Figure 5–996 shows the estimated release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–997, the chemical hazard drivers. The release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period of analysis). For the radiological COPCs (technetium-99 and iodine-129) in IDF-West, the releases range over five orders of magnitude depending on the source. Over 99 percent of the radiological waste is from offsite waste. The chromium in IDF-West and essentially all of the nitrate derive from releases associated with waste management secondary waste and onsite-generated waste. Of the chromium sources, less than 1 percent is from FFTF Decommissioning Alternative 3 waste, 66 percent is from waste management secondary waste and onsite-generated waste, and 34 percent is from offsite-generated waste.

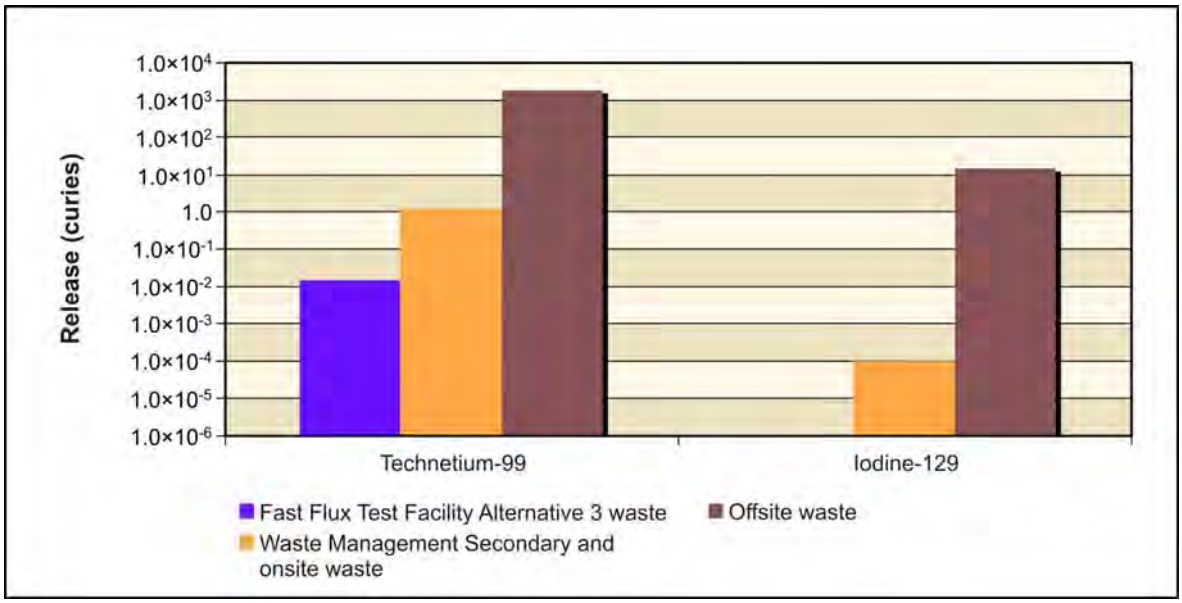


Figure 5–996. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

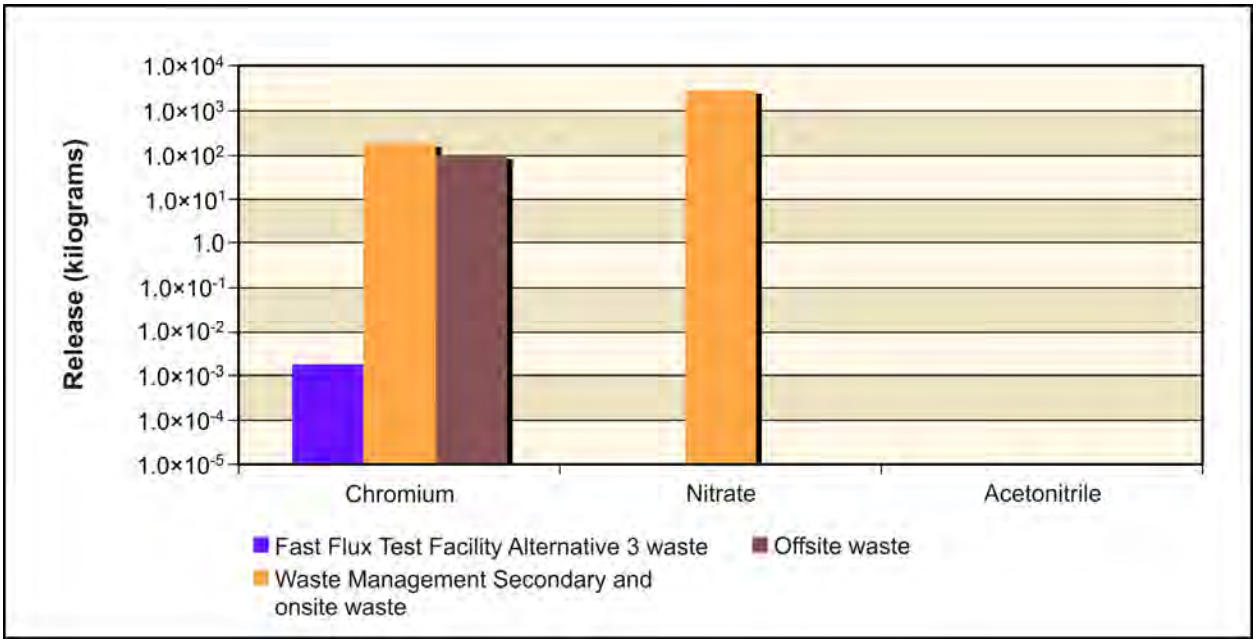


Figure 5–997. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–998 shows the estimated release at IDF-West to groundwater for the radiological risk drivers and Figure 5–999, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate) the amount released to groundwater is essentially equal to the amount released to the vadose zone.

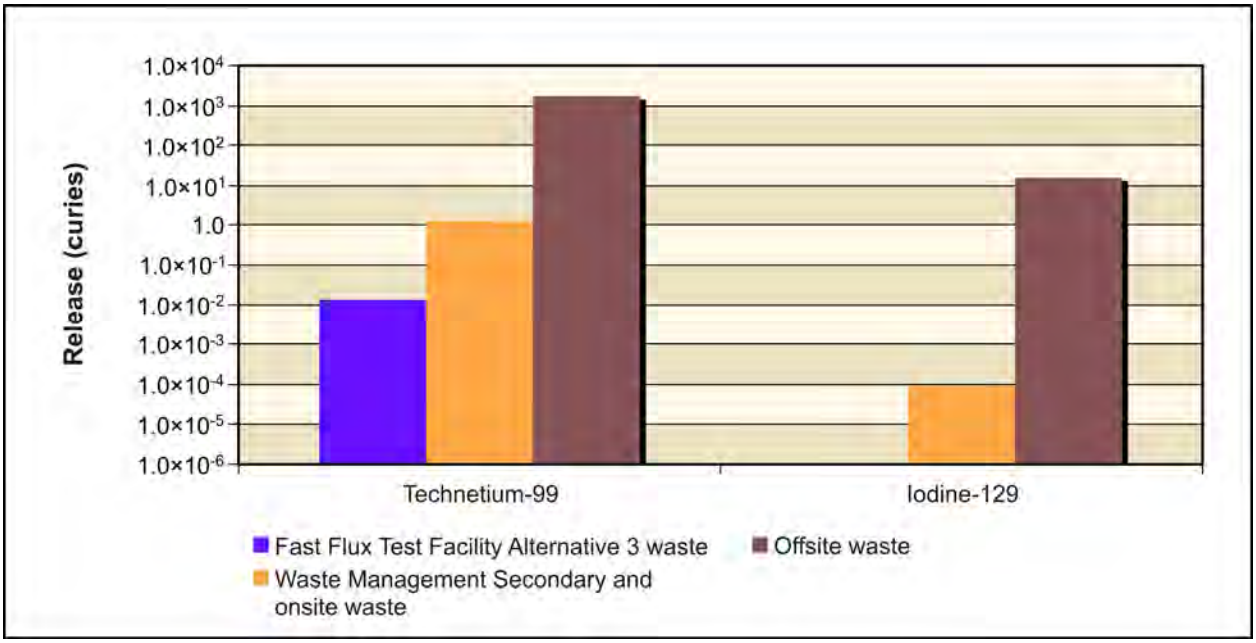


Figure 5–998. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

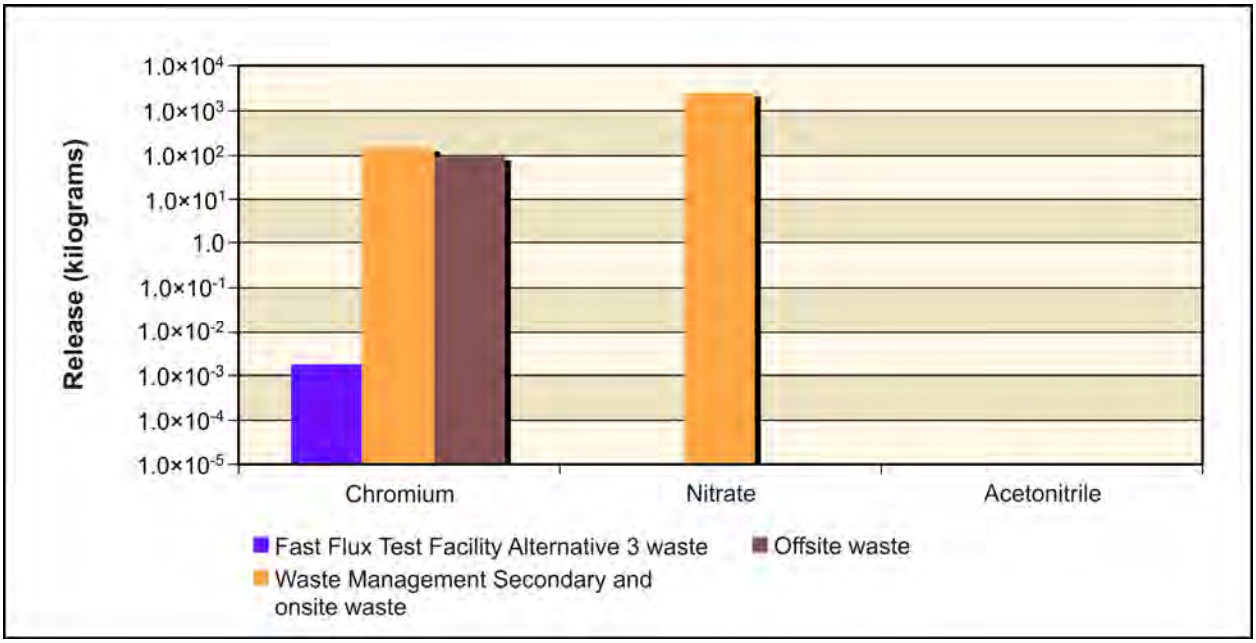


Figure 5–999. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–1000 shows the estimated release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–1001, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate) the amount released to the Columbia River is approximately 5 percent less than the amount released to the vadose zone.

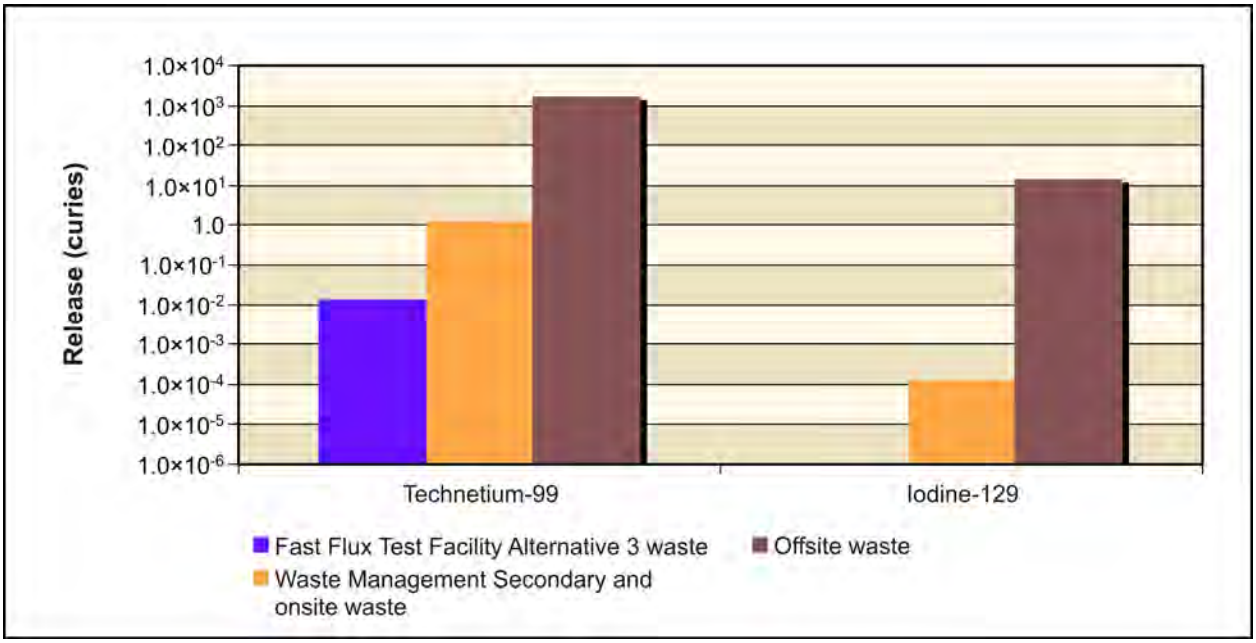


Figure 5–1000. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

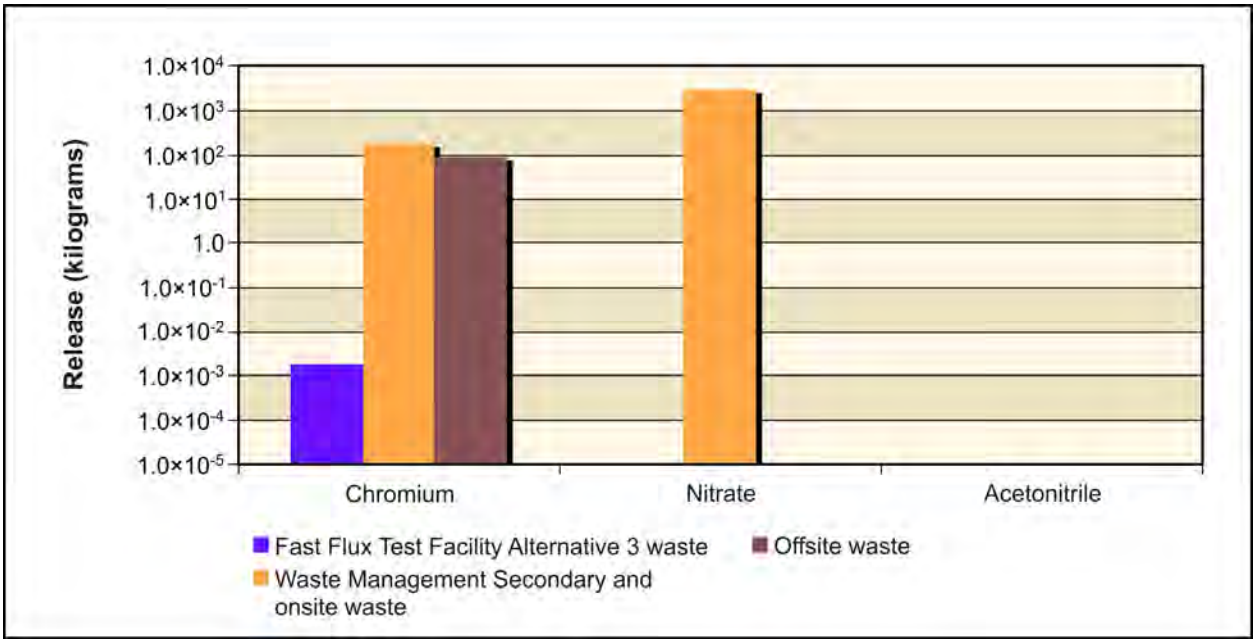


Figure 5–1001. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–1002 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–1003, the chemical hazard drivers. The release of technetium-99 is more than two orders of magnitude greater than the releases of iodine-129 in the RRPDF. The chemical constituents show nitrate as the predominant COPC, its release about two orders of magnitude greater than that of chromium and five orders of magnitude greater than that of acetonitrile.

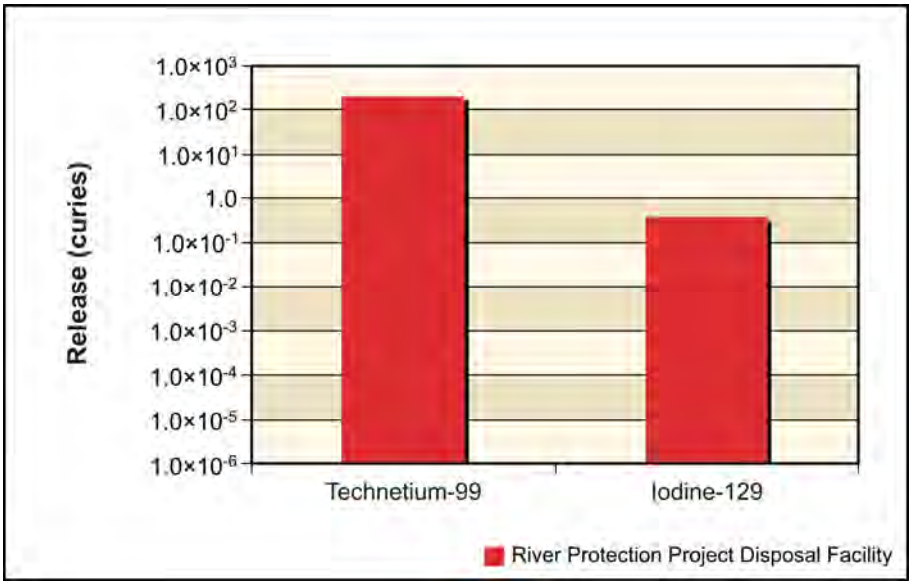


Figure 5–1002. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

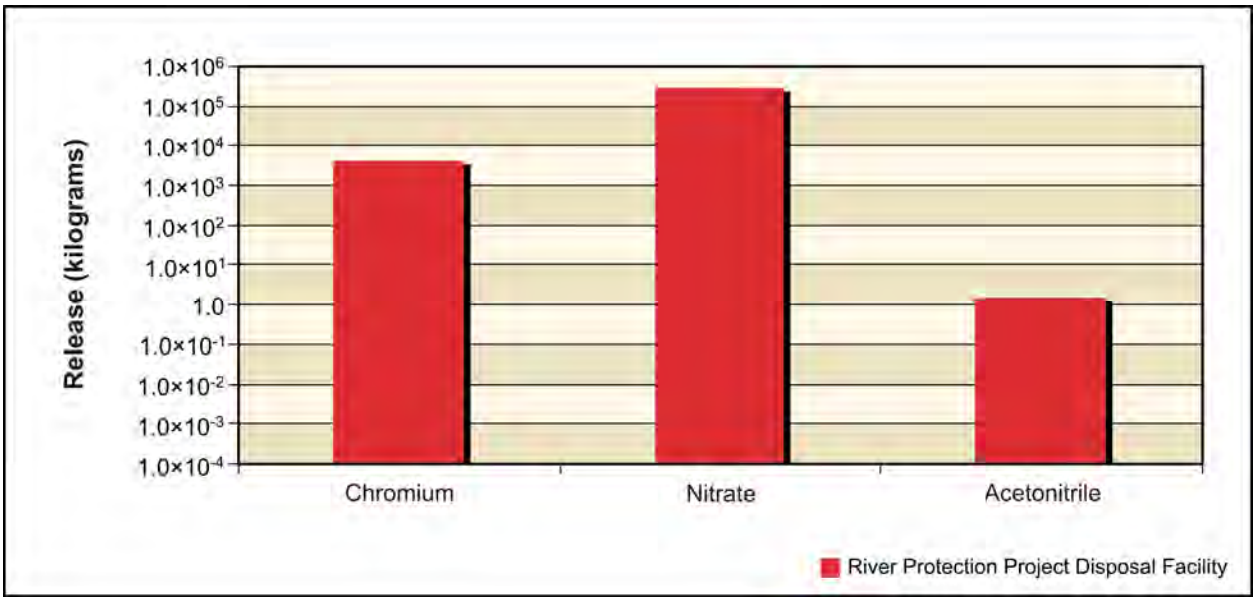


Figure 5–1003. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–1004 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–1005, the chemical hazard drivers. For the conservative tracers (iodine-129, technetium-99, acetonitrile, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

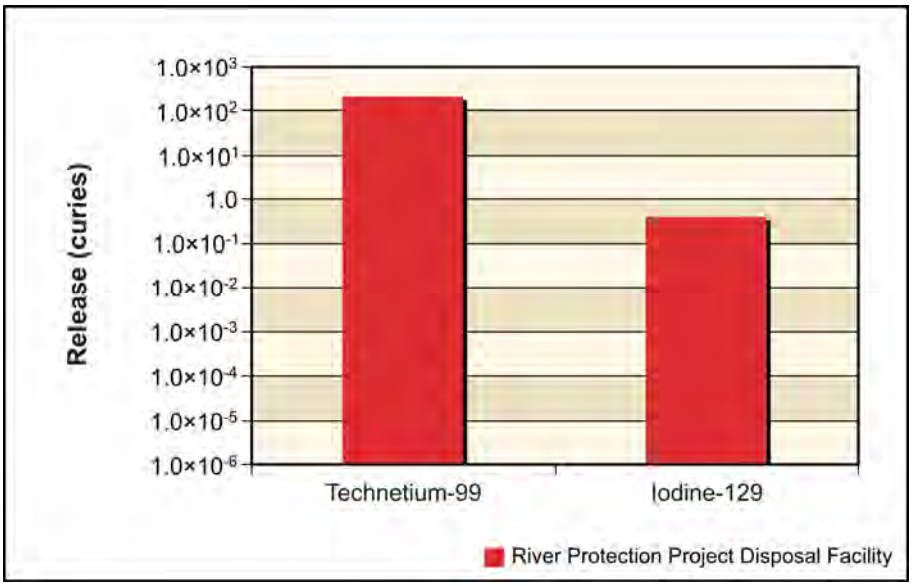


Figure 5–1004. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

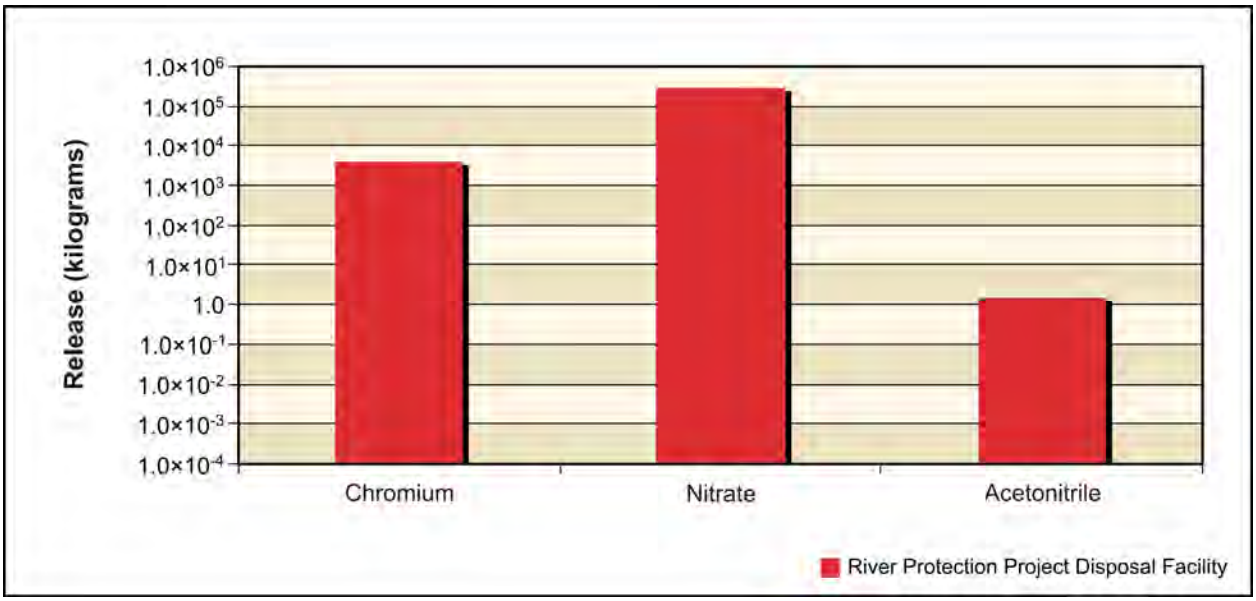


Figure 5–1005. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–1006 shows the release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–1007, the chemical hazard drivers. Both figures show similar trends, as mentioned in the above paragraph, for release to the Columbia River for all COPC drivers in the RRPDF.

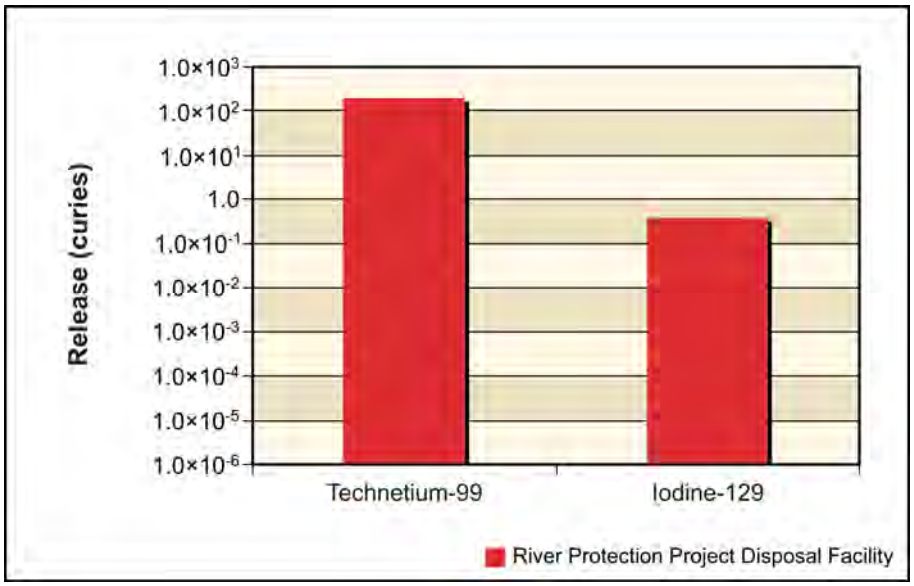


Figure 5–1006. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

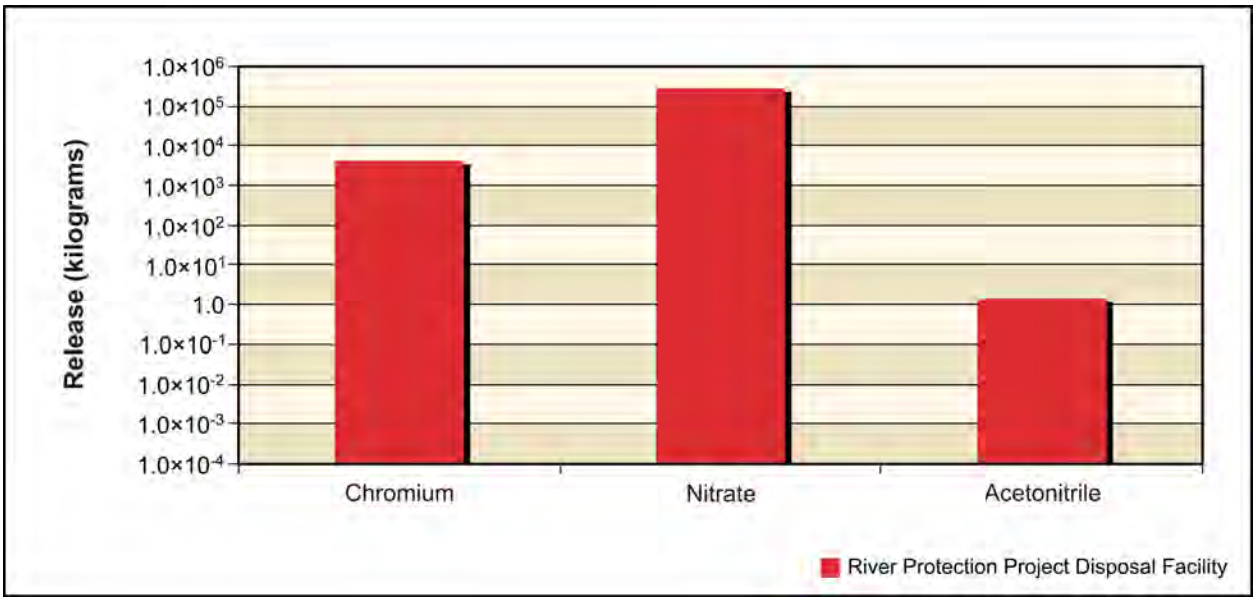


Figure 5–1007. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration of each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on a few graphs. Confidence intervals are calculated to show the length of time (in this case, 95 percent of the time) a concentration is likely to be at or below a given value. The confidence interval is basically a statistical aid to interpreting data presenting with a significant amount of random fluctuation (noise). In this analysis, the confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, or the concentration was near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude.

Figures 5–1008 through 5–1011 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Releases from IDF-East, IDF-West, and the RRPDF at the Core Zone Boundary cause groundwater concentrations to exceed the benchmark for iodine-129 at CY 3500. Calculations using the confidence interval show that the iodine-129 concentrations exceed the benchmark at both the Core Zone Boundary and the Columbia River nearshore after CY 5500. The trend for technetium-99 concentrations is similar to that for iodine-129 concentrations but below the benchmark during the period of analysis. Chromium and nitrate measurements at the Core Zone Boundary and the Columbia River nearshore are below the benchmark concentrations by one to three orders of magnitude, and the concentration trends are similar to those for iodine-129 and technetium-99. Table 5–97 shows the maximum concentrations in groundwater.

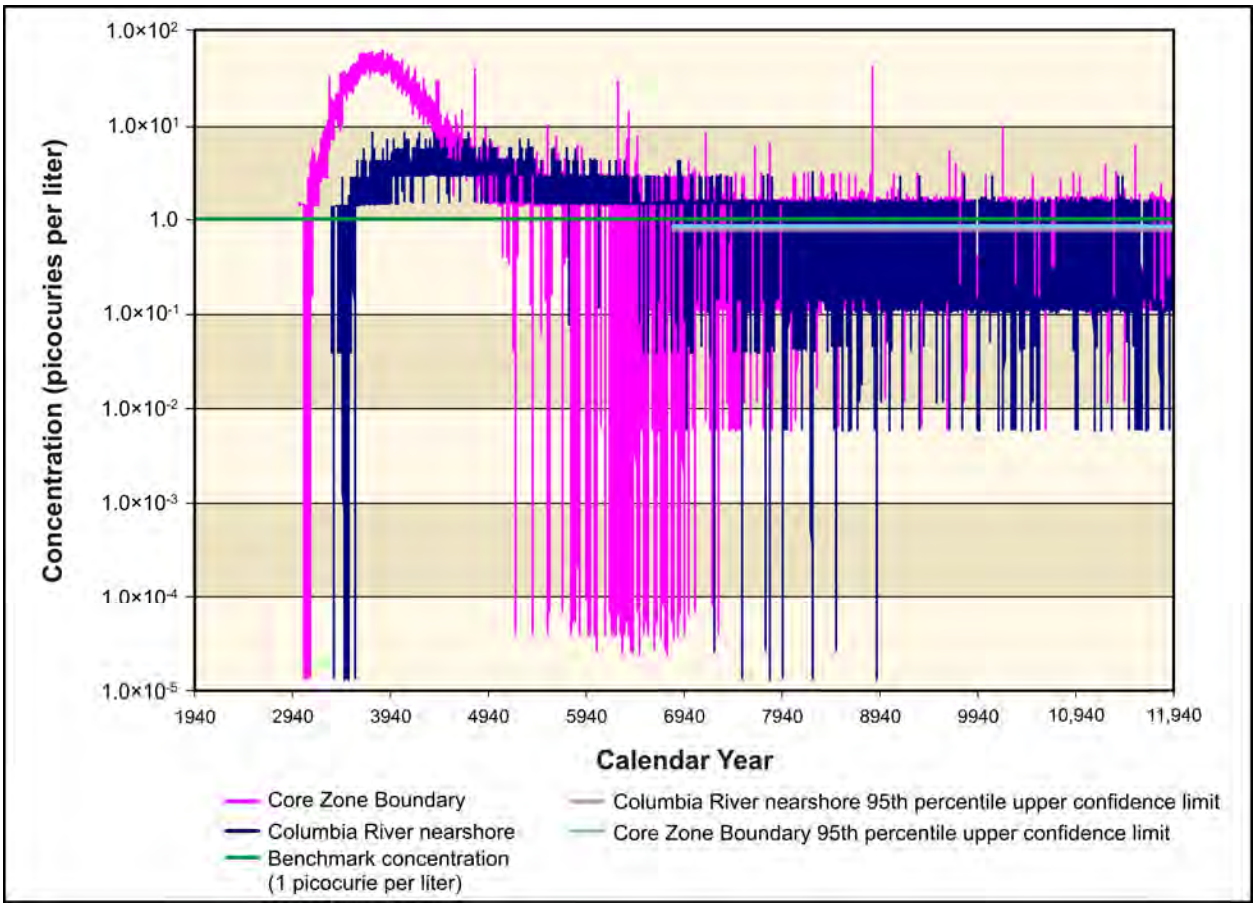


Figure 5–1008. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Iodine-129 Concentration Versus Time

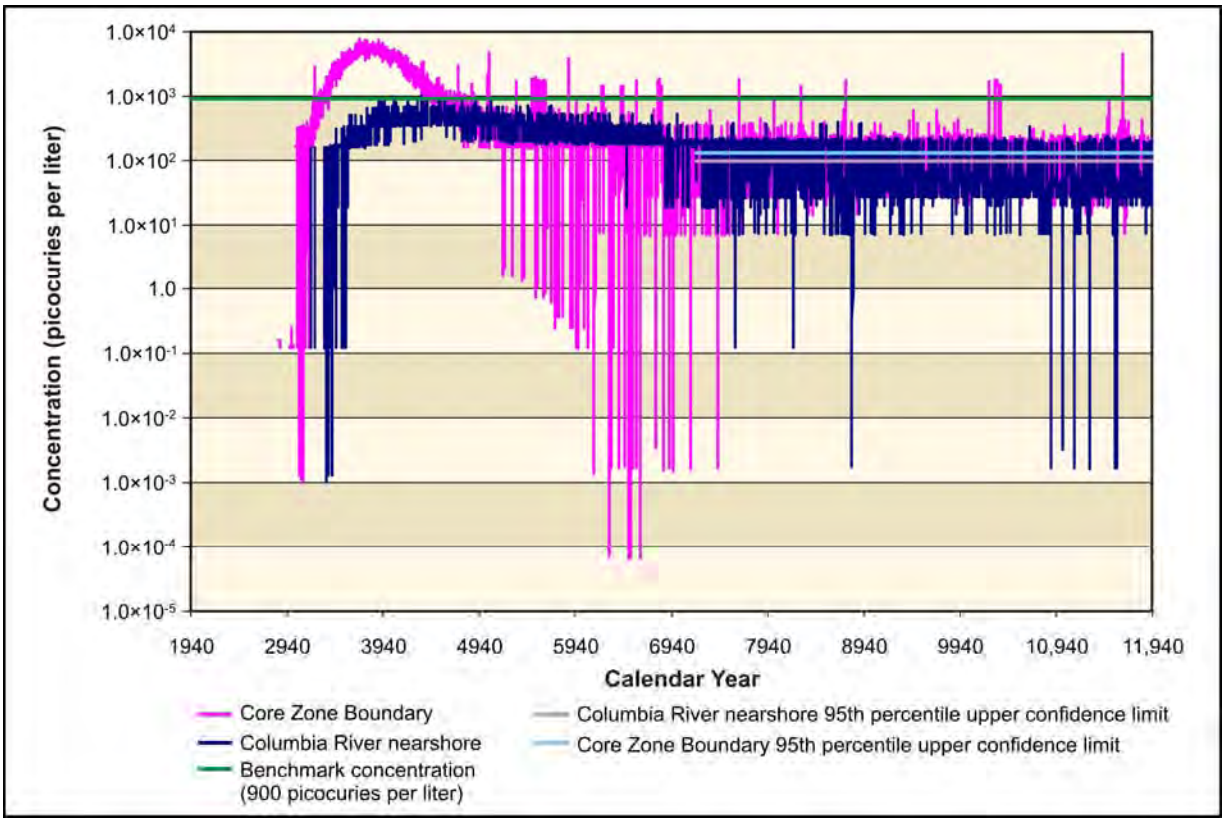


Figure 5–1009. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Technetium-99 Concentration Versus Time

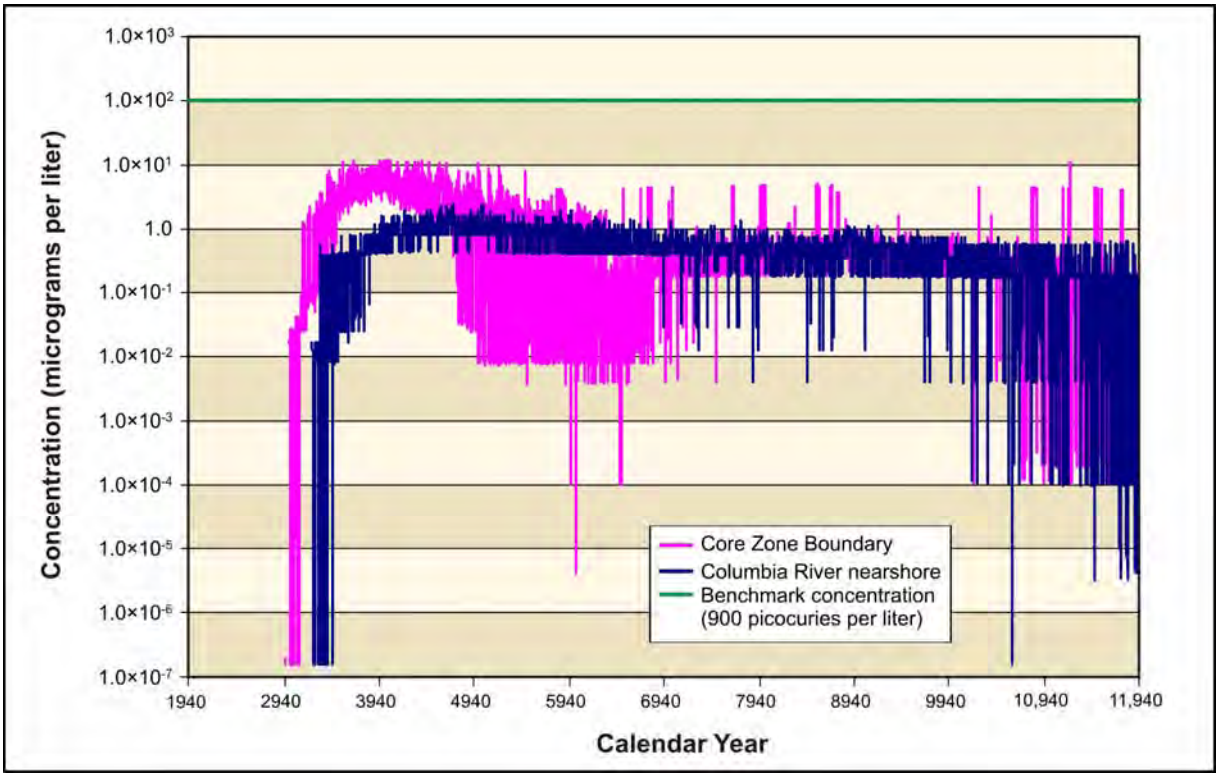


Figure 5–1010. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chromium Concentration Versus Time

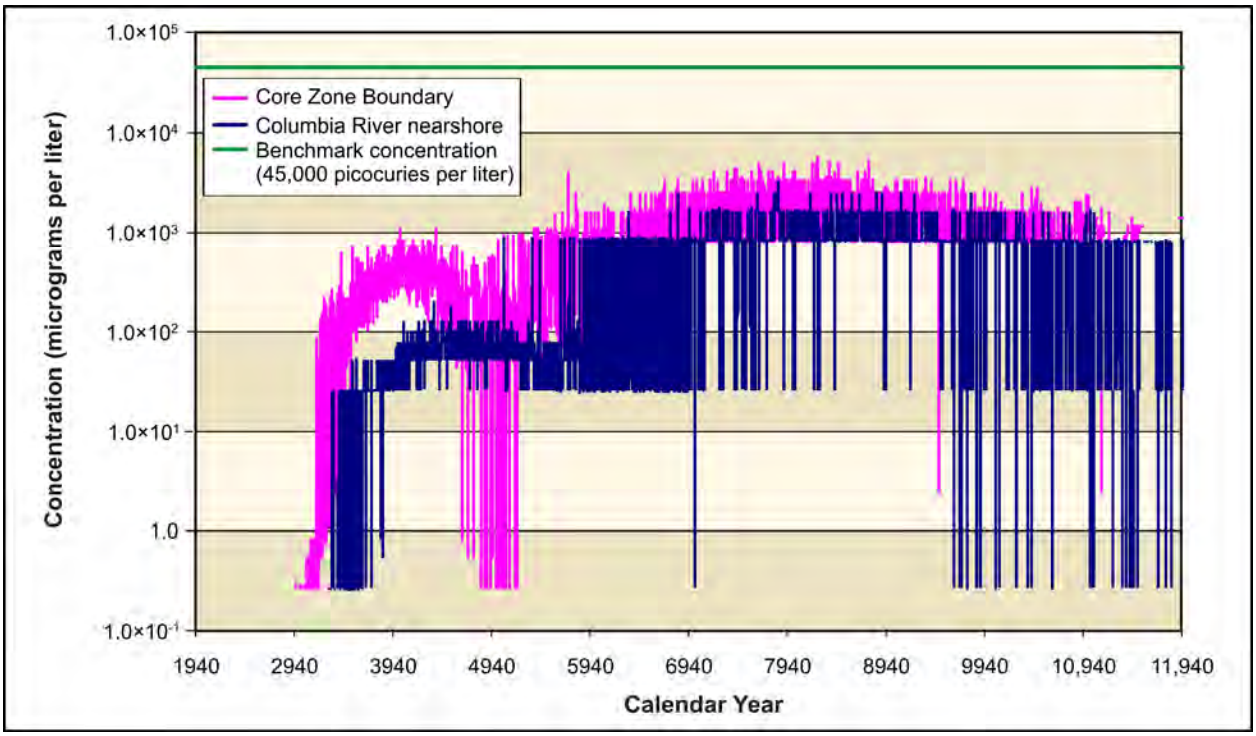


Figure 5–1011. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Nitrate Concentration Versus Time

Table 5–97. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	347	**20,200**	283	**7,750**	**1,180**	900
	(10,643)	(3713)	(3889)	(3690)	(3884)	
Iodine-129	**2**	**173**	0.5	**61**	**8**	1
	(11,363)	(3797)	(4089)	(3853)	(4392)	
Chemical in microgram per liter						
Chromium	3	2	6	12	2	100
	(8281)	(3696)	(3868)	(4042)	(4714)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	16,600	17	353	5,750	3,310	45,000
	(8162)	(3703)	(3996)	(8245)	(7831)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–1012 and 5–1013 show concentration versus time for uranium-238 and total uranium. Because of the high retardation of both forms, no total uranium or uranium-238 groundwater contamination appears until roughly CY 9000. Concentrations of both total uranium and uranium-238 continue to rise until the end of the 10,000-year period of analysis, but remain at least three orders of magnitude below the benchmark for both the Core Zone Boundary and the Columbia River nearshore at the end of the period of analysis.

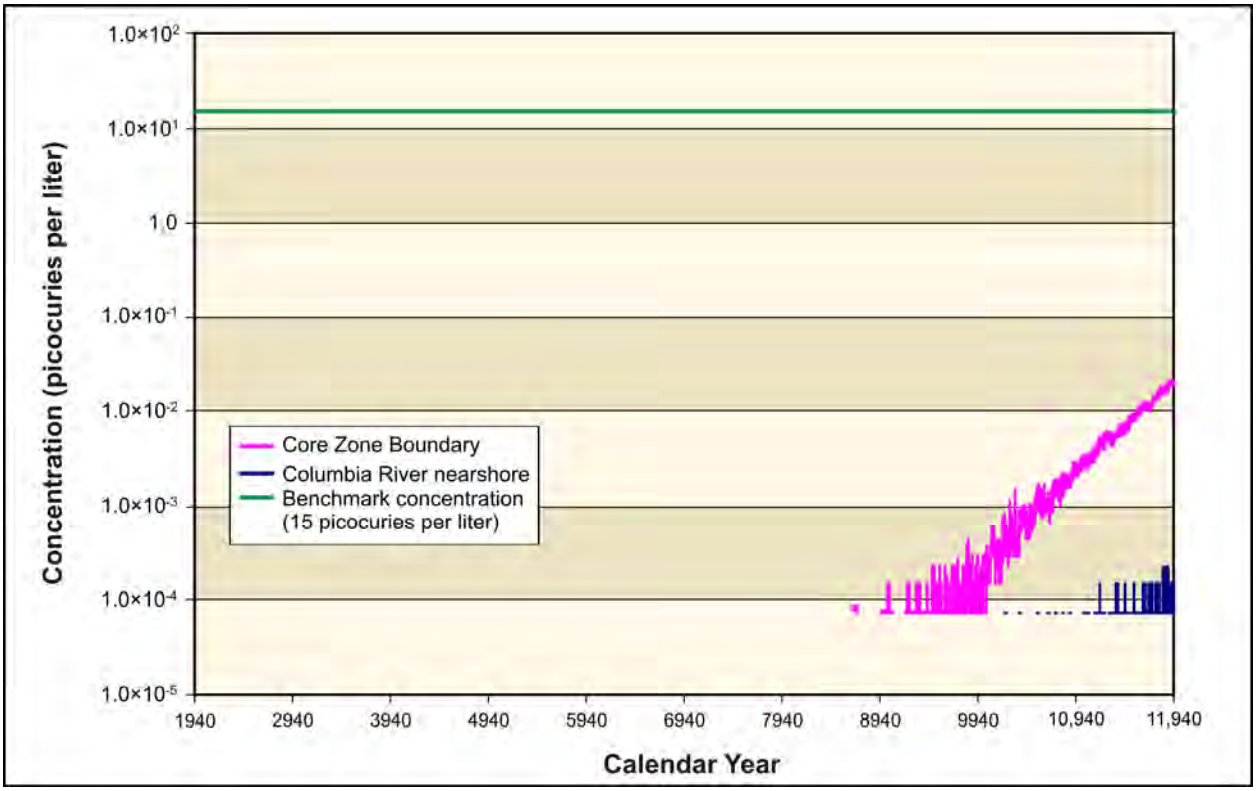


Figure 5–1012. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Uranium-238 Concentration Versus Time

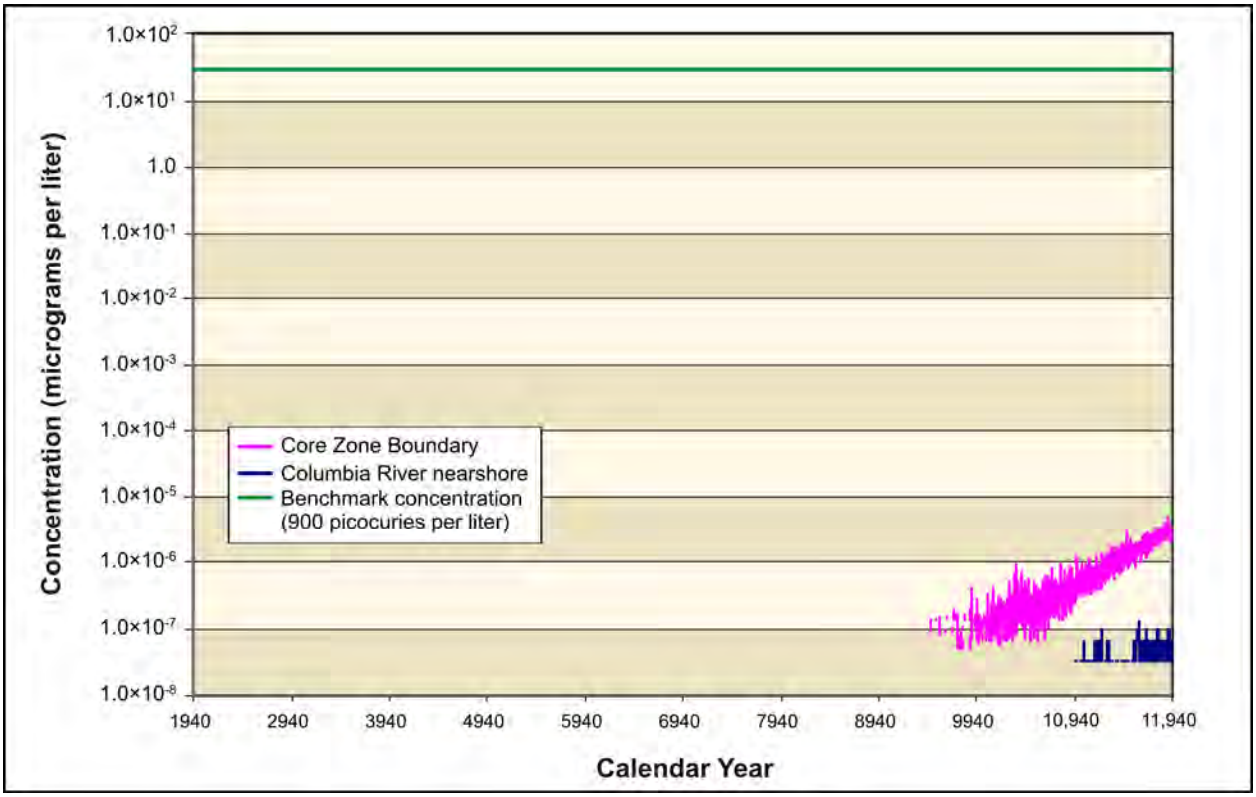
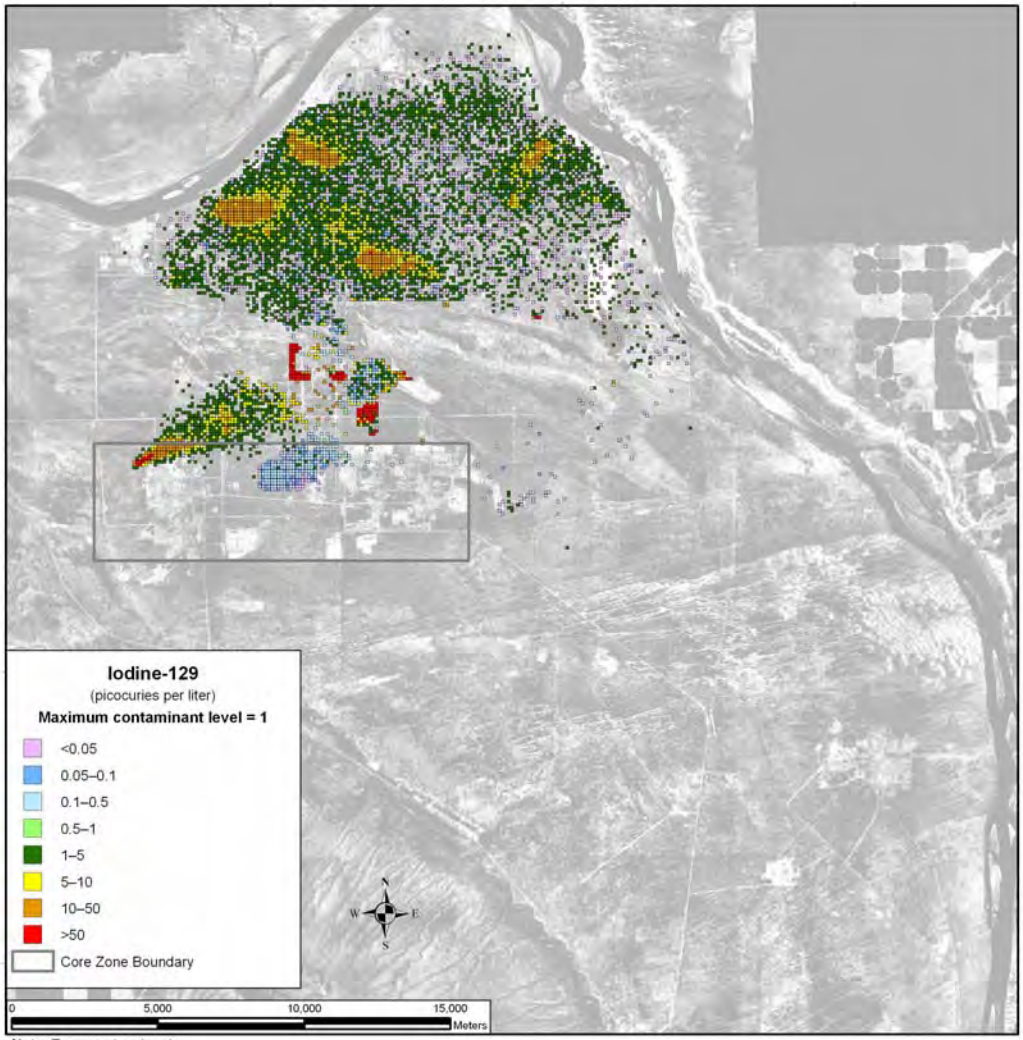


Figure 5–1013. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Total Uranium Concentration Versus

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

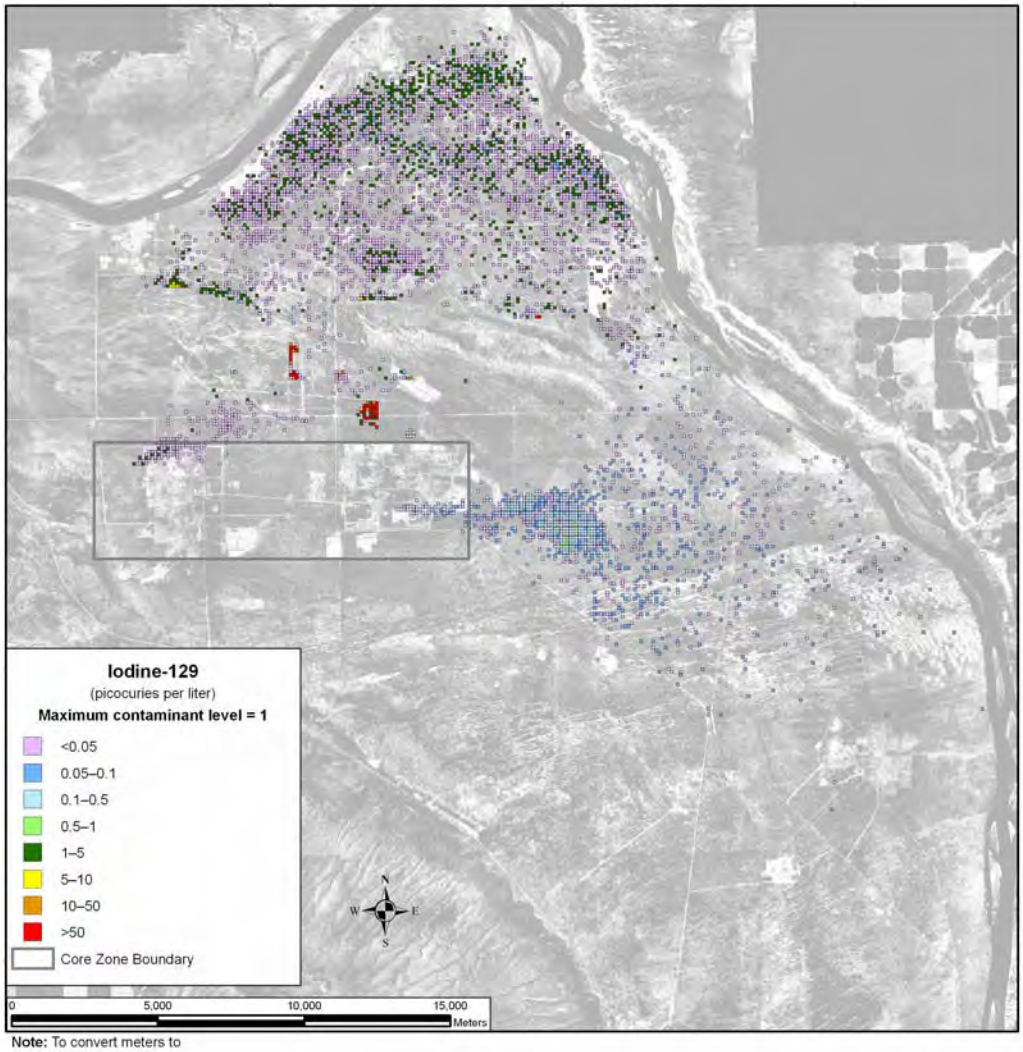
This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale indicative of the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations lower than the benchmark, by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–1014 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890, when there is a concentrated plume, with concentrations many times greater than the benchmark, that stretches north from IDF-West and the RPPDF through Gable Gap. By CY 7140 (see Figure 5–1015), the plume from the RPPDF is reduced, but a new plume is beginning to form, traveling east from IDF-East. The peak concentrations in the second plume are greater than the benchmark. By CY 11,885, the plume continues to spread towards the river and the concentrations continue to increase (see Figure 5–1016). Technetium-99 (see Figures 5–1017 through 5–1019), chromium (see Figures 5–1020 through 5–1022), and nitrate (see Figures 5–1023 through 5–1025) show similar spatial distributions at selected times, but the concentrations remain lower, similar to the later plumes mentioned above. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).



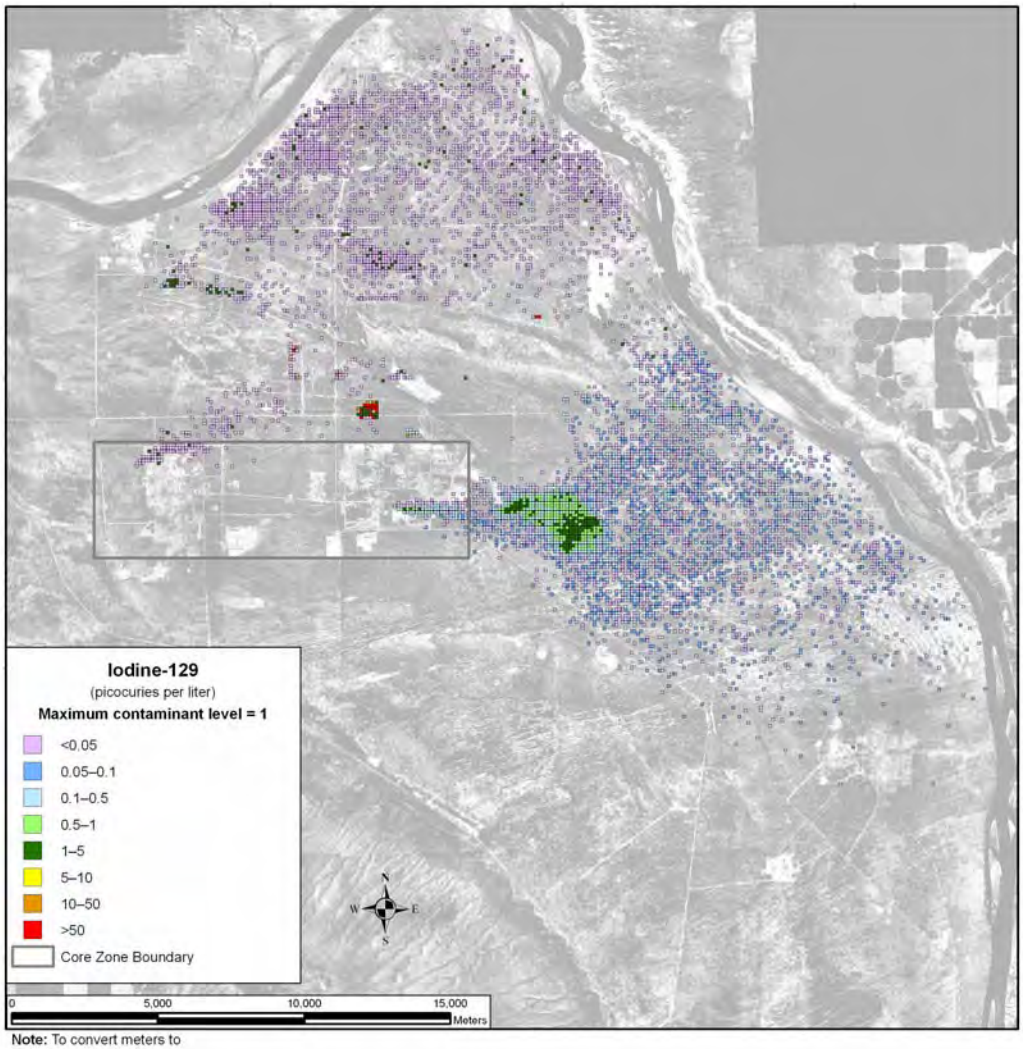
Note: To convert meters to feet, multiply by 3.281

Figure 5–1014. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



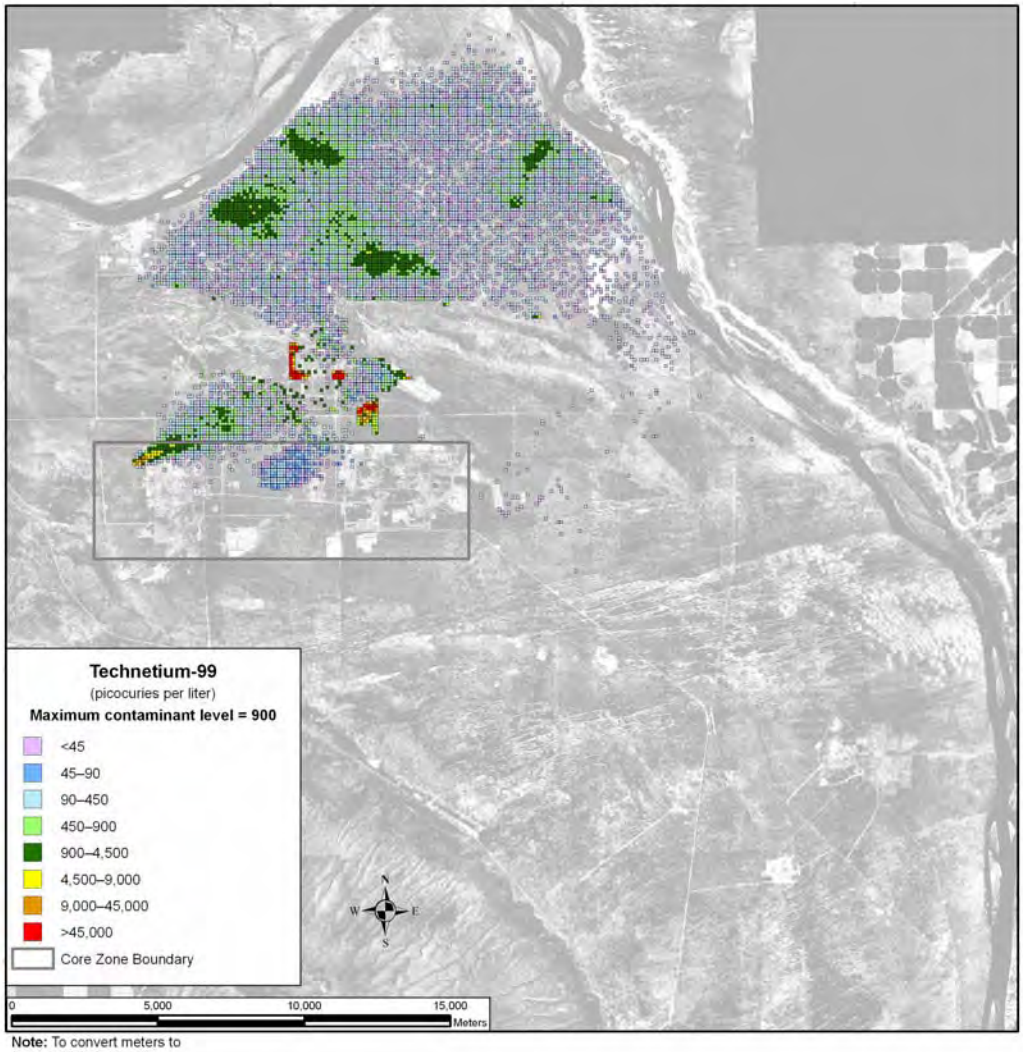
Note: To convert meters to feet, multiply by 3.281

Figure 5–1015. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



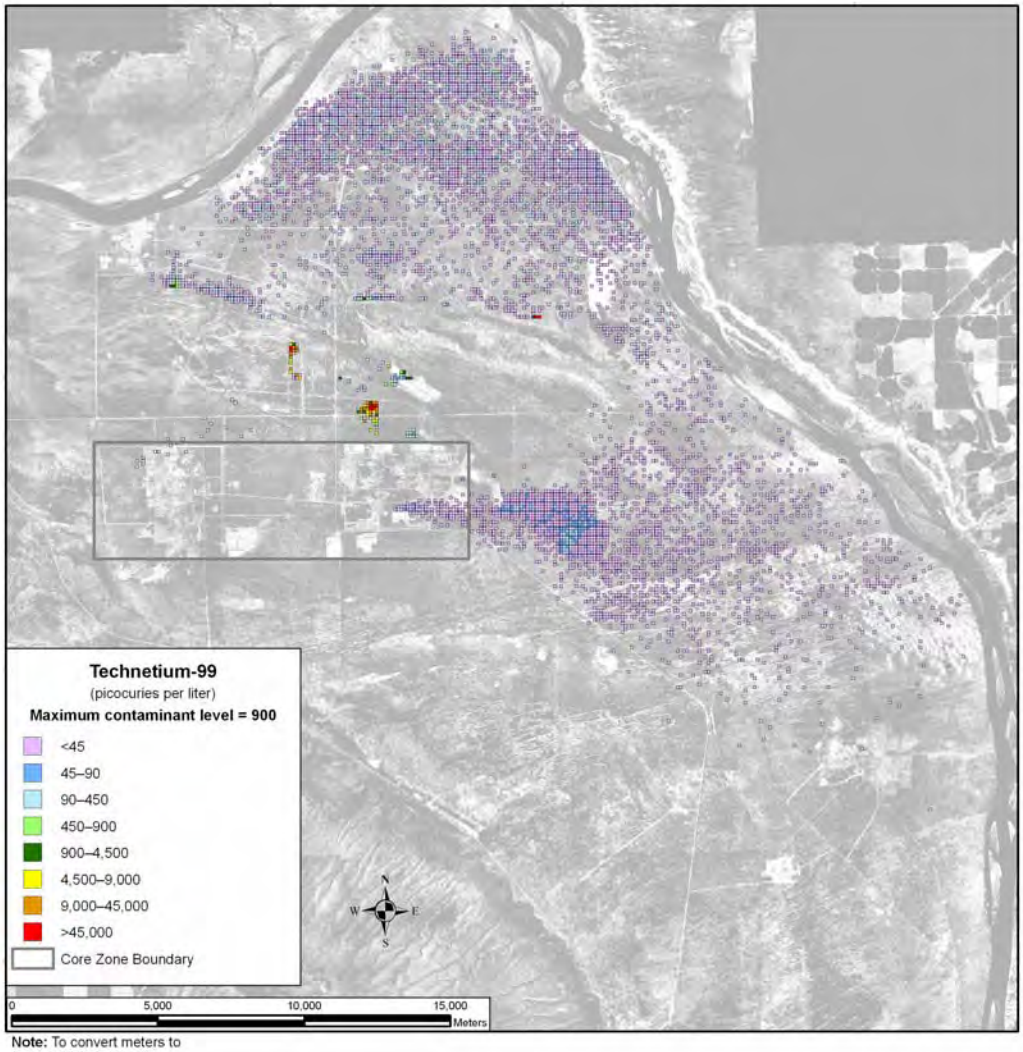
Note: To convert meters to feet, multiply by 3.281

Figure 5–1016. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



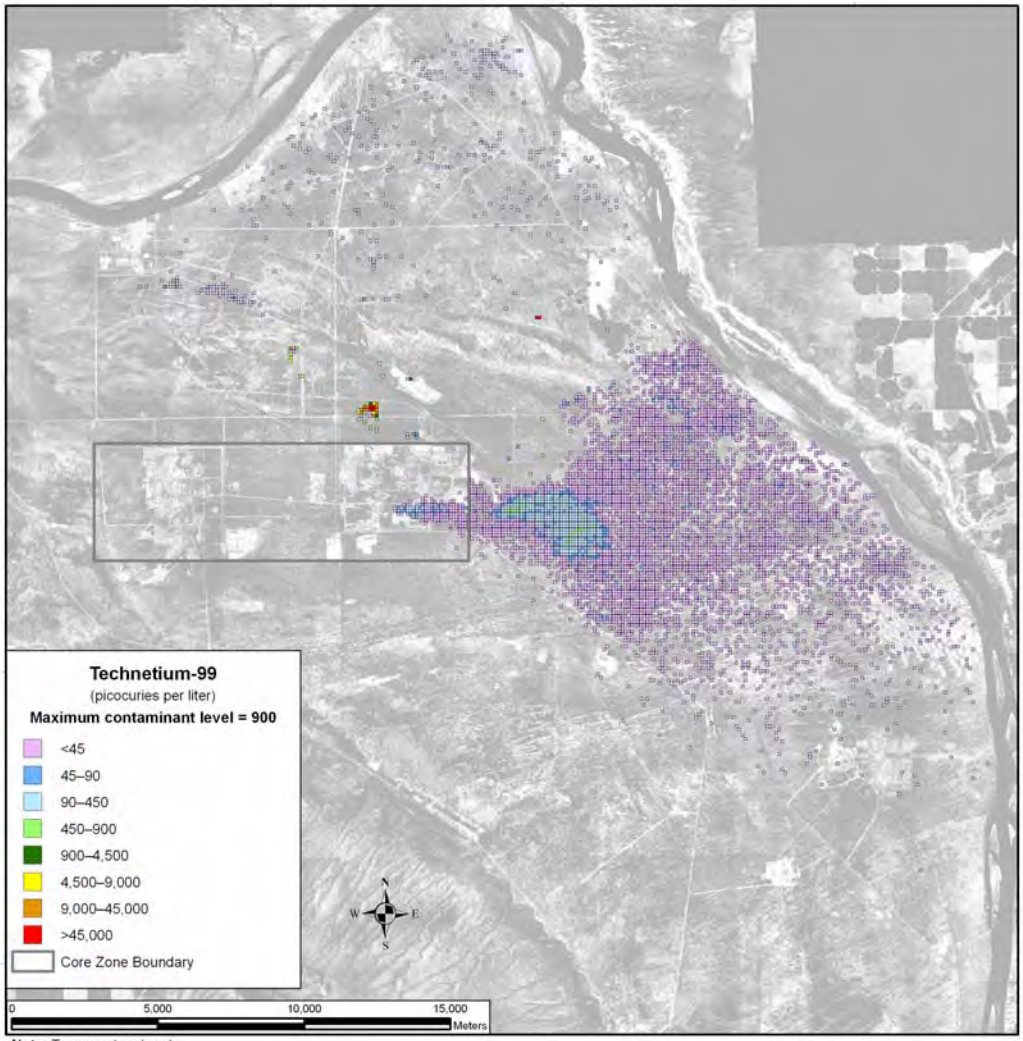
Note: To convert meters to feet, multiply by 3.281

Figure 5–1017. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



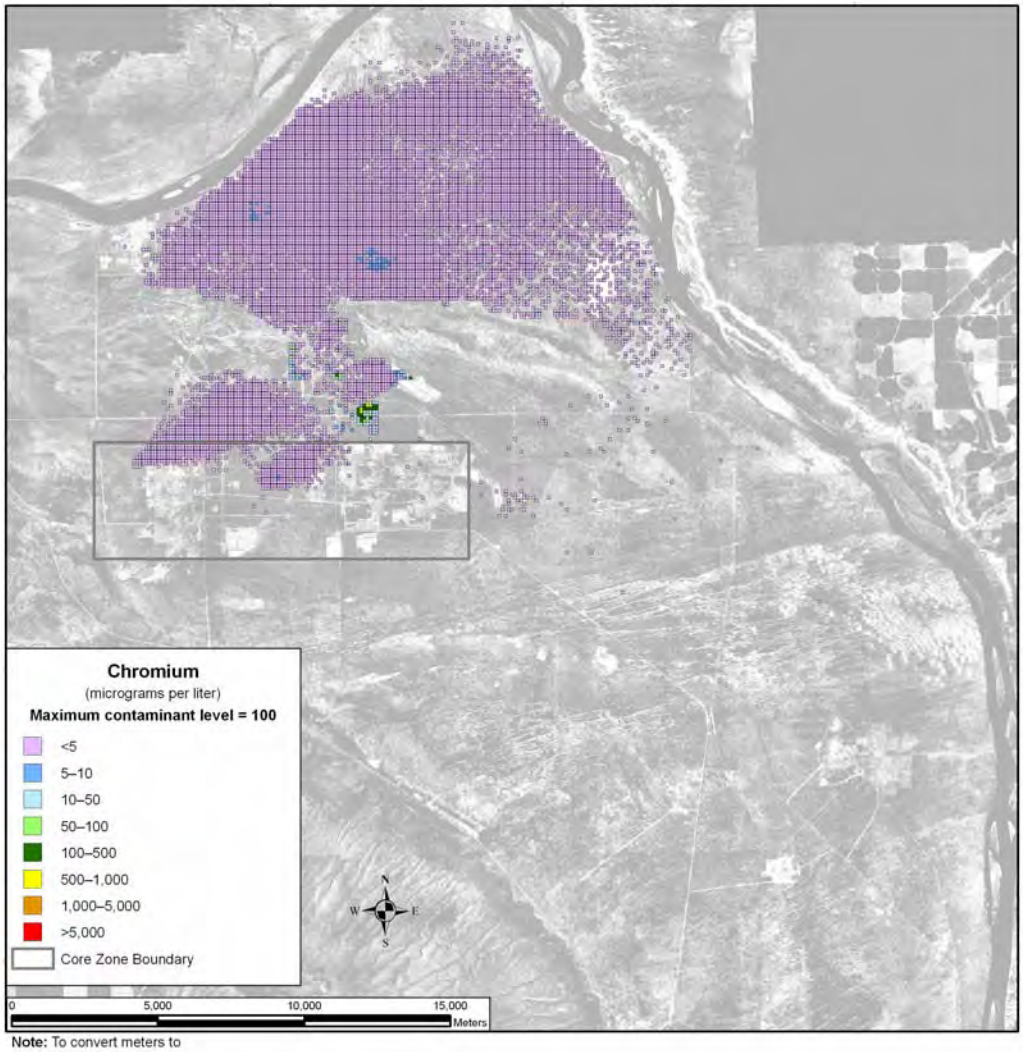
Note: To convert meters to feet, multiply by 3.281

Figure 5–1018. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



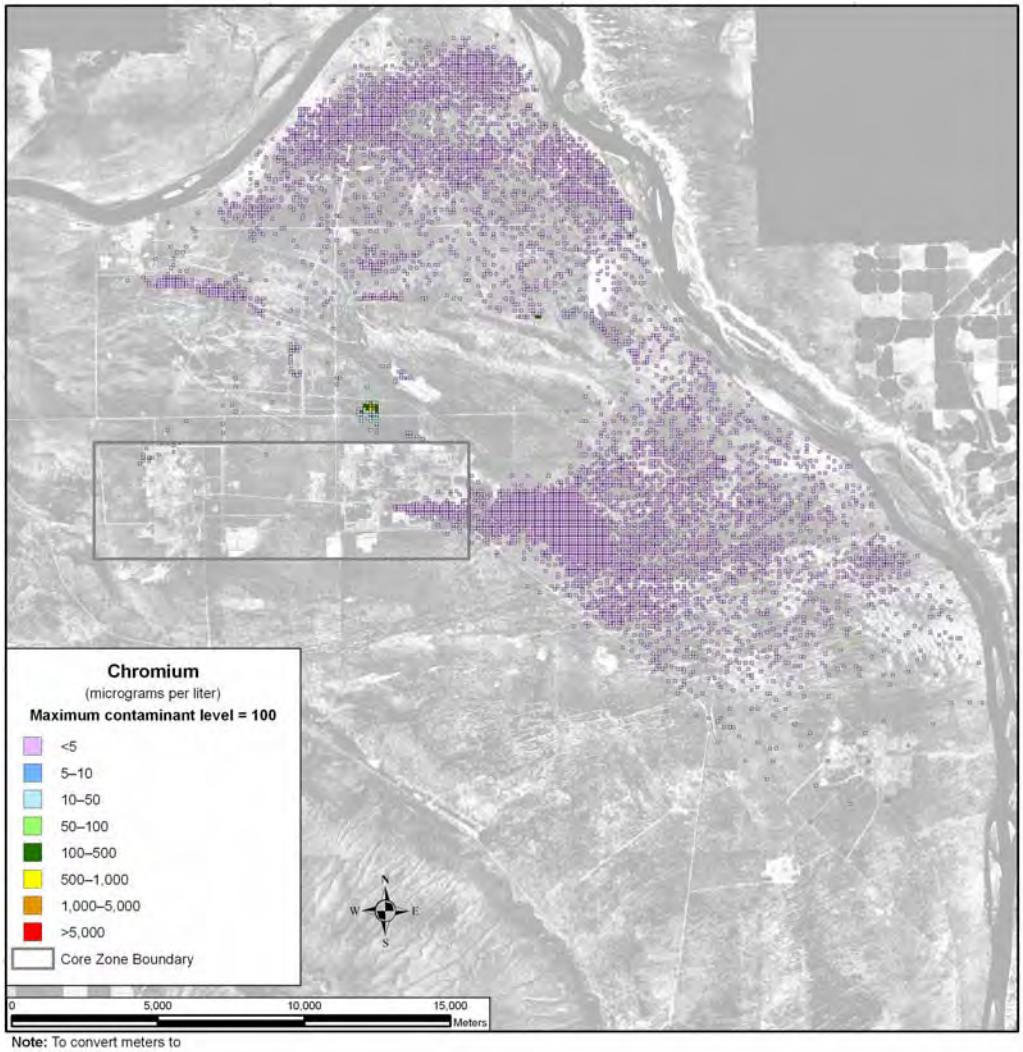
Note: To convert meters to feet, multiply by 3.281

Figure 5–1019. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



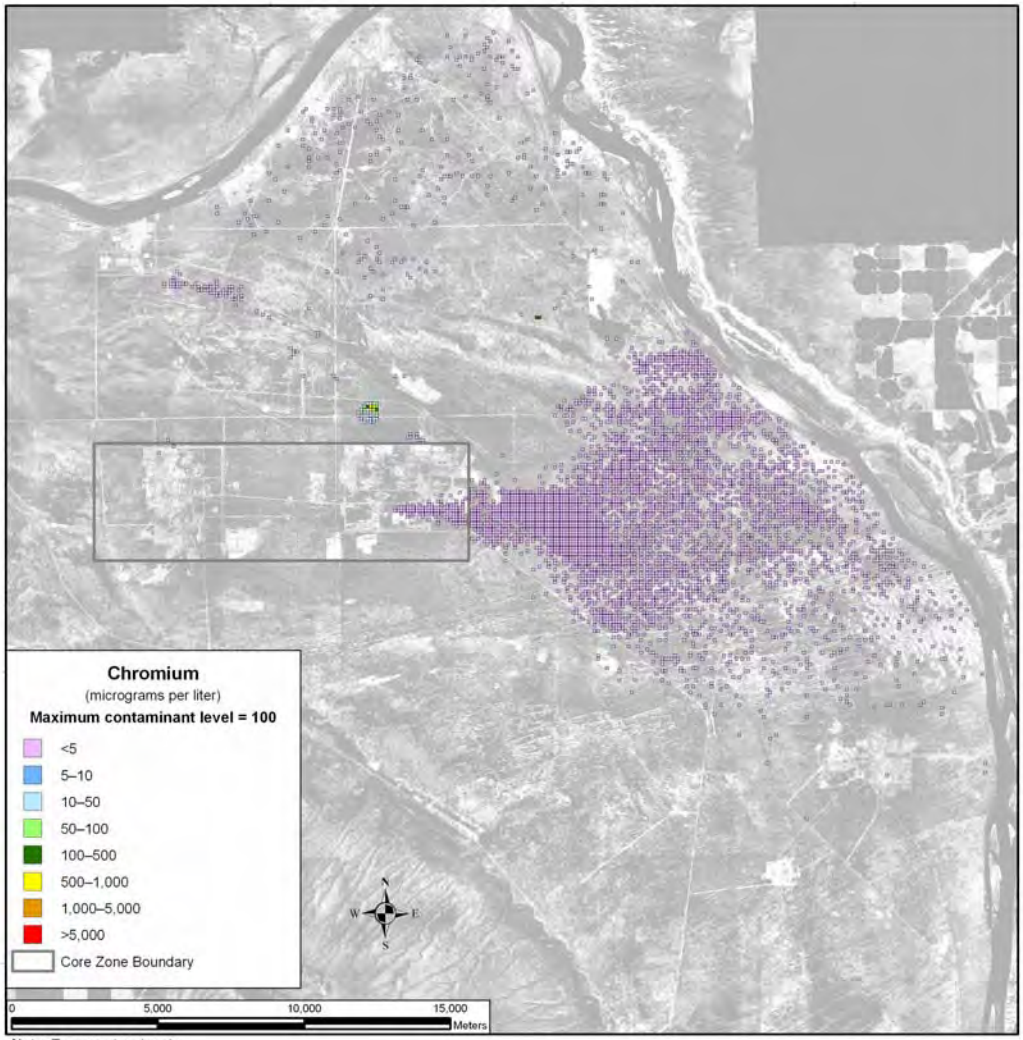
Note: To convert meters to feet, multiply by 3.281

Figure 5–1020. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



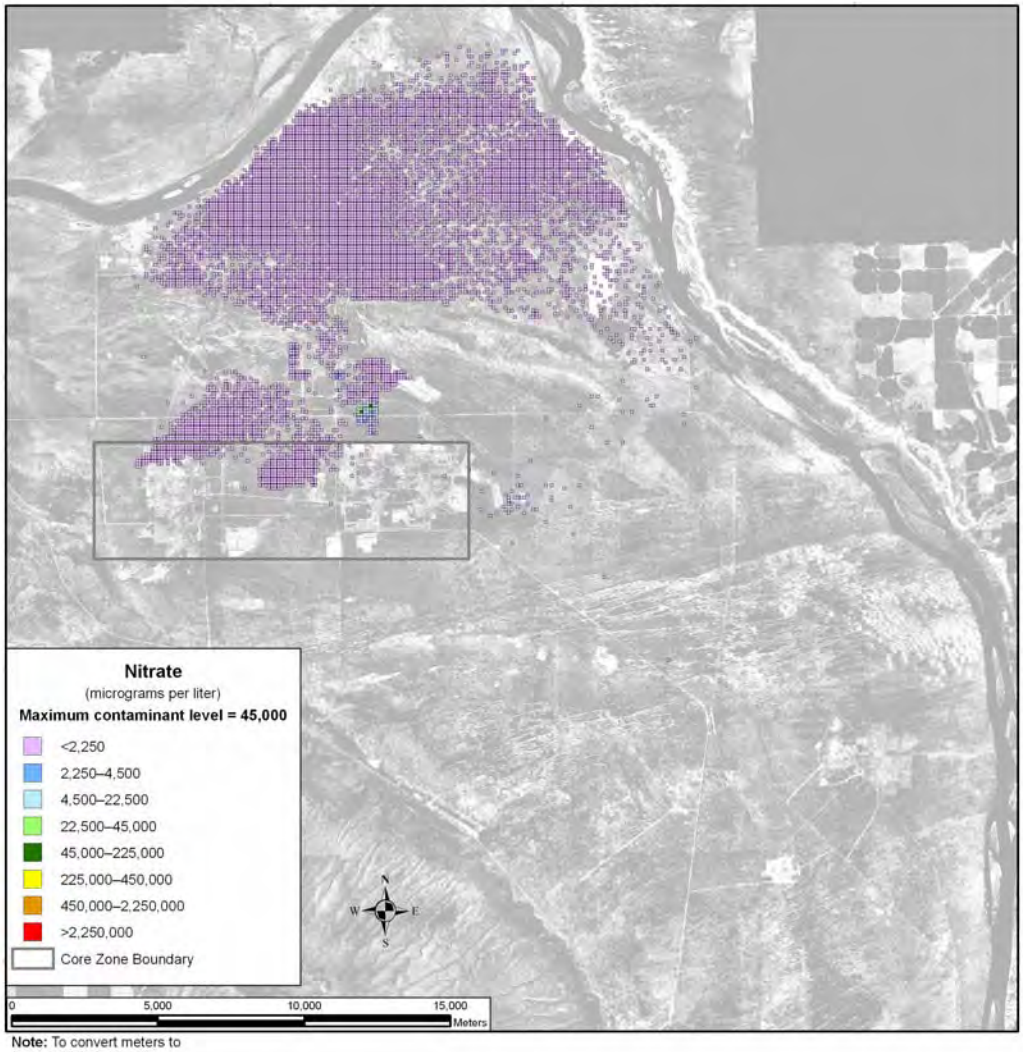
Note: To convert meters to feet, multiply by 3.281

Figure 5–1021. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



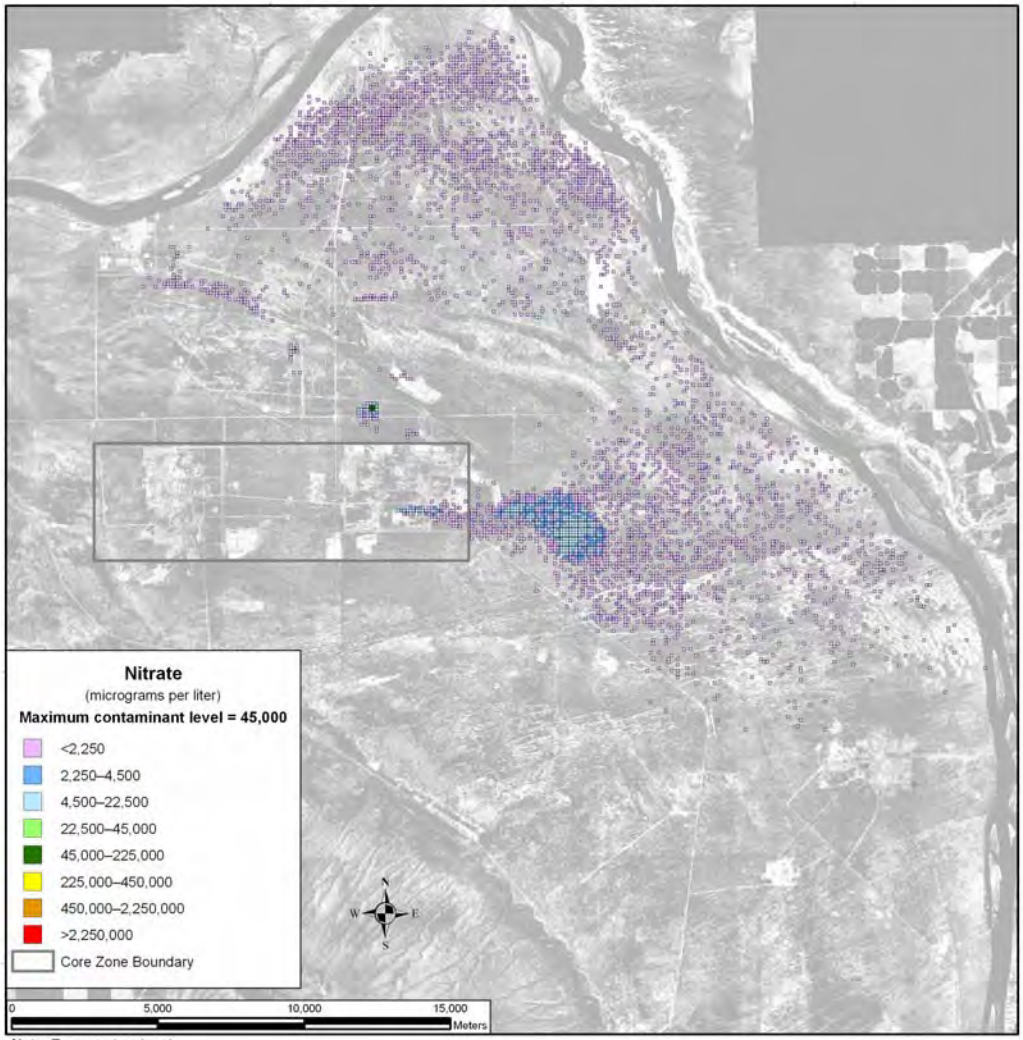
Note: To convert meters to feet, multiply by 3.281

Figure 5–1022. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



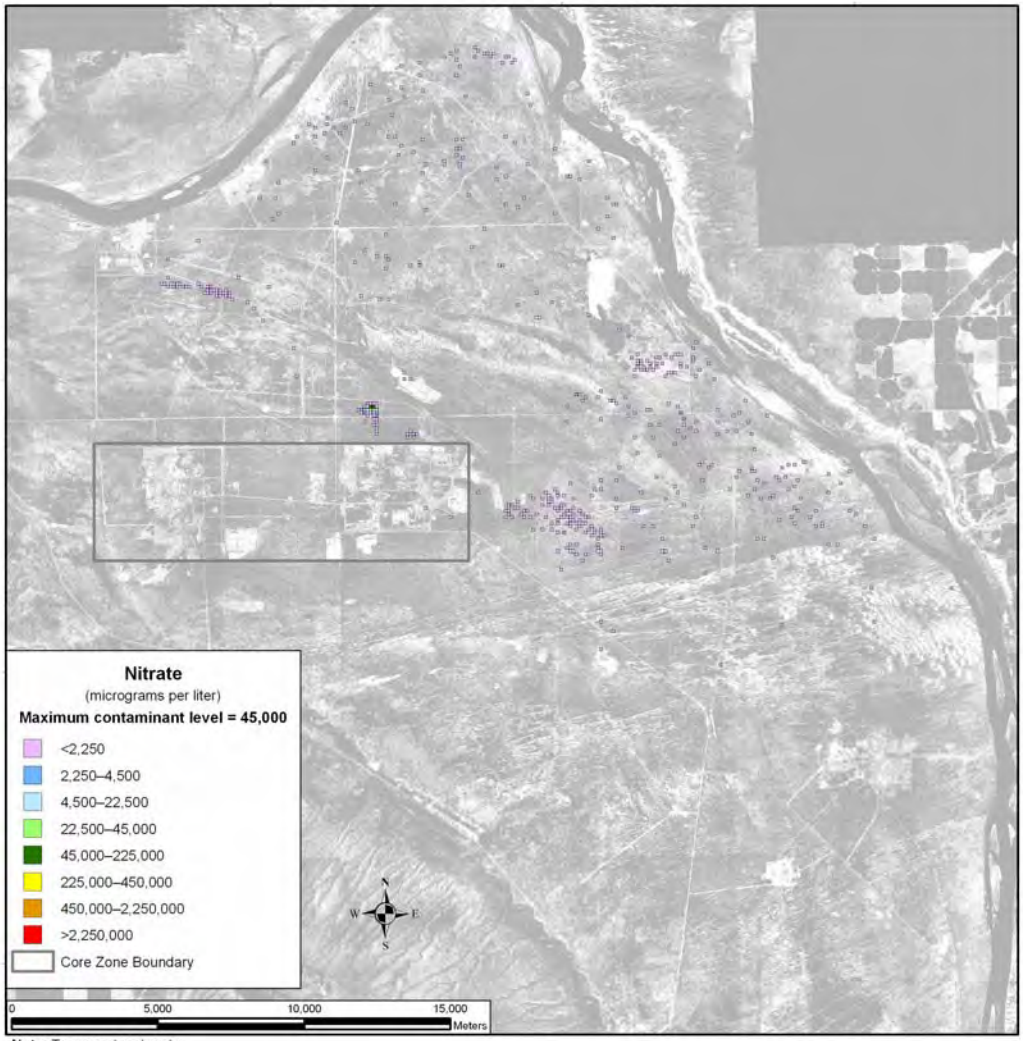
Note: To convert meters to feet, multiply by 3.281

Figure 5–1023. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

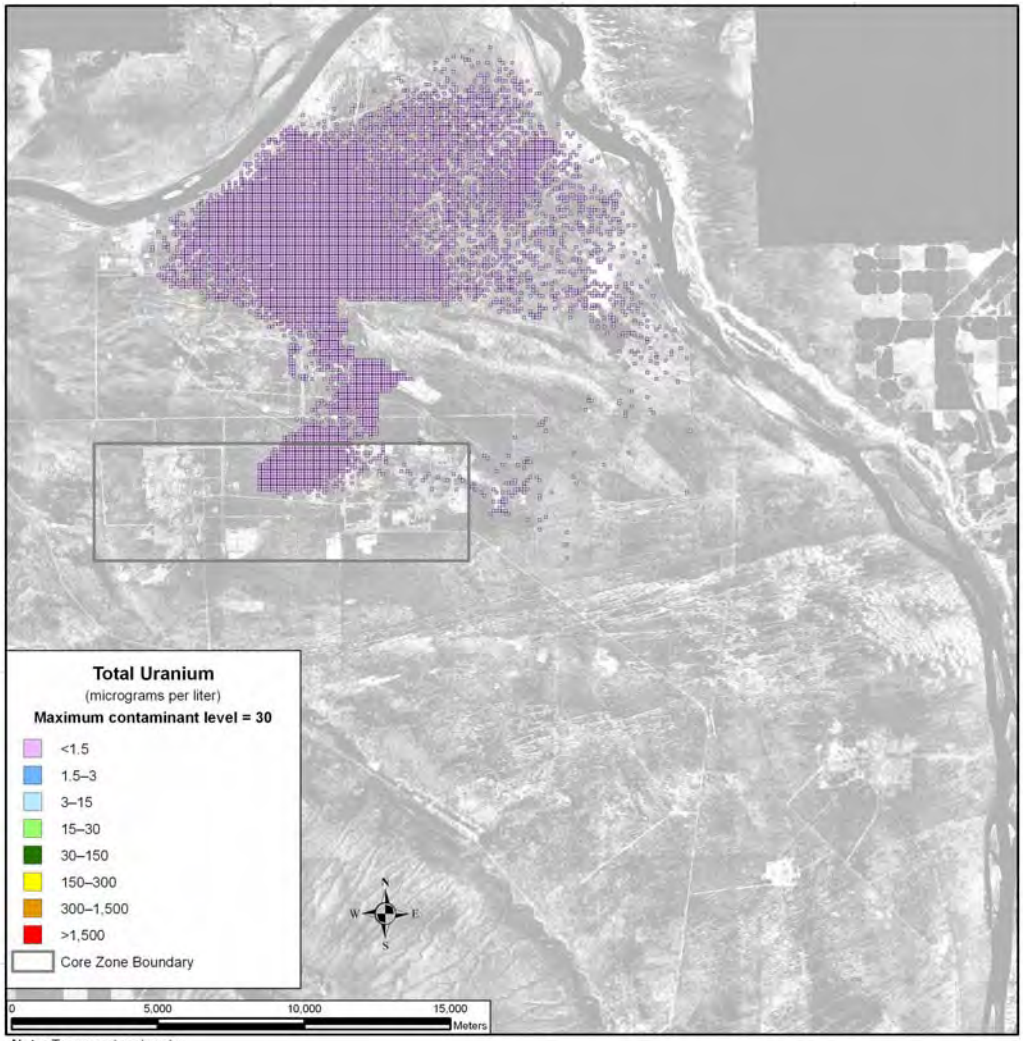
Figure 5–1024. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–1025. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Total uranium shows a different spatial distribution over time. This COPC is not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–1026 shows the distribution of total uranium at CY 11,885. There is a low concentration plume that stretches north from IDF-West and the RPPDF through Gable Gap. Concentrations in all areas of the plume remain below one-tenth of the benchmark.



Note: To convert meters to feet, multiply by 3.281

Figure 5–1026. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, in general, the inventory remaining in IDF-East and IDF-West, available for release to the environment at the start of the post-disposal period, is the predominant contributor. The inventory available for release from the RRPDF during the post-disposal period is a secondary contributor.

For the conservative tracers, concentrations at the Core Zone Boundary exceed or approach the benchmark standards during most of the period of analysis. Concentrations at the Columbia River nearshore are about two orders of magnitude lower. The intensities and areas of these groundwater plumes peak between CY 3500 and CY 5500.

For total uranium, limited mobility is an important factor governing the timeframe and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or the Columbia River by CY 10,000. The peak intensity and area of the contamination plume are largest near the end of the period of analysis.

5.3.1.3.2.3 Disposal Group 2, Subgroup 2-B, Option Case

Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, is designed to show the impacts of waste disposal at IDF-East and the RPPDF.

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, covers the disposal of wastes generated during Tank Closure Alternatives 6B, Option Case; FFTF Decommissioning Alternatives 2 or 3; and onsite- and offsite-generated waste.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009 and continues through CY 2050 for IDF-West and CY 2100 for IDF-East and the RPPDF, when the disposal facilities will be operationally closed. During the disposal period, the materials in these permitted, operational facilities are not available for release to the environment.

- The post-disposal period starts in CY 2101 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, IDF-East and IDF-West are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case (i.e., Tank Closure Alternative 6B, Option Case; FFTF Decommissioning Alternatives 2 and 3; and onsite- and offsite-generated waste), is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: acetonitrile, boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, then selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, acetonitrile, chromium, and nitrate) are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, in terms of total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Subtotals are plotted as releases from three disposal facilities: IDF-West (FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste); IDF-East (PPF glass, ETF-generated secondary waste, retired melters, and tank closure secondary waste); and the RRPDF. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over more than 10 orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–1027 shows the release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–1028, the chemical hazard drivers. The release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period of analysis). For the radiological COPCs (technetium-99 and iodine-129), the releases range over five orders of magnitude, depending on the sources of the radionuclides. ETF-generated secondary waste and tank closure secondary waste account for most of the releases. The release of nitrate in IDF-East is all associated with ETF-generated secondary waste. Chromium comes from ETF-generated secondary waste, tank closure secondary waste, PPF glass, and retired melters.

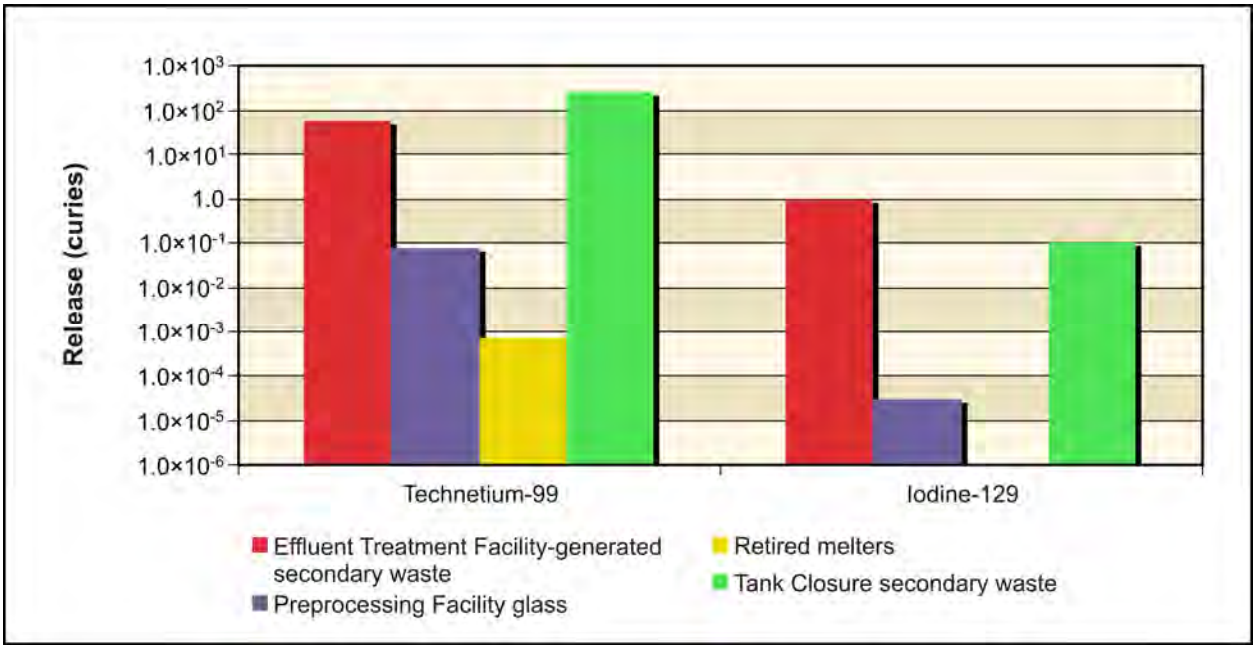


Figure 5–1027. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

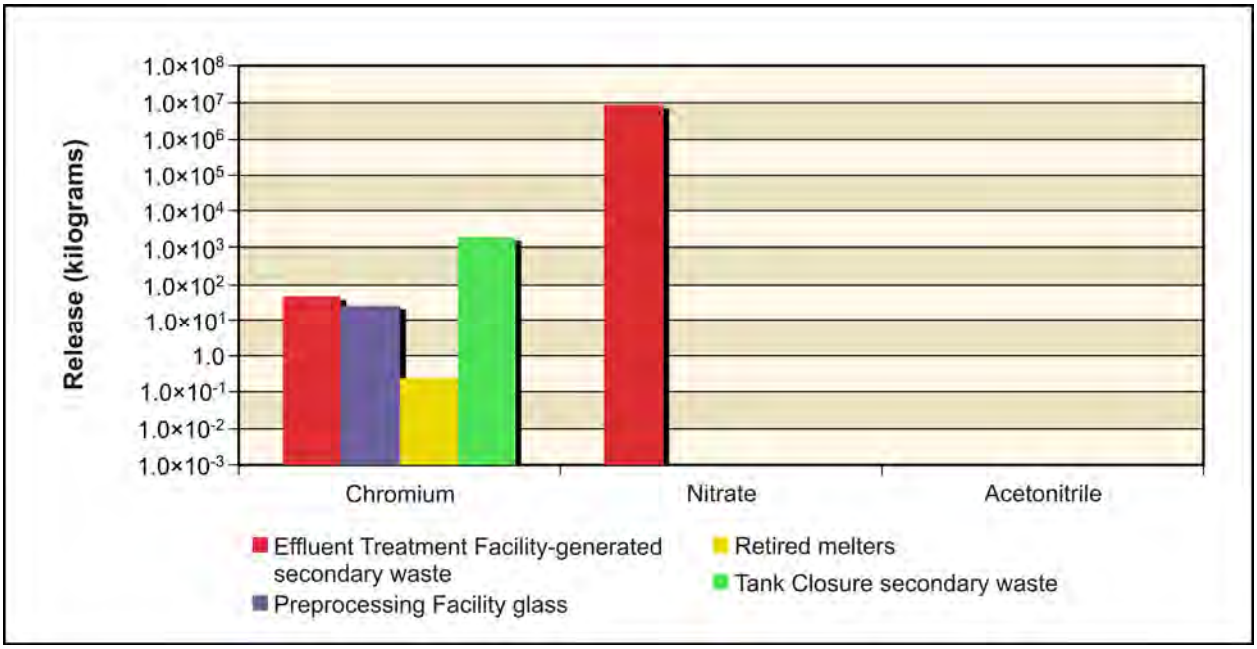


Figure 5–1028. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–1029 shows the release at IDF-East to groundwater for the radiological risk drivers and Figure 5–1030, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

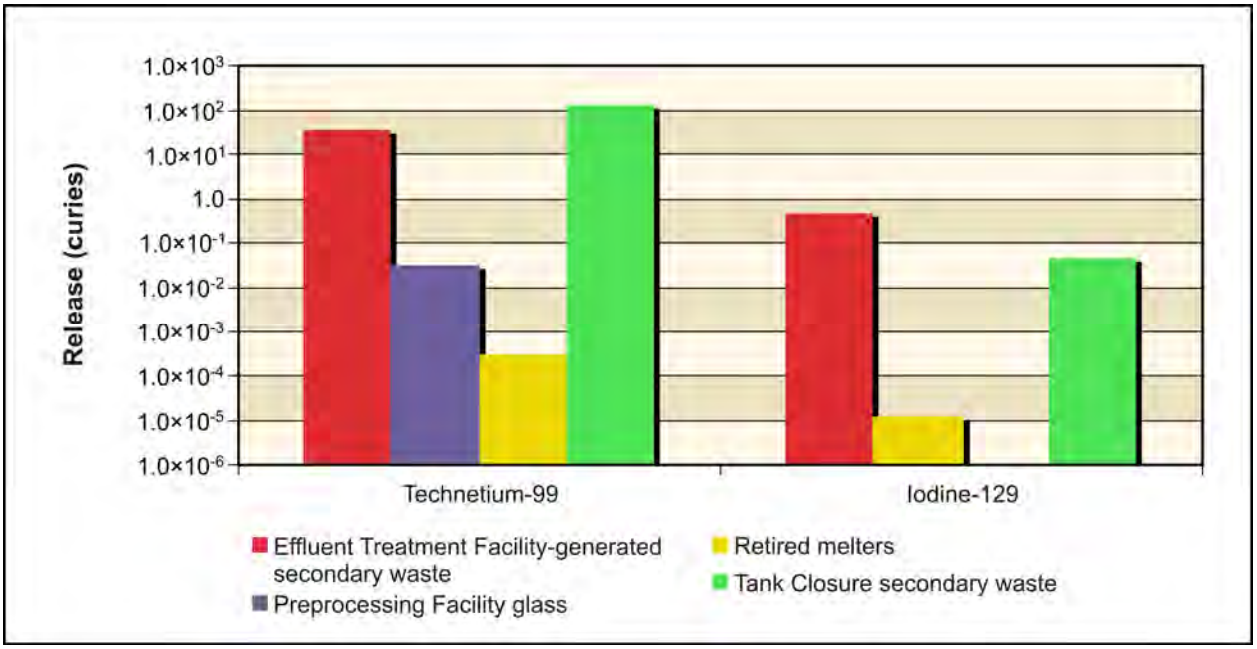


Figure 5–1029. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

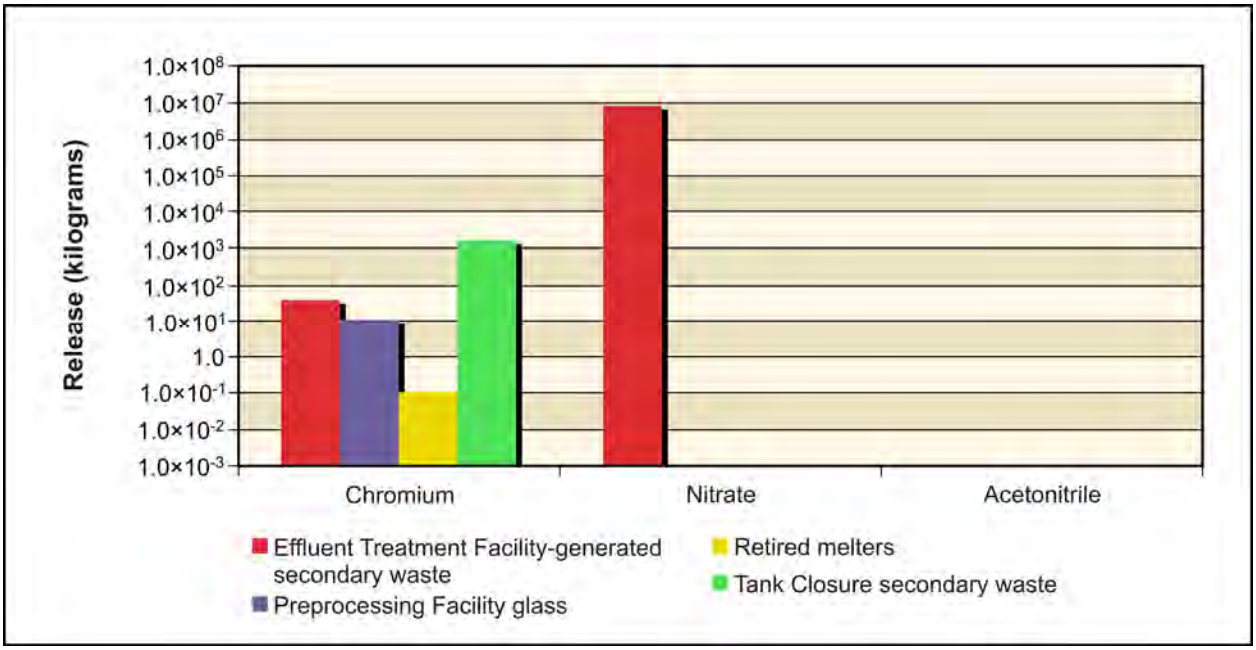


Figure 5–1030. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–1031 shows the release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–1032, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater.

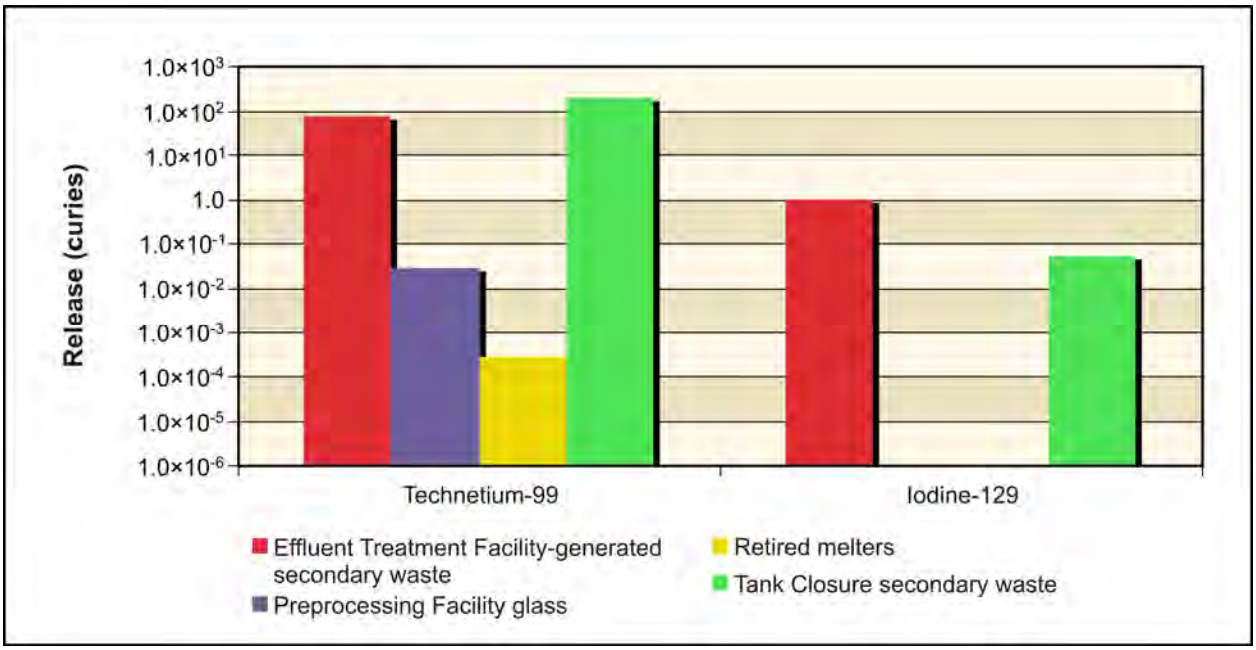


Figure 5–1031. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

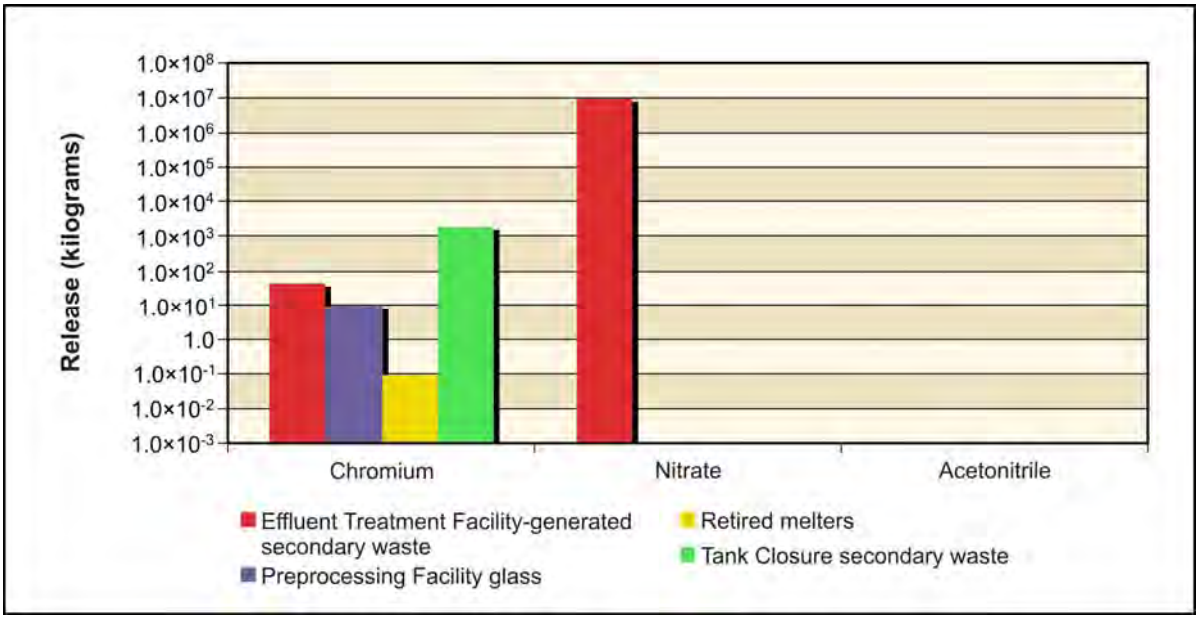


Figure 5–1032. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

Figure 5–1033 shows the release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–1034, the chemical hazard drivers. The release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period of analysis). For the radiological COPCs (technetium-99 and iodine-129) in IDF-West, the releases range over five orders of magnitude depending on the source. Over 99 percent of the radiological waste is from offsite-generated waste. The chemical COPCs (chromium, and nitrate) in IDF-West, essentially all of it nitrate, have releases associated with waste management secondary waste and onsite-generated waste. Of the chromium sources, less than 1 percent is from FFTF Decommissioning Alternative 3 waste, 66 percent is from waste management secondary and onsite-generated waste, and 34 percent is from offsite-generated waste.

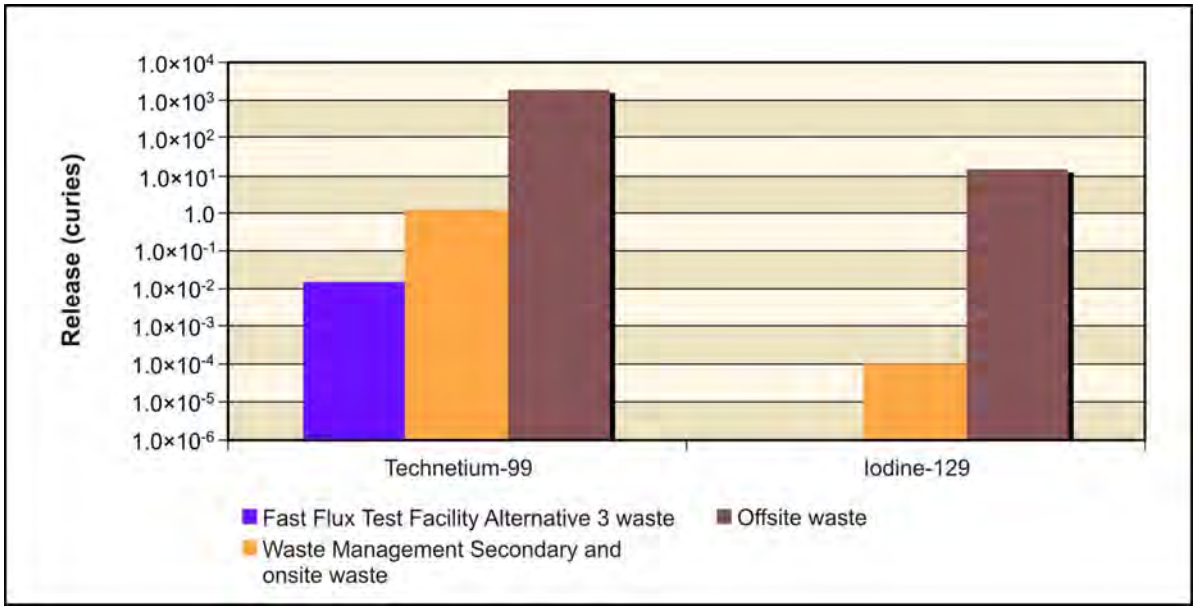


Figure 5–1033. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

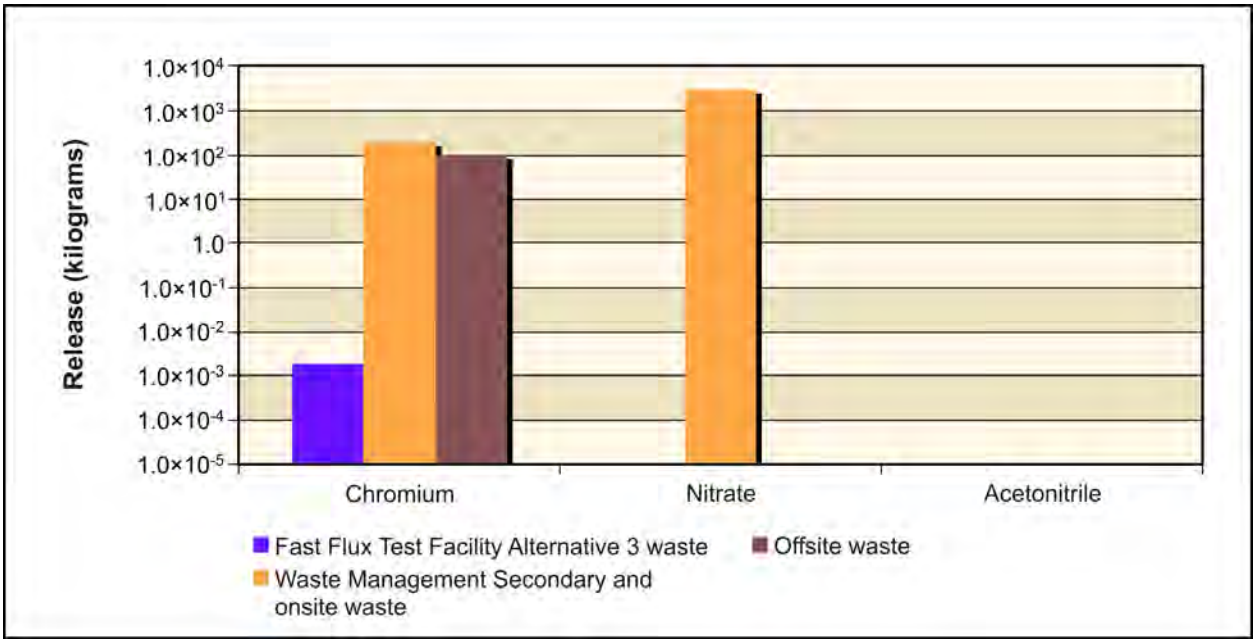


Figure 5–1034. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–1035 shows the release at IDF-West to groundwater for the radiological risk drivers and Figure 5–1036, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

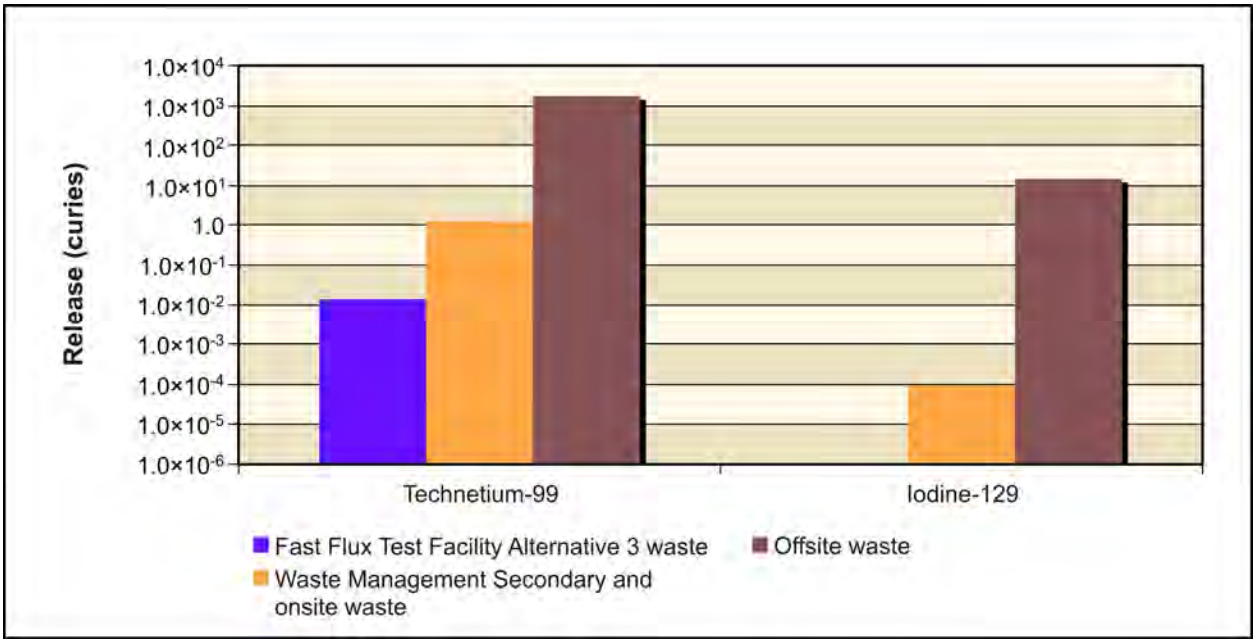


Figure 5–1035. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

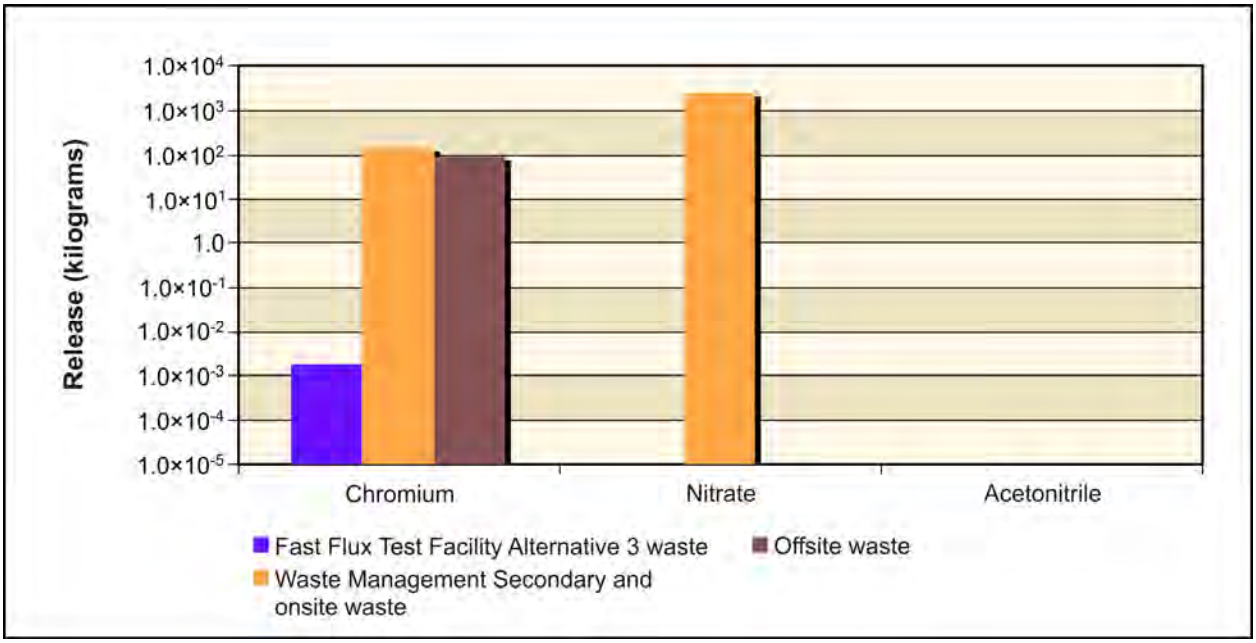


Figure 5–1036. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–1037 shows the release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–1038, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is approximately 5 percent less than that released to the vadose zone.

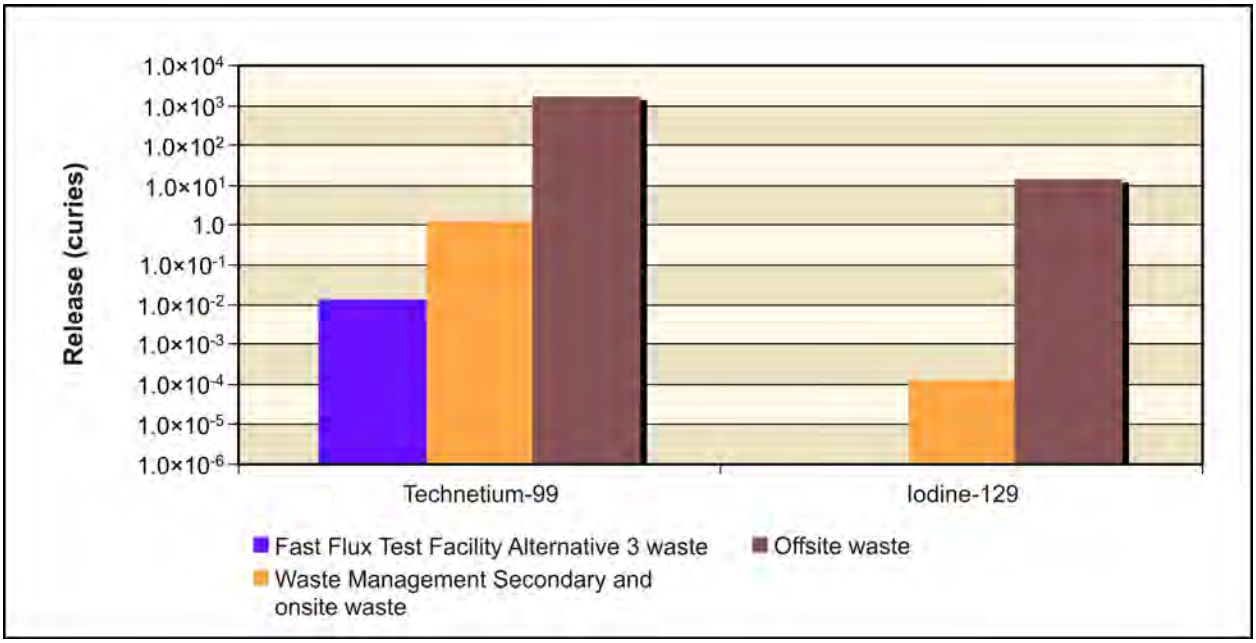


Figure 5–1037. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

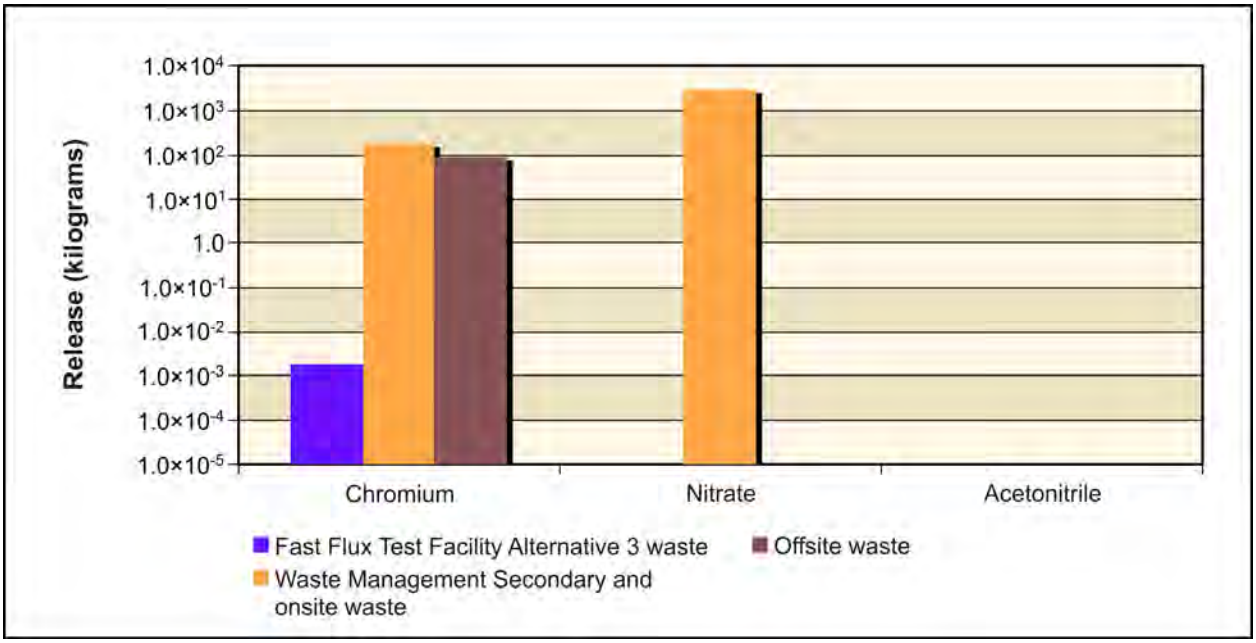


Figure 5–1038. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–1039 shows the release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–1040, the chemical hazard drivers. The release of technetium-99 is more than two orders of magnitude greater than the release of iodine-129 at the RRPDF. The chemical constituents show nitrate as the predominant COPC; its release is more than two orders of magnitude greater than that of chromium and about seven orders of magnitude greater than that of acetonitrile.

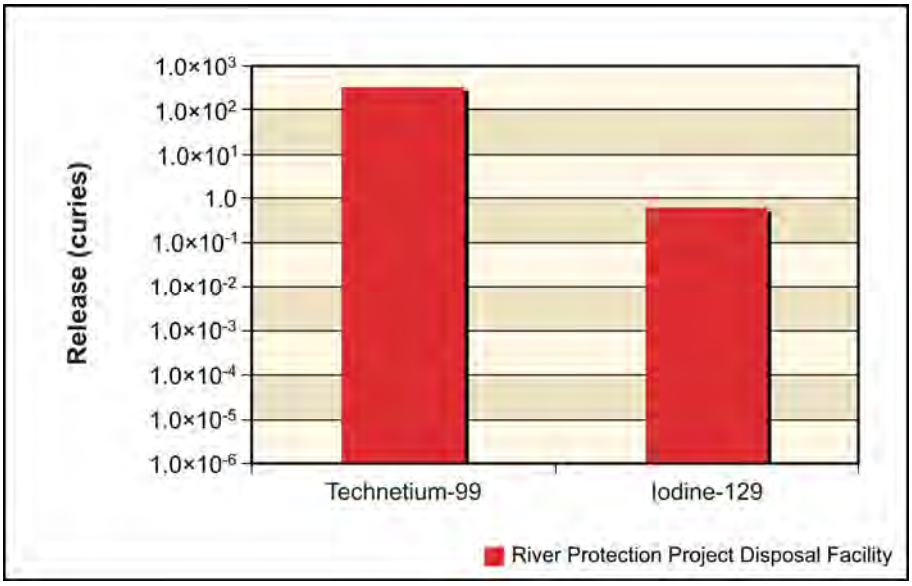


Figure 5–1039. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

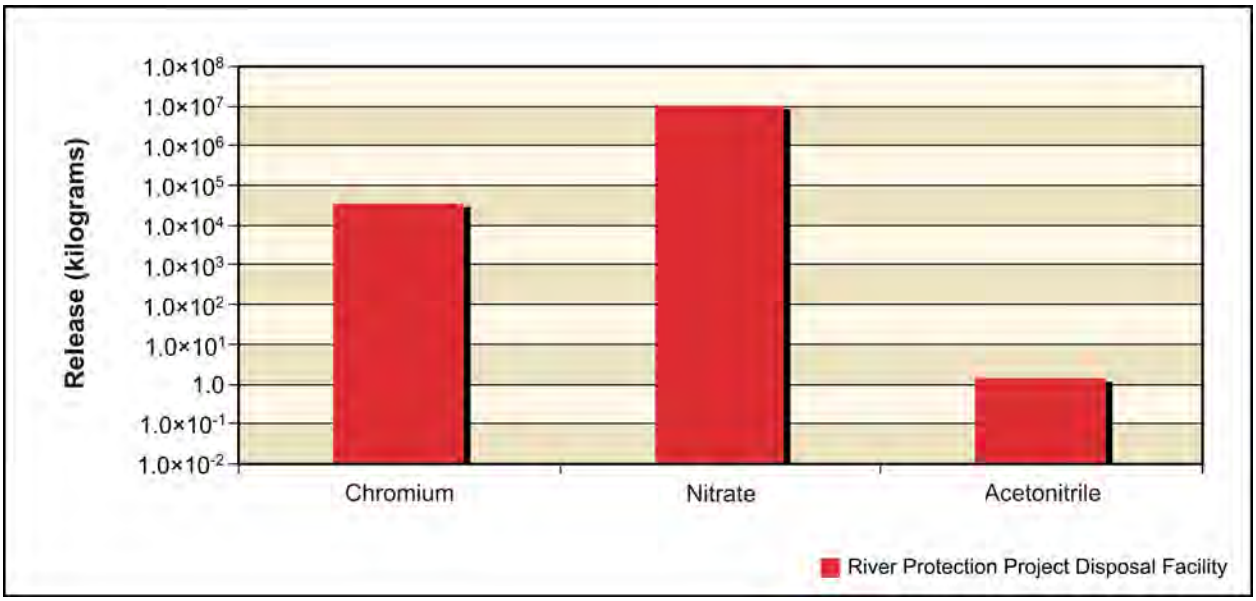


Figure 5–1040. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–1041 shows the release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–1042, the chemical hazard drivers. For the conservative tracers (iodine-129, technetium-99, acetonitrile, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

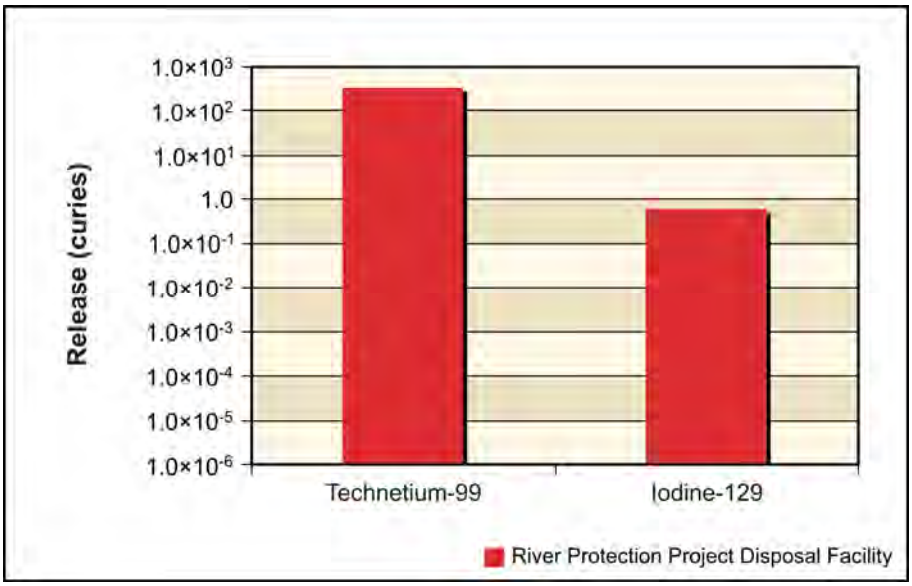


Figure 5–1041. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

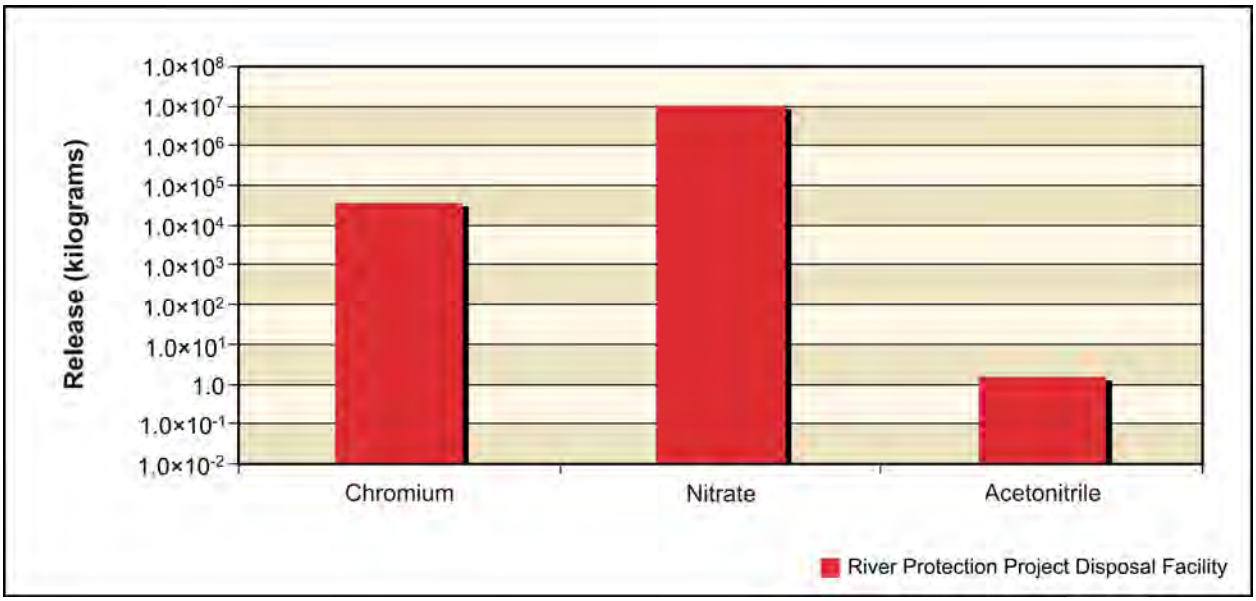


Figure 5–1042. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–1043 shows the release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–1044, the chemical hazard drivers. Both figures show trends similar to those described in the above paragraph regarding the release to the Columbia River of all COPC drivers at the RRPDF.

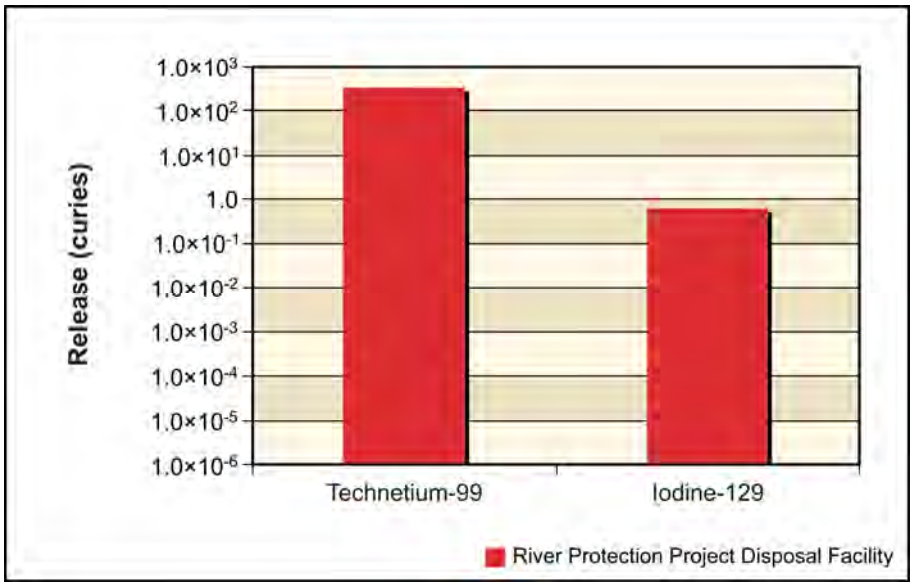


Figure 5–1043. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

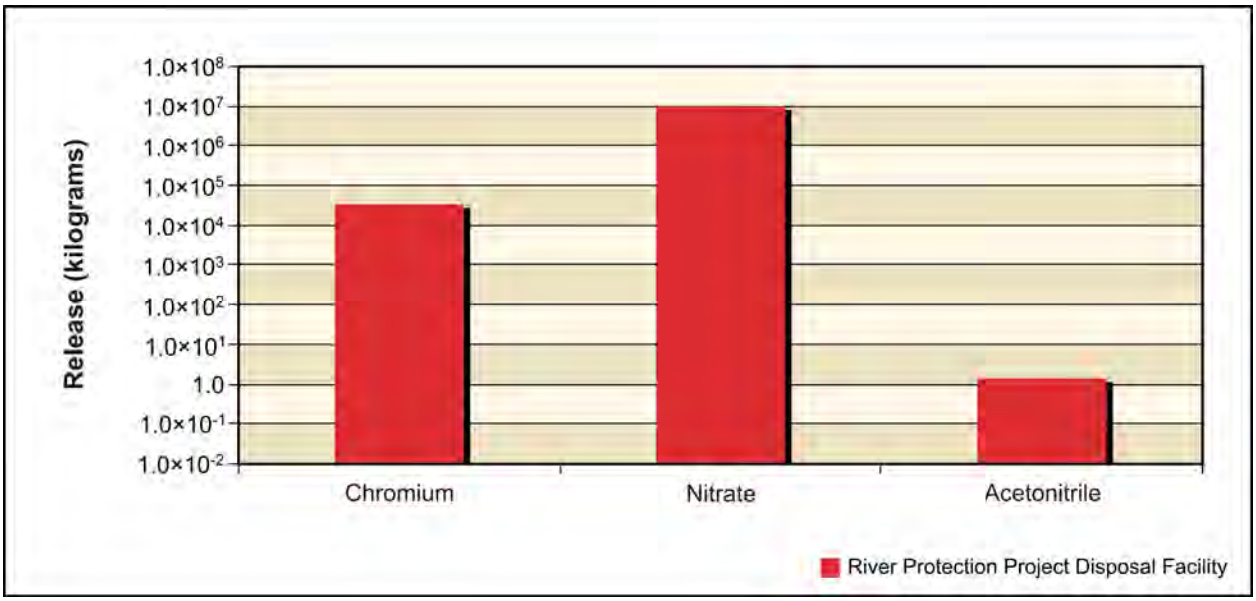


Figure 5–1044. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration of each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on a few graphs. Confidence intervals are calculated to show the length of time (in this case, 95 percent of the time) a concentration is likely to be at or below this value. The confidence interval is basically a statistical aid to interpreting data presenting a significant amount of random fluctuation (noise). In this analysis, the confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentration was near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude.

Figures 5–1045 through 5–1048 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Releases from IDF-East, IDF-West, and the RPPDF at the Core Zone Boundary cause groundwater concentrations to exceed the benchmark for iodine-129 at CY 3500. Calculations using the confidence interval show that the concentrations exceed the benchmark at both the Core Zone Boundary and the Columbia River nearshore after CY 5500. The trend for technetium-99 concentrations is similar to that for iodine-129 concentrations but below the benchmark during the period of analysis. Chromium and nitrate measurements at the Core Zone Boundary and the Columbia River nearshore are below the benchmark concentrations by one to three orders of magnitude, and the concentration trends are similar to those for iodine-129 and technetium-99. Table 5–98 shows the maximum concentrations in groundwater.

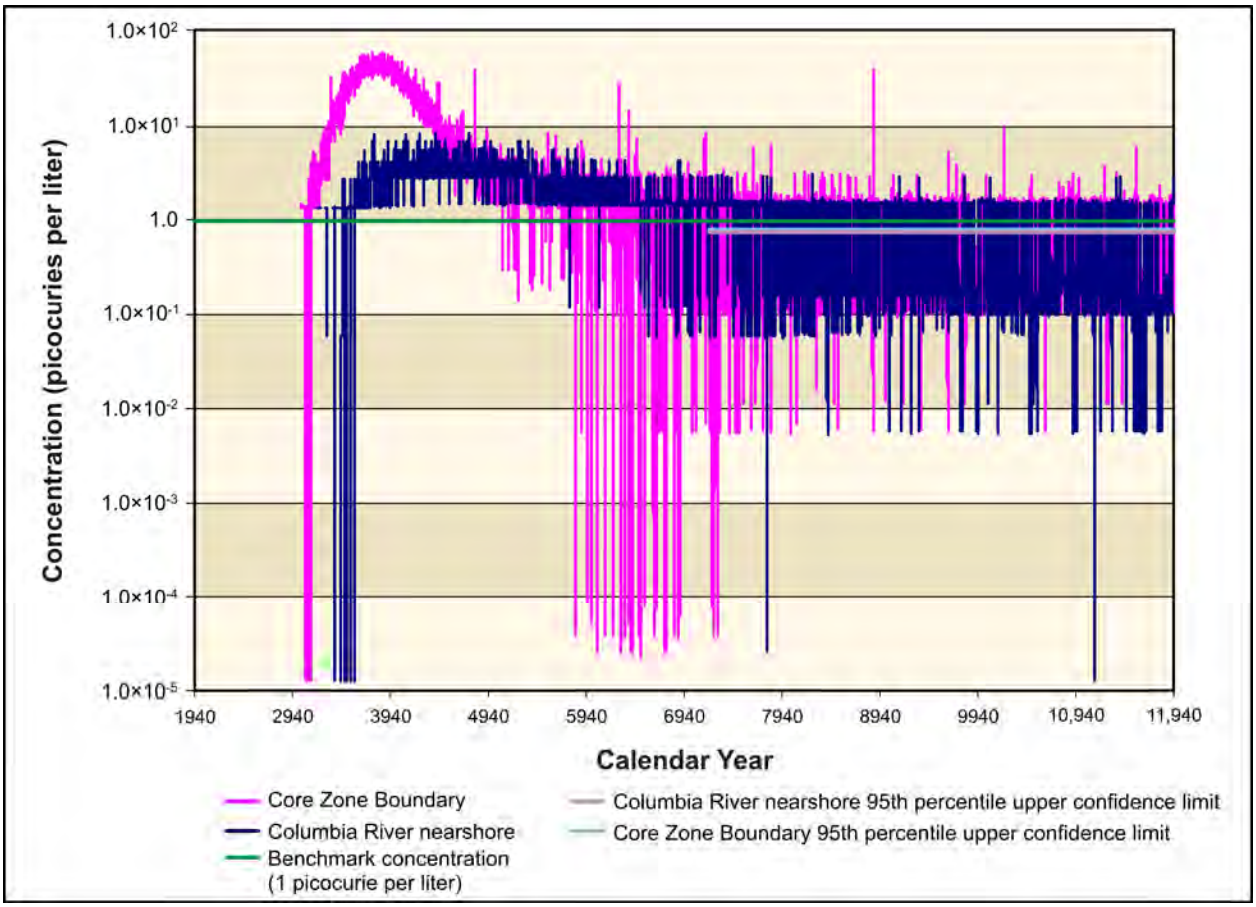


Figure 5–1045. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Iodine-129 Concentration Versus Time

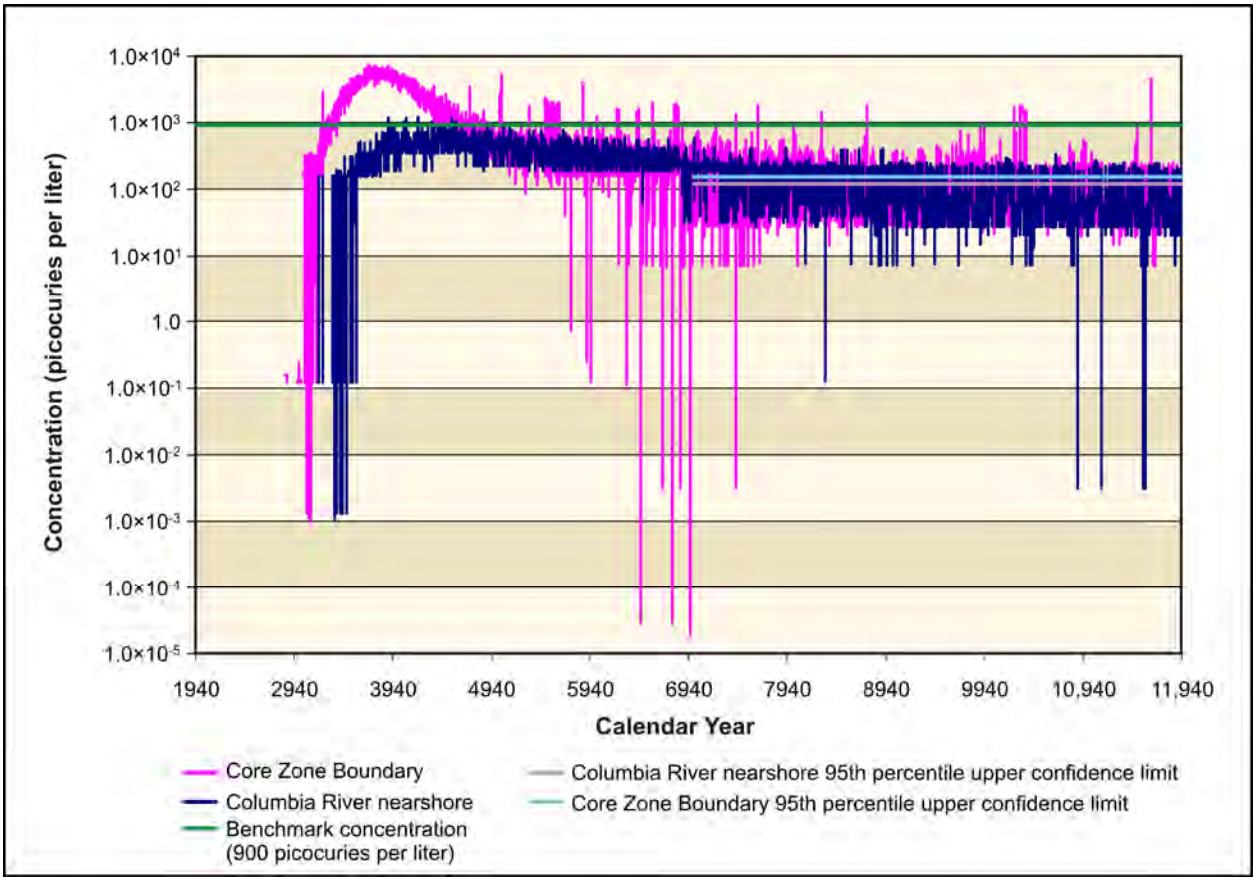


Figure 5–1046. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Technetium-99 Concentration Versus Time

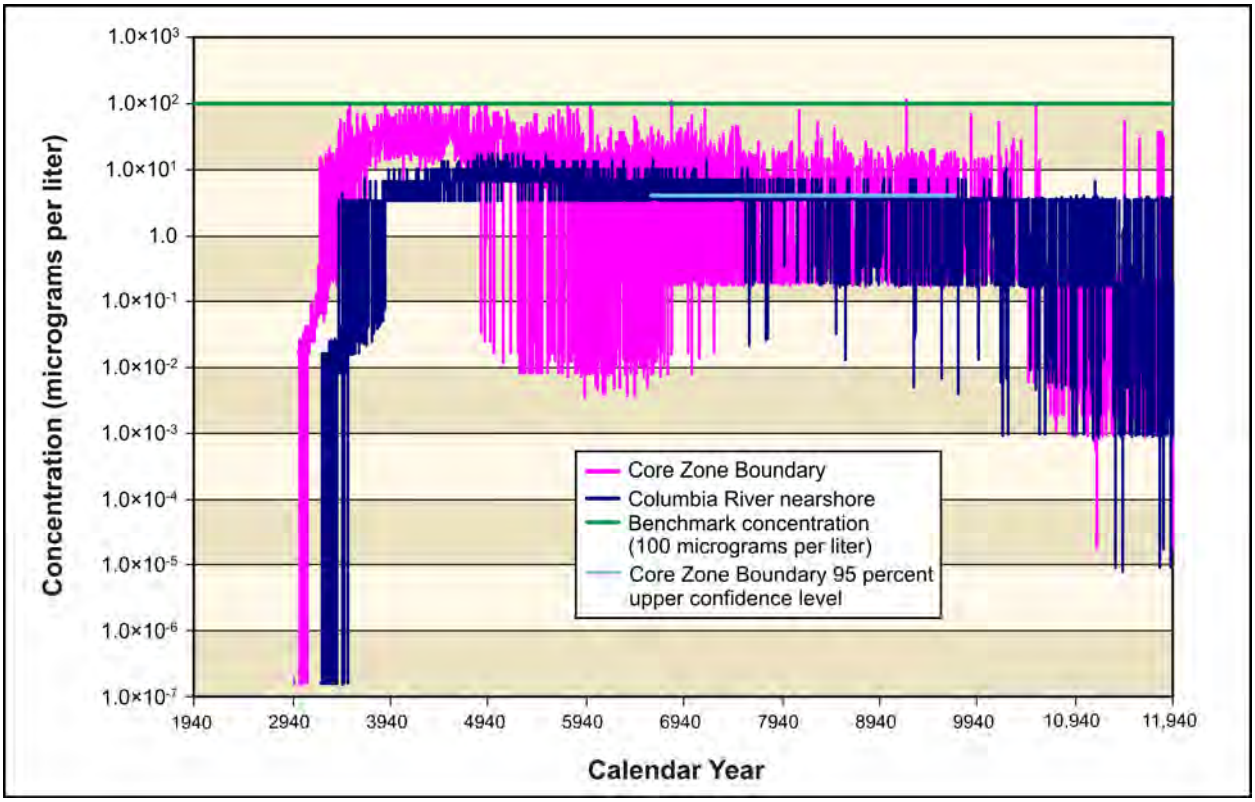


Figure 5–1047. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Chromium Concentration Versus Time

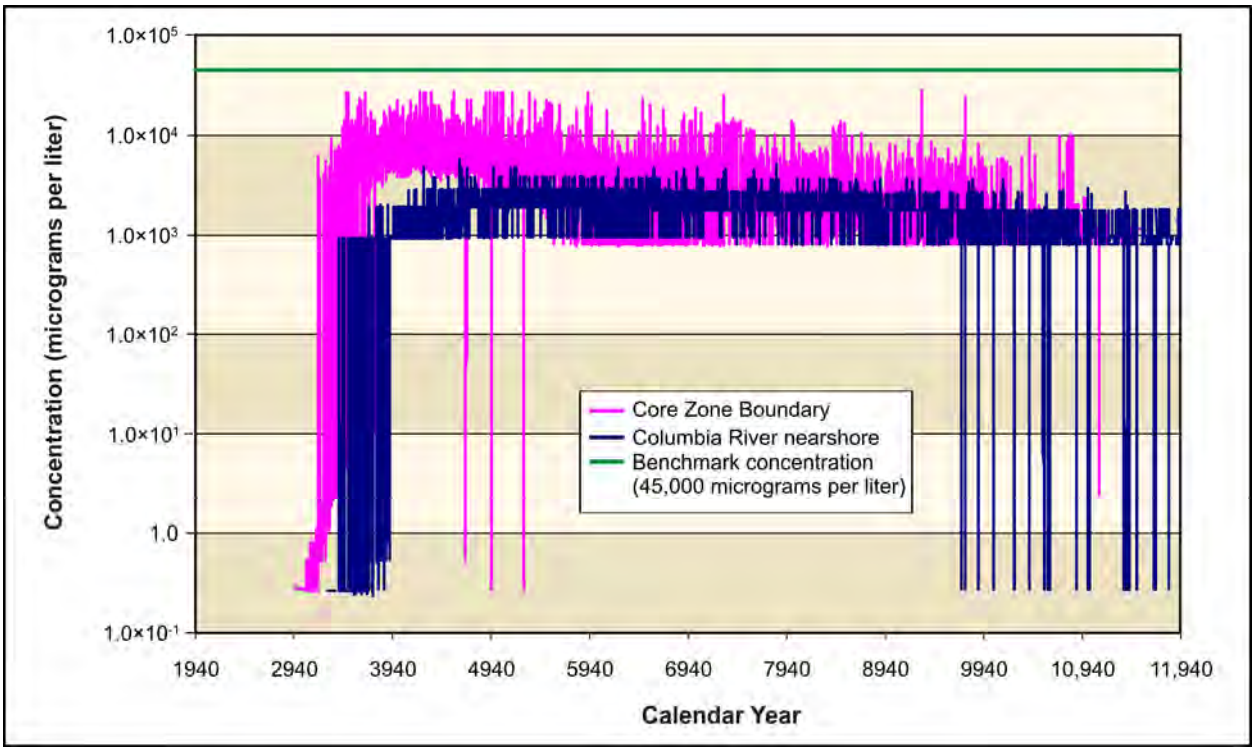


Figure 5–1048. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Nitrate Concentration Versus Time

Table 5–98. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	347	**20,200**	340	**7,590**	**1,190**	900
	(10,643)	(3713)	(4213)	(3690)	(4191)	
Iodine-129	**2**	**173**	0.6	**61**	**8**	1
	(11,363)	(3797)	(4176)	(3853)	(4392)	
Chemical in micrograms per liter						
Chromium	3	2	33	97	17	100
	(8281)	(3696)	(4118)	(10,533)	(5522)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	16,600	17	9,070	28,400	5,700	45,000
	(8162)	(3703)	(3962)	(9305)	(4618)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figure 5–1049 shows concentration versus time for total uranium. Because of the high retardation of uranium, no contamination appears until roughly CY 9500. Total uranium concentrations rise throughout the remainder of the period of analysis, but remain at least seven orders of magnitude lower than the benchmark concentration. Uranium-238 (see Figure 5–1050) also continues to rise after CY 9000, remaining at about two to three orders of magnitude below the benchmark at the end of the period of analysis.

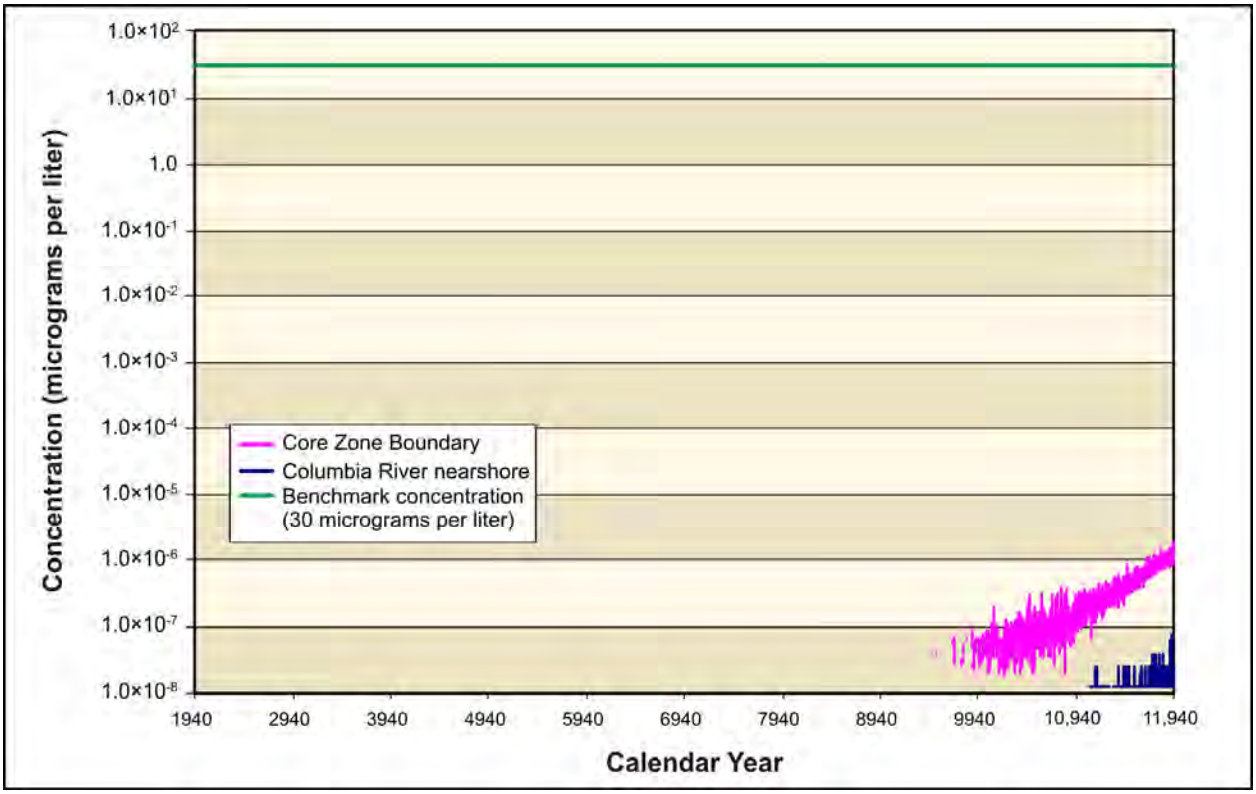


Figure 5–1049. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Total Uranium Concentration Versus Time

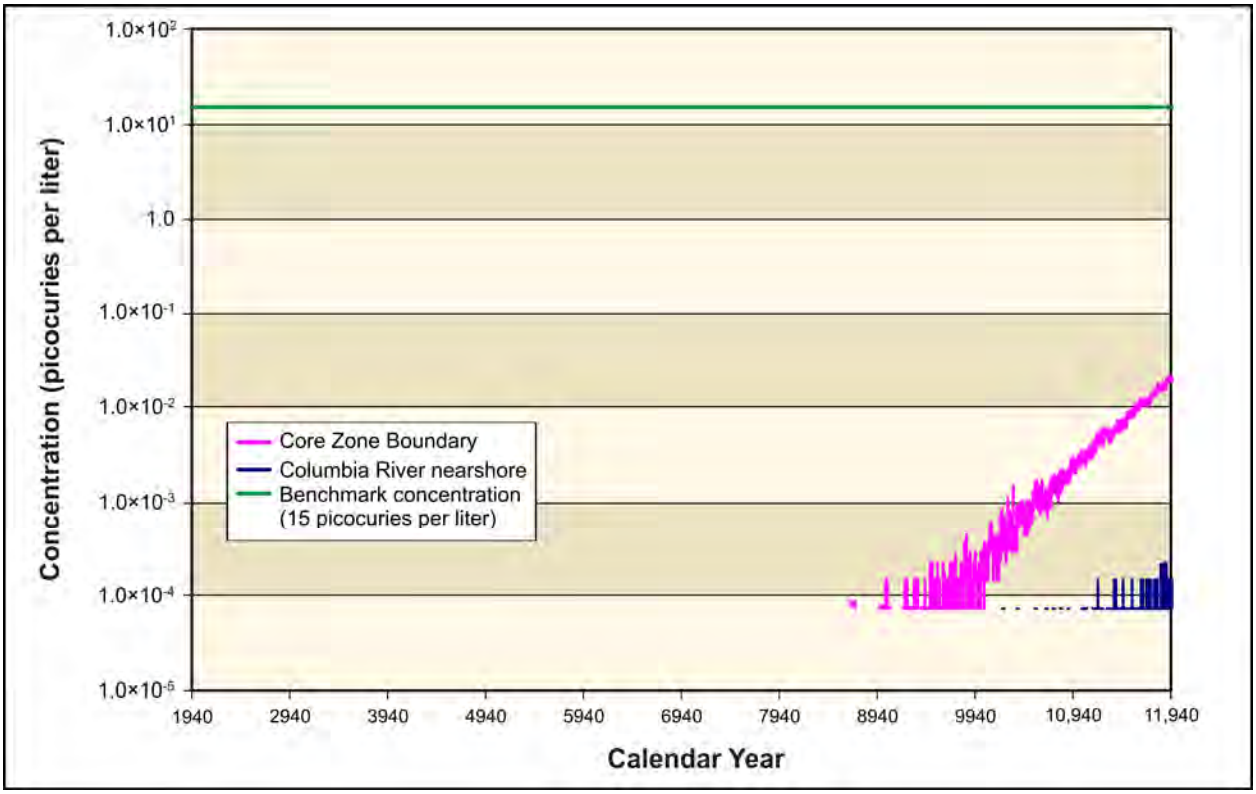
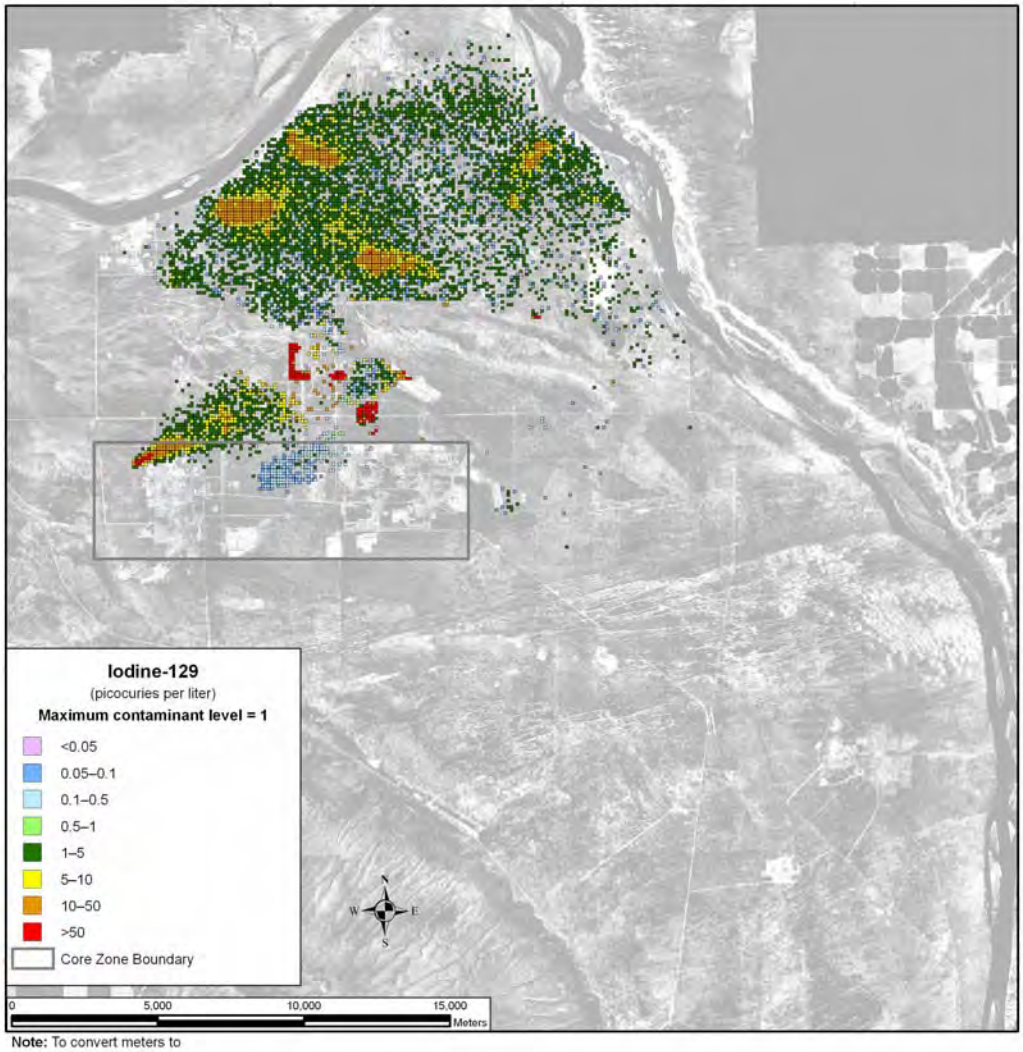


Figure 5–1050. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Uranium-238 Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

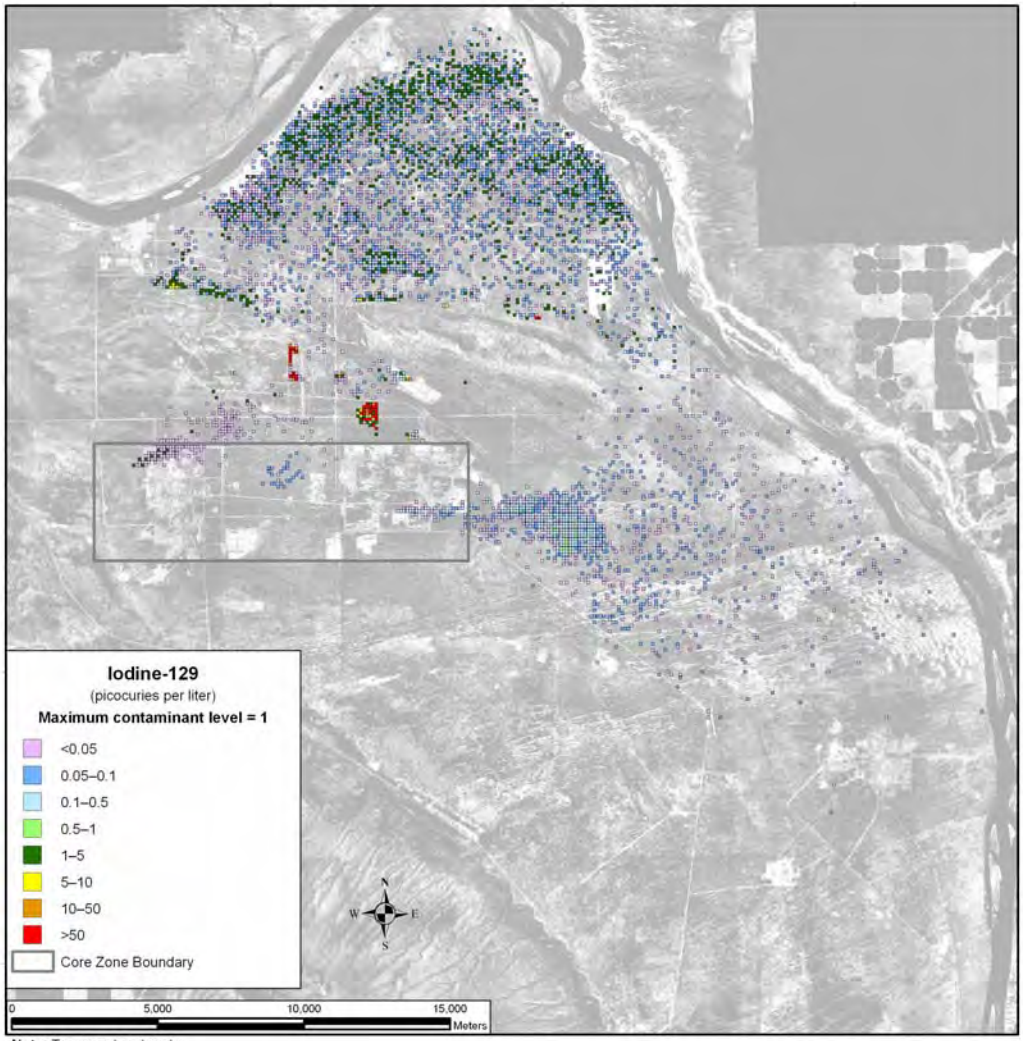
This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale indicative of the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations below the benchmark, by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–1051 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890 as a concentrated plume, with concentrations many times greater than the benchmark, that stretches north from IDF-West and the RPPDF through Gable Gap. By CY 7140 (see Figure 5–1052), the plume from the RPPDF is reduced, but a new plume is beginning to form, traveling east from IDF-East. The peak concentrations in the second plume are greater than the benchmark. By CY 11,885, the plume continues to spread toward the river and the concentrations continue to increase (see Figure 5–1053). Technetium-99 (see Figures 5–1054 through 5–1056), chromium (see Figures 5–1057 through 5–1059), and nitrate (see Figures 5–1060 through 1062) show similar spatial distributions at selected times, but the concentrations remain lower, similar to the later plumes mentioned above. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).



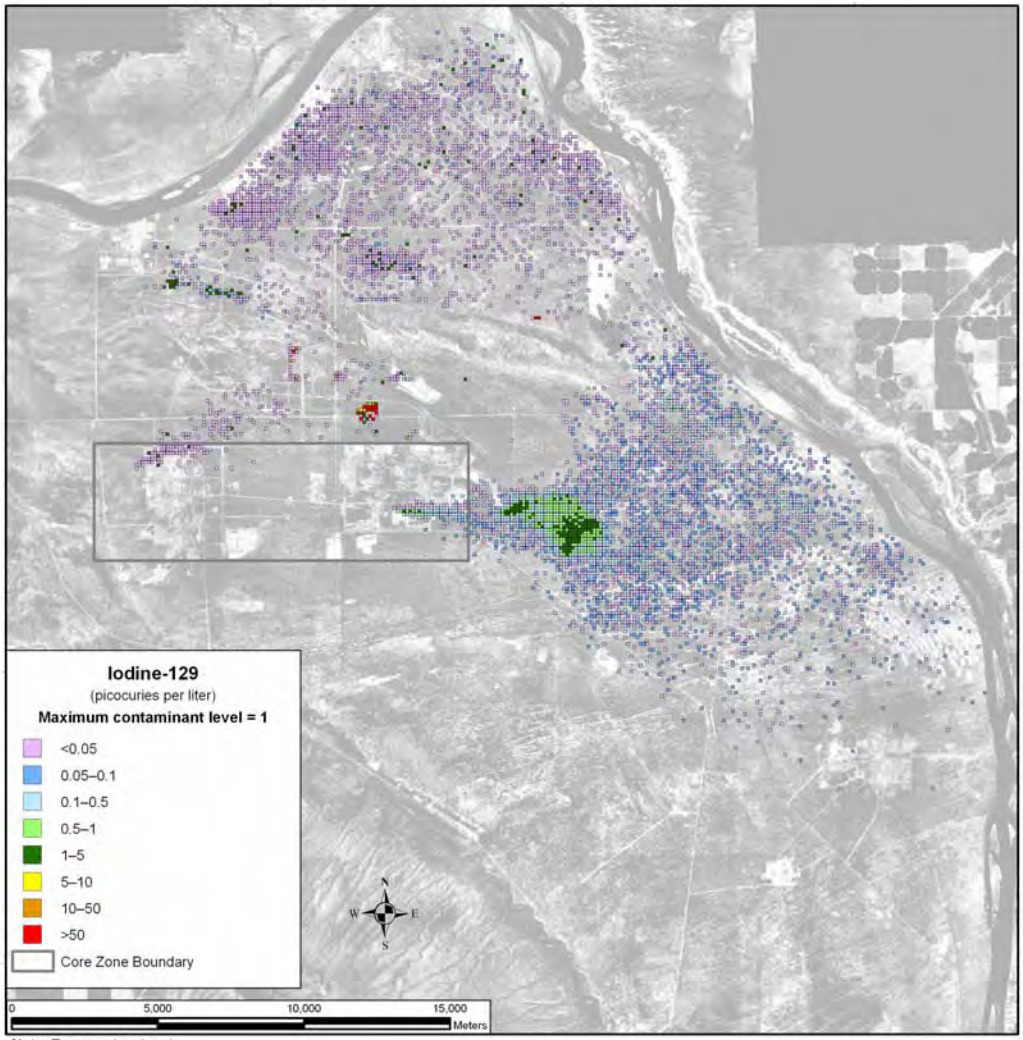
Note: To convert meters to feet, multiply by 3.281

Figure 5–1051. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



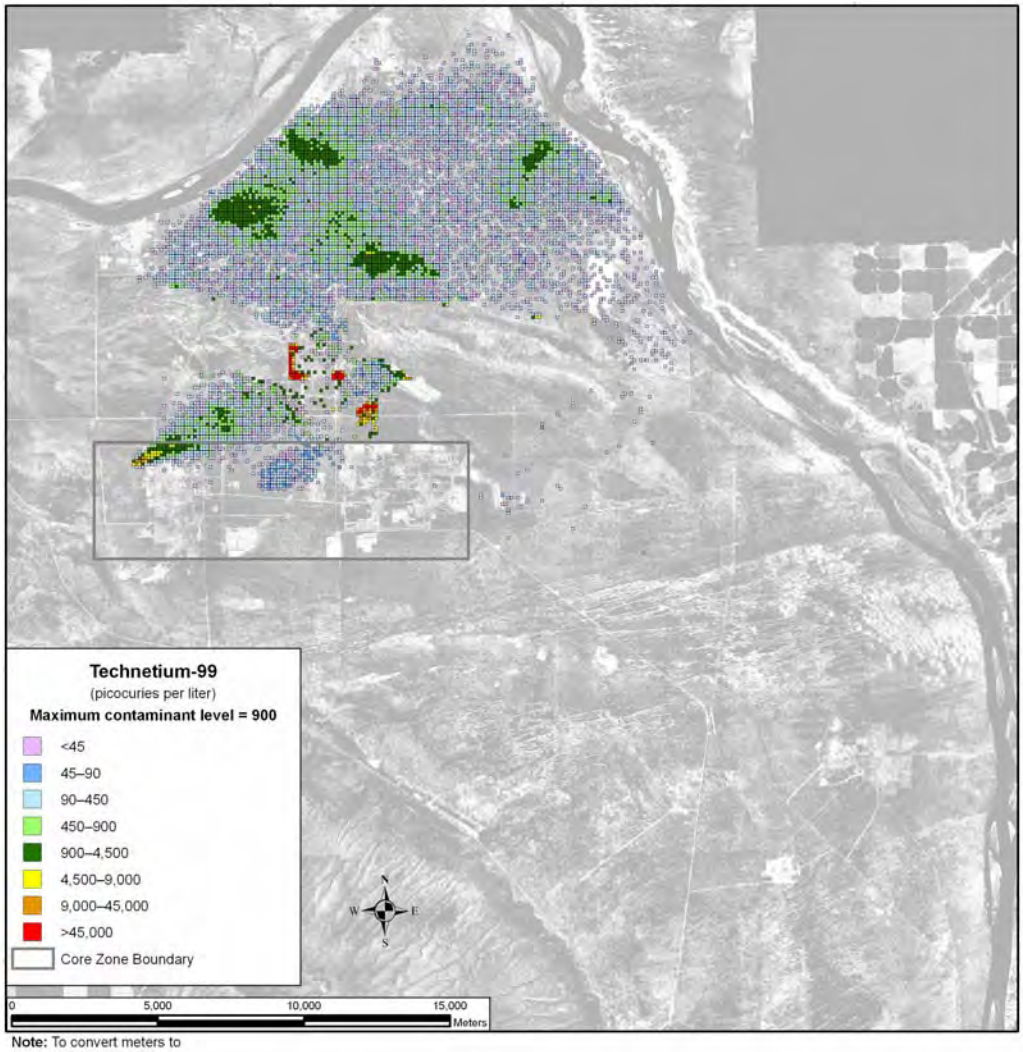
Note: To convert meters to feet, multiply by 3.281

Figure 5–1052. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



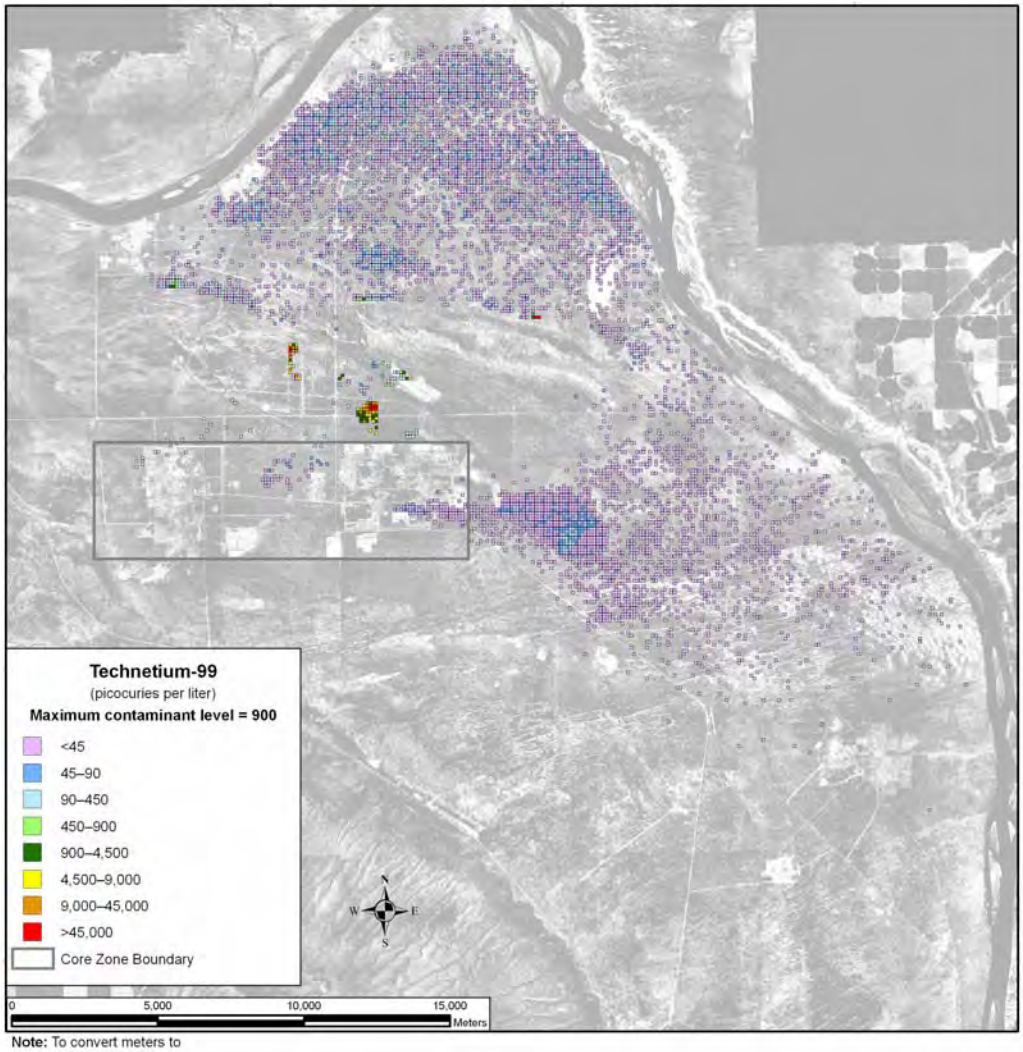
Note: To convert meters to feet, multiply by 3.281

Figure 5–1053. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



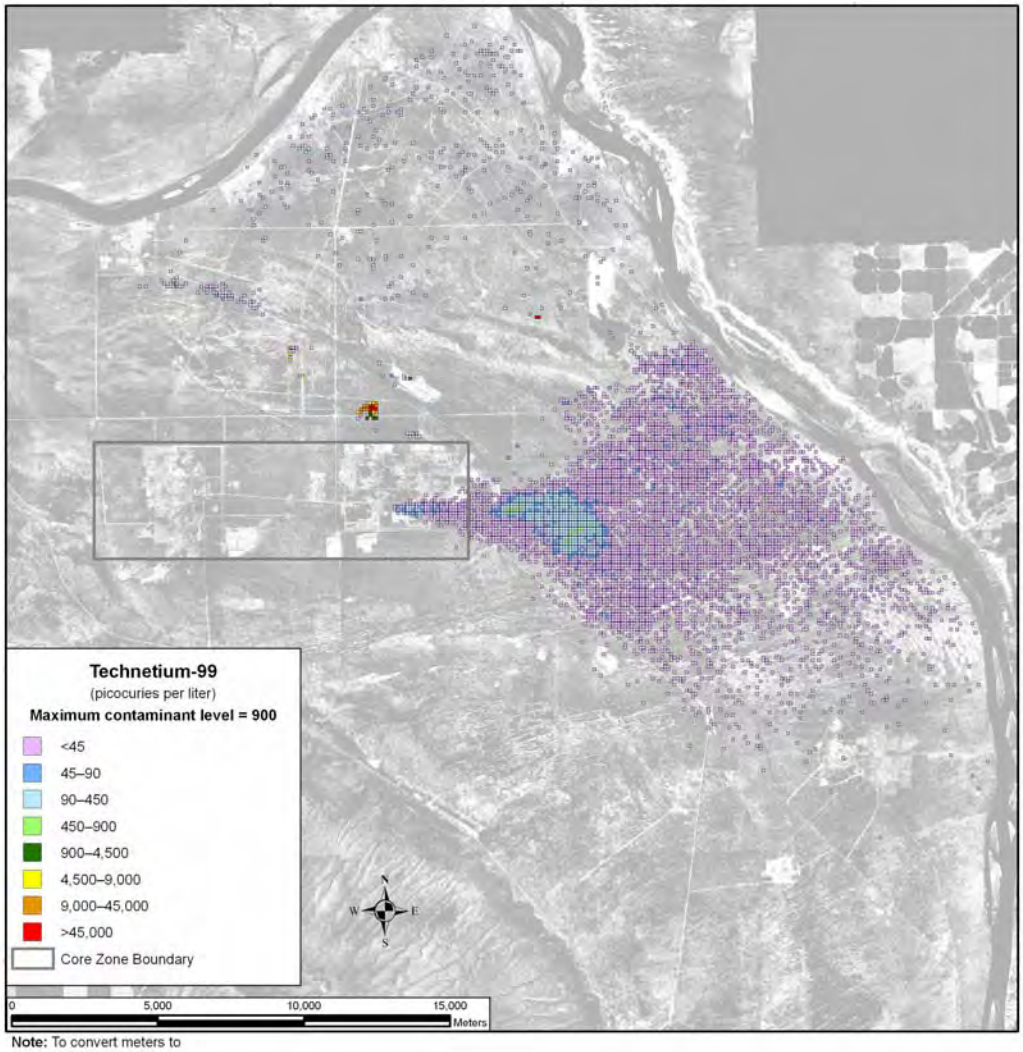
Note: To convert meters to feet, multiply by 3.281

Figure 5–1054. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



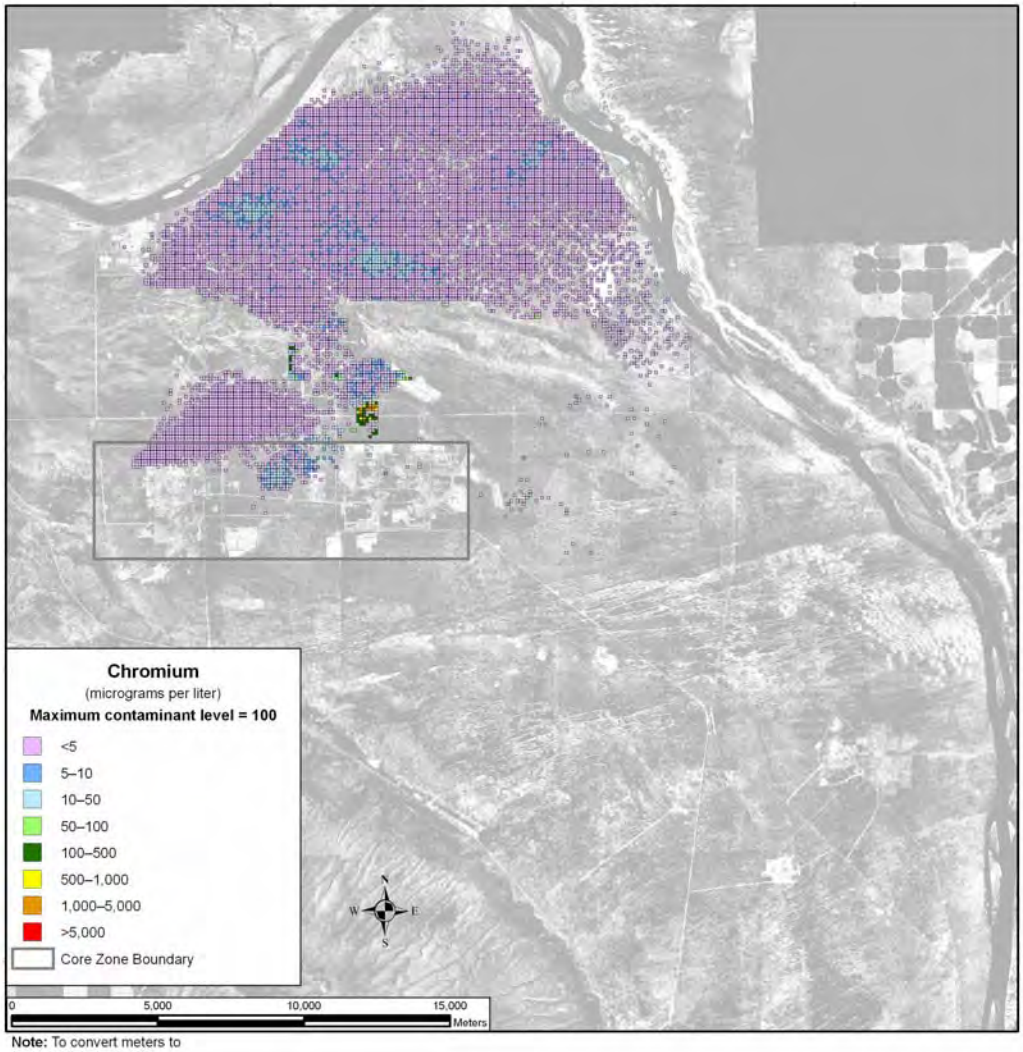
Note: To convert meters to feet, multiply by 3.281

Figure 5–1055. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



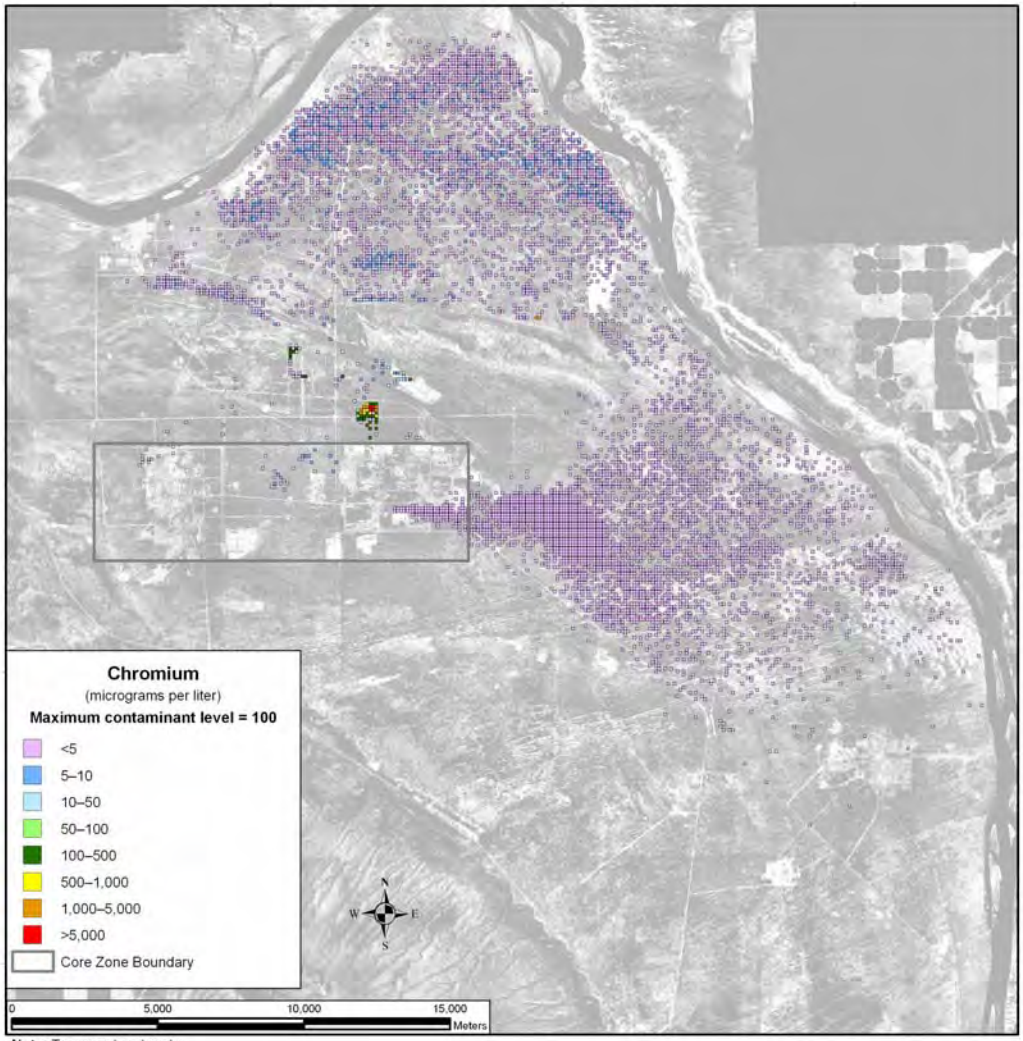
Note: To convert meters to feet, multiply by 3.281

Figure 5–1056. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



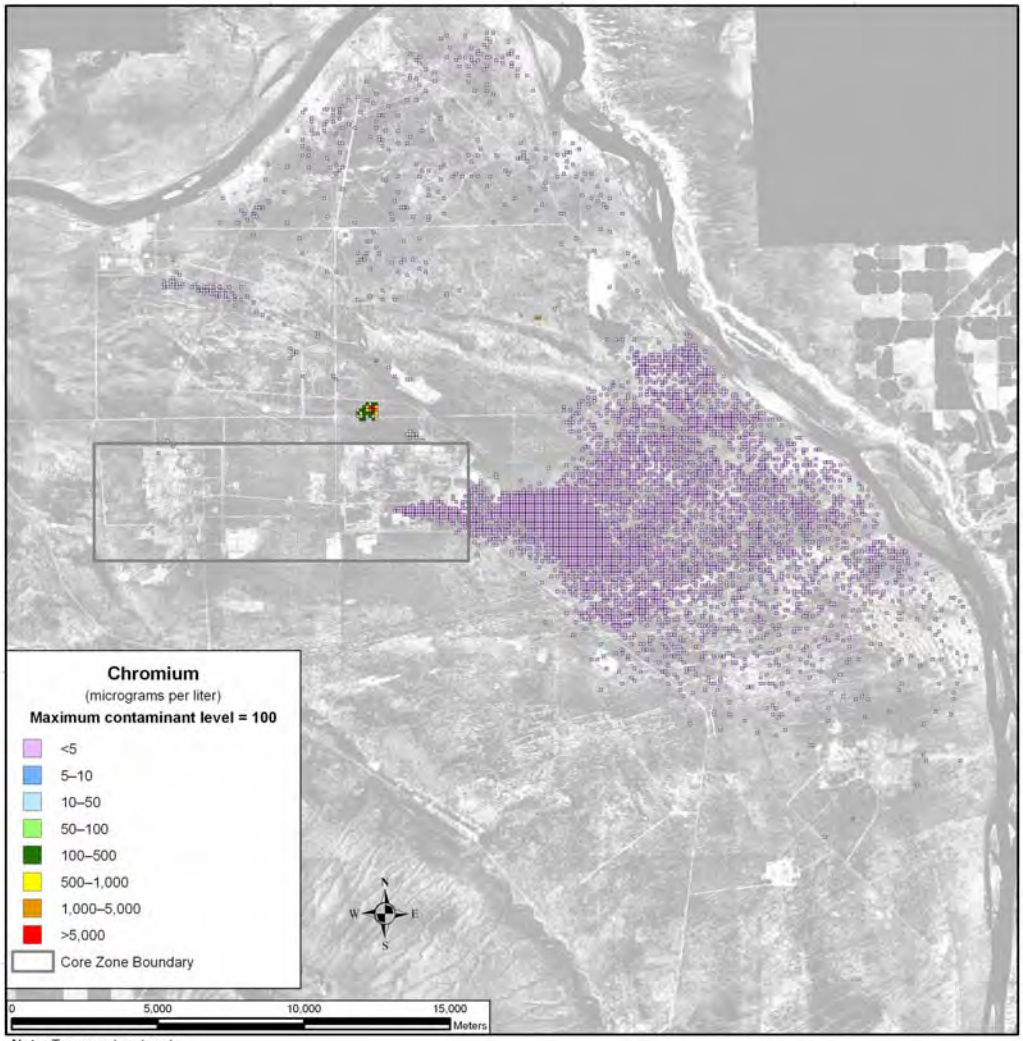
Note: To convert meters to feet, multiply by 3.281

Figure 5–1057. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



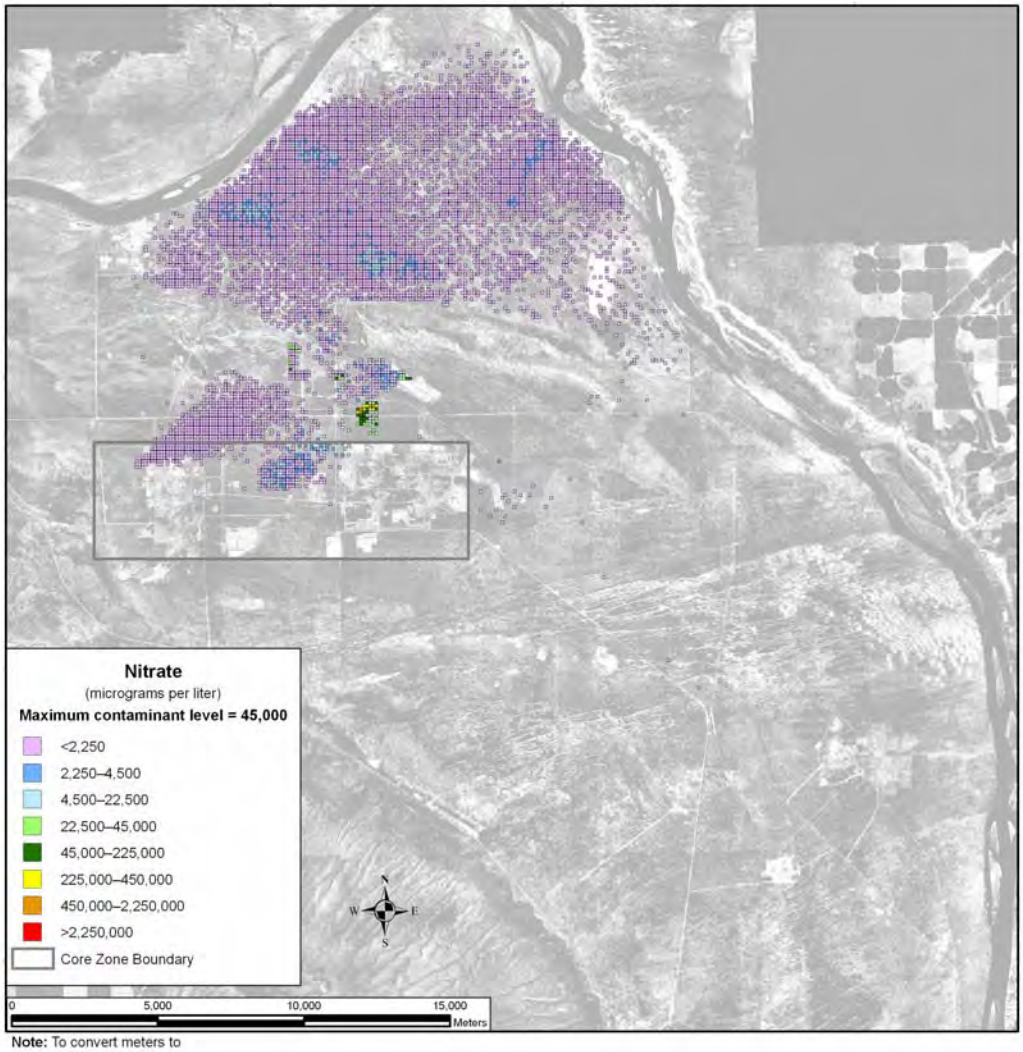
Note: To convert meters to feet, multiply by 3.281

Figure 5–1058. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



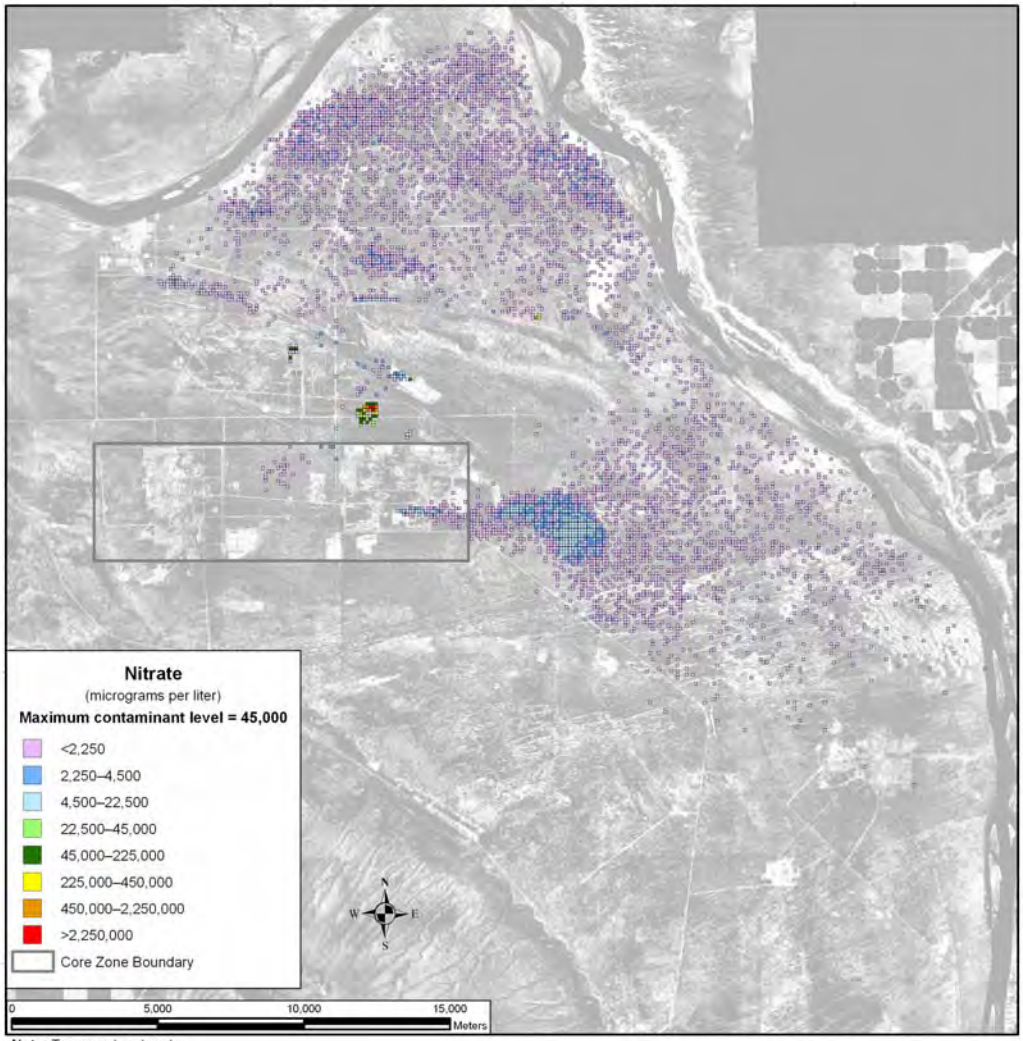
Note: To convert meters to feet, multiply by 3.281

Figure 5–1059. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



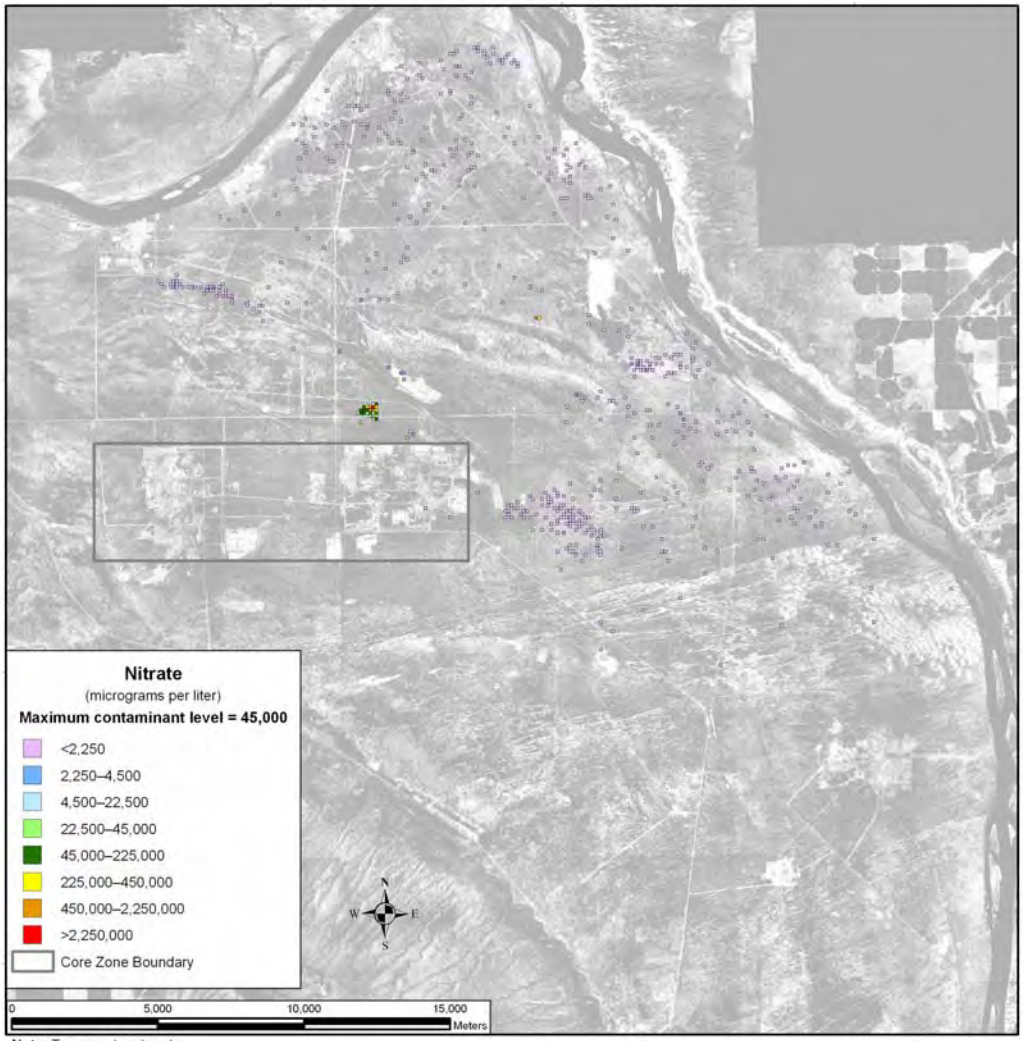
Note: To convert meters to feet, multiply by 3.281

Figure 5–1060. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

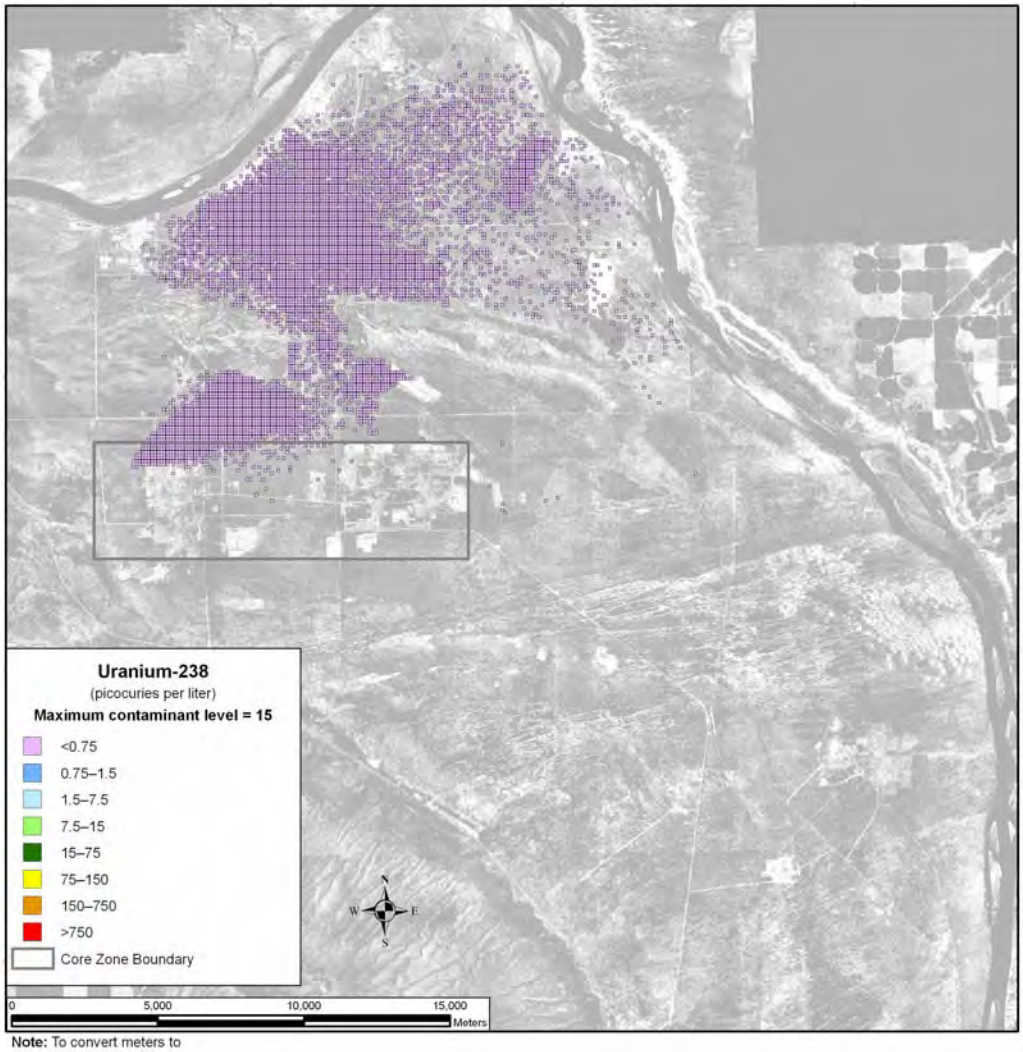
Figure 5–1061. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–1062. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Total uranium shows a different spatial distribution over time. This COPC is not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–1063 shows the distribution of uranium-238 at CY 11,885. Figure 5–1064 shows the distribution of total uranium at CY 11,885. Both total uranium and uranium-238 show low concentration plumes that stretch north from IDF-West and the RPPDF through Gable Gap. Concentrations in all areas of the plume remain below one-tenth of the benchmark.



Note: To convert meters to feet, multiply by 3.281

Figure 5–1063. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

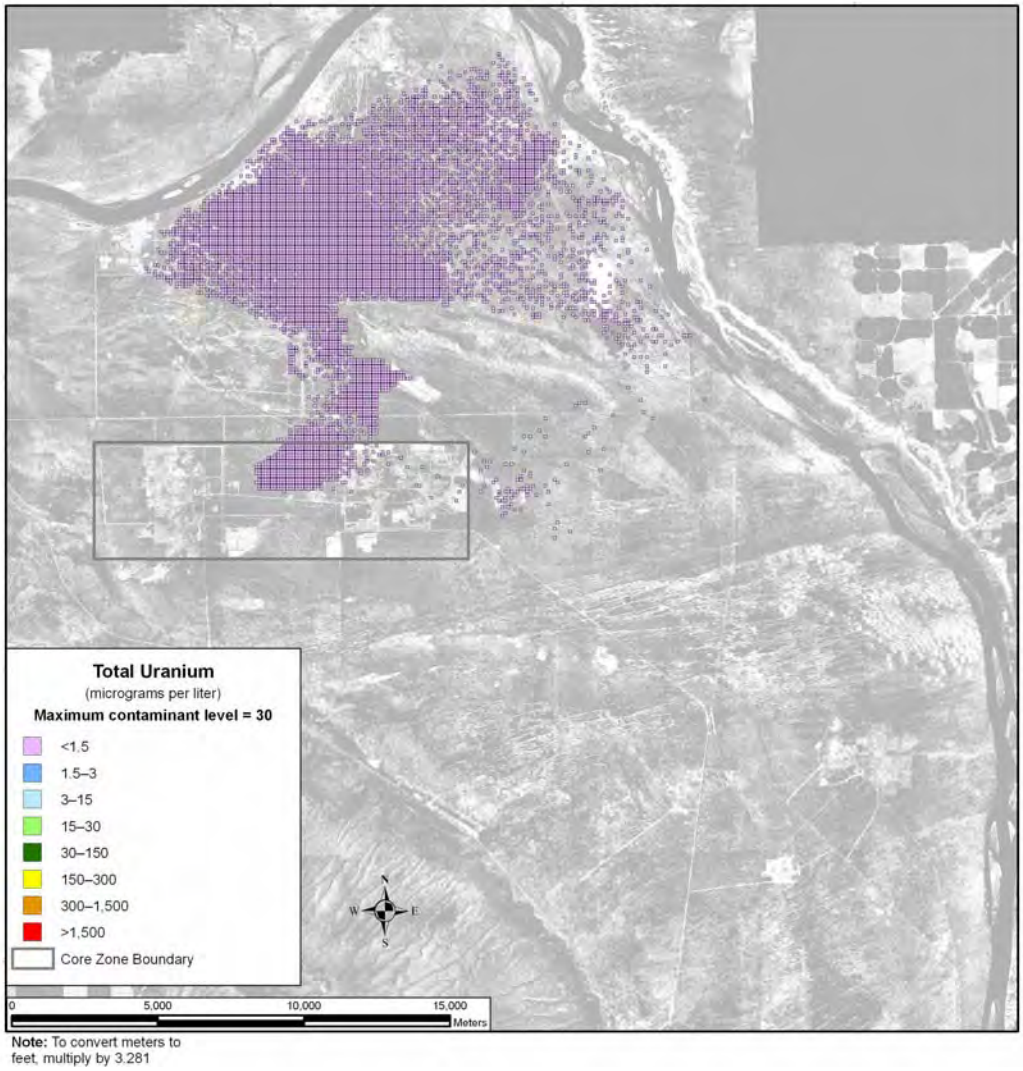


Figure 5–1064. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, in general, the inventory remaining in IDF-East and IDF-West available for release to the environment at the start of the post-disposal period is the predominant contributor. The increased inventory available for release from the RPPDF during the post-disposal period is still a secondary contributor.

For the conservative tracers, concentrations at the Core Zone Boundary exceed or approach the benchmark standards during most of the period of analysis. Concentrations at the Columbia River are about two orders of magnitude lower. The intensities and areas of these groundwater plumes peak between CY 3500 and CY 5500.

For total uranium, limited mobility is an important factor governing the timeframe and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or the Columbia River by CY 10,000. The peak intensity and area of the contamination plume are greatest near the end of the period of analysis.

5.3.1.3.3 Disposal Group 3

Disposal Group 3 is characterized by operational completion dates of CY 2165 for IDF-East and the RPPDF and CY 2050 for IDF-West. In Disposal Group 3, IDF-West has a large capacity (90,000 cubic meters [117,720 cubic yards]), IDF-East has a larger capacity (340,000 cubic meters [425,100 cubic yards]), and the RPPDF has an even larger capacity (8,330,000 cubic meters [10,947,960 cubic yards]). These capacities were designed to meet the waste generation volumes associated with Tank Closure Alternative 6A, FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste.

5.3.1.3.3.1 Disposal Group 3, Base Case

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 3, Base Case, includes Tank Closure Alternative 6A, Base Case, FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 3, Base Case:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continues through CY 2165 when the disposal facilities will be operationally closed. During the disposal period, the materials in these permitted, operational facilities are not available for release to the environment.

- The post-disposal period starts in CY 2166 and continues through the 10,000-year period of analysis. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 3, Base Case, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 3, Base Case. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 3, Base Case, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129 and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and acetonitrile

The COPC drivers for Waste Management Alternative 3, Disposal Group 3, Base Case, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, and selecting the major contributors. This process is described in Appendix Q. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above account for over 99 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 3, Base Case.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, chromium, nitrate, and acetonitrile) are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. The other COPCs

that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 3, Base Case, (IDF-East, IDF-West, and the RPPDF), in terms of the total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over 10 orders of magnitude.

200-East Area Integrated Disposal Facility

IDF-East has four subtotals plotted representing releases from ETF-generated secondary waste, PPF glass, retired melters, and tank closure secondary waste.

Figure 5–1065 shows the release to the vadose zone for the radiological risk drivers and Figure 5–1066, the chemical hazard drivers. For all four types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 and chromium is tank closure and secondary waste. Iodine-129 and nitrate have ETF-generated secondary waste as the predominant source. Acetonitrile does not exist at IDF-East.

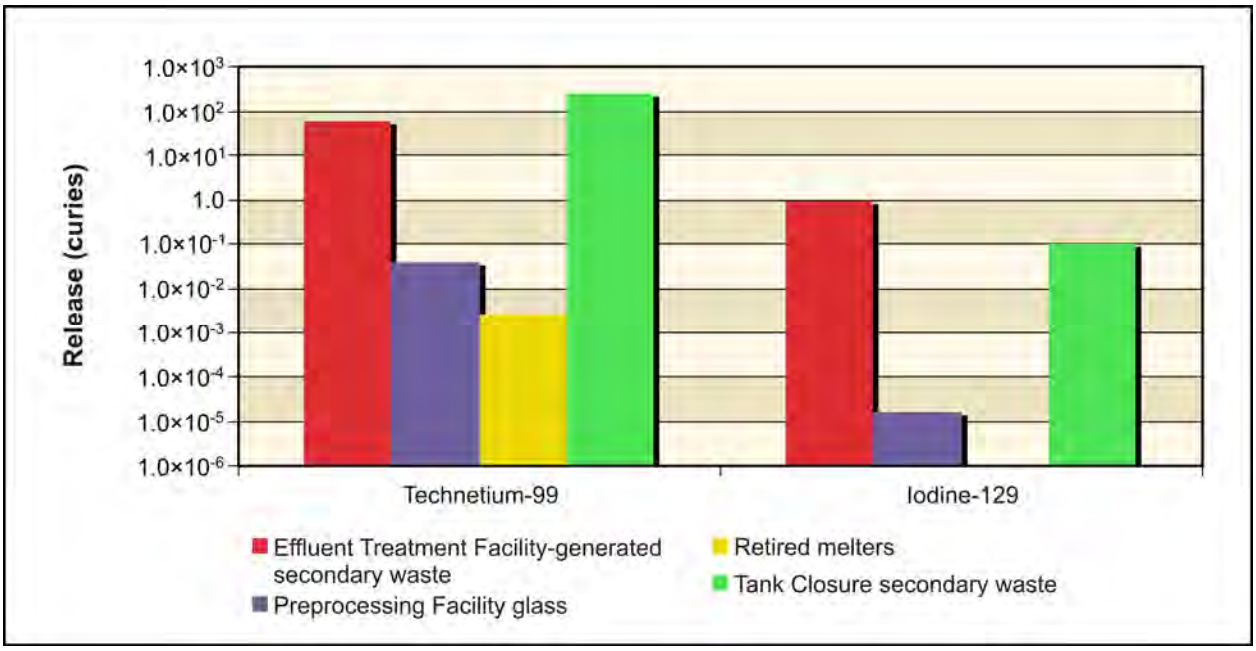


Figure 5–1065. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

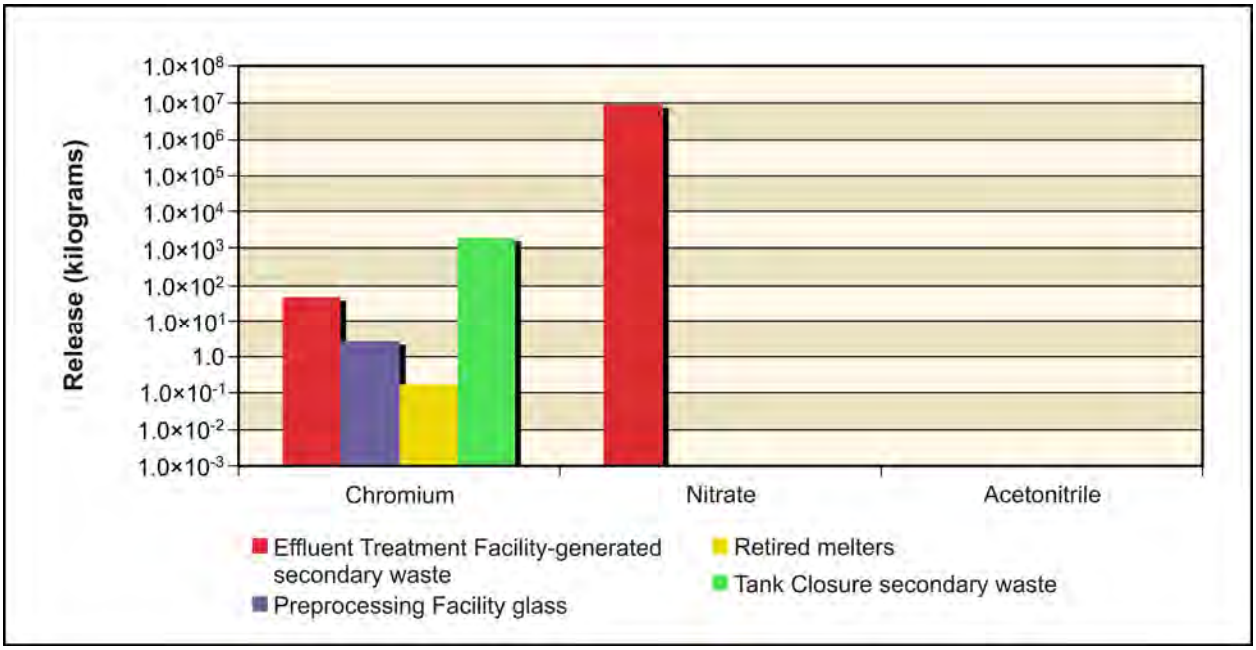


Figure 5–1066. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–1067 shows the release to groundwater for the radiological risk drivers and Figure 5–1068, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. "Essentially equal" means that there is a difference of less than one order of magnitude. Overall, about 58 percent of the radionuclides (curies) released to the vadose zone during the period of analysis reach groundwater; approximately 100 percent of the chemicals (kilograms) do.

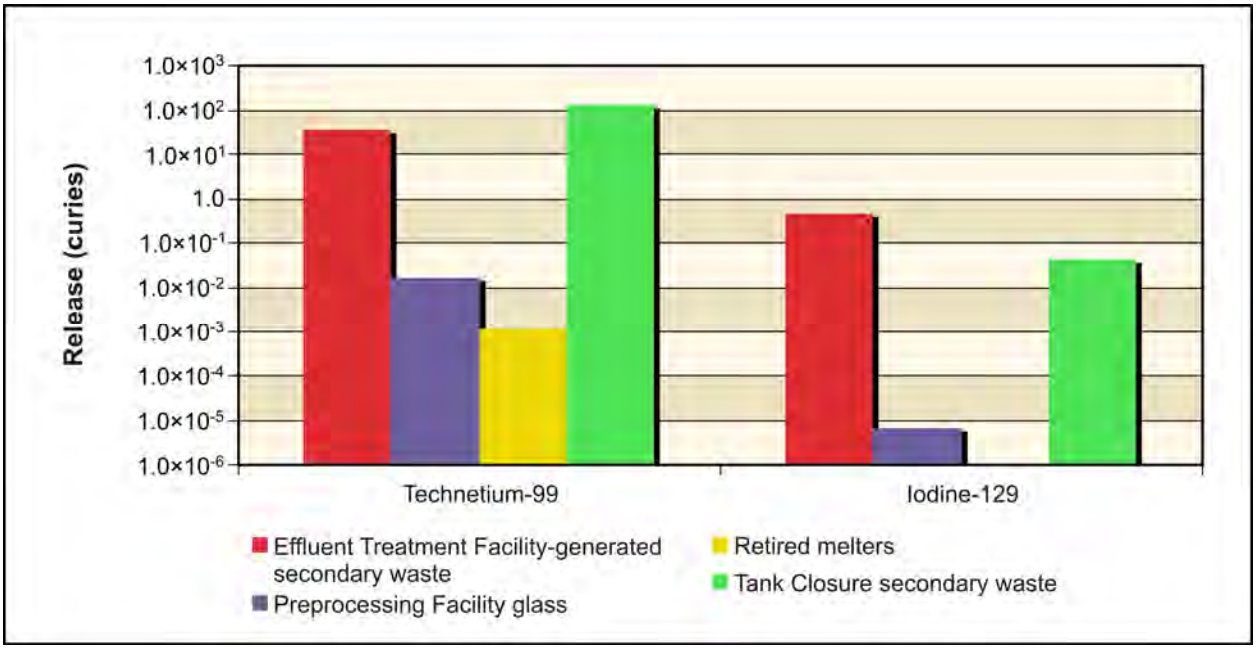


Figure 5–1067. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

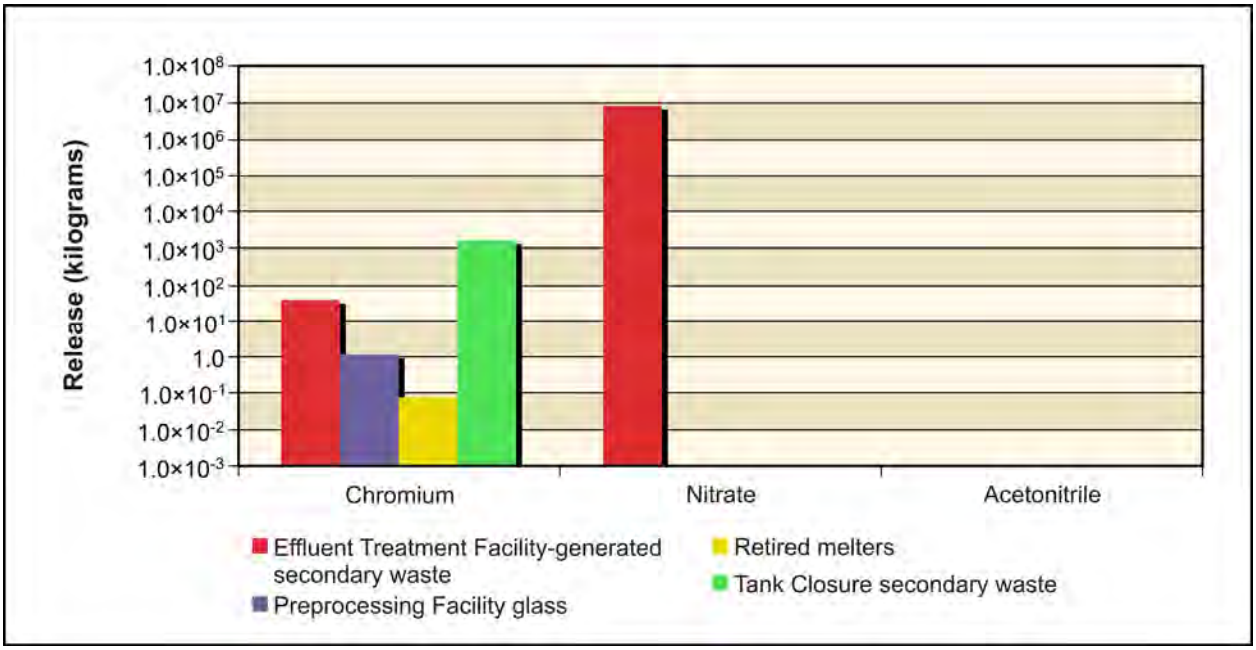


Figure 5–1068. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–1069 shows the release to the Columbia River for the radiological risk drivers and Figure 5–1070, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, iodine-129, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 70 percent of the radionuclides (curies) released to groundwater during the period of analysis reach the river; approximately 99 percent of the chemicals (kilograms) do.

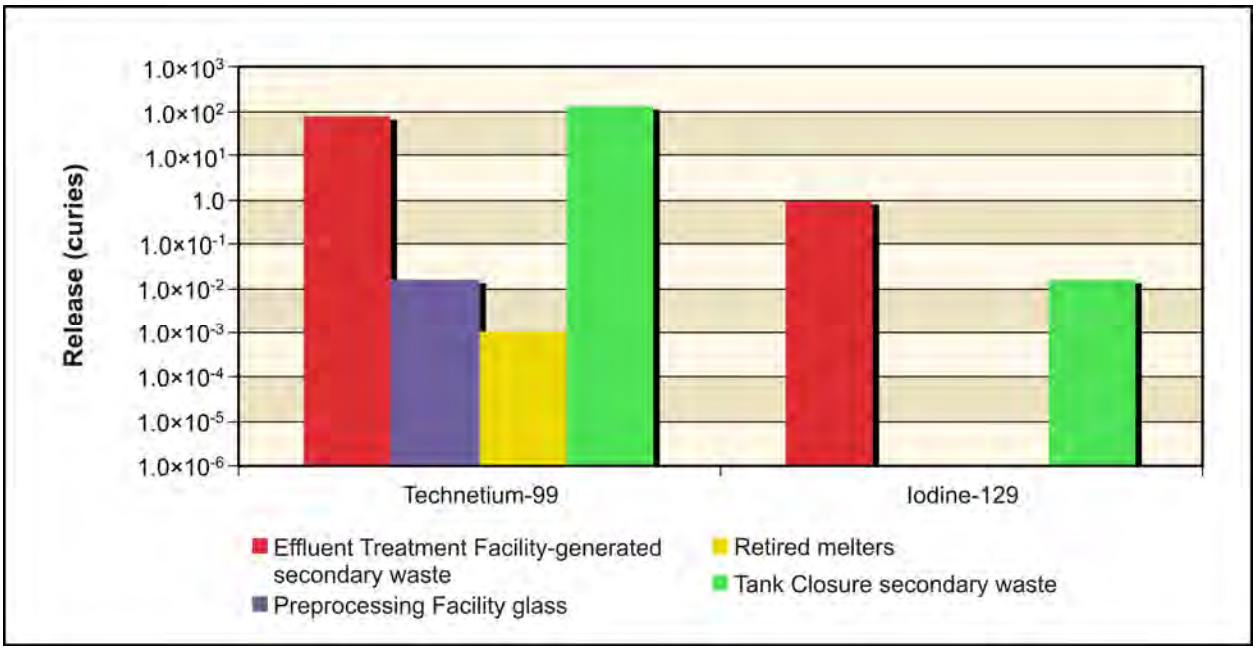


Figure 5–1069. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

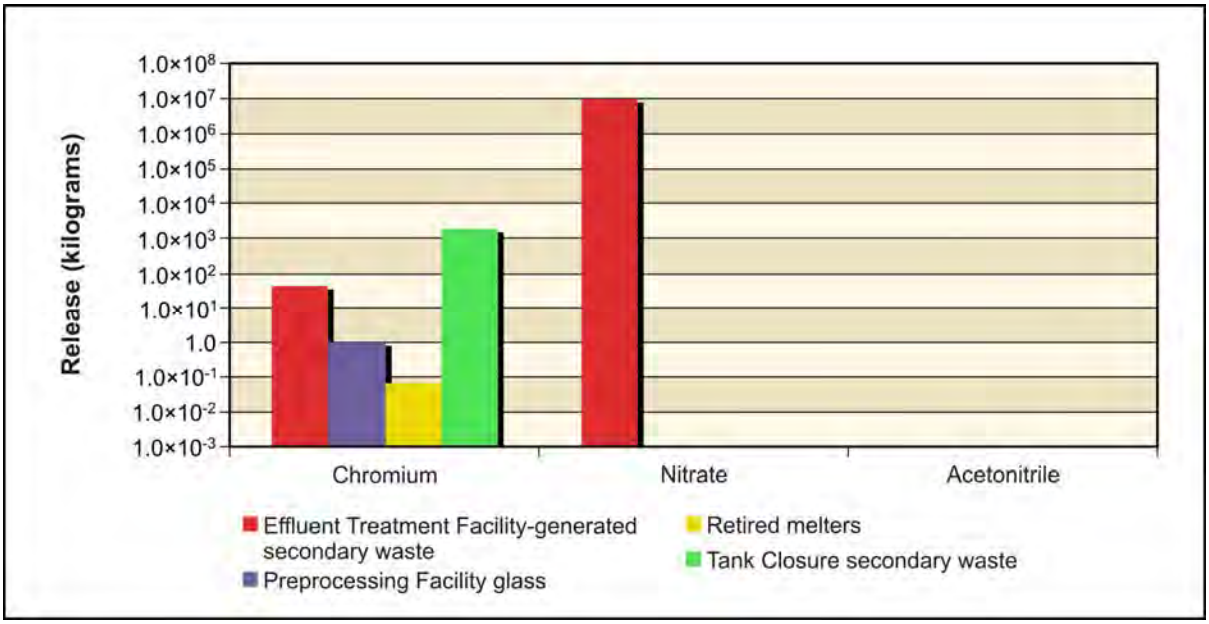


Figure 5–1070. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

IDF-West has three subtotals plotted representing releases from FFTF Decommissioning Alternative 3 waste, waste management secondary waste and onsite-generated waste, and offsite-generated waste.

Figure 5–1071 shows the release to the vadose zone for the radiological risk drivers and Figure 5–1072, the chemical hazard drivers. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). The predominant source of technetium-99 and iodine-129 is offsite-generated waste. For chromium and nitrate, the predominant sources are waste management secondary waste and onsite-generated waste.

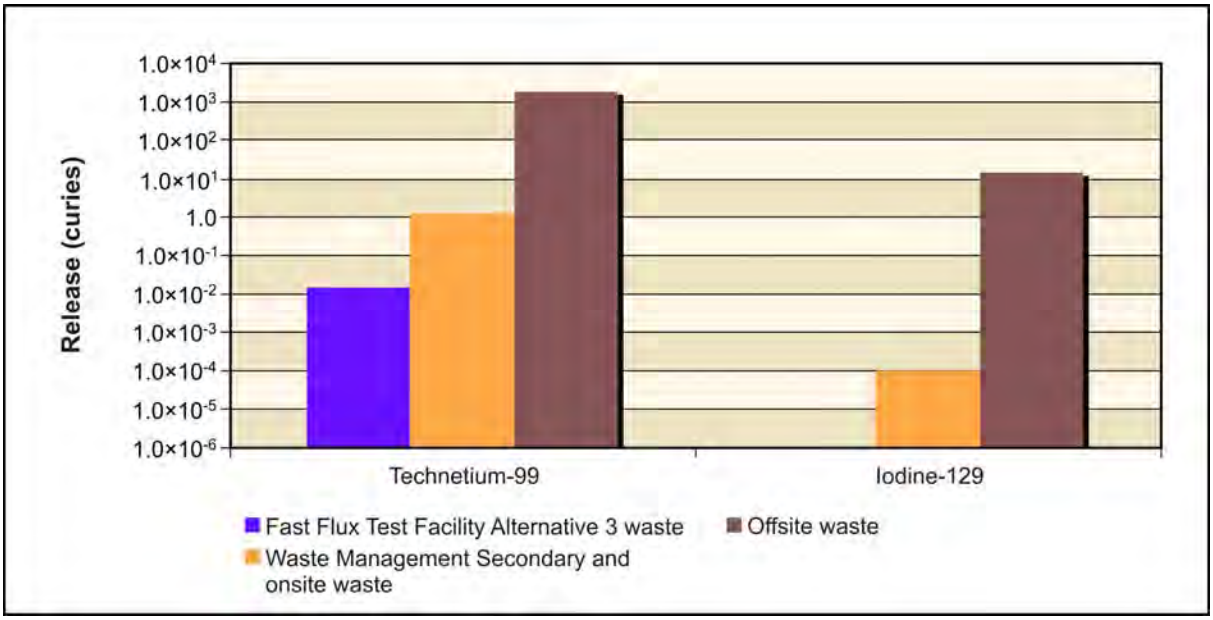


Figure 5–1071. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

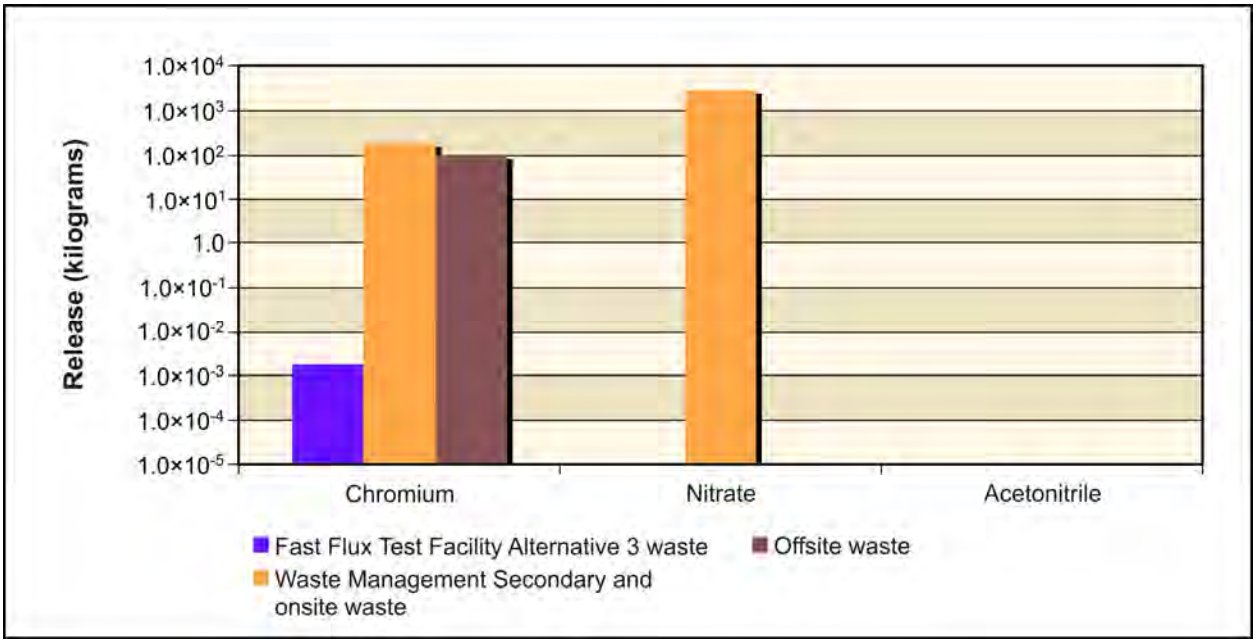


Figure 5–1072. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–1073 shows the release to groundwater for the radiological risk drivers and Figure 5–1074, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. "Approximately equal" means that there is a difference of less than one order of magnitude. Overall, about 98 percent of the radionuclides (curies) released to the vadose zone during the period of analysis reach the groundwater; approximately 100 percent of the chemicals (kilograms) do.

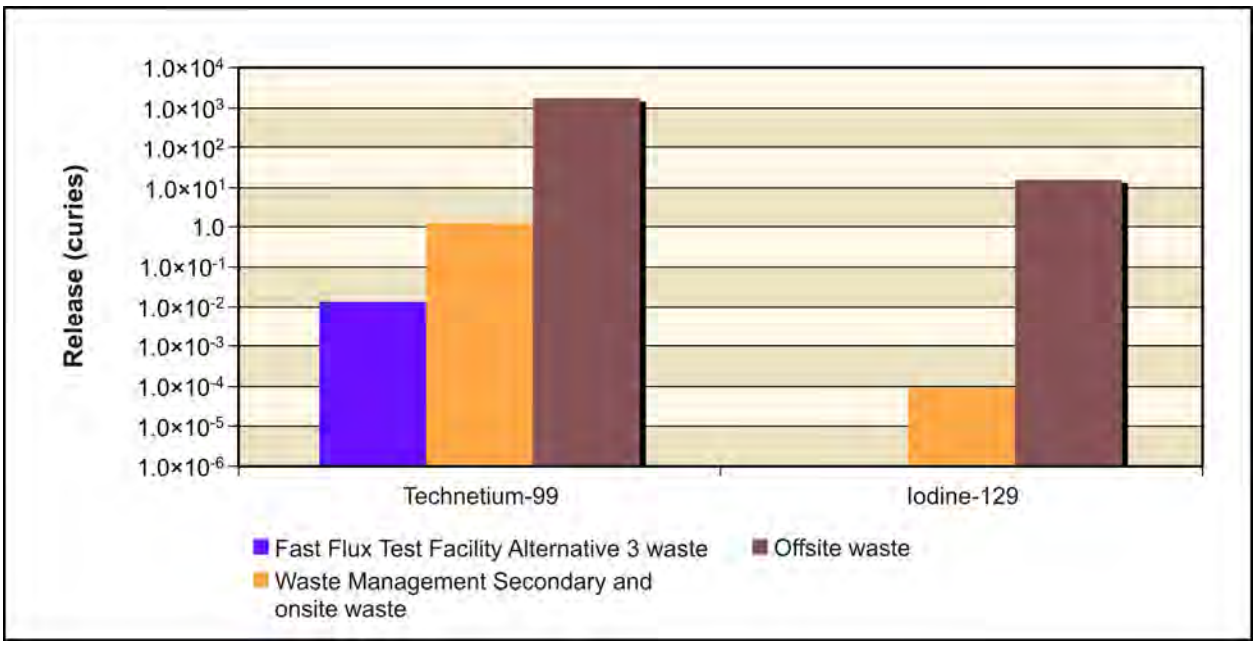


Figure 5–1073. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

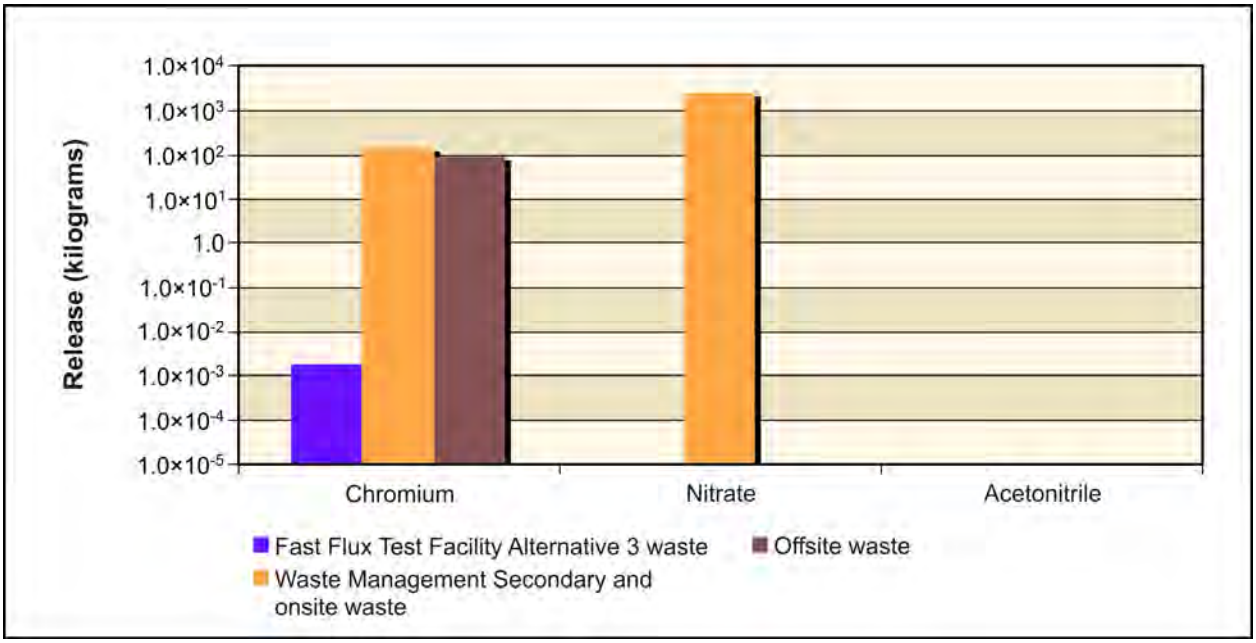


Figure 5–1074. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–1075 shows the release to the Columbia River for the radiological risk drivers and Figure 5–1076, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For techetium-99, iodine-129, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. About 97 percent of the radionuclides (curies) released to groundwater during the period of analysis reach the river; approximately 98 percent of the chemicals (kilograms) do.

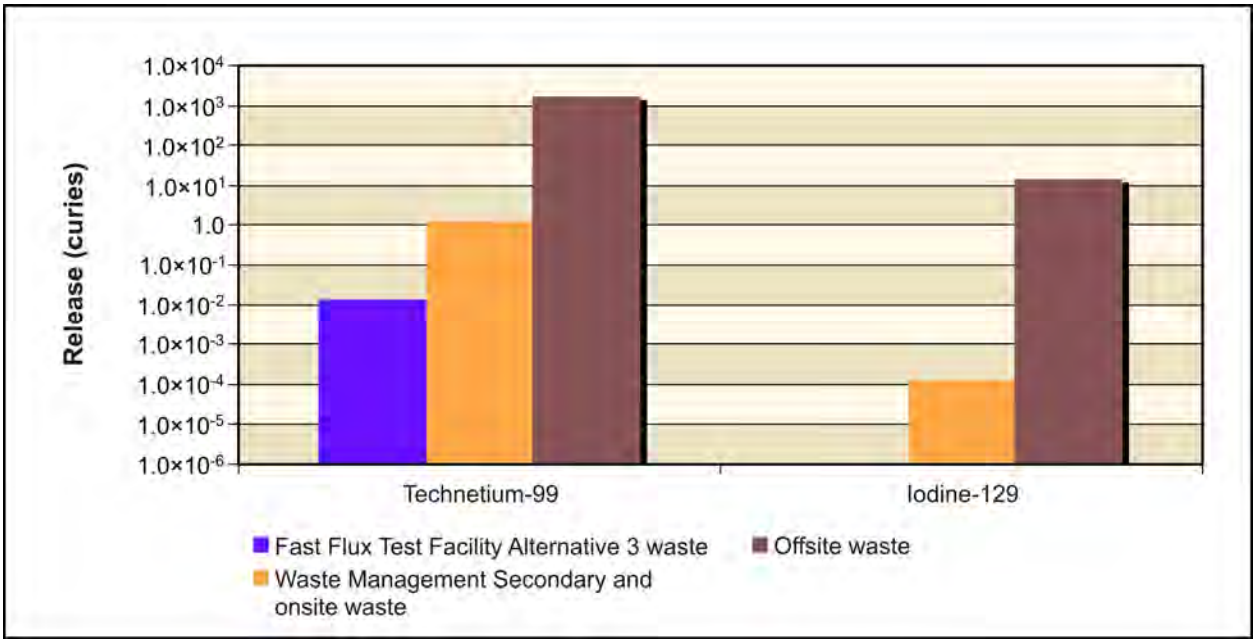


Figure 5–1075. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

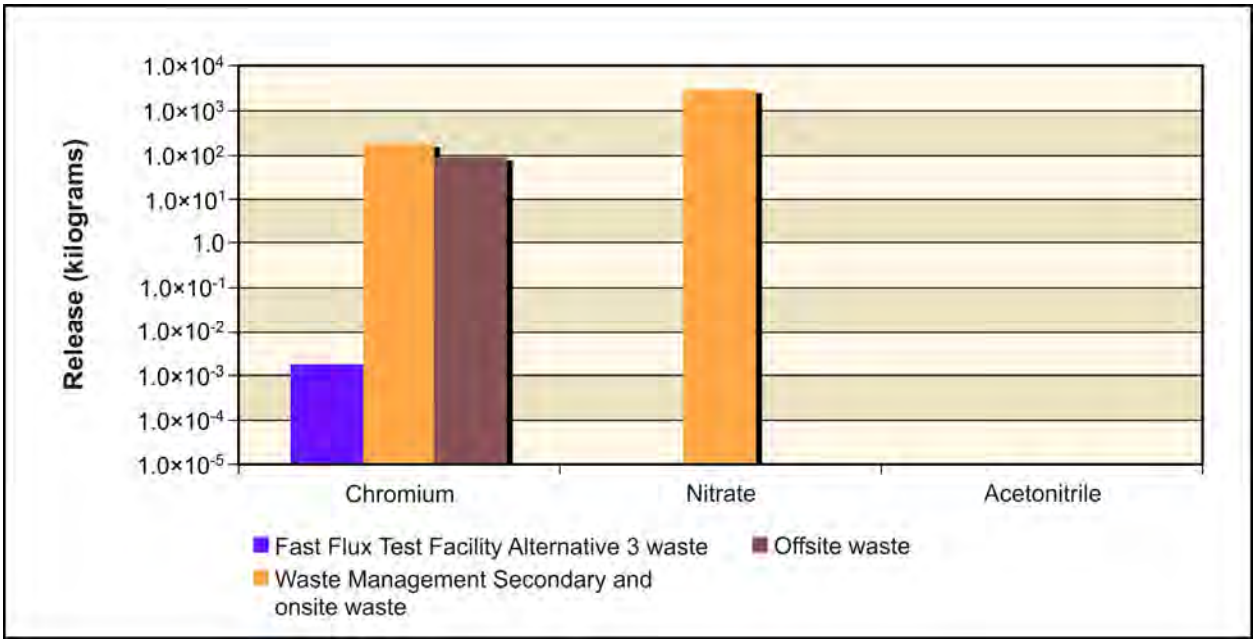


Figure 5–1076. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–1077 shows the release to the vadose zone for the radiological risk drivers and Figure 5–1078, the chemical hazard drivers. Release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the post-disposal period). Radiological sources of risk to the vadose zone from the RPPDF, highest to lowest, are technetium-99 and iodine-129; chemical hazards, again highest to lowest, are nitrate, chromium, and acetonitrile.

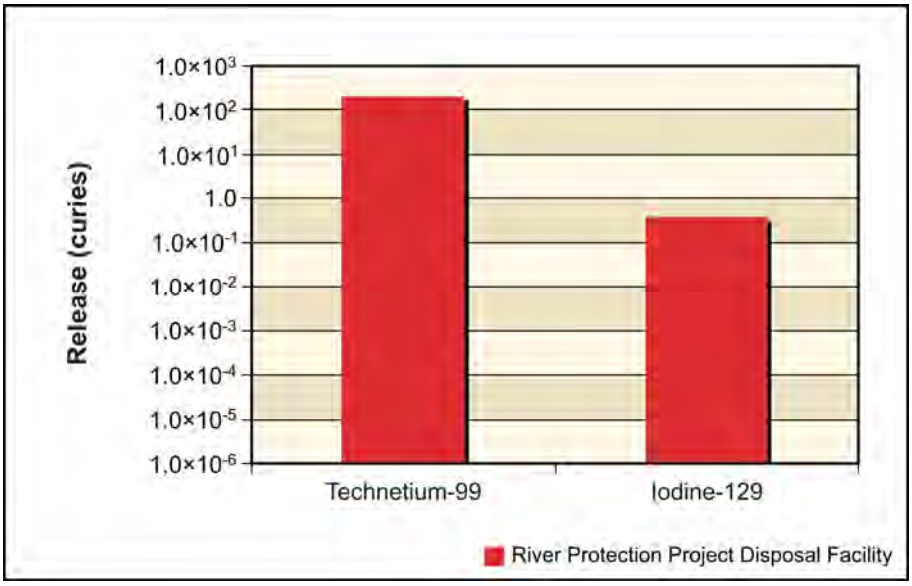


Figure 5–1077. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

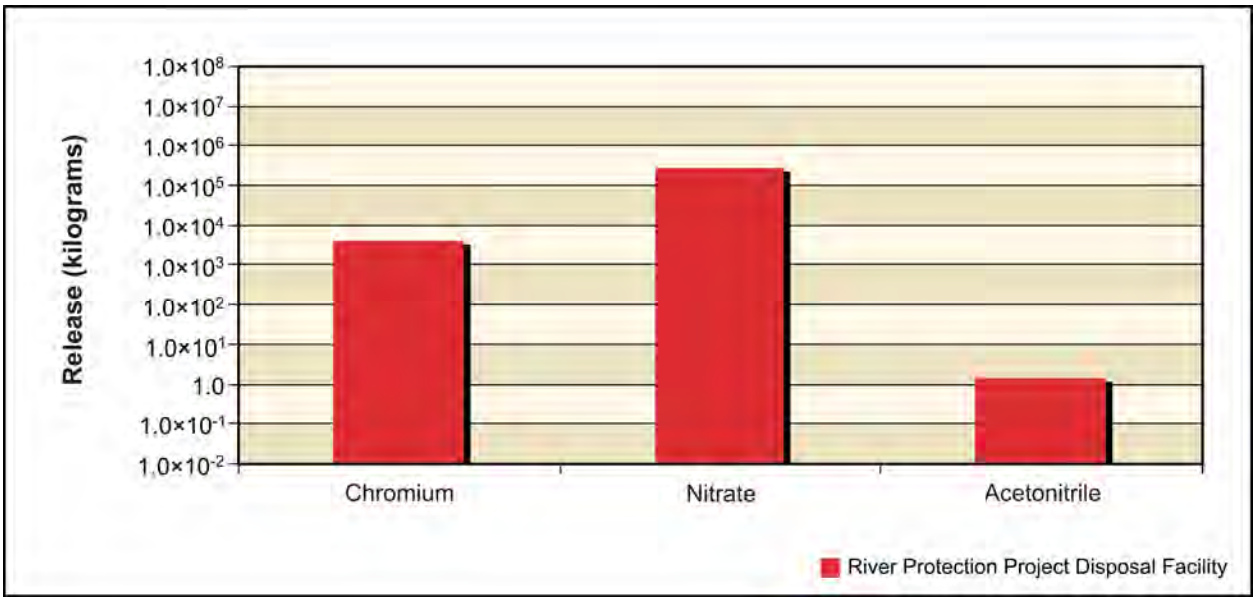


Figure 5–1078. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–1079 shows the release to groundwater for the radiological risk drivers and Figure 5–1080, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For iodine-129, technetium-99, chromium, and nitrate, the amount released to groundwater is essentially equal to the amount released to the vadose zone. Overall, about 100 percent of the radionuclides (curies) released to the vadose zone during the period of analysis reach the groundwater; also, approximately 100 percent of the chemicals (kilograms) do.

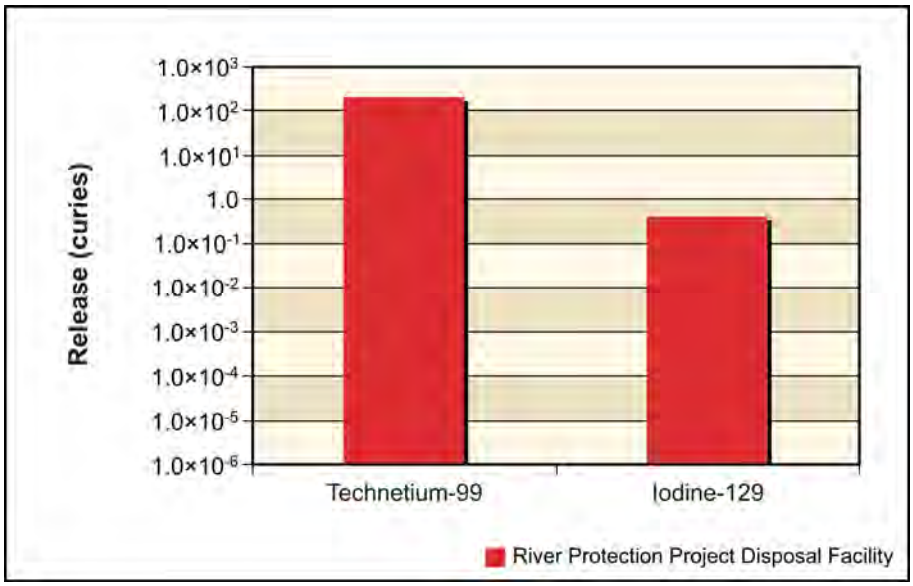


Figure 5–1079. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

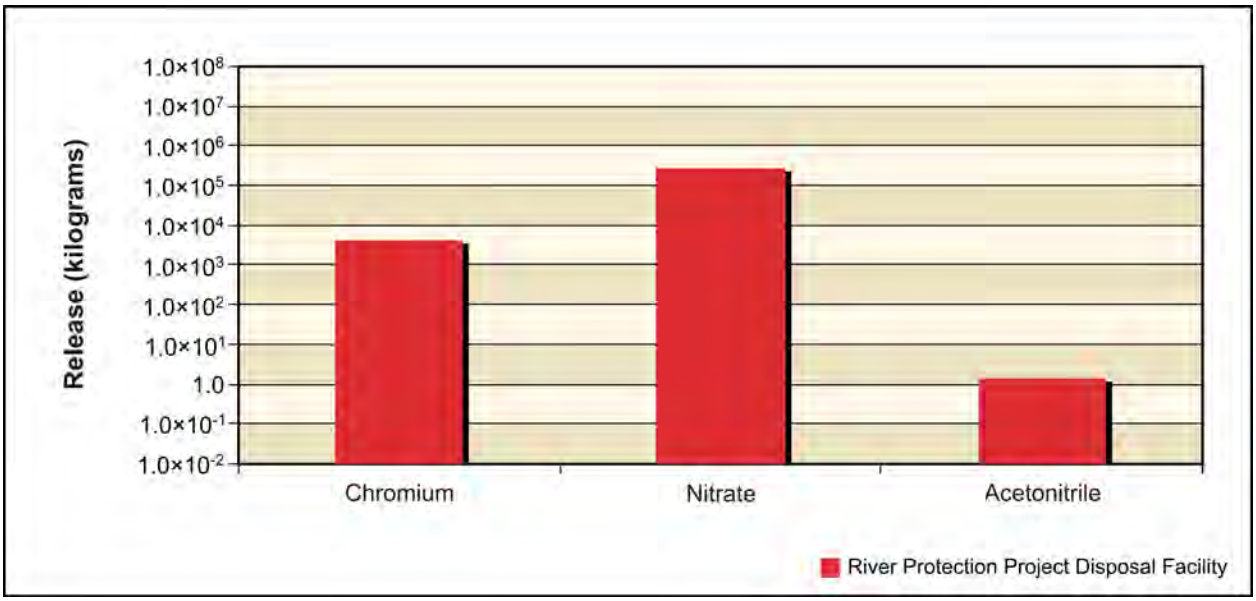


Figure 5–1080. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–1081 shows the release to the Columbia River for the radiological risk drivers and Figure 5–1082, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For iodine-129, technetium-99, chromium, and nitrate, the amount released to the Columbia River is essentially equal to the amount released to groundwater. Overall, 95 percent of the radionuclides (curies) released to the groundwater during the period of analysis reach the river; likewise, 95 percent of the chemicals (kilograms) do.

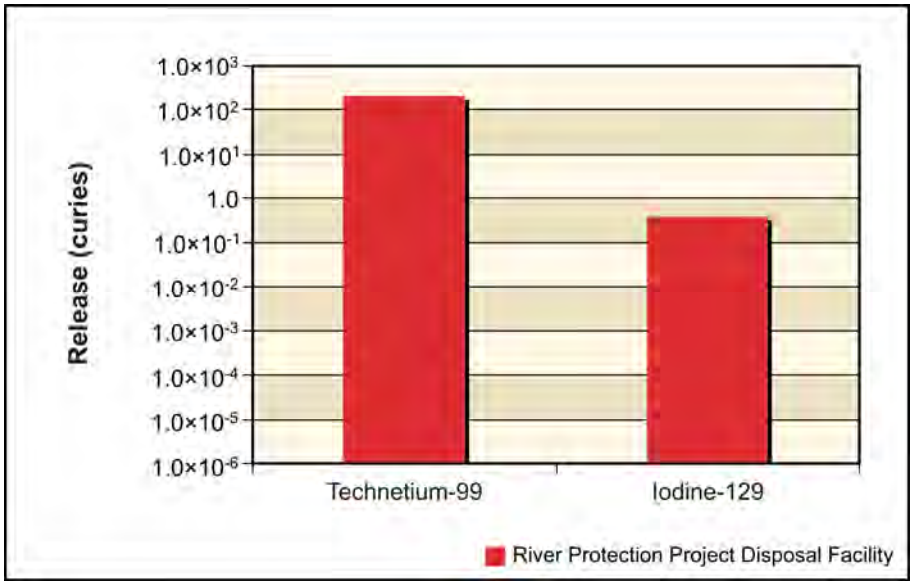


Figure 5–1081. Waste Management Alternative 3, Disposal Group 3, Base Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

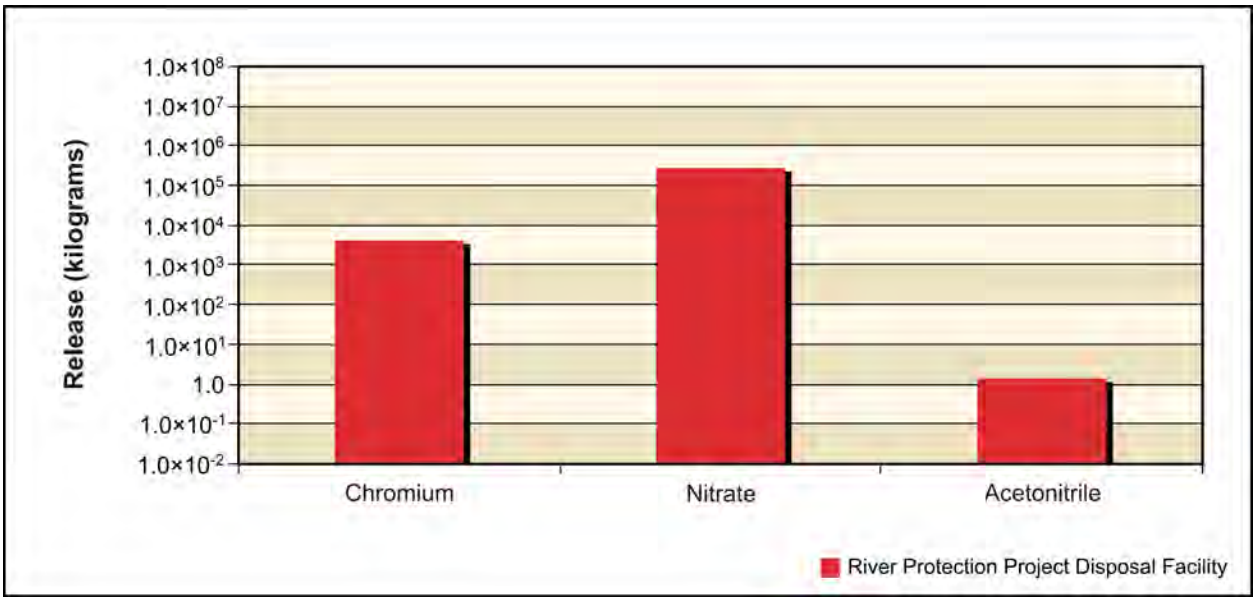


Figure 5–1082. Waste Management Alternative 3, Disposal Group 3, Base Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 3, Base Case, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration of each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations.

Figures 5–1083 through 5–1086 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. Releases from IDF-East, IDF-West, and the RPPDF cause groundwater concentrations of iodine-129 to exceed benchmark concentrations at the Core Zone Boundary and the Columbia River nearshore by approximately one order of magnitude. Iodine-129 exceeds the benchmark in the earlier part of the period of analysis. Technetium-99 has one peak at the Core Zone Boundary that exceeds the benchmark by one order of magnitude. This peak lasts only for about 10 percent of the period of analysis. Technetium-99 sporadically exceeds the benchmark at the Columbia River nearshore, and the 95th percentile upper confidence limit is within an order of magnitude below the benchmark for most of the period of analysis. Nitrate and chromium do not exceed benchmark concentrations at the Core Zone Boundary or the Columbia River nearshore. Table 5–99 shows the maximum concentrations in groundwater.

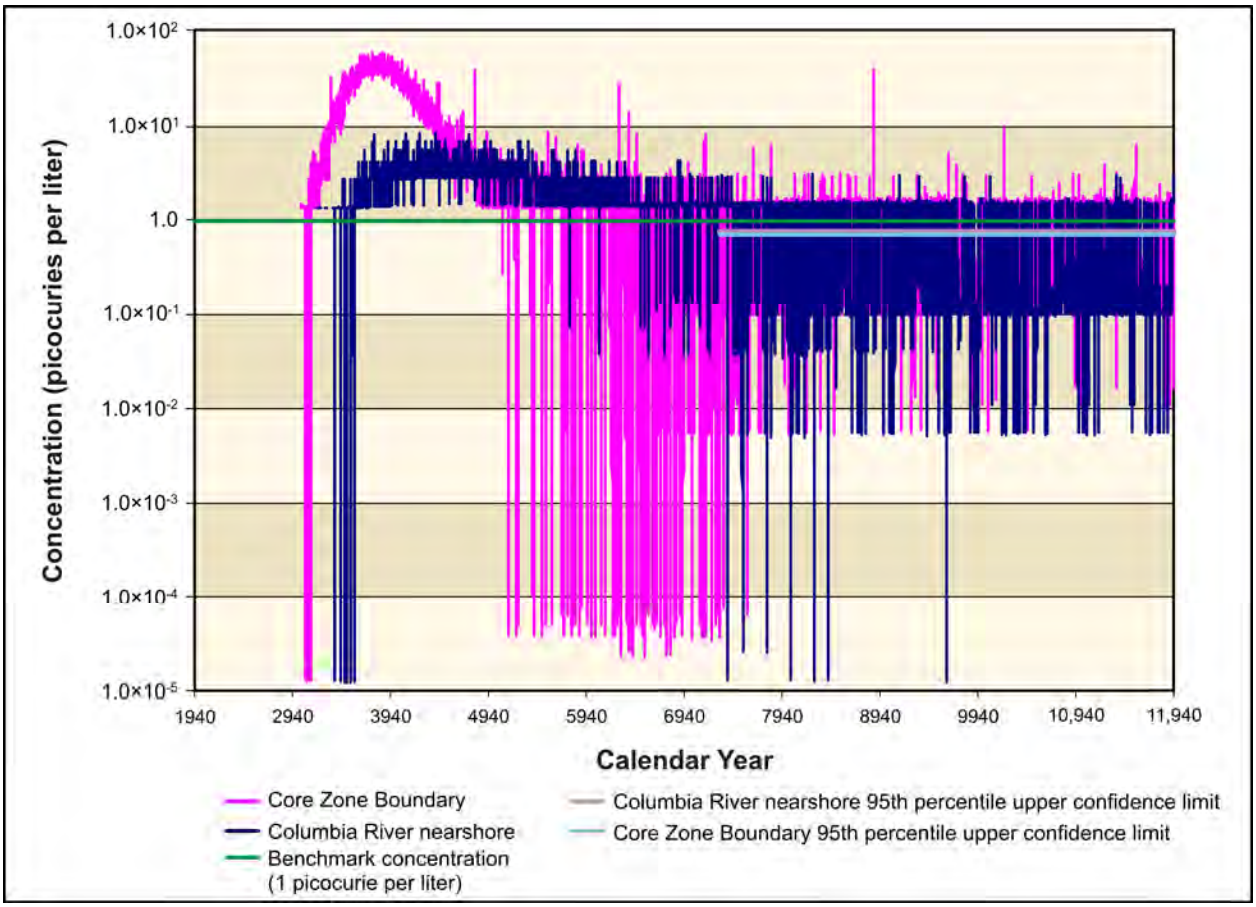


Figure 5–1083. Waste Management Alternative 3, Disposal Group 3, Base Case, Iodine-129 Concentration Versus Time

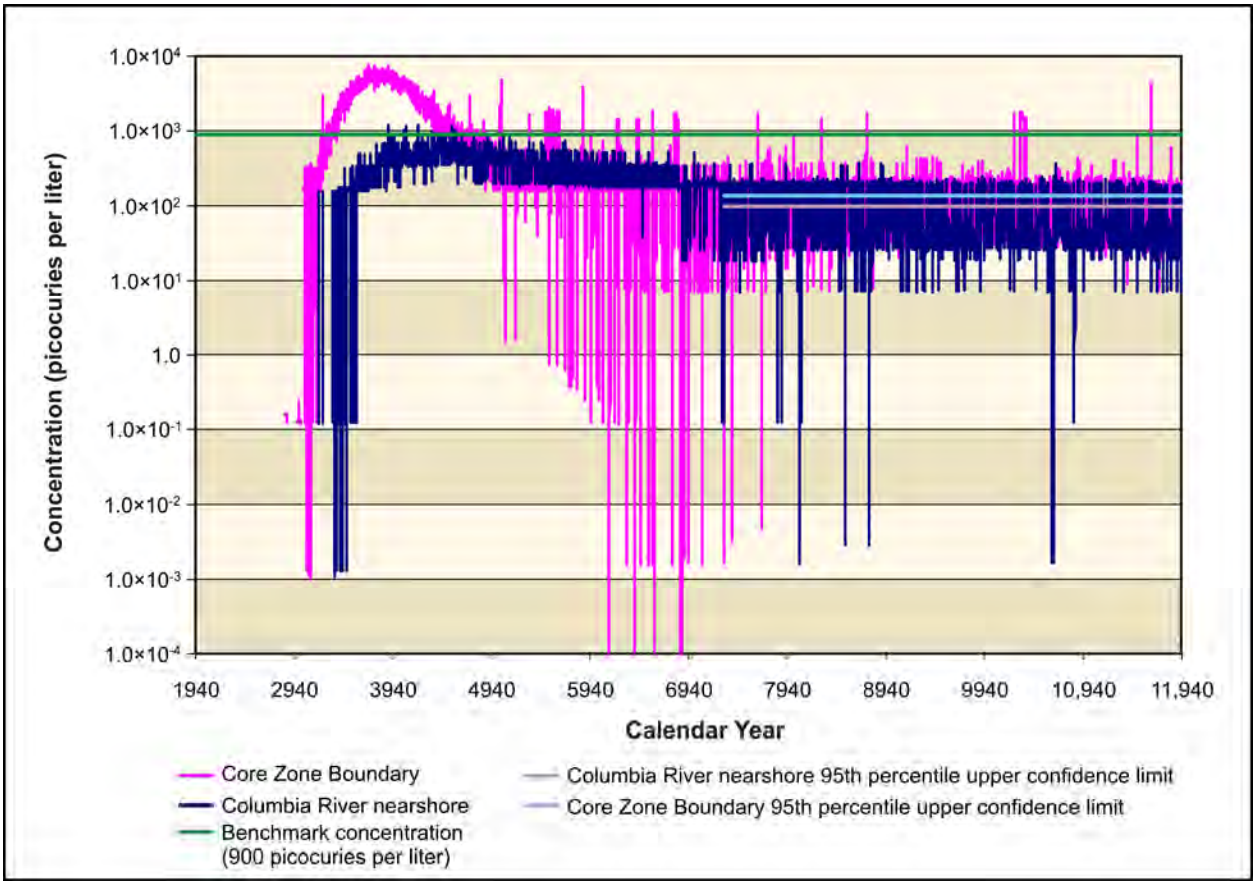


Figure 5–1084. Waste Management Alternative 3, Disposal Group 3, Base Case, Technetium-99 Concentration Versus Time

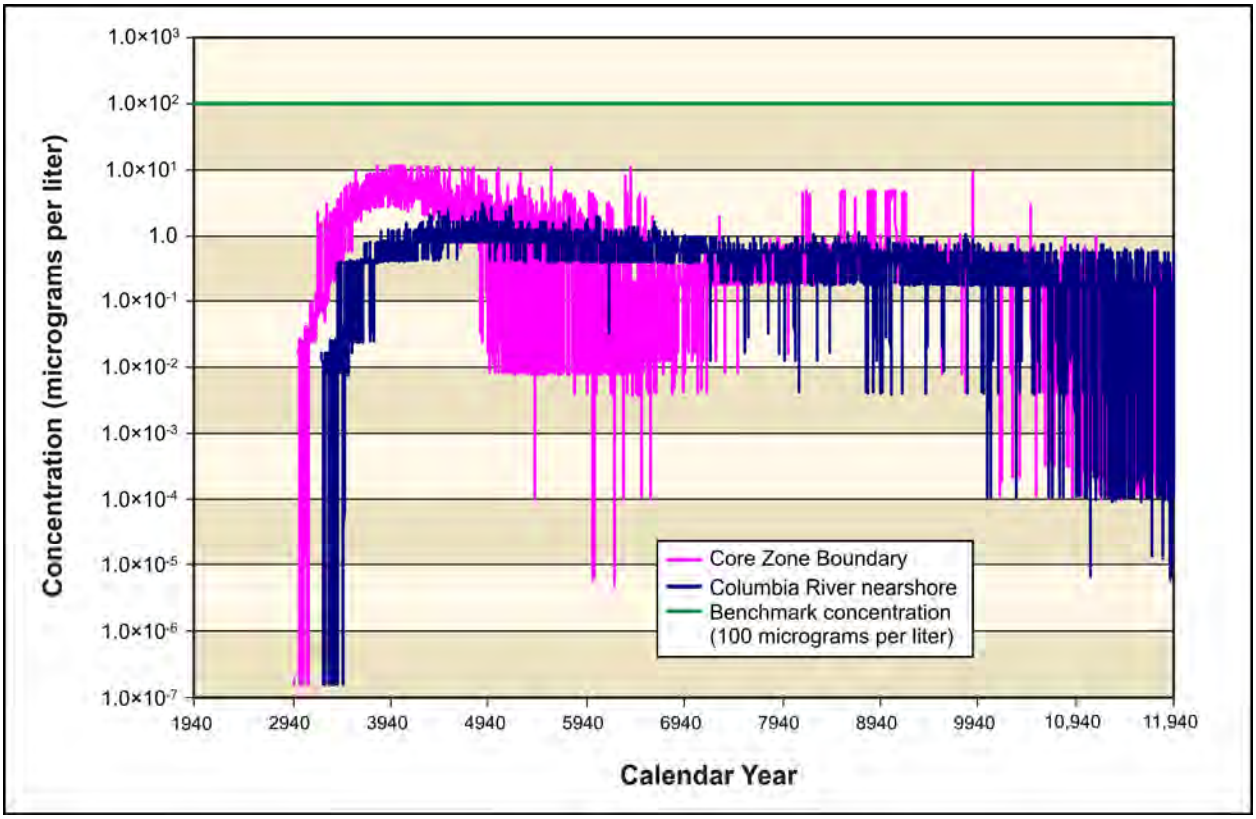


Figure 5–1085. Waste Management Alternative 3, Disposal Group 3, Base Case, Chromium Concentration Versus Time

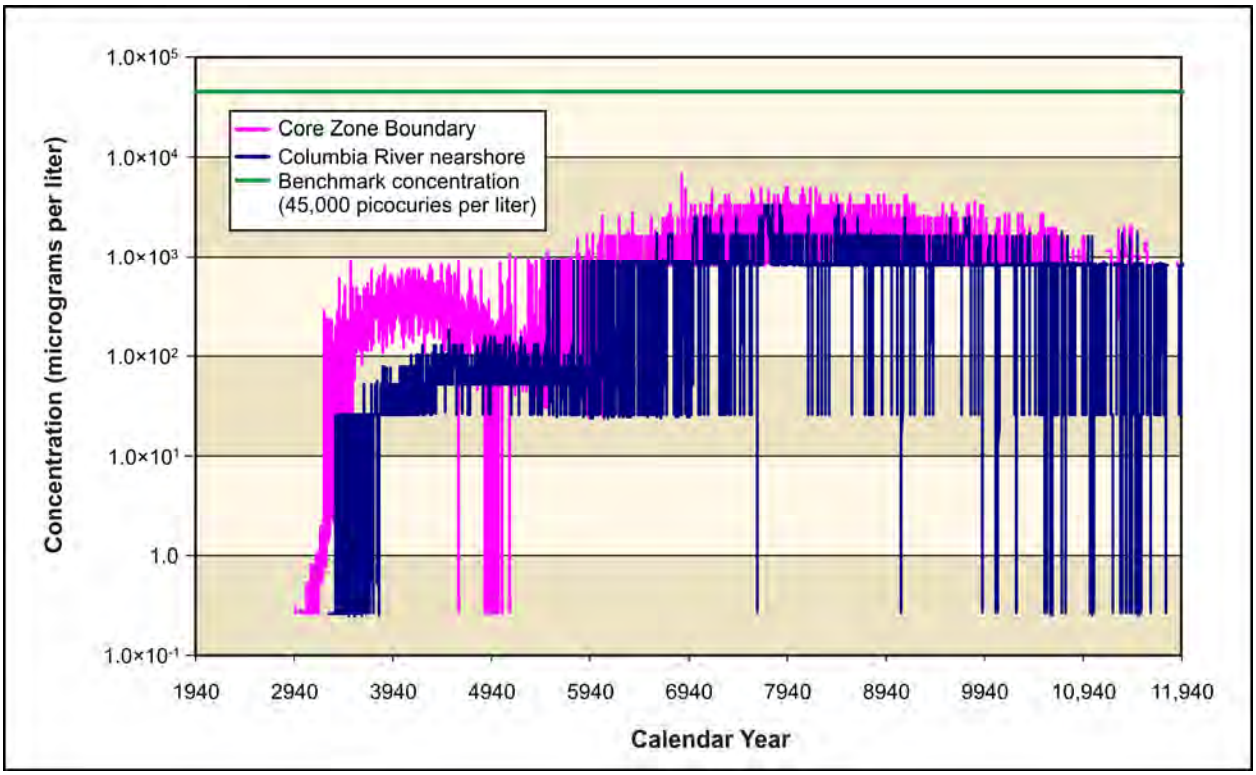


Figure 5–1086. Waste Management Alternative 3, Disposal Group 3, Base Case, Nitrate Concentration Versus Time

Table 5–99. Waste Management Alternative 3, Disposal Group 3, Base Case, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	389	**20,200**	303	**7,770**	**1,180**	900
	(9324)	(3713)	(3987)	(3690)	(4186)	
Iodine-129	**2**	**173**	0.5	**61**	**8**	1
	(11,096)	(3797)	(4073)	(3853)	(4392)	
Chemical in micrograms per liter						
Chromium	3	2	6	12	3	100
	(8037)	(3696)	(4109)	(4035)	(4877)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	16,600	17	404	6,550	3,310	45,000
	(7367)	(3703)	(4001)	(6859)	(7717)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–1087 and 5–1088 show concentration versus time for uranium-238 and total uranium. Because uranium-238 and total uranium are slow moving through the vadose zone, releases from IDF-East, IDF-West, and the RPPDF result in groundwater concentrations that are several orders of magnitude lower than benchmark concentrations. Uranium-238 and total uranium concentrations, while minimal, continue to rise throughout the duration of the period of analysis, but never exceed benchmark concentrations by more than three orders of magnitude by the end of the period of analysis.

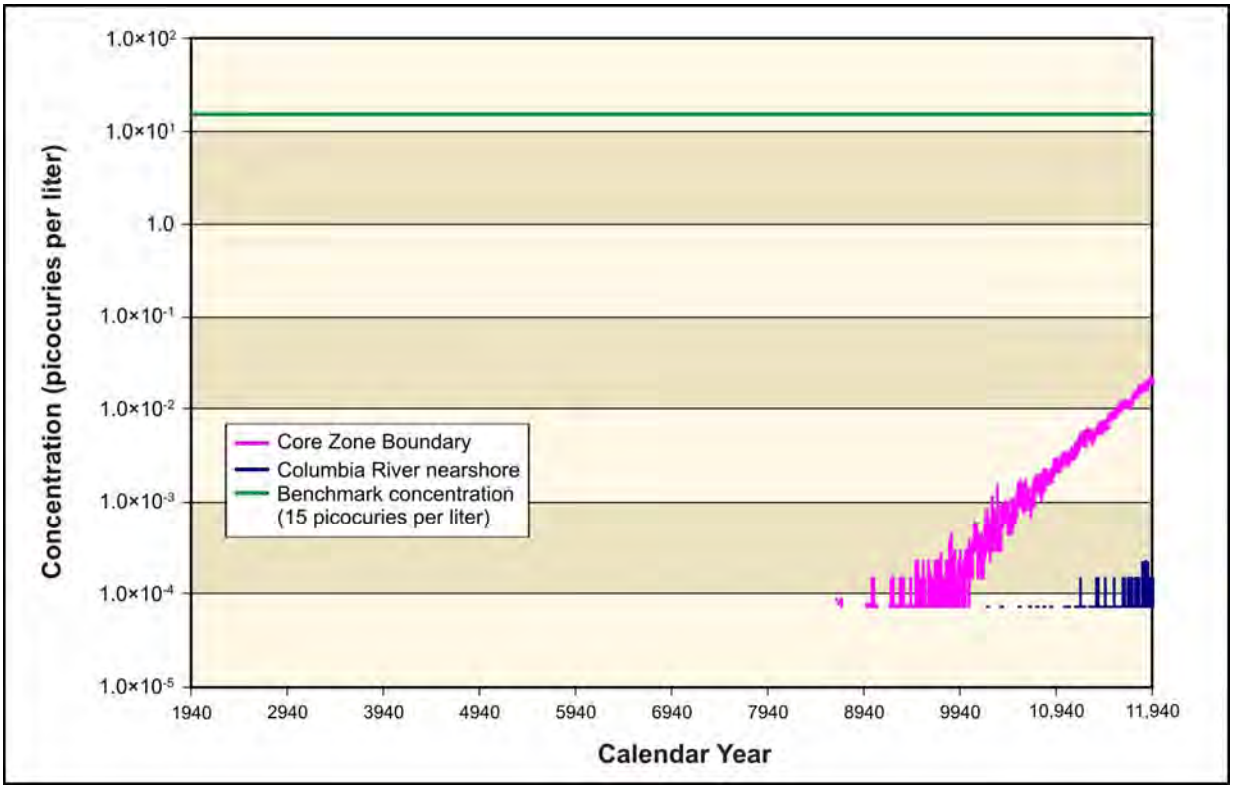


Figure 5–1087. Waste Management Alternative 3, Disposal Group 3, Base Case, Uranium-238 Concentration Versus Time

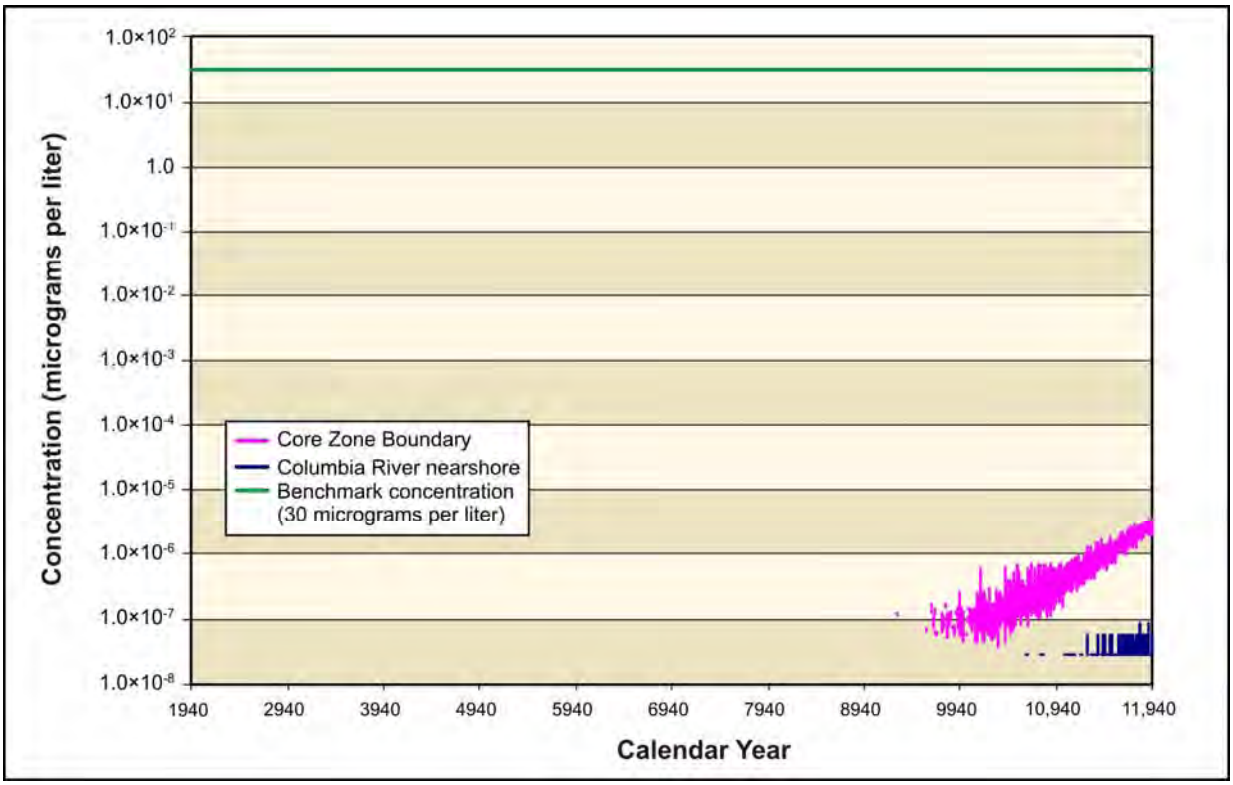
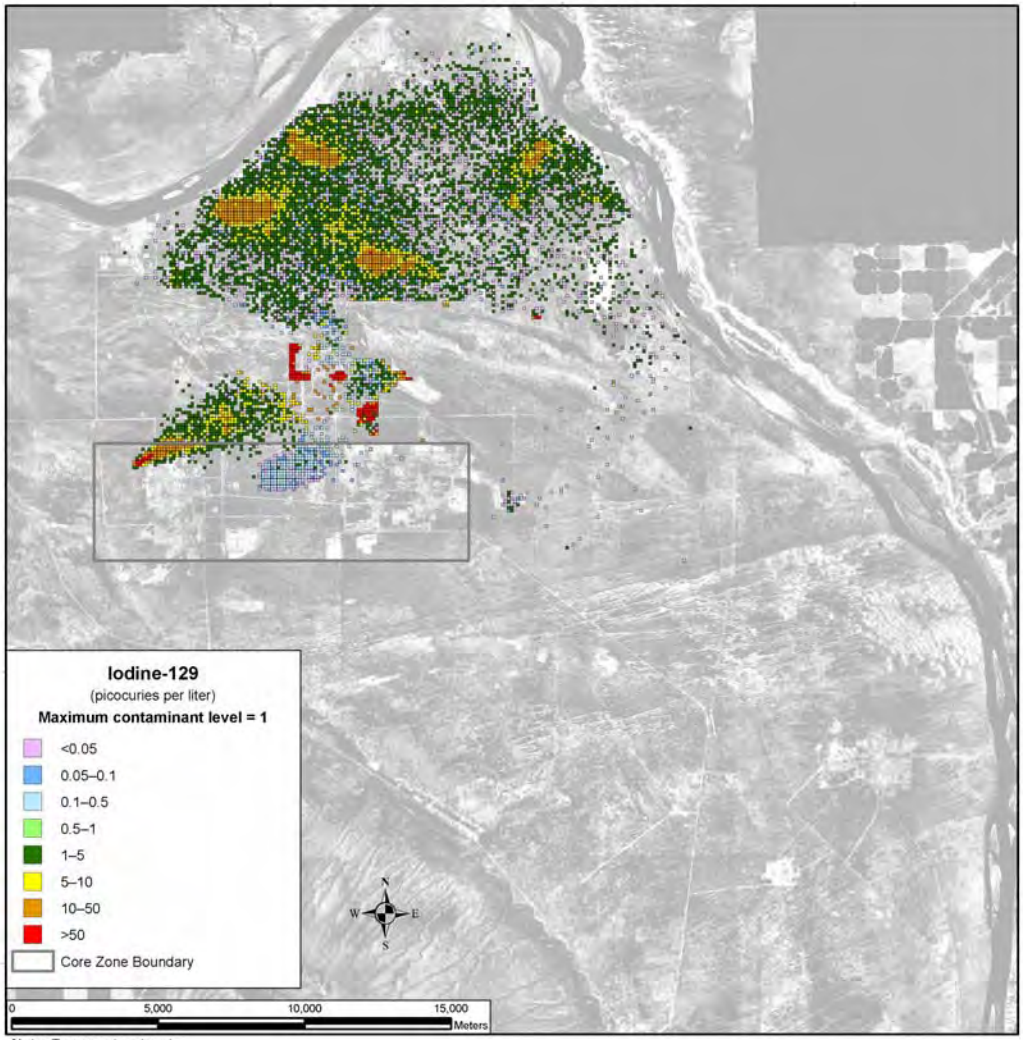


Figure 5–1088. Waste Management Alternative 3, Disposal Group 3, Base Case, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

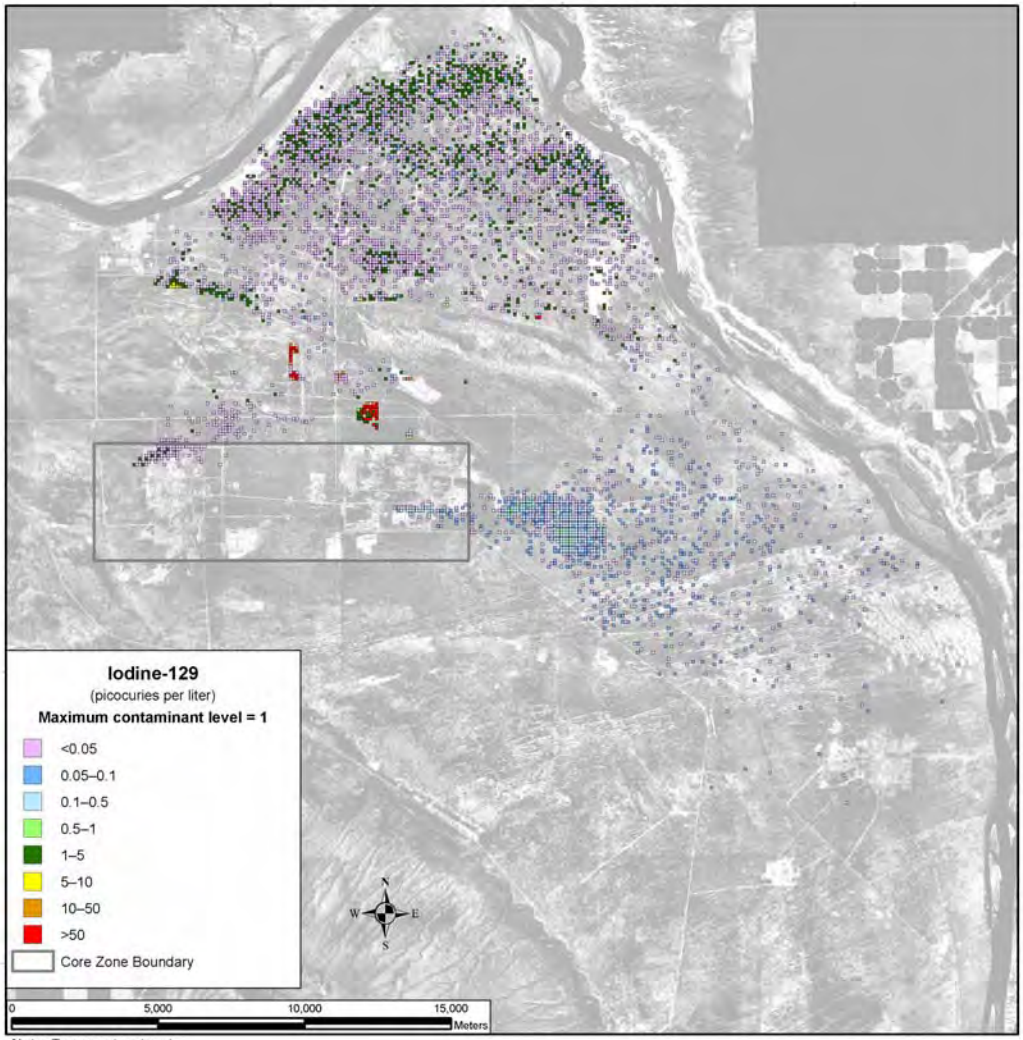
This section presents the impacts of Waste Management Alternative 3, Disposal Group 3, Base Case, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale indicative of the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations lower than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figure 5–1089 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890. Releases from IDF-West and the RPPDF result in a groundwater plume starting in the Core Zone and heading north through Gable Mountain. This plume exceeds the benchmark concentration at the Core Zone Boundary and north of the Core Zone Boundary by one to two orders of magnitude. During CY 7140, releases from IDF-East create a groundwater plume, not exceeding the benchmark, extending from the 200-East Area eastward toward the Columbia River (see Figure 5–1090). Also by CY 7140, most of the IDF-West and RPPDF plume continues to move north and reaches the Columbia River. By CY 11,885, most of the mass in the IDF-East plume is still moving eastward toward the Columbia River with only small, isolated pockets exceeding the benchmark concentration (see Figure 5–1091). Technetium-99 (see Figures 5–1092 through 5–1094) shows similar spatial distributions at selected times and exceeds the benchmark concentrations at approximately the same time and locations. Chromium (see Figures 5–1095 through 5–1097), and nitrate (see Figures 5–1098 through 5–1100) show similar spatial distributions at selected times, but the peak concentrations are lower than iodine-129 and technetium-99 relative to their respective benchmark concentrations. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).



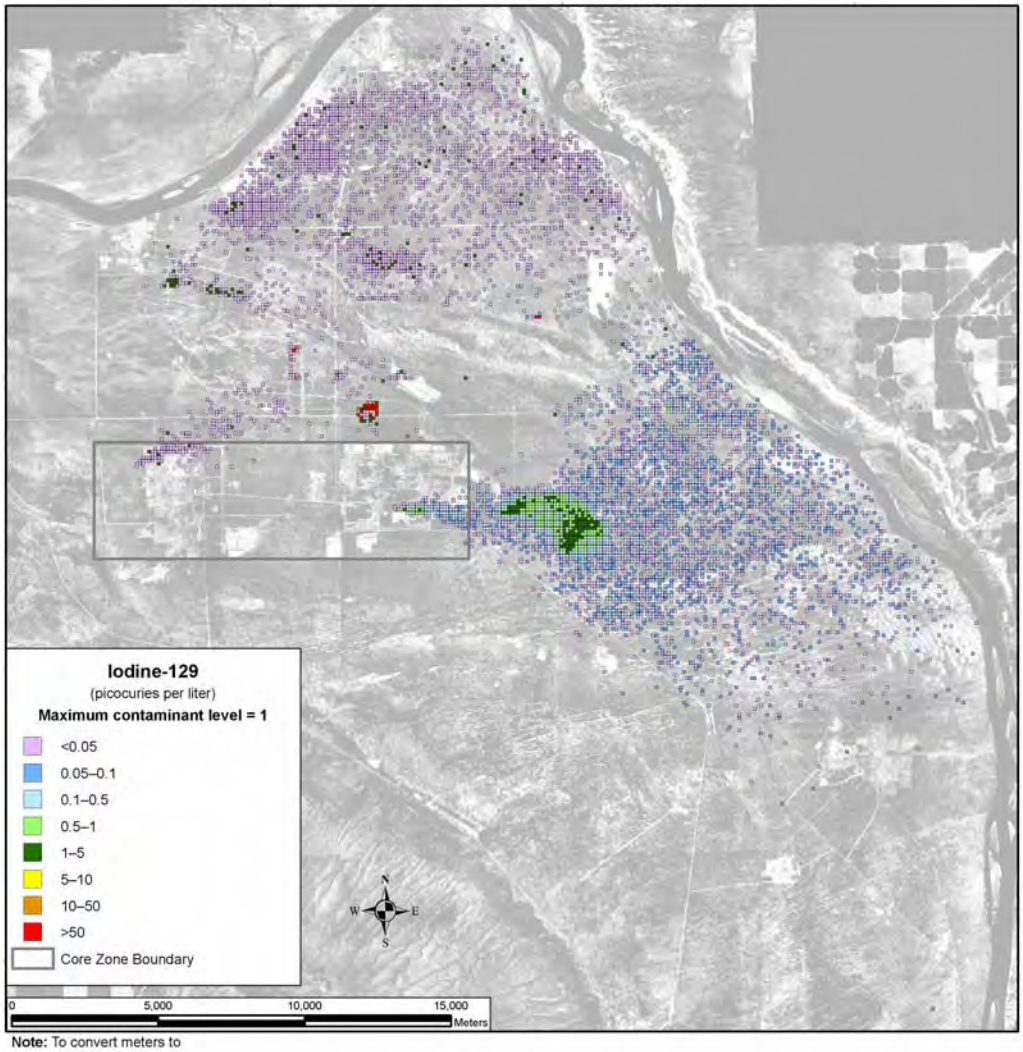
Note: To convert meters to feet, multiply by 3.281

Figure 5–1089. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



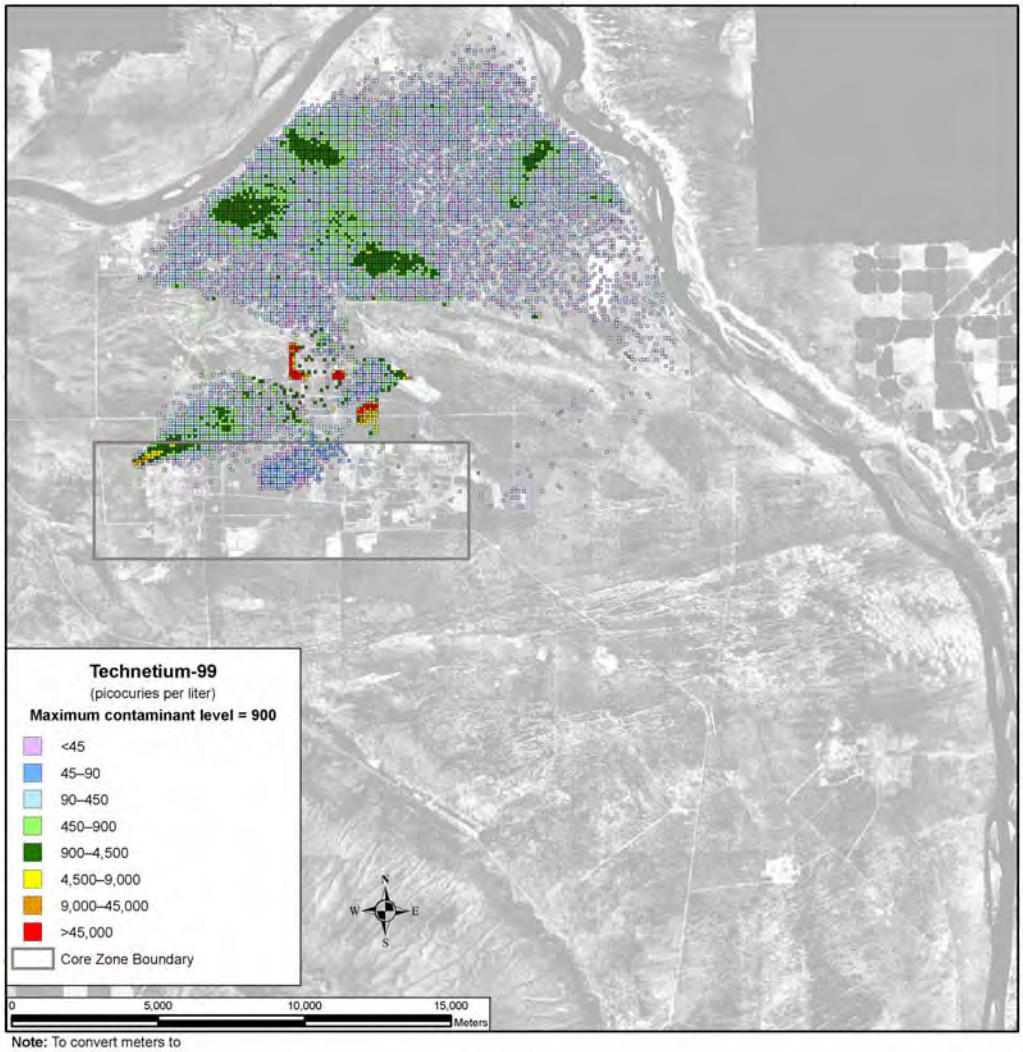
Note: To convert meters to feet, multiply by 3.281

Figure 5–1090. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



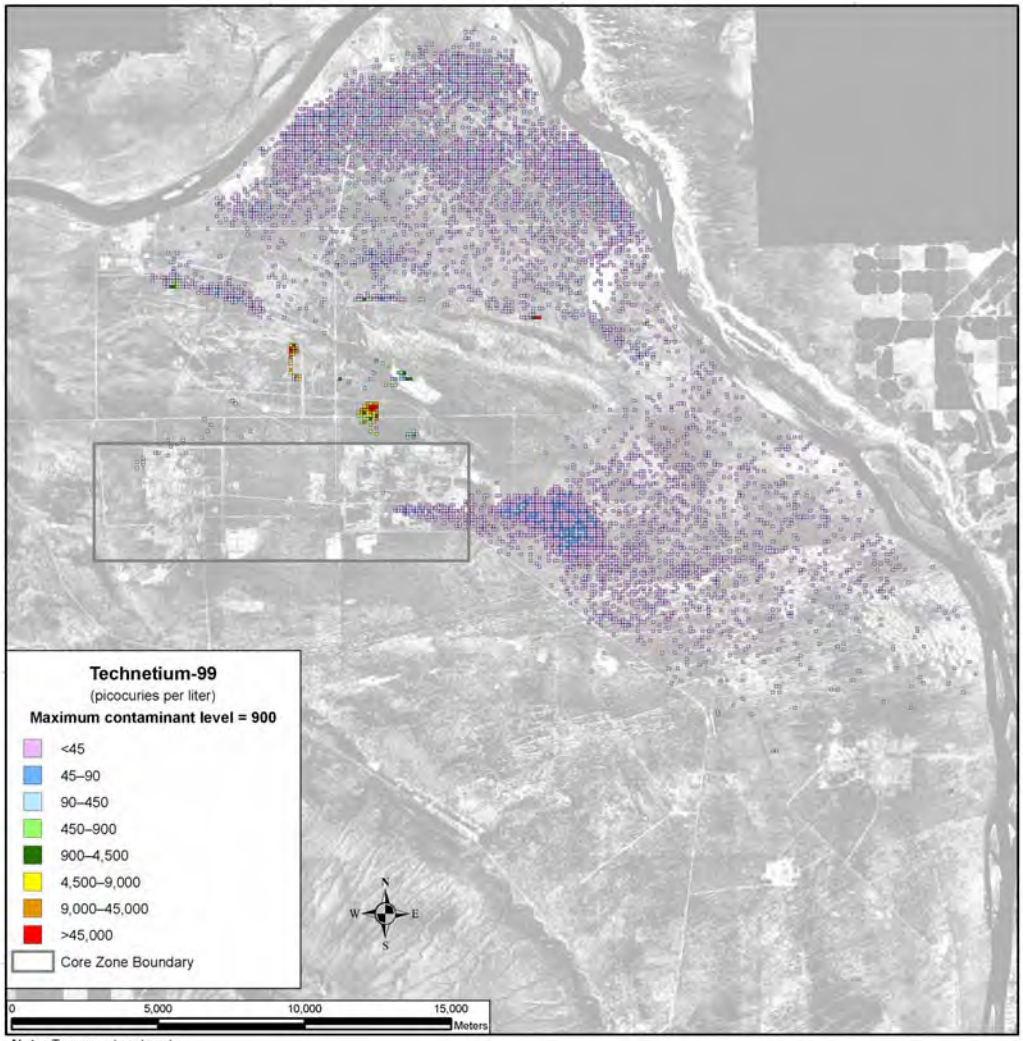
Note: To convert meters to feet, multiply by 3.281

Figure 5–1091. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



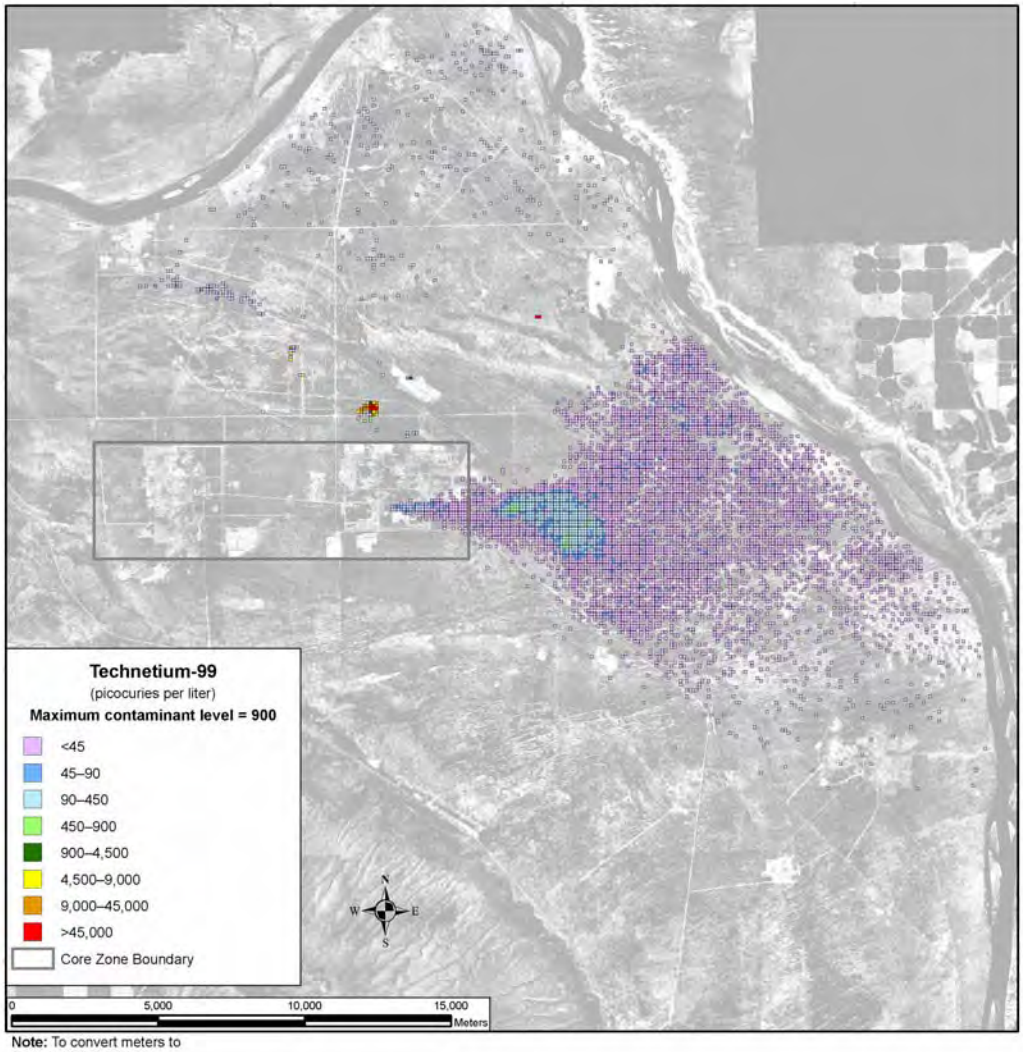
Note: To convert meters to feet, multiply by 3.281

Figure 5–1092. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



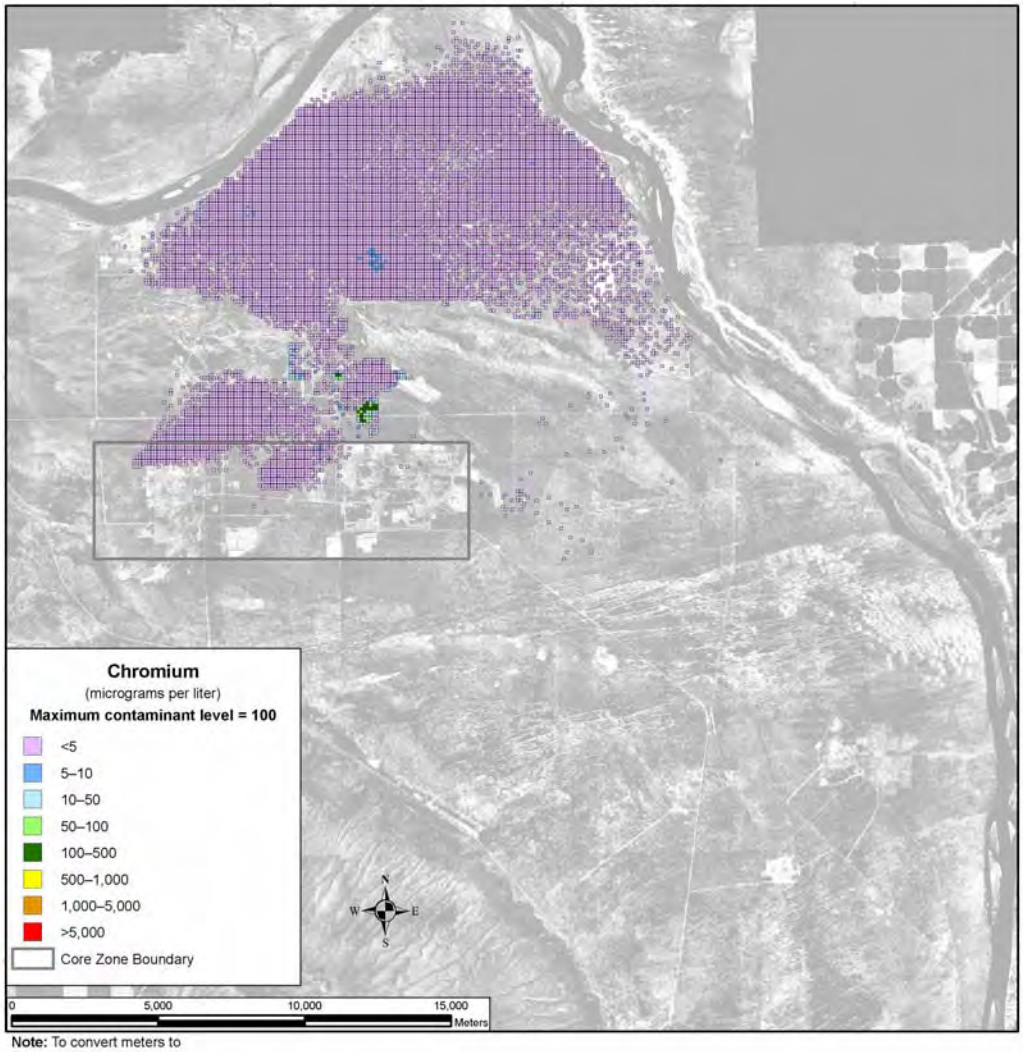
Note: To convert meters to feet, multiply by 3.281

Figure 5–1093. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



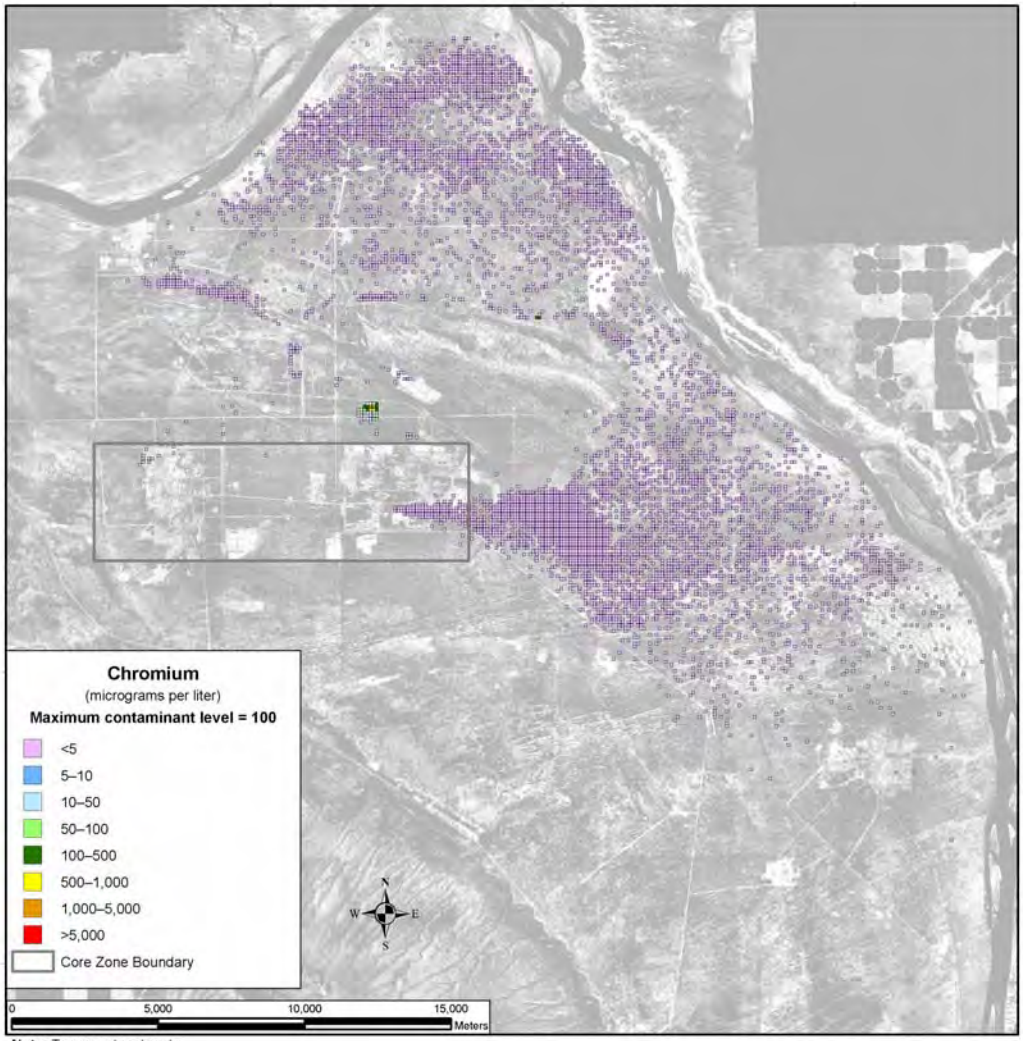
Note: To convert meters to feet, multiply by 3.281

Figure 5–1094. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



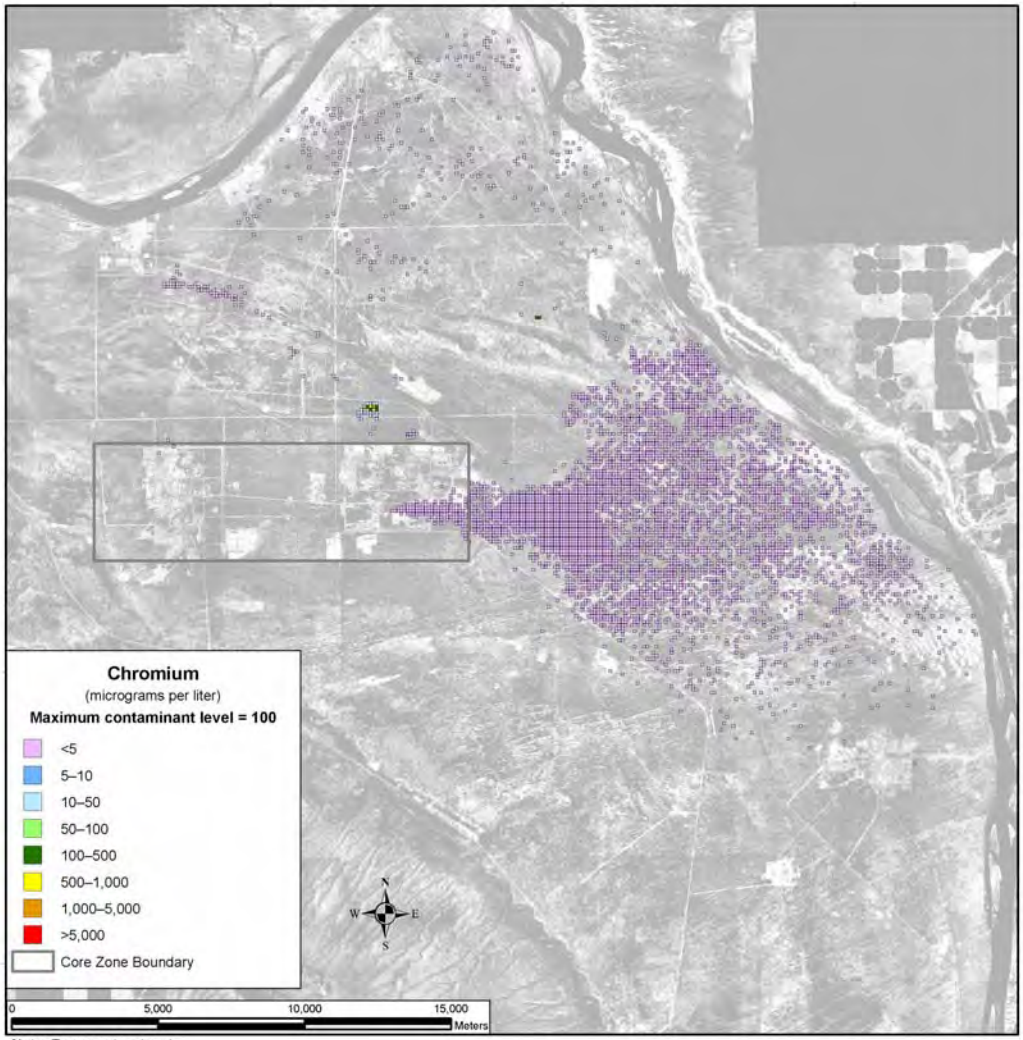
Note: To convert meters to feet, multiply by 3.281

Figure 5–1095. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



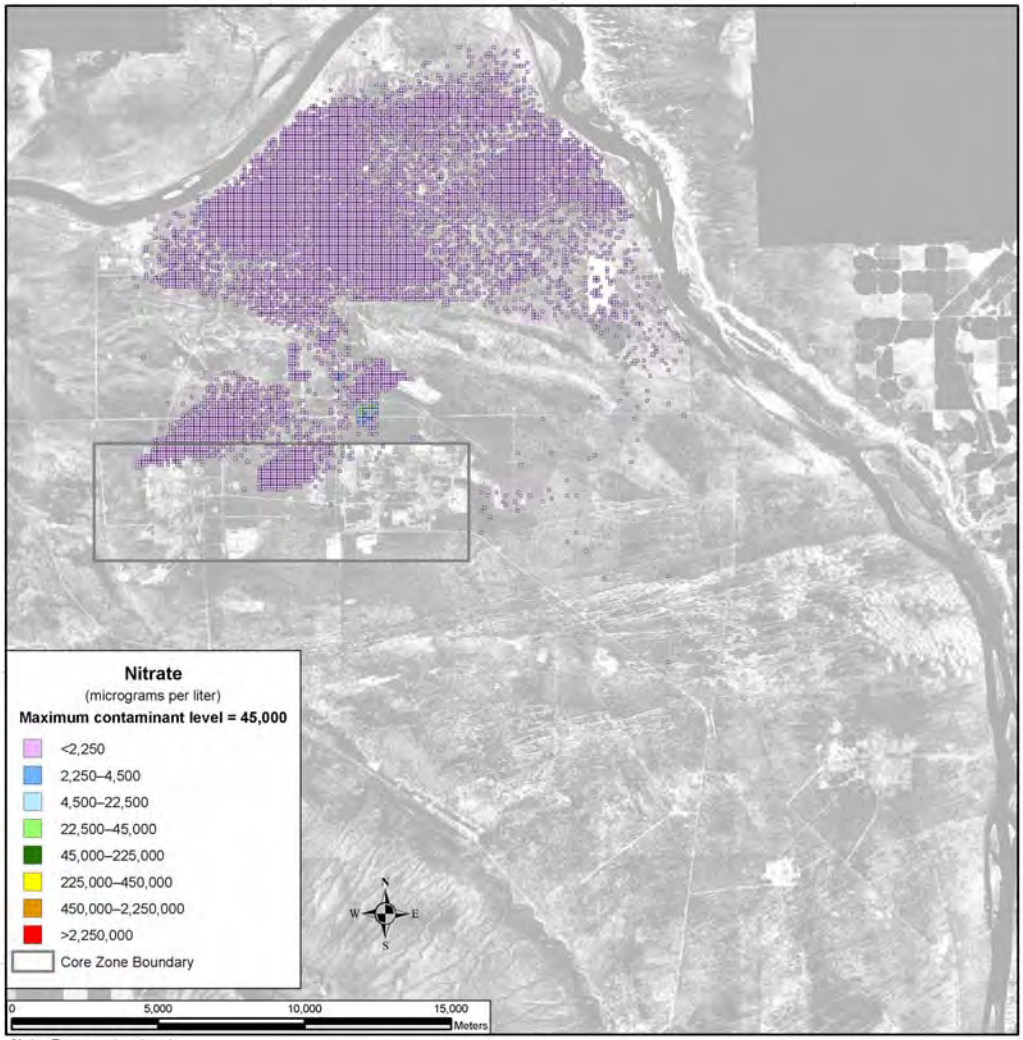
Note: To convert meters to feet, multiply by 3.281

Figure 5–1096. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



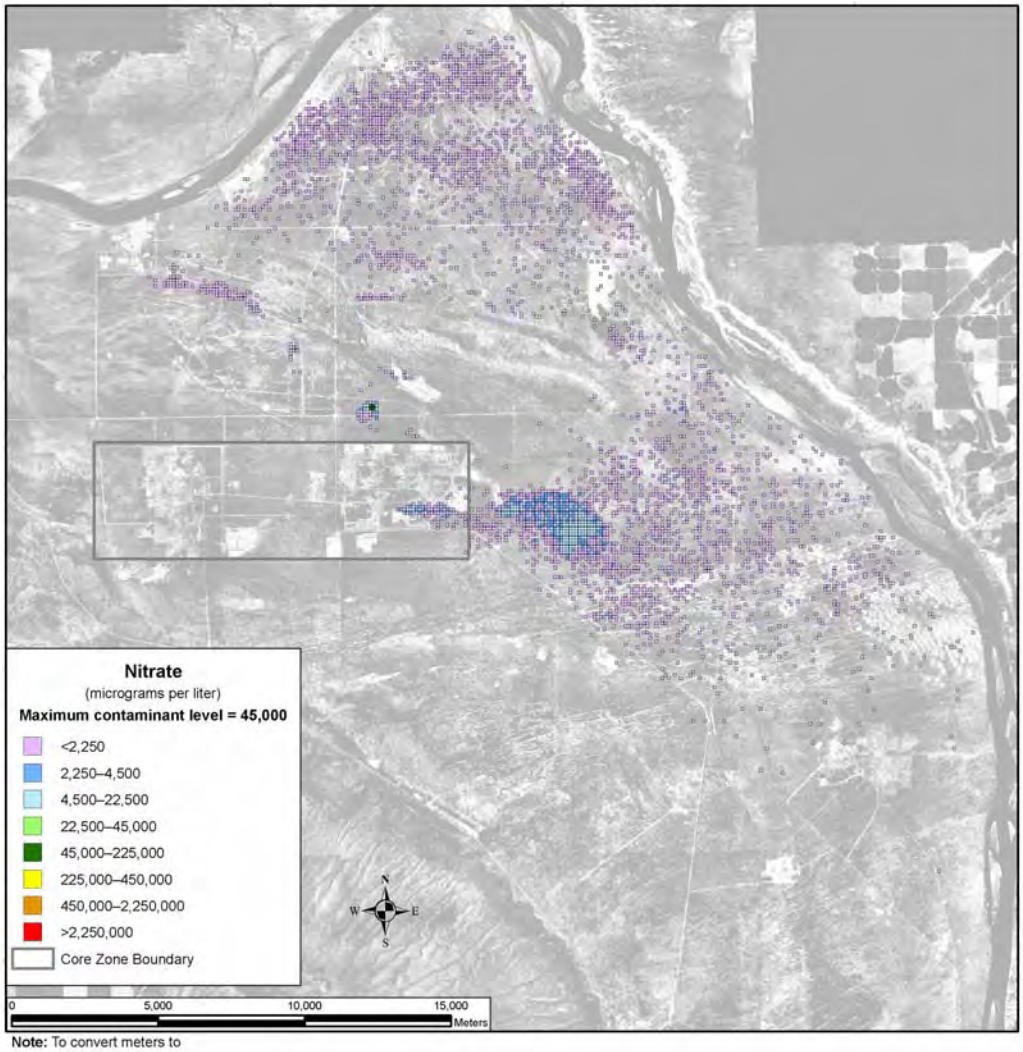
Note: To convert meters to feet, multiply by 3.281

Figure 5–1097. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



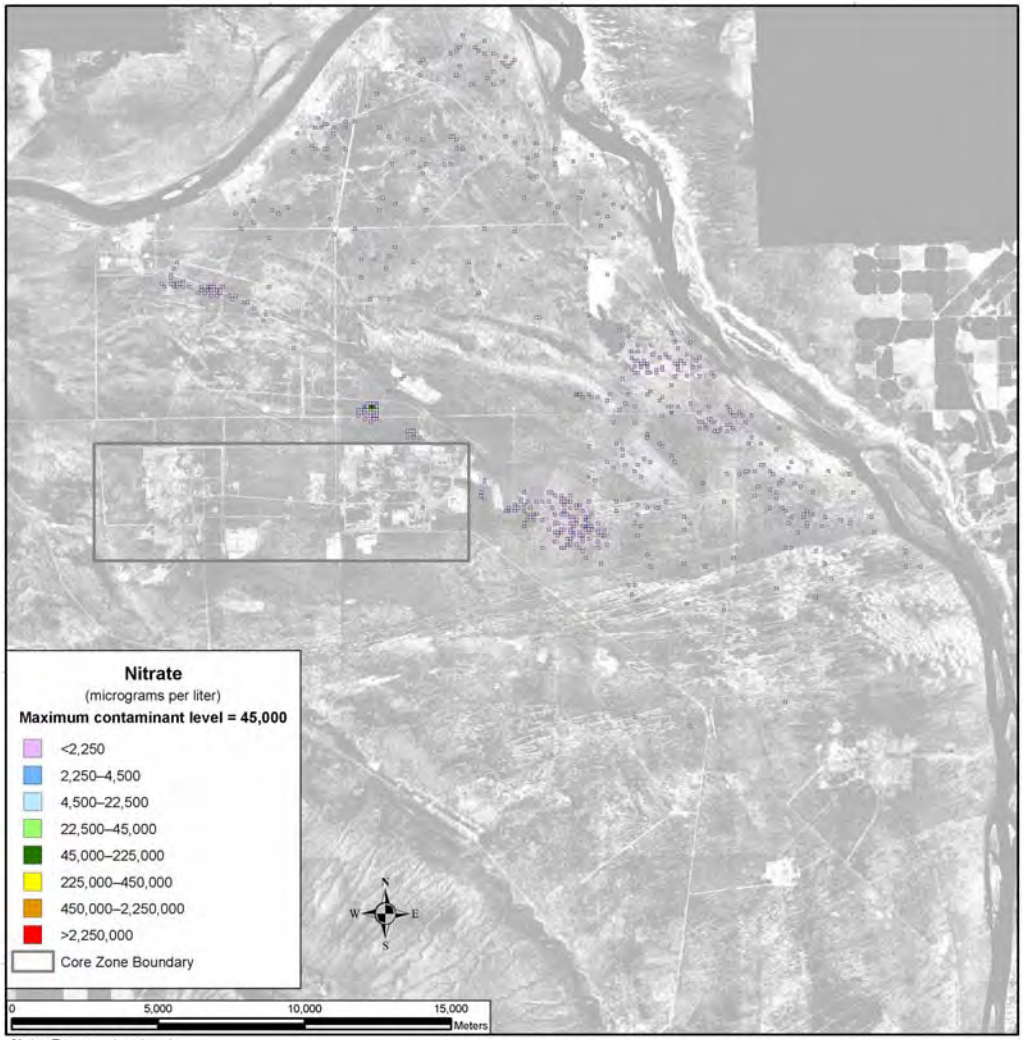
Note: To convert meters to feet, multiply by 3.281

Figure 5–1098. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

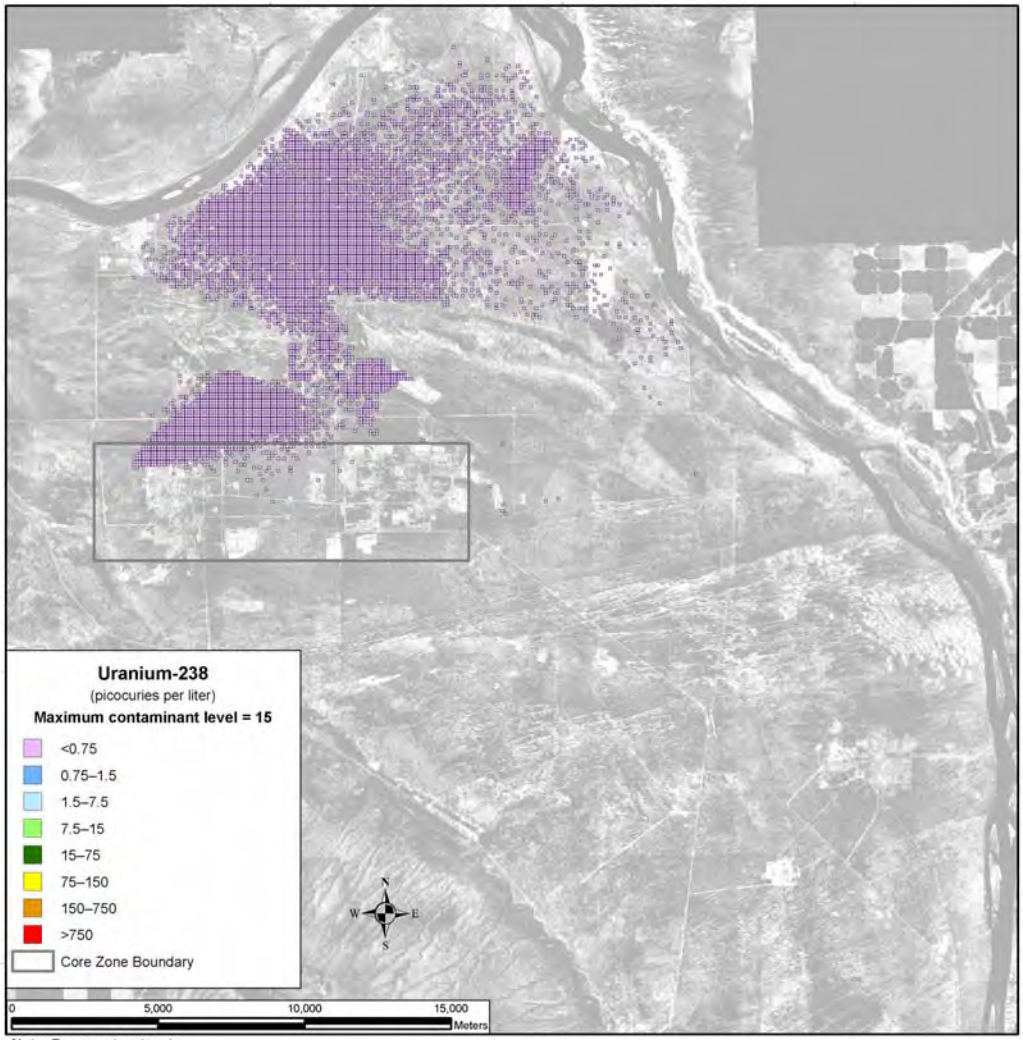
Figure 5–1099. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–1100. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Uranium-238 and total uranium show a different spatial distribution over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figures 5–1101 and 5–1102 show the distribution of uranium-238 and total uranium during CY 11,885. Releases from IDF-West and the RPPDF result in a groundwater plume that starts in the Core Zone and moves north through Gable Mountain. However, concentrations in this plume do not exceed the benchmark concentration during the period of analysis.



Note: To convert meters to feet, multiply by 3.281

Figure 5–1101. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

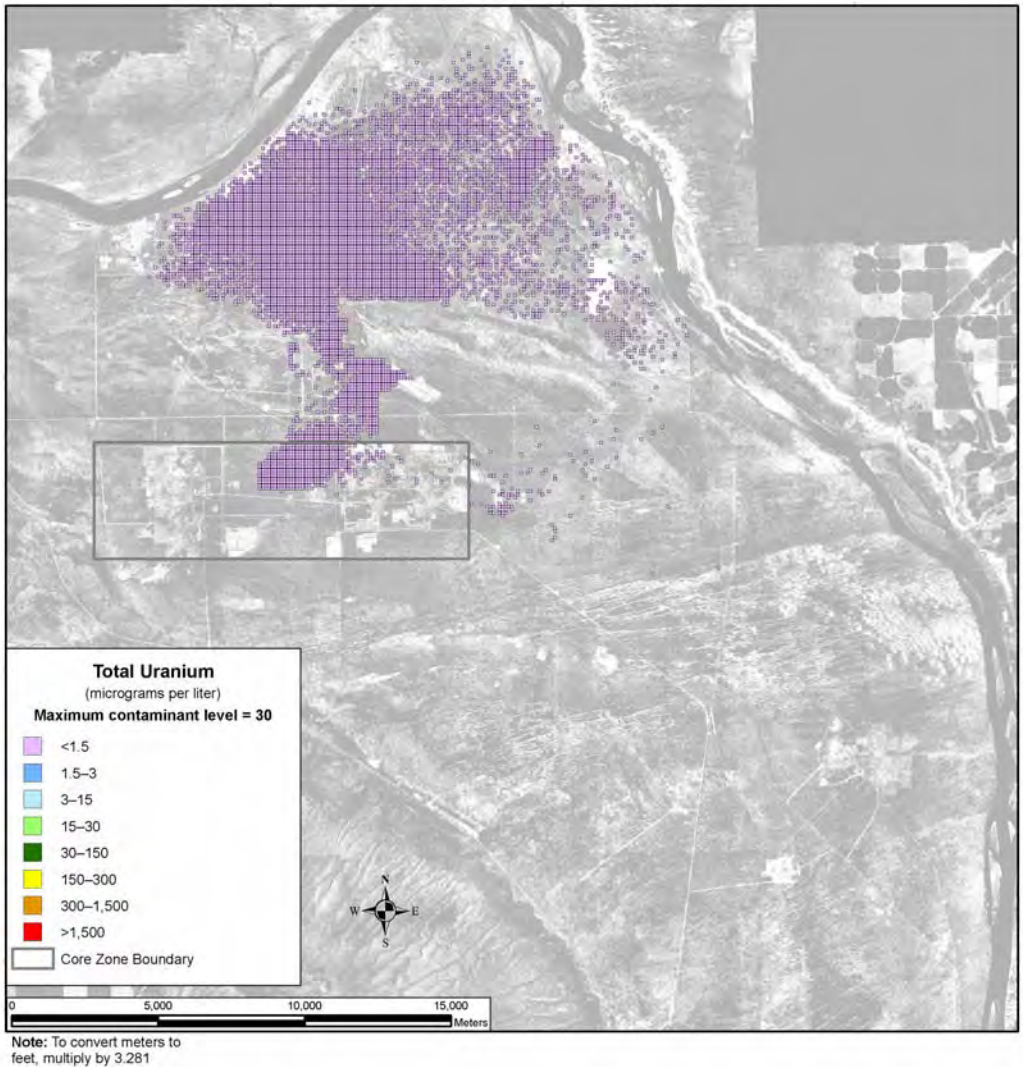


Figure 5–1102. Waste Management Alternative 3, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 3, Base Case, in general, the inventory remaining at IDF-East, IDF-West, and the RPPDF, which is available for release to the environment at the start of the post-disposal period, is the predominant contributor.

For the conservative tracers, concentrations slightly outside the Core Zone Boundary exceed benchmark standards by one to two orders of magnitude during most of the period of analysis. Concentration at the Columbia River is about one to two orders of magnitude smaller. The intensities and areas of these groundwater plumes peak between CY 3890 and CY 7140.

Uranium-238 and total uranium is limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species do not exceed the benchmark at the Core Zone Boundary or the Columbia River nearshore.

5.3.1.3.3.2 Disposal Group 3, Option Case

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 3, Disposal Group 3, Option Case, includes Tank Closure Alternative 6A, Option Case; FFTF Decommissioning Alternative 2 or 3; and onsite- and offsite-generated waste.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 3, Disposal Group 3, Option Case:

- The disposal period starts with the onset of disposal operations for IDF-East and IDF-West in CY 2009, and the RPPDF in CY 2022 and continues through CY 2165 when the disposal facilities will be operationally closed. During the disposal period, the materials in these permitted, operational facilities are not available for release to the environment.

- The post-disposal period starts in CY 2166 and continues through the 10,000-year period of analysis. At the start of this period, materials in IDF-East, IDF-West, and the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 3, Option Case, IDF-East, IDF-West, and the RPPDF are assumed to be covered by a barrier limiting infiltration for the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 3, Disposal Group 3, Option Case. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 3, Disposal Group 3, Option Case, is focused on the following COPC drivers:

- Radiological risk drivers: iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: acetonitrile, boron, chromium, fluoride, nitrate, and total uranium

The COPC drivers for Waste Management Alternative 3, Disposal Group 3, Option Case, were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contribution to risk and hazard are not dominant during the year of peak risk or hazard, they become major contributors toward the end of the period of analysis. The radiological risk drivers listed above account for essentially 100 percent of the radiological risk. There is no chemical risk. The chemical hazard drivers above account for 100 percent of the chemical hazard associated with Waste Management Alternative 3, Disposal Group 3, Option Case.

The COPC drivers that are discussed in detail in this section fall into two categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., they move with groundwater) and long-lived (relative to the 10,000-year period of analysis) or stable. They are essentially conservative tracers. Uranium-238 and total uranium are long-lived or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of both factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Waste Management Alternative 3, Disposal Group 3, Option Case, in terms of total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Three subtotals are plotted representing releases from ETF-generated secondary waste, PPF glass, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste and onsite-generated waste, offsite-generated waste, and the RPPDF. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over seven orders of magnitude.

200-East Area Integrated Disposal Facility

Figure 5–1103 shows the release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–1104, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). The predominant source of technetium-99 and chromium is tank closure secondary waste. ETF-generated secondary waste is the predominant source of iodine-129 and nitrate.

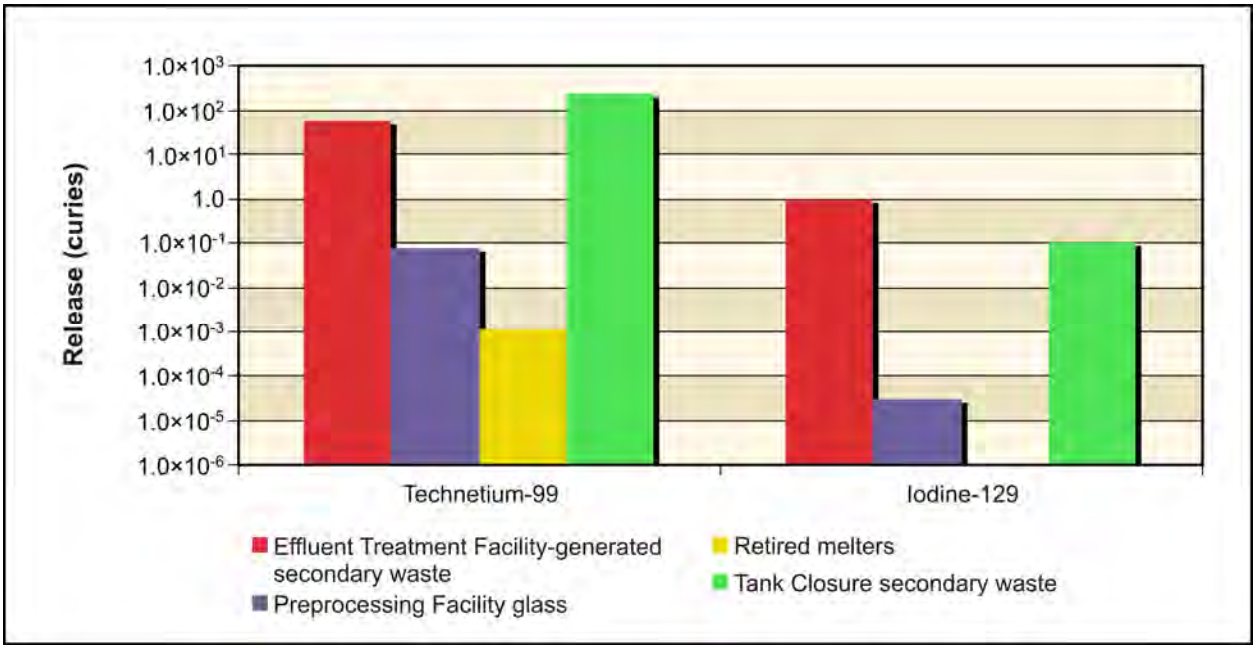


Figure 5–1103. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

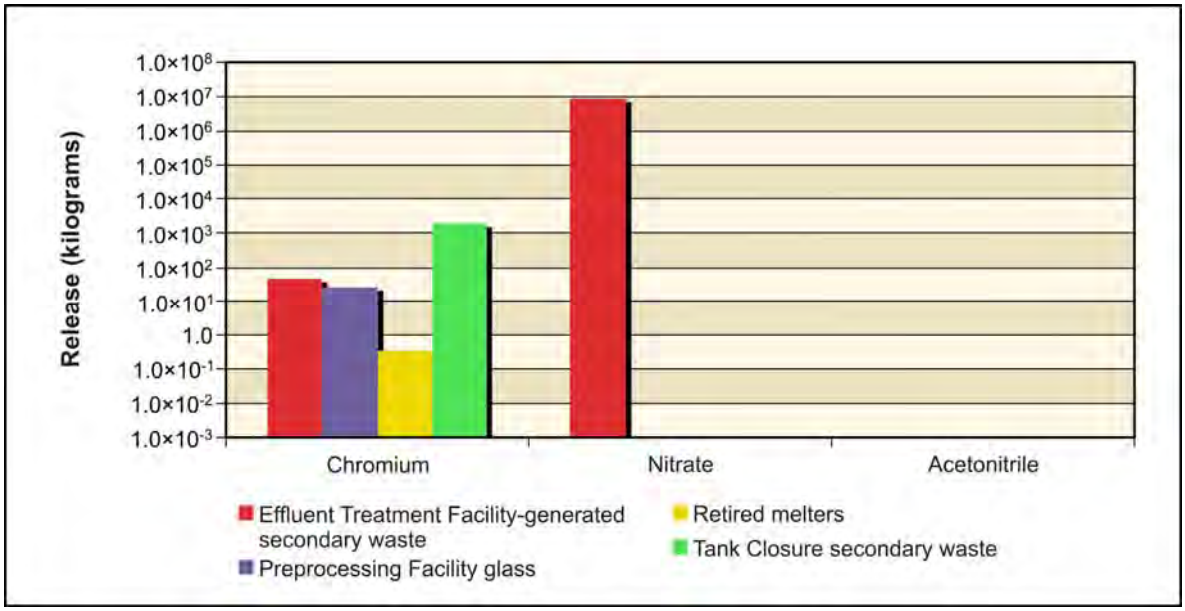


Figure 5–1104. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–1105 shows the release at IDF-East to groundwater for the radiological risk drivers and Figure 5–1106, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. With the exception of technetium-99 released from ETF-generated secondary waste, of which nearly all released to the vadose zone reaches groundwater, only 40 to 50 percent of the technetium-99 and iodine-129 released to the vadose zone reaches groundwater. Only 40 to 50 percent of the chromium originating in PPF glass and retired melters reaches groundwater. Essentially all of the chromium released from ETF-generated secondary waste and tank closure secondary waste reaches groundwater. Nearly all nitrate released to the vadose zone reaches groundwater.

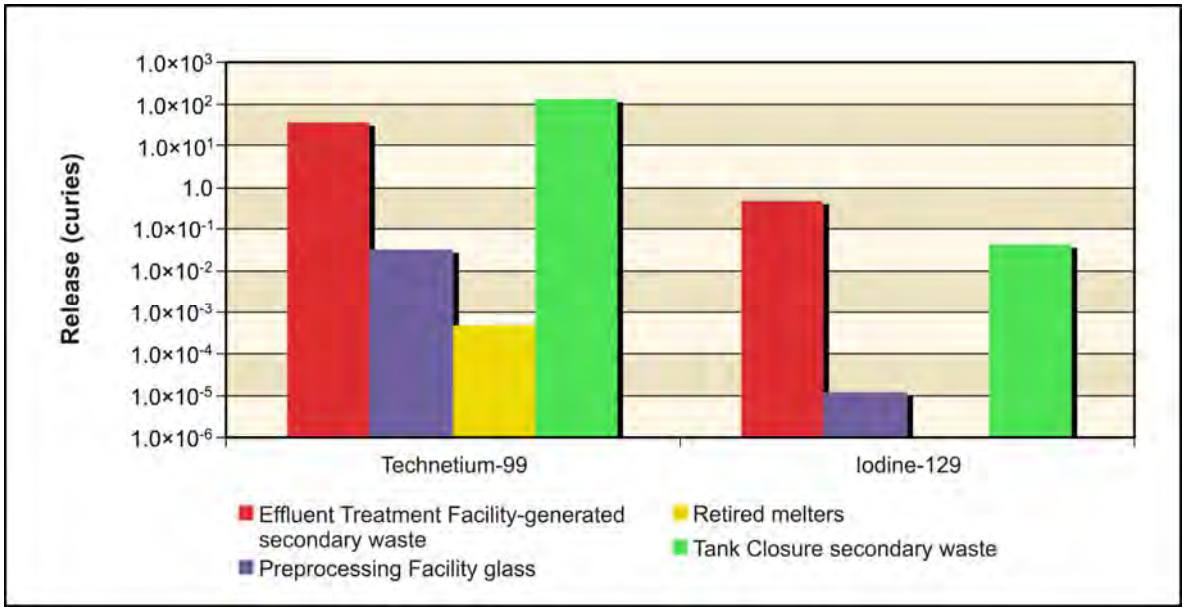


Figure 5–1105. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

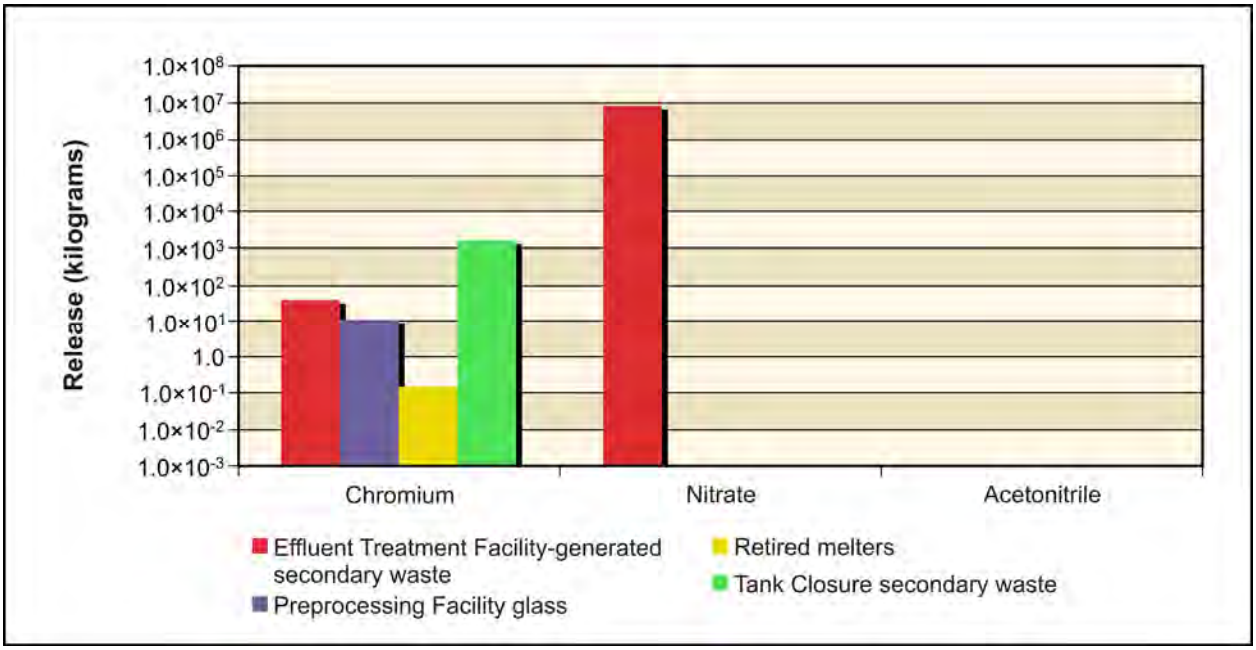


Figure 5–1106. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–1107 shows the release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–1108 the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. In all cases, between 90 and 100 percent of the amount released to groundwater reaches the Columbia River.

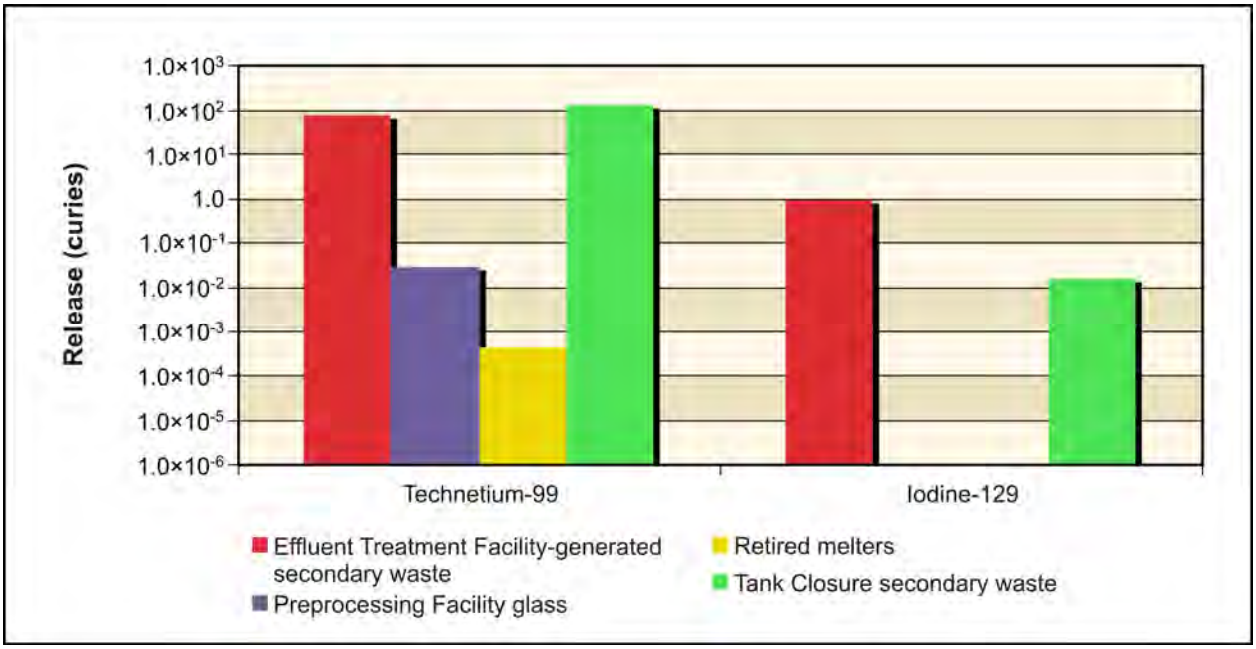


Figure 5–1107. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

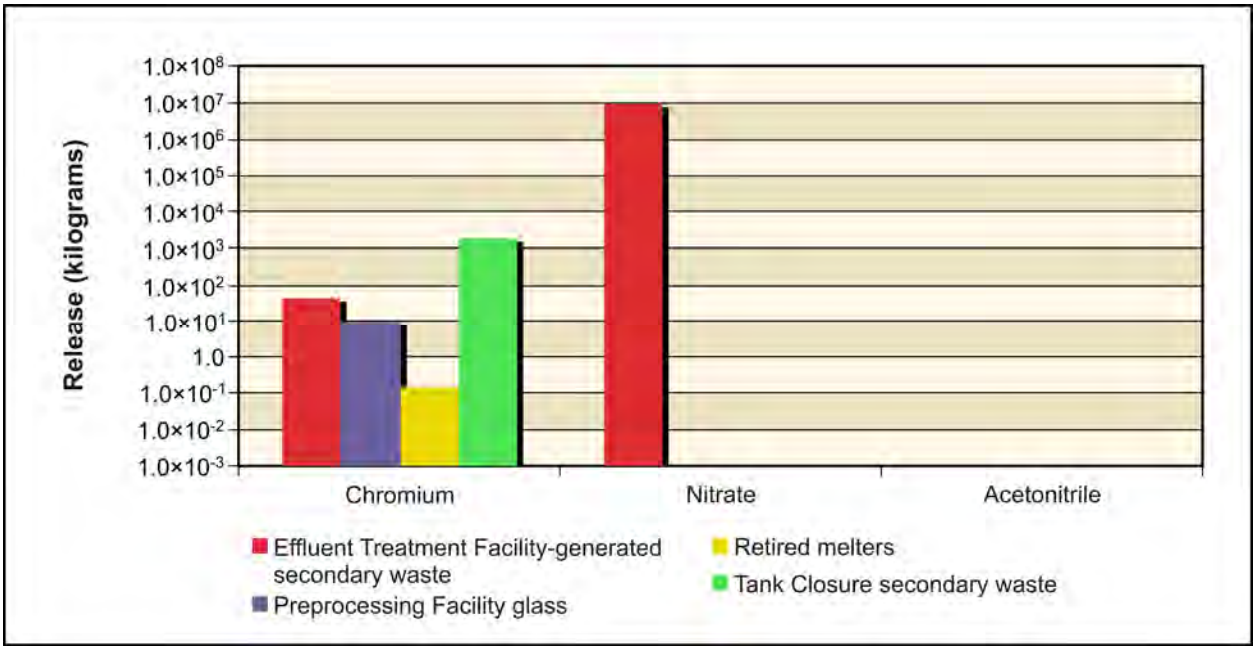


Figure 5–1108. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

200-West Area Integrated Disposal Facility

Figure 5–1109 shows the release at IDF-West to the vadose zone for the radiological risk drivers and Figure 5–1110, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, chromium, and nitrate are all present in IDF-West.

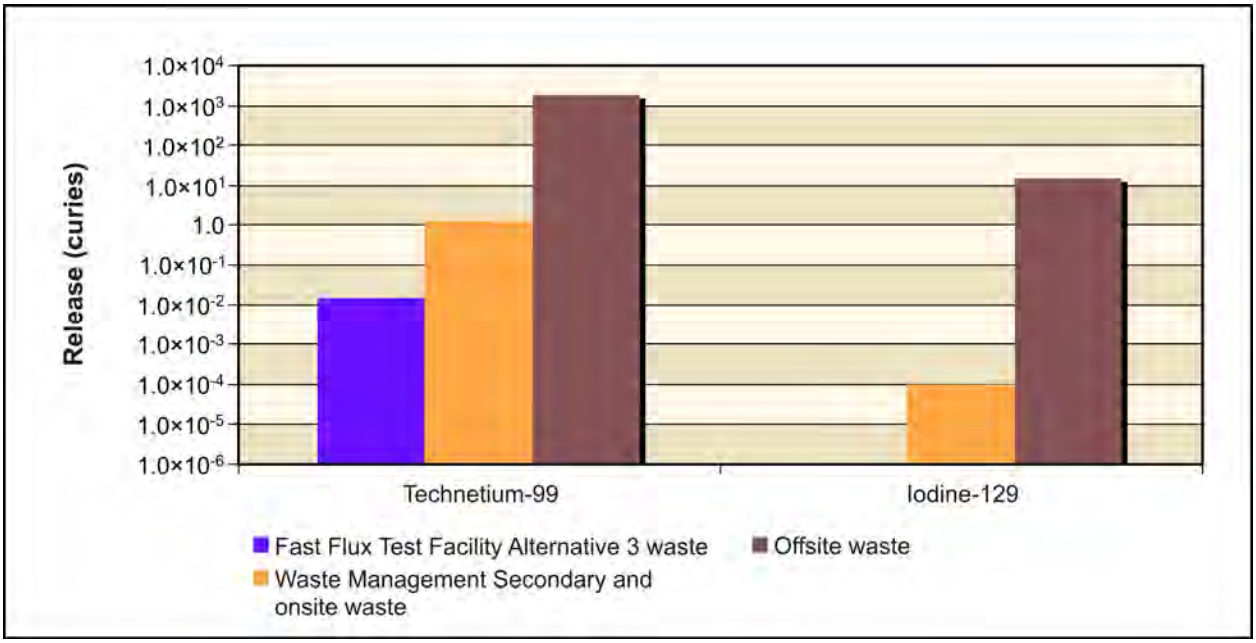


Figure 5–1109. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

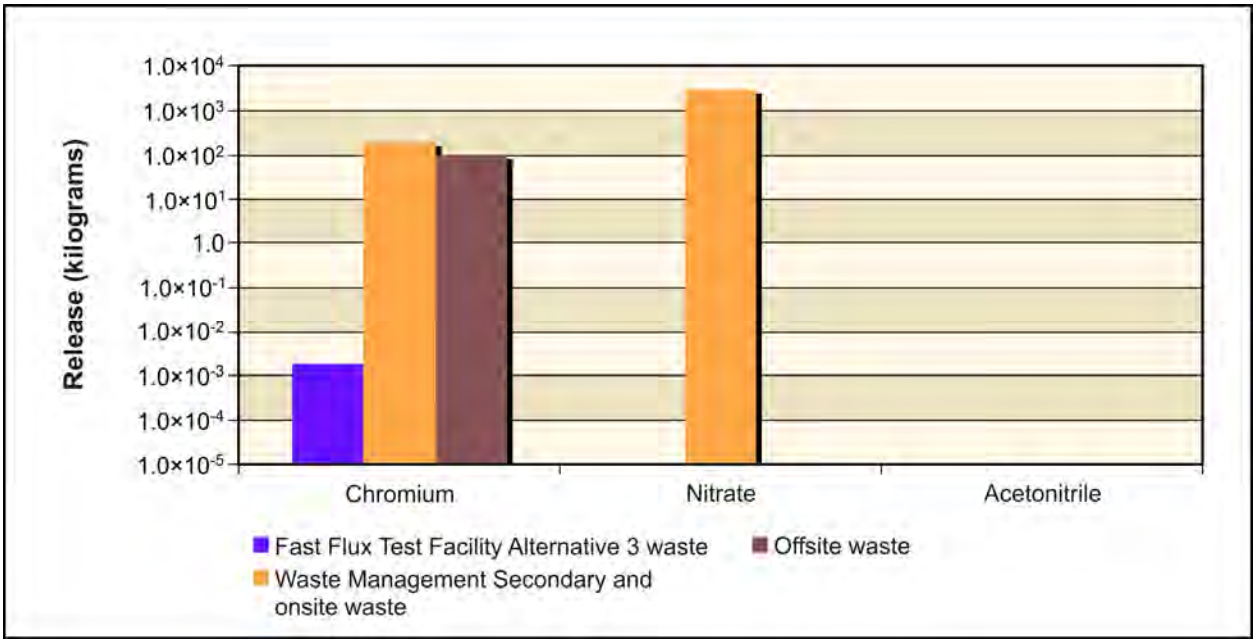


Figure 5–1110. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

Figure 5–1111 shows the release at IDF-West to groundwater for the radiological risk drivers and Figure 5–1112, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present in IDF-West behave as conservative tracers, with essentially all of the mass released to the vadose zone reaching groundwater.

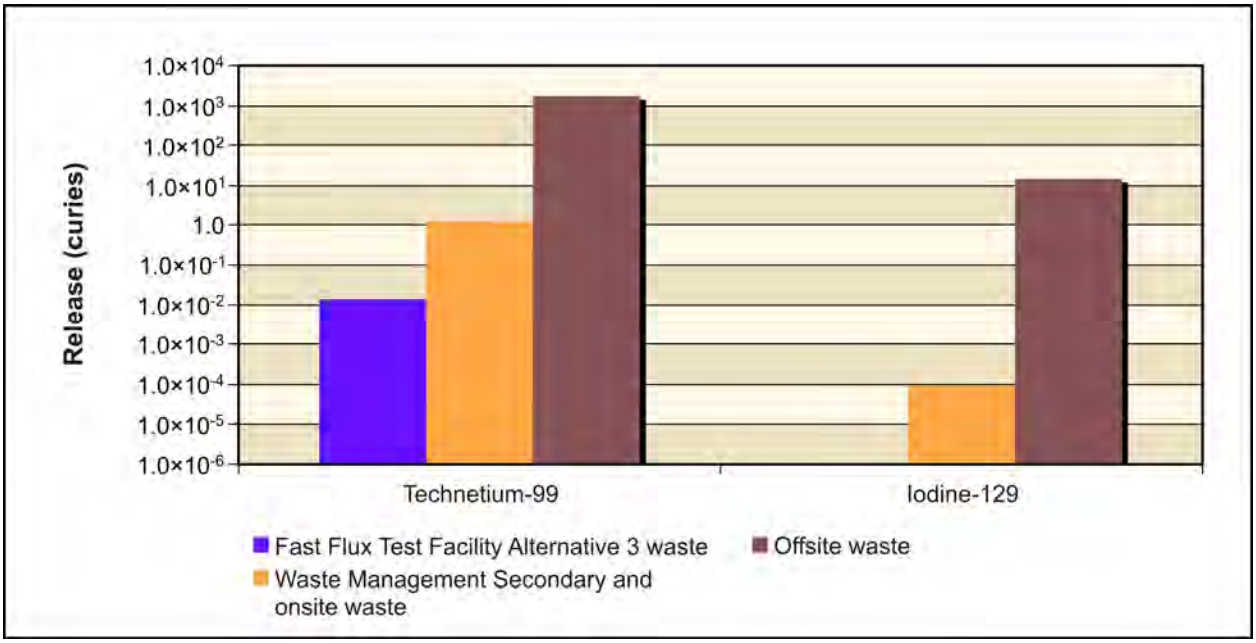


Figure 5–1111. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

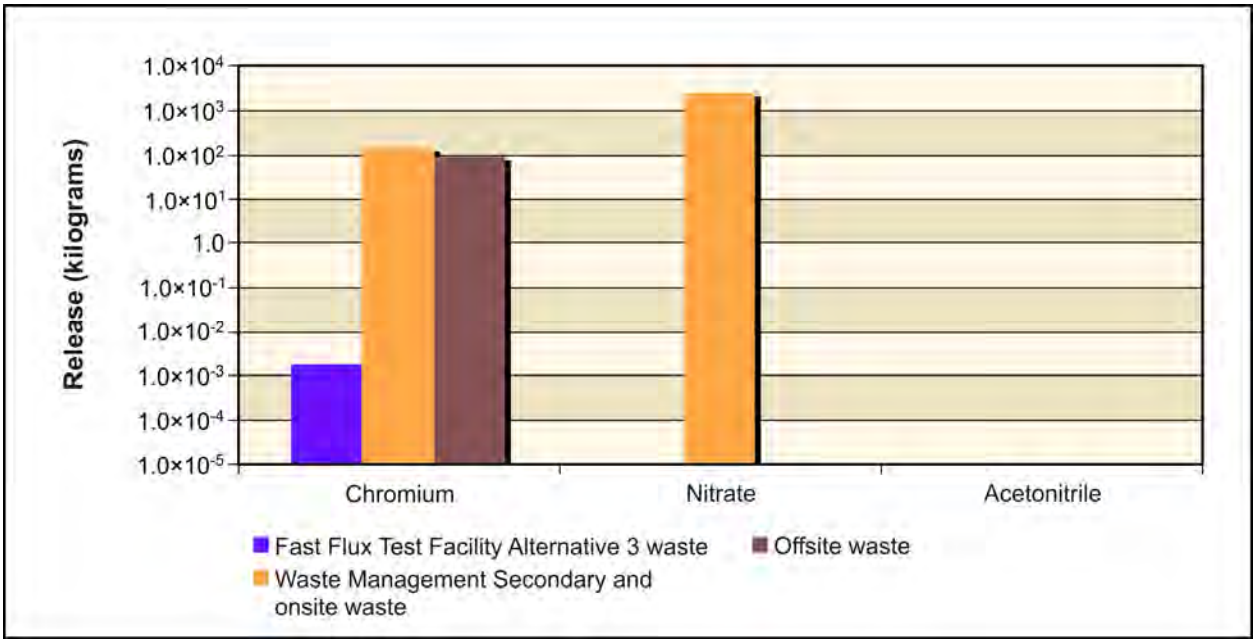


Figure 5–1112. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

Figure 5–1113 shows the release at IDF-West to the Columbia River for the radiological risk drivers and Figure 5–1114, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Essentially all of the COPC drivers released to groundwater reach the Columbia River.

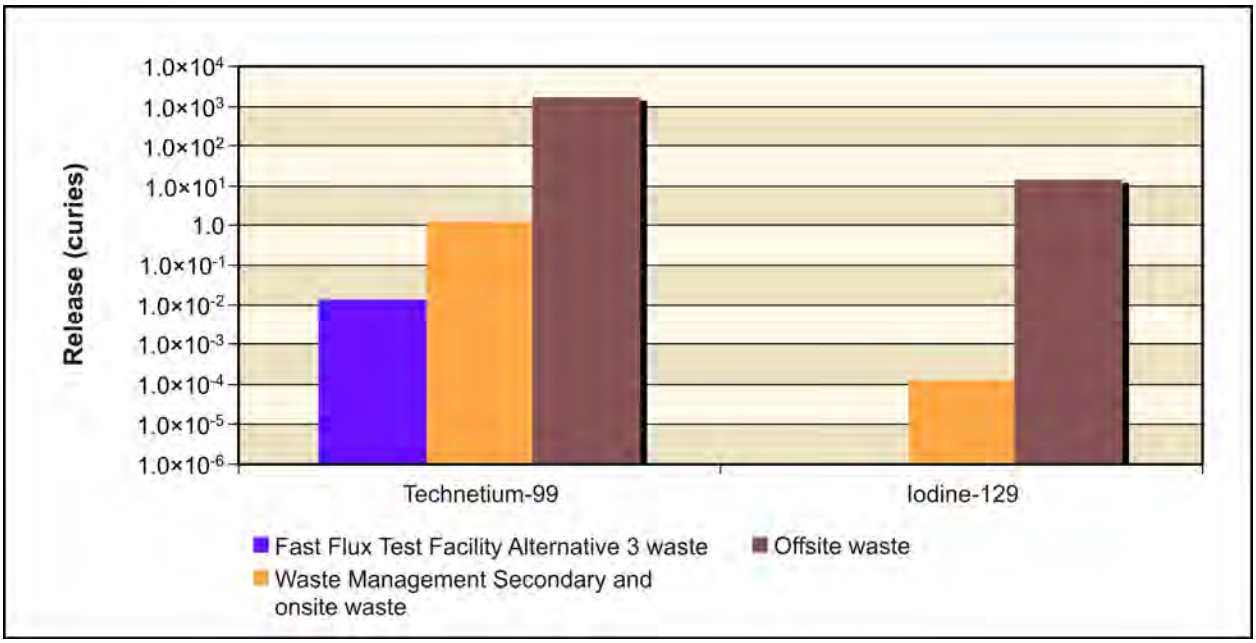


Figure 5–1113. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

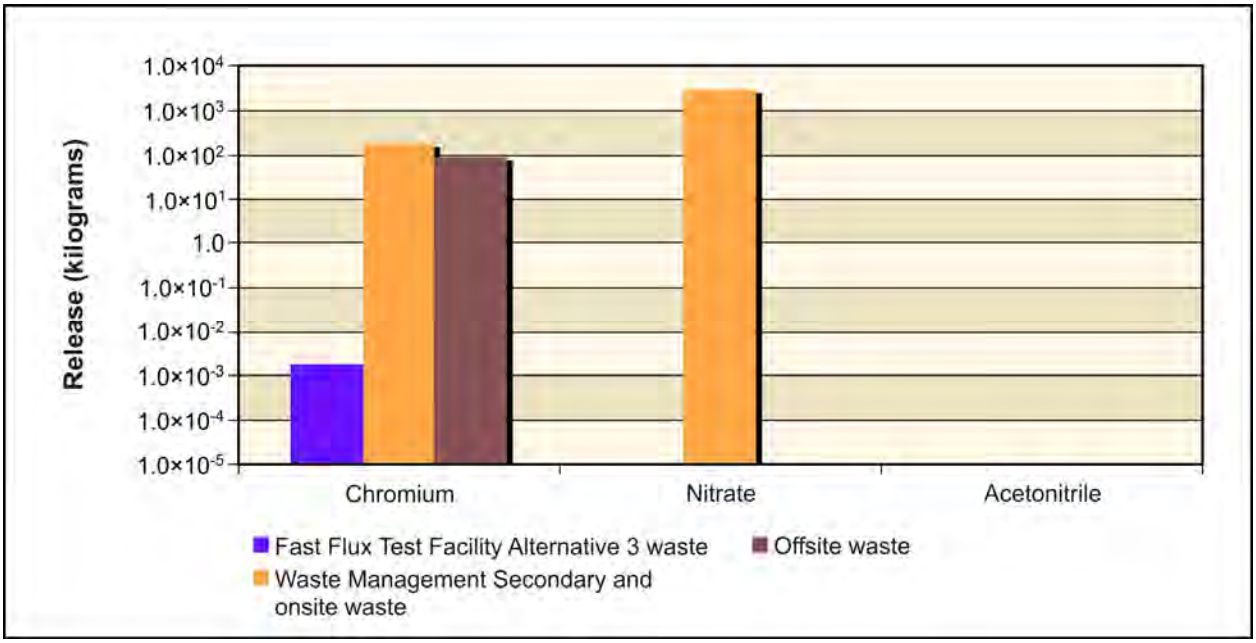


Figure 5–1114. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–1115 shows the release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–1116, the chemical hazard drivers. For all types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory was released during the period of analysis). Technetium-99, iodine-129, chromium, and nitrate are all present at the RPPDF.

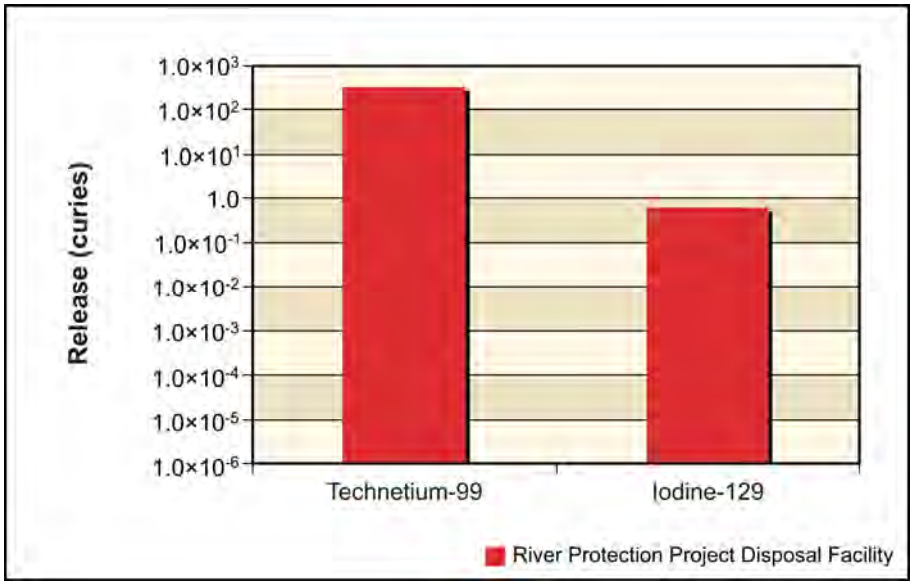


Figure 5–1115. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

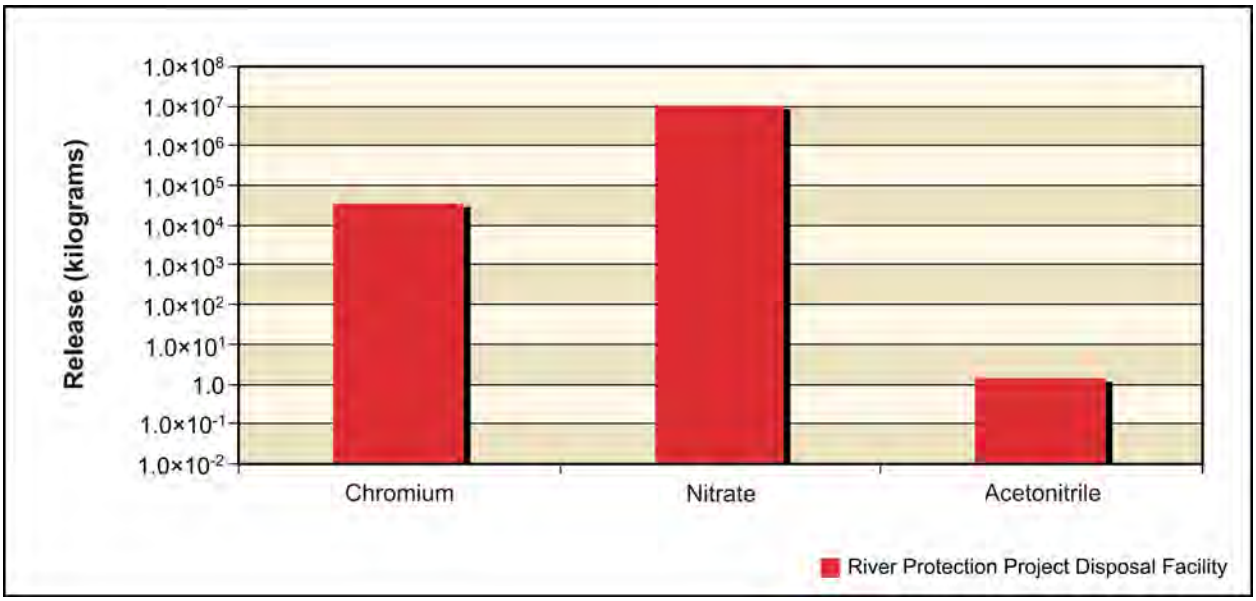


Figure 5–1116. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–1117 shows the release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–1118, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. All of the COPC drivers present at the RPPDF behave as conservative tracers, with essentially all of the mass released to the vadose zone reaching groundwater.

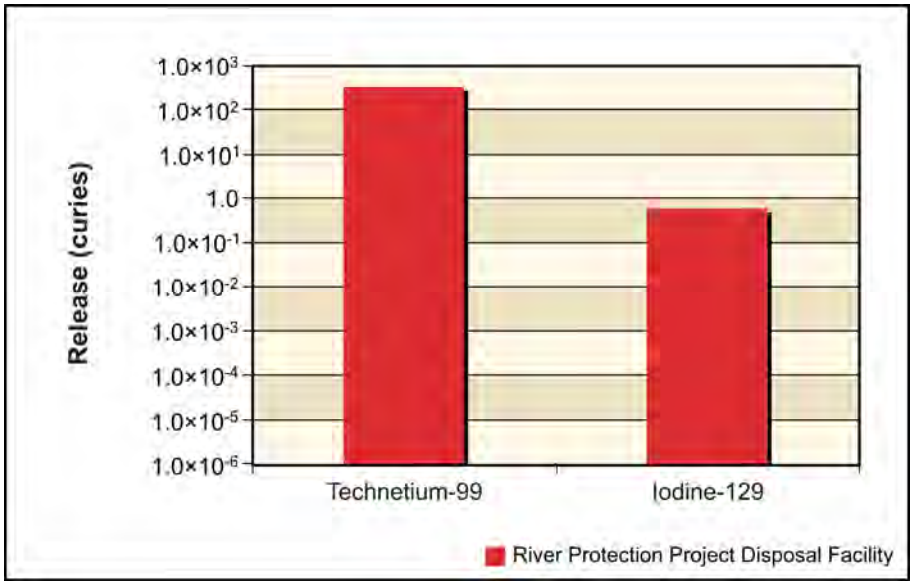


Figure 5–1117. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

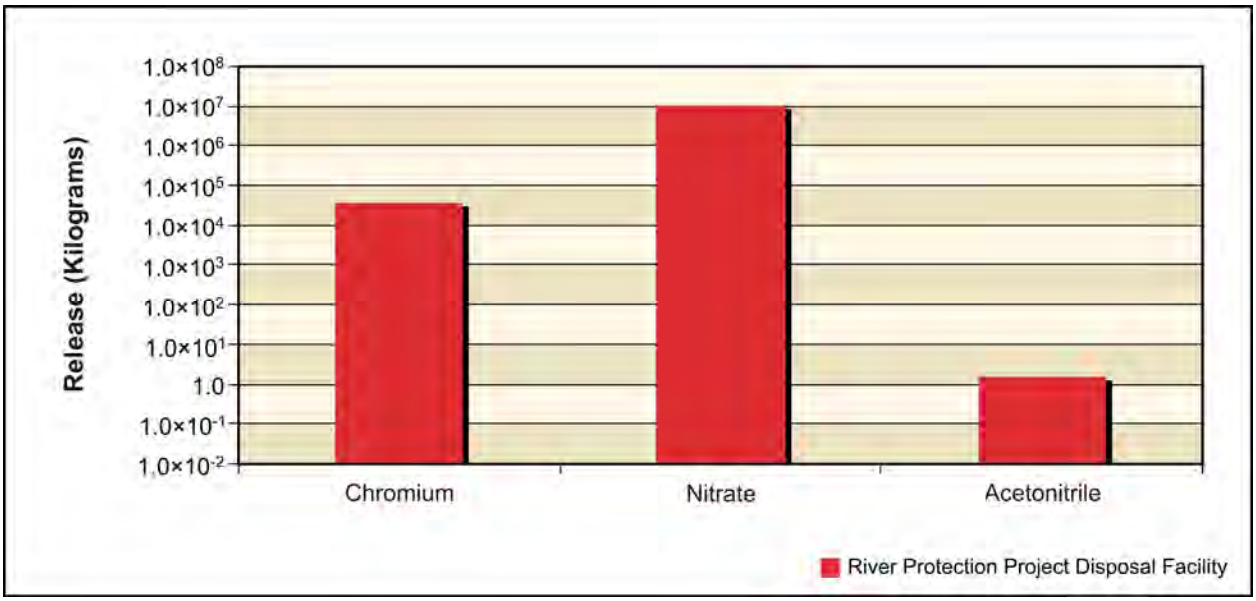


Figure 5–1118. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–1119 shows the release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–1120, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Essentially all of the COPC drivers released to groundwater reach the Columbia River.

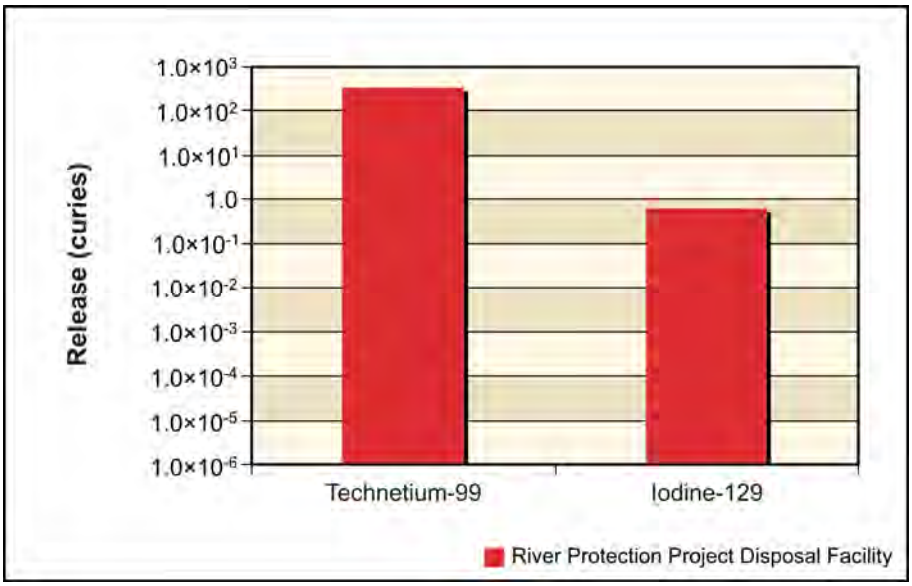


Figure 5–1119. Waste Management Alternative 3, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

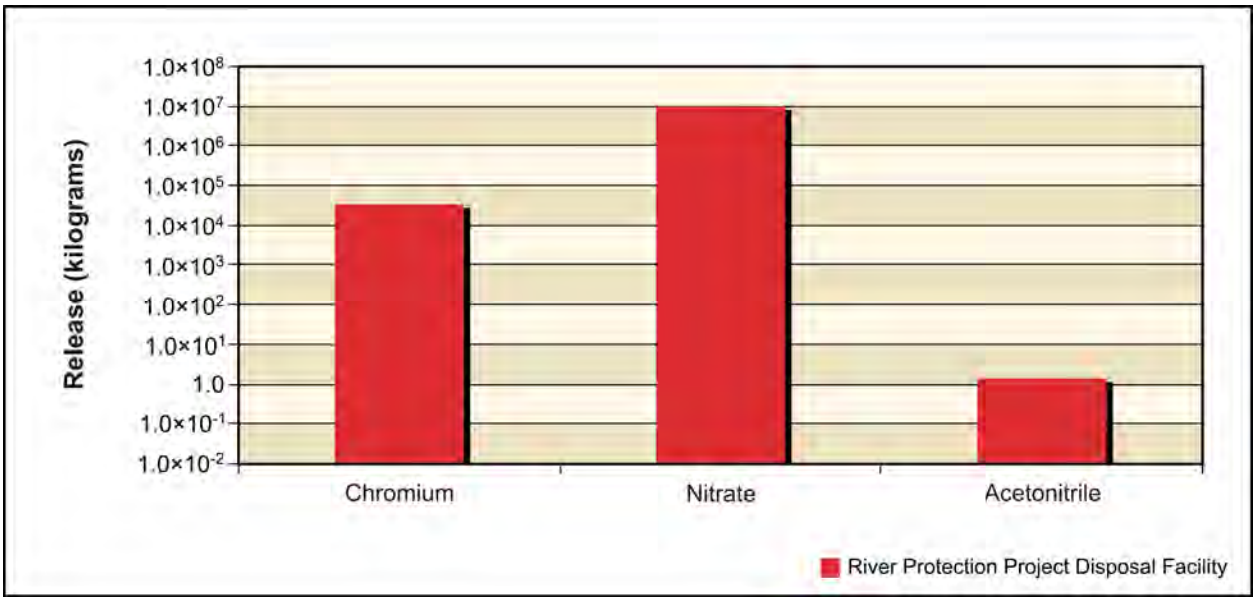


Figure 5–1120. Waste Management Alternative 3, Disposal Group 3, Option Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 3, Disposal Group 3, Option Case, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration of each radionuclide and chemical is also shown. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval is likely (95 percent of the time) to be at or below this value. The confidence interval is basically a statistical aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration's trend was level, and the concentrations were near the benchmark. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figures 5–1121 through 5–1124 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). For technetium-99, concentrations at the Core Zone Boundary rise early in the simulation, reaching a peak around CY 3940 at about an order of magnitude above the benchmark concentration. Concentrations then slowly decline to nearly an order of magnitude below the benchmark. Iodine-129 follows a similar pattern, with concentrations falling slightly below the benchmark after peaking at nearly two orders of magnitude above the benchmark. Chromium and nitrate follow a similar pattern, with an early peak in concentrations at the Core Zone Boundary followed by a slow decline. Both chromium and nitrate concentrations (at the Core Zone Boundary) approach within one order of magnitude of the benchmark concentration for most of the analysis period. Note that the actual time periods of exceedance associated with the peak values (listed in Table 5–100) are extremely limited, and that the 95th percentile upper confidence limit on chromium concentrations is an order of magnitude below the benchmark concentrations. Table 5–100 shows the maximum concentrations in groundwater.

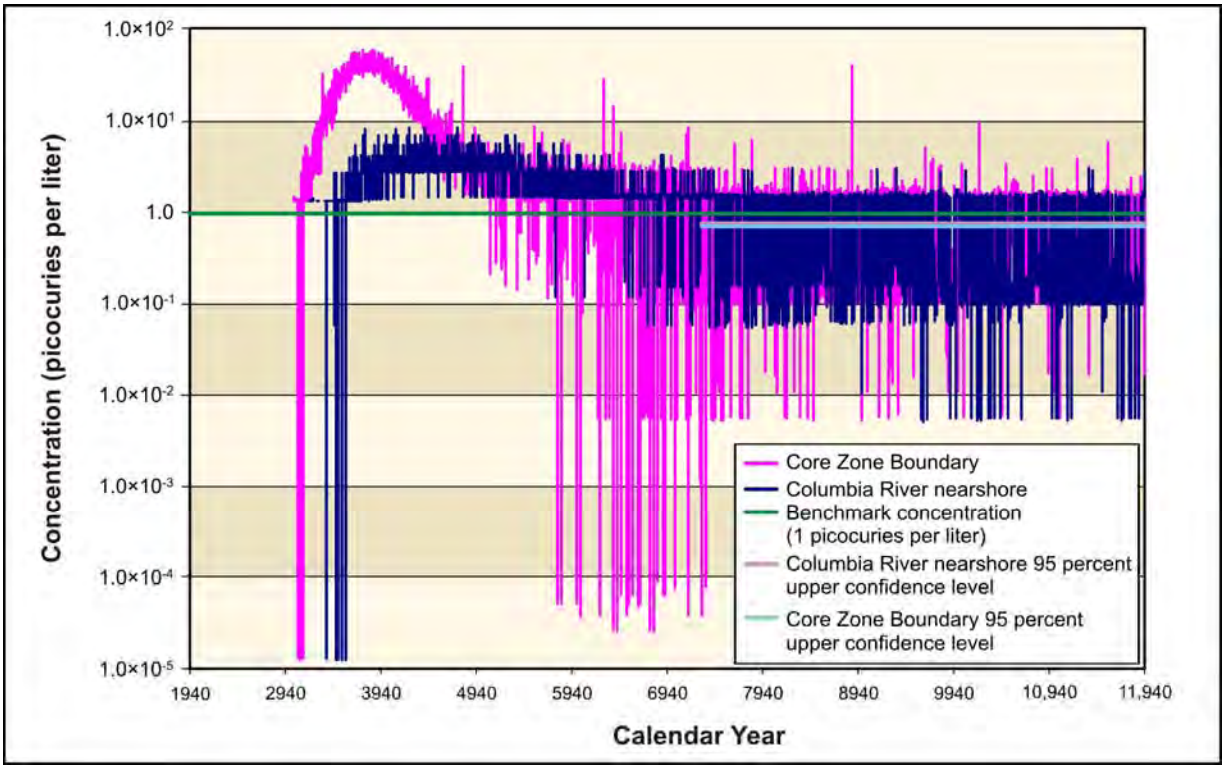


Figure 5–1121. Waste Management Alternative 3, Disposal Group 3, Option Case, Iodine-129 Concentration Versus Time

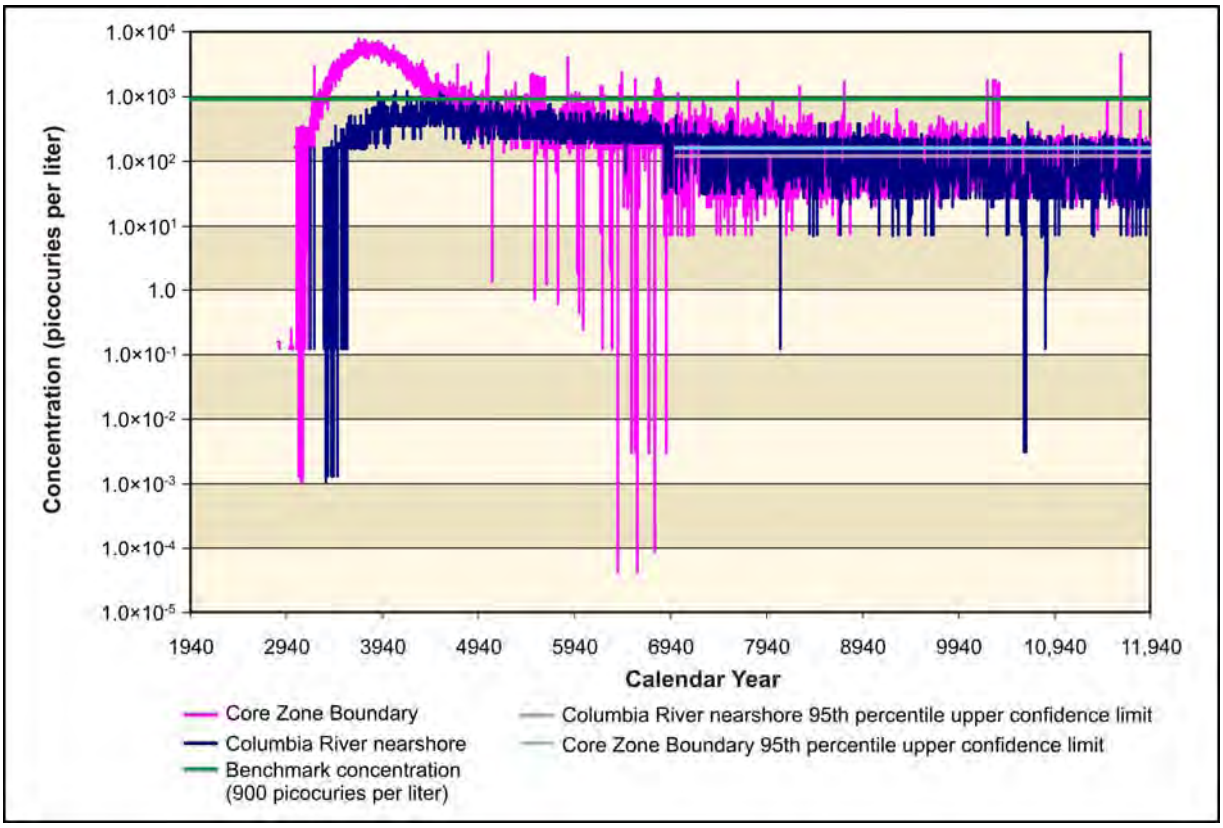


Figure 5–1122. Waste Management Alternative 3, Disposal Group 3, Option Case, Technetium-99 Concentration Versus Time

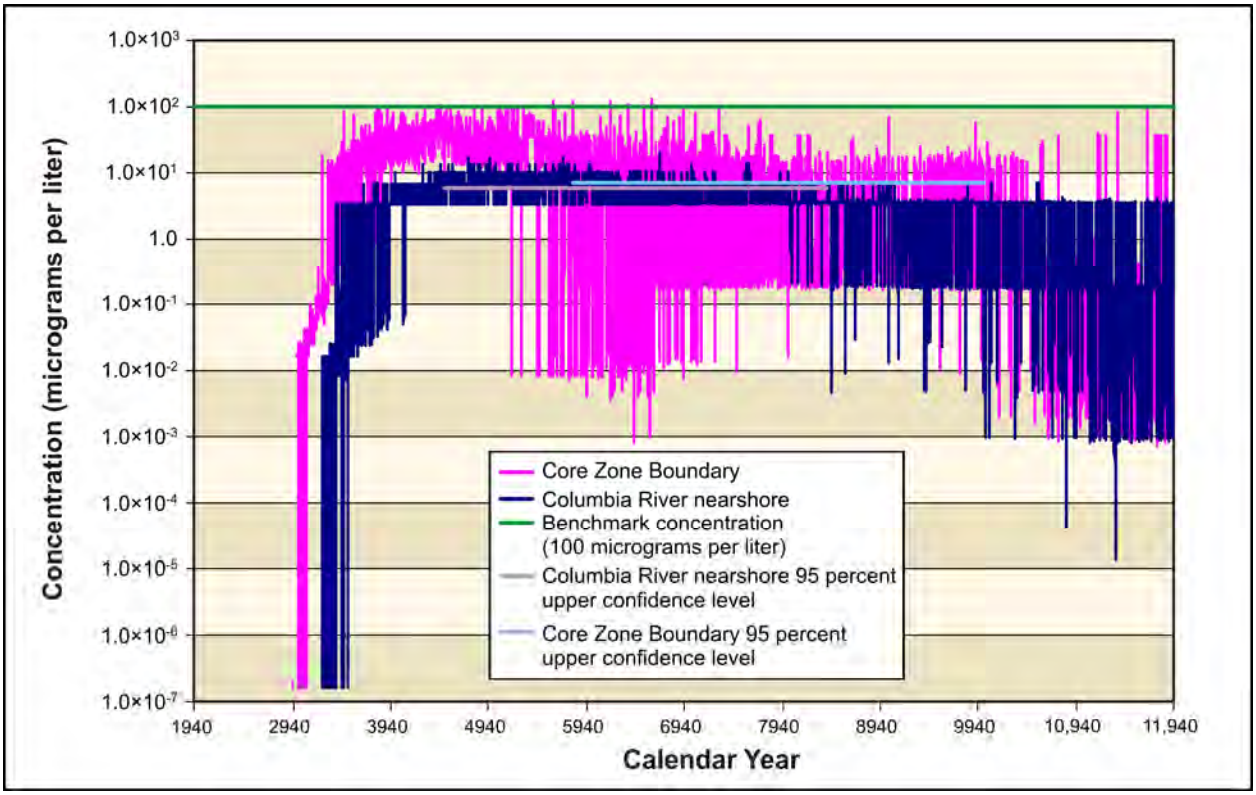


Figure 5–1123. Waste Management Alternative 3, Disposal Group 3, Option Case, Chromium Concentration Versus Time

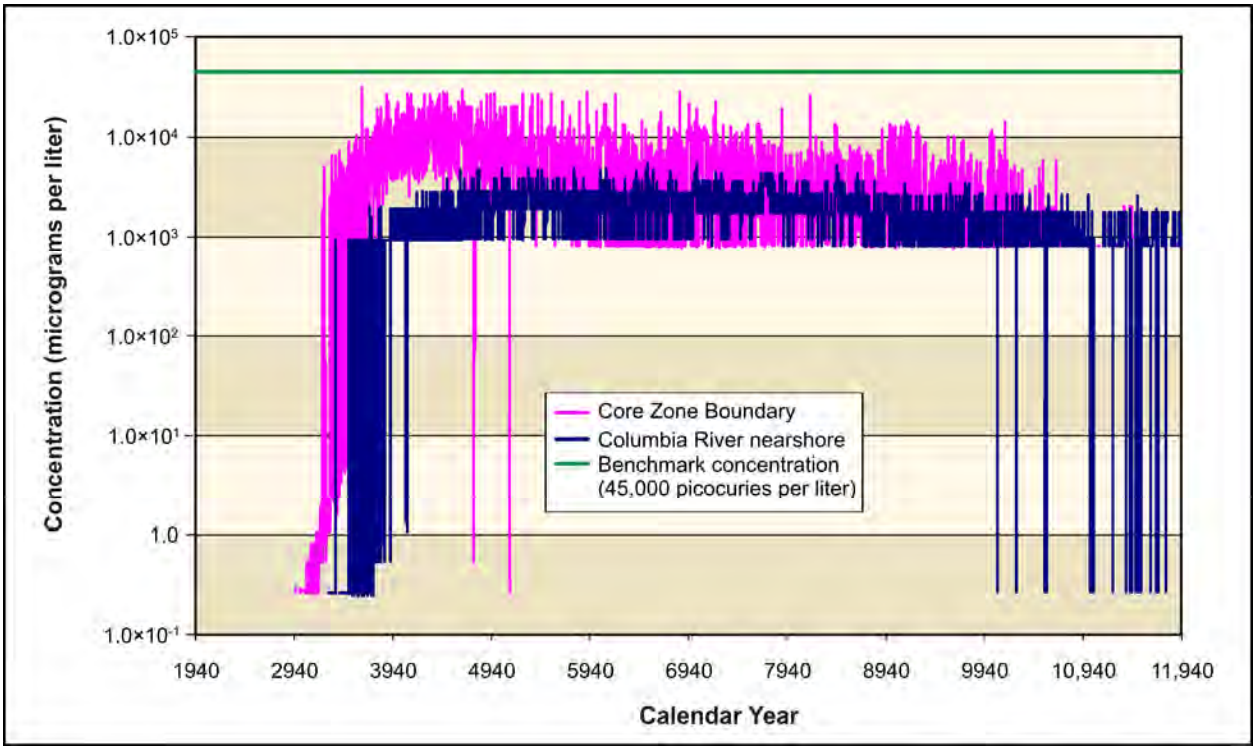


Figure 5–1124. Waste Management Alternative 3, Disposal Group 3, Option Case, Nitrate Concentration Versus Time

Table 5–100. Waste Management Alternative 3, Disposal Group 3, Option Case, Maximum COPC Concentrations in the Peak Year at IDF-East, IDF-West, the RPPDF, the Core Zone Boundary, and the Columbia River Nearshore

Contaminant	IDF-East	IDF-West	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter						
Technetium-99	389	**20,200**	386	**7,940**	**1,220**	900
	(9324)	(3713)	(4013)	(3690)	(4066)	
Iodine-129	**2**	**173**	0.6	**61**	**8**	1
	(11,096)	(3797)	(4172)	(3853)	(4728)	
Chemical in micrograms per liter						
Chromium	3	2	36	**125**	20	100
	(8037)	(3696)	(3878)	(6610)	(6701)	
Fluoride	0	1	0	1	0	4,000
	(1940)	(3684)	(1940)	(3907)	(4555)	
Nitrate	16,600	17	10,300	30,200	5,620	45,000
	(7367)	(3703)	(4544)	(4627)	(6522)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–1125 and 5–1126 show concentration versus time for uranium-238 and total uranium. Because of the high retardation of uranium, no contamination appears until CY 8940, when uranium-238 concentrations at the Core Zone Boundary first surpass 1.0×10^{-8} micrograms per liter. Uranium-238 remains three orders of magnitude below the benchmark throughout the simulation. Total uranium remains over seven orders of magnitude below the benchmark concentration at the Core Zone Boundary throughout the simulation.

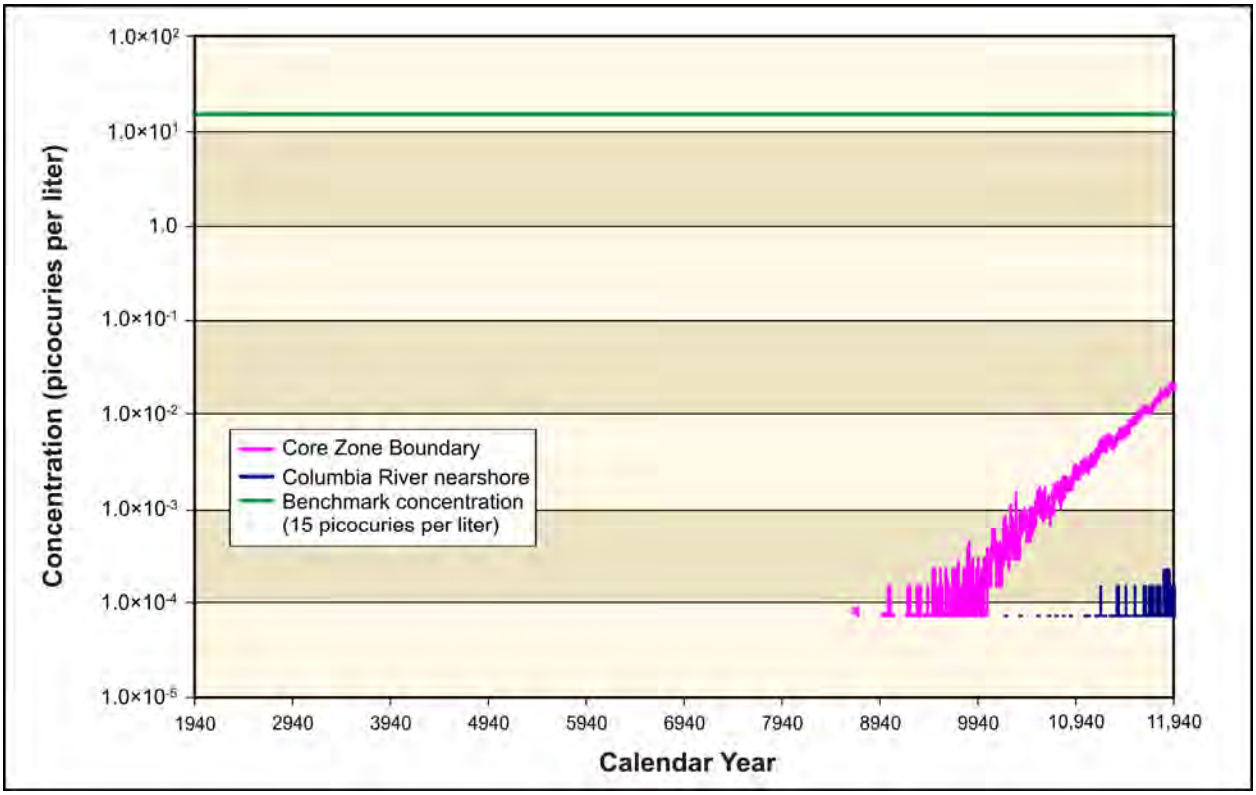


Figure 5–1125. Waste Management Alternative 3, Disposal Group 3, Option Case, Uranium-238 Concentration Versus Time

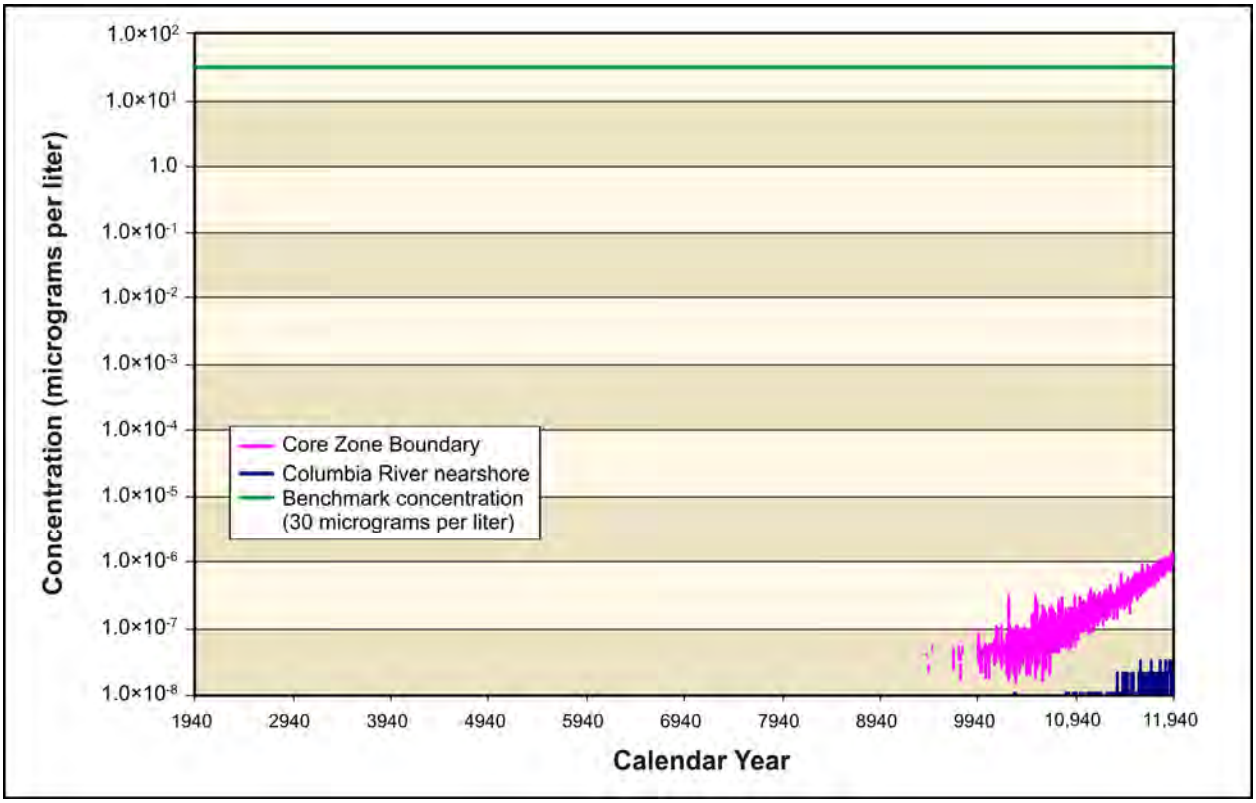
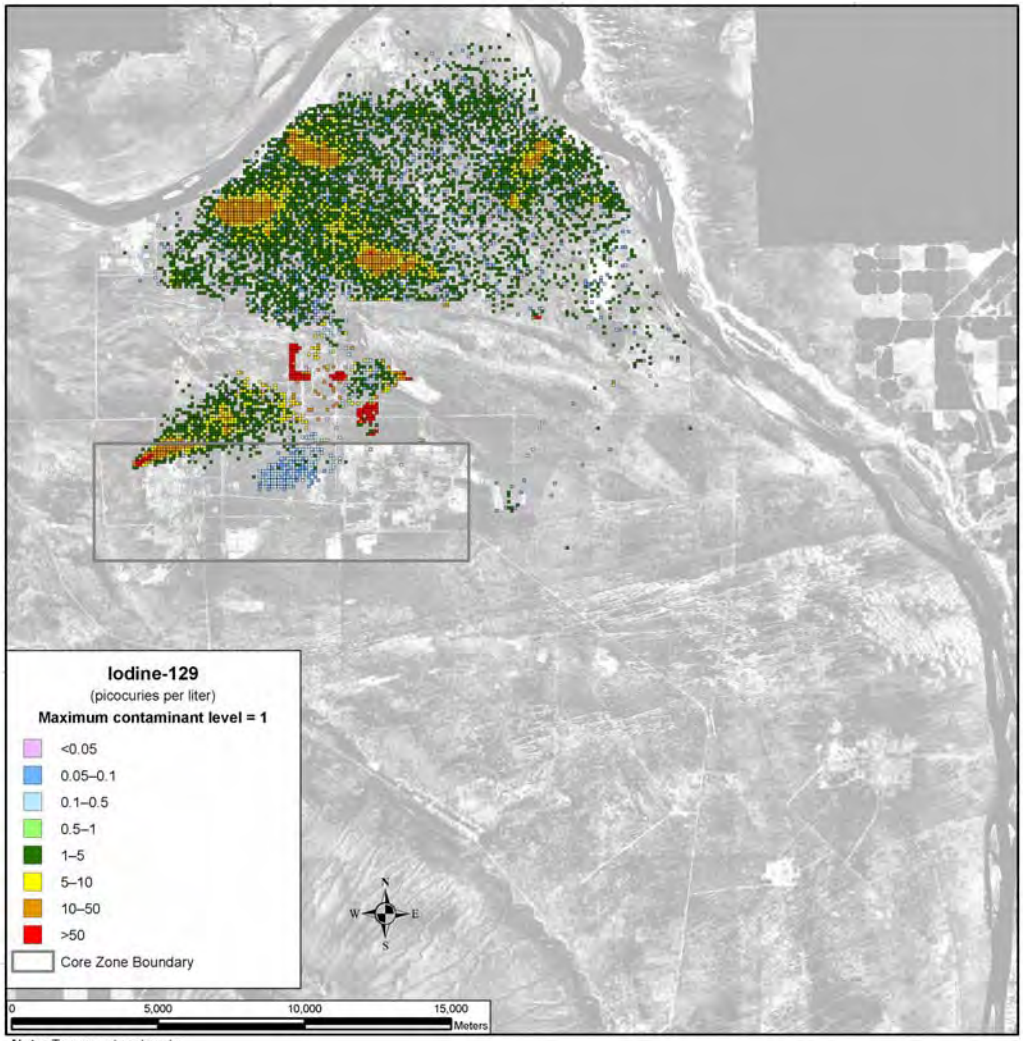


Figure 5–1126. Waste Management Alternative 3, Disposal Group 3, Option Case, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

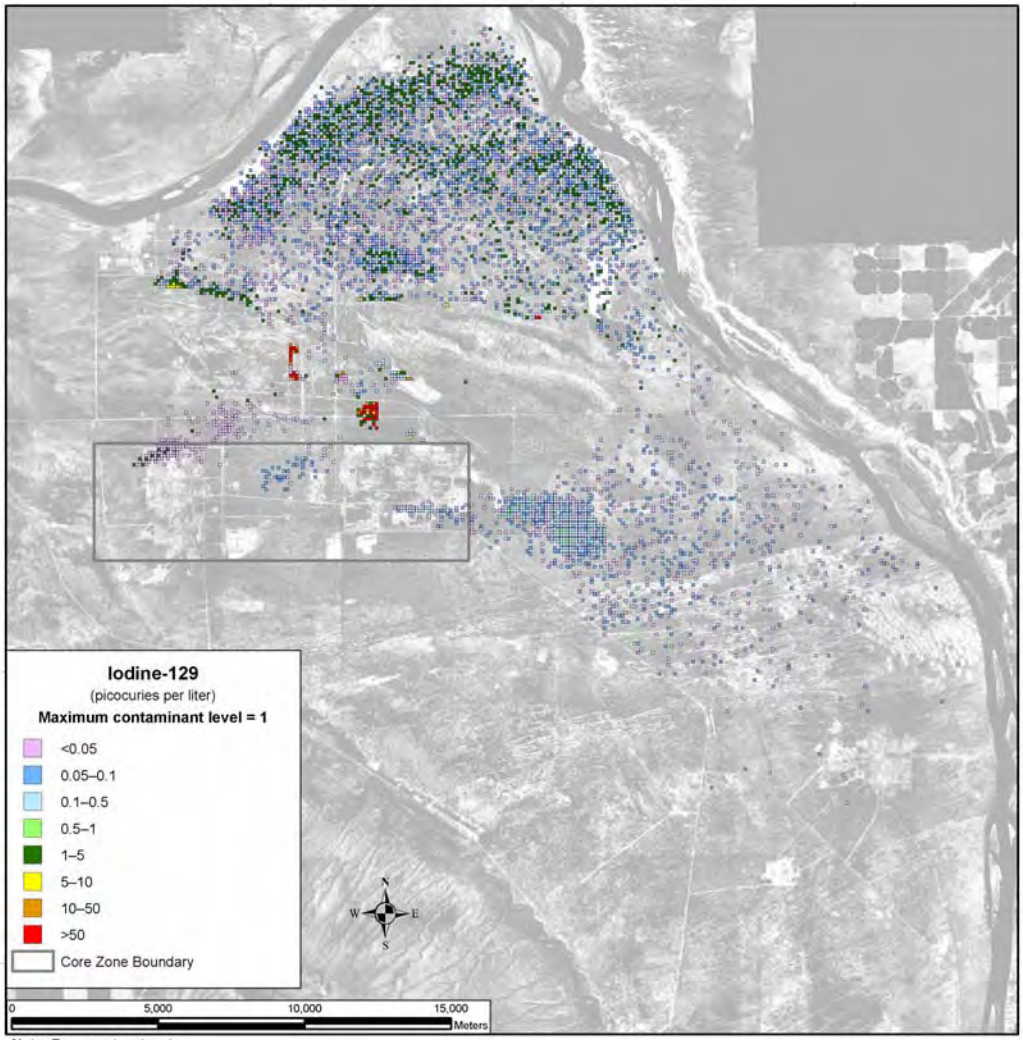
This section presents the impacts of Waste Management Alternative 3, Disposal Group 3, Option Case, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale indicative of the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration; concentrations below the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

At CY 3890 (see Figure 5–1127), there is a high-concentration plume of iodine-129 stretching northeast of IDF-West, and a low-concentration plume stretching north from the RPPDF through Gable Gap. Four separate high-concentration areas have also formed north of Gable Mountain and Gable Butte. By CY 7140 (see Figure 5–1128), the plumes from IDF-West and the RPPDF have dissipated, but a new plume has formed, traveling east from IDF-East. Figure 5–1129 shows the spatial distribution of groundwater concentration for iodine-129 during CY 11,885. Concentrations in this plume remain close to the benchmark. Technetium-99 (see Figures 5–1130 through 5–1132) shows a similar spatial distribution, but has lower concentrations. Chromium and nitrate (see Figures 5–1133 through 5–1135 and Figures 5–1136 through 5–1138) show similar spatial distributions at selected times, but have concentrations consistently well below the benchmark. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., they move at the pore water velocity).



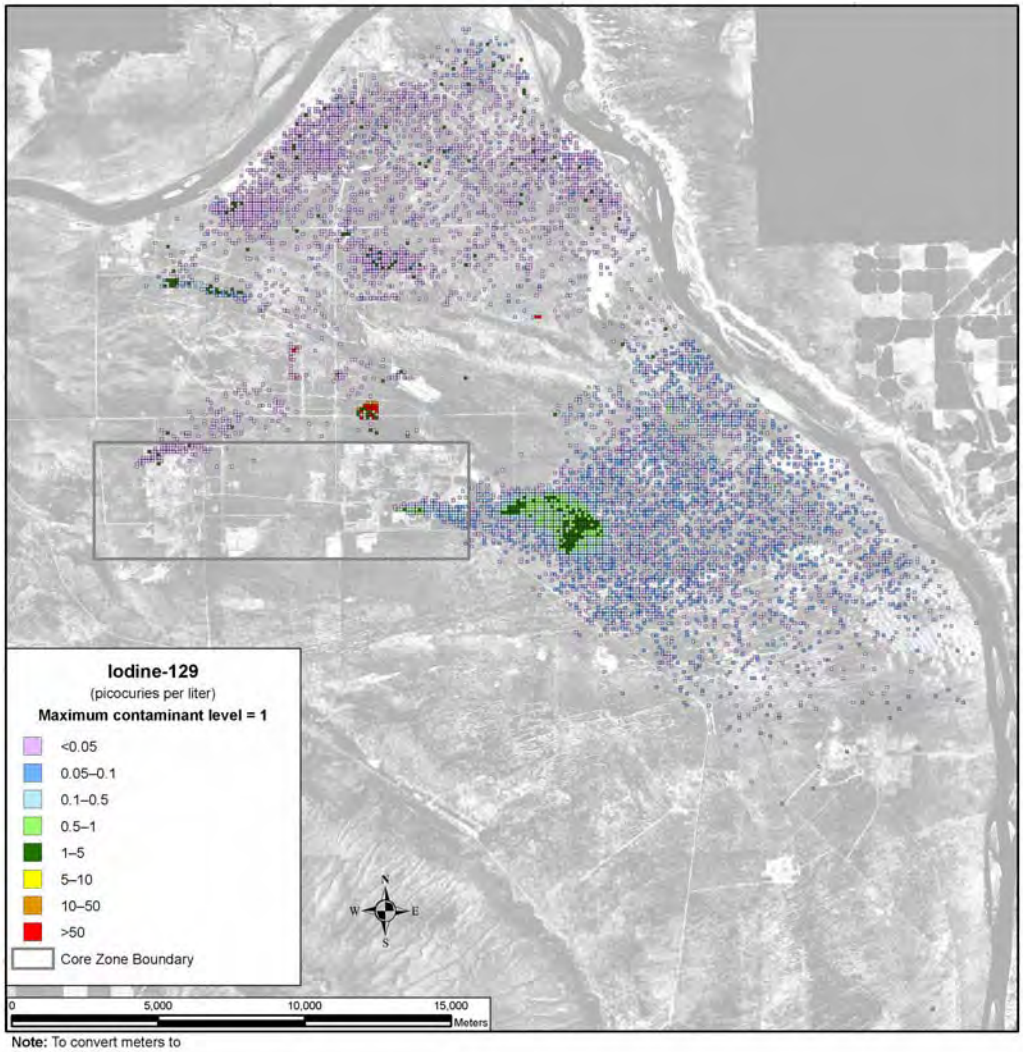
Note: To convert meters to feet, multiply by 3.281

Figure 5–1127. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



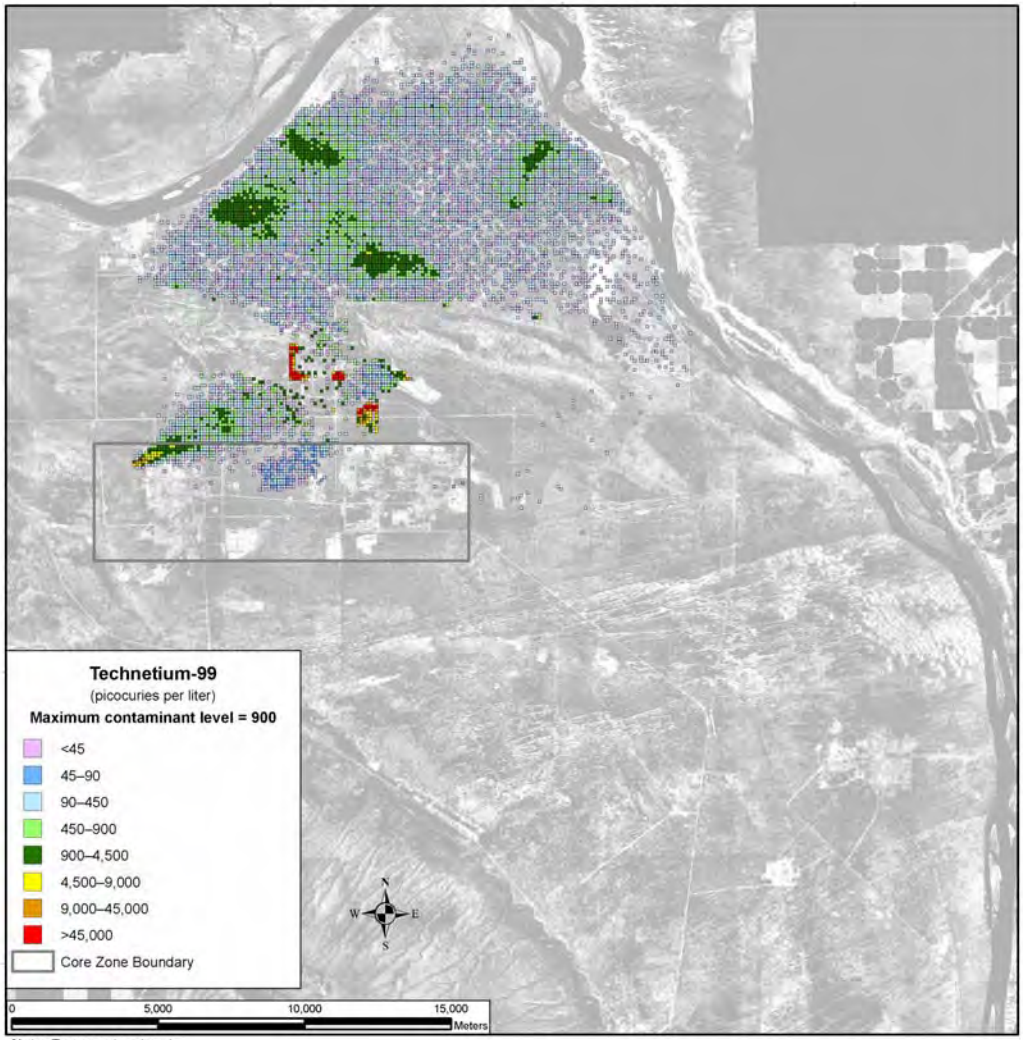
Note: To convert meters to feet, multiply by 3.281

Figure 5–1128. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



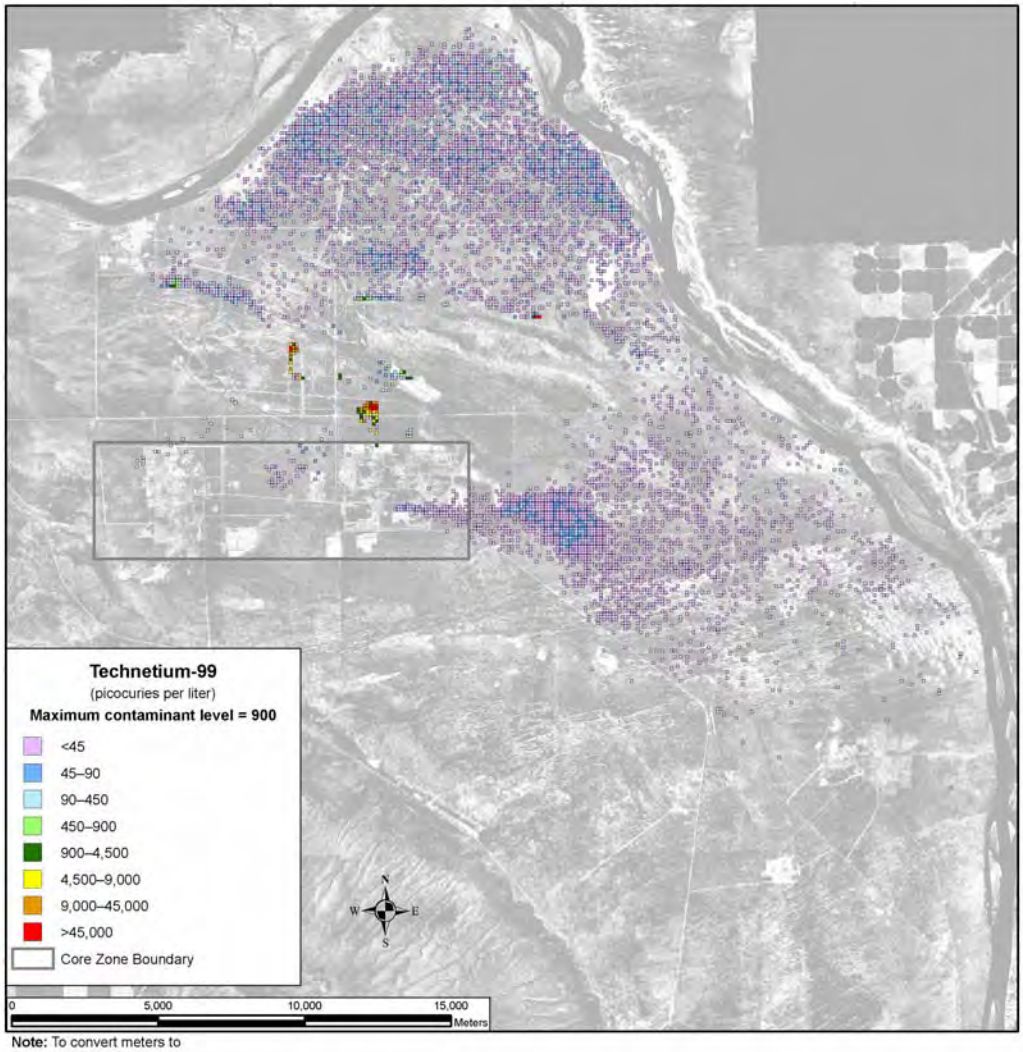
Note: To convert meters to feet, multiply by 3.281

Figure 5–1129. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



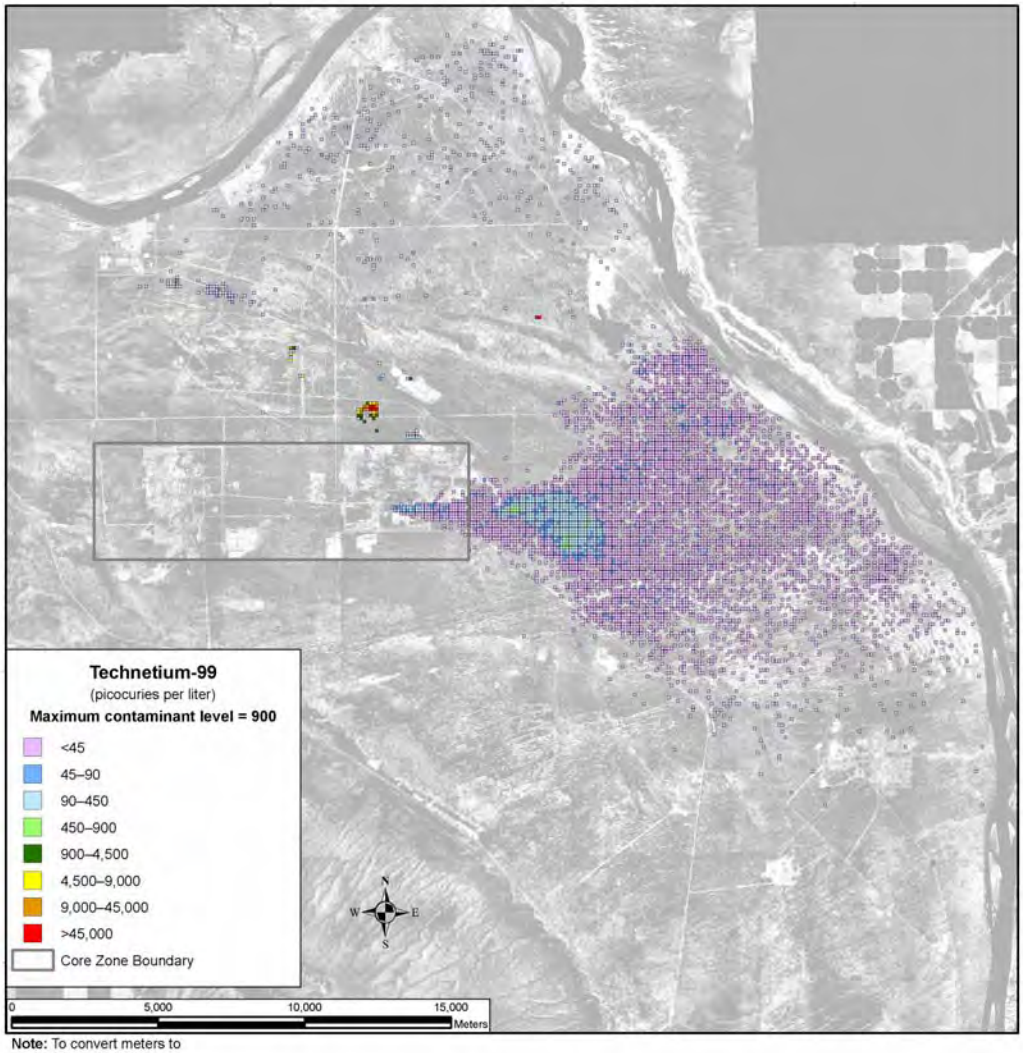
Note: To convert meters to feet, multiply by 3.281

Figure 5–1130. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



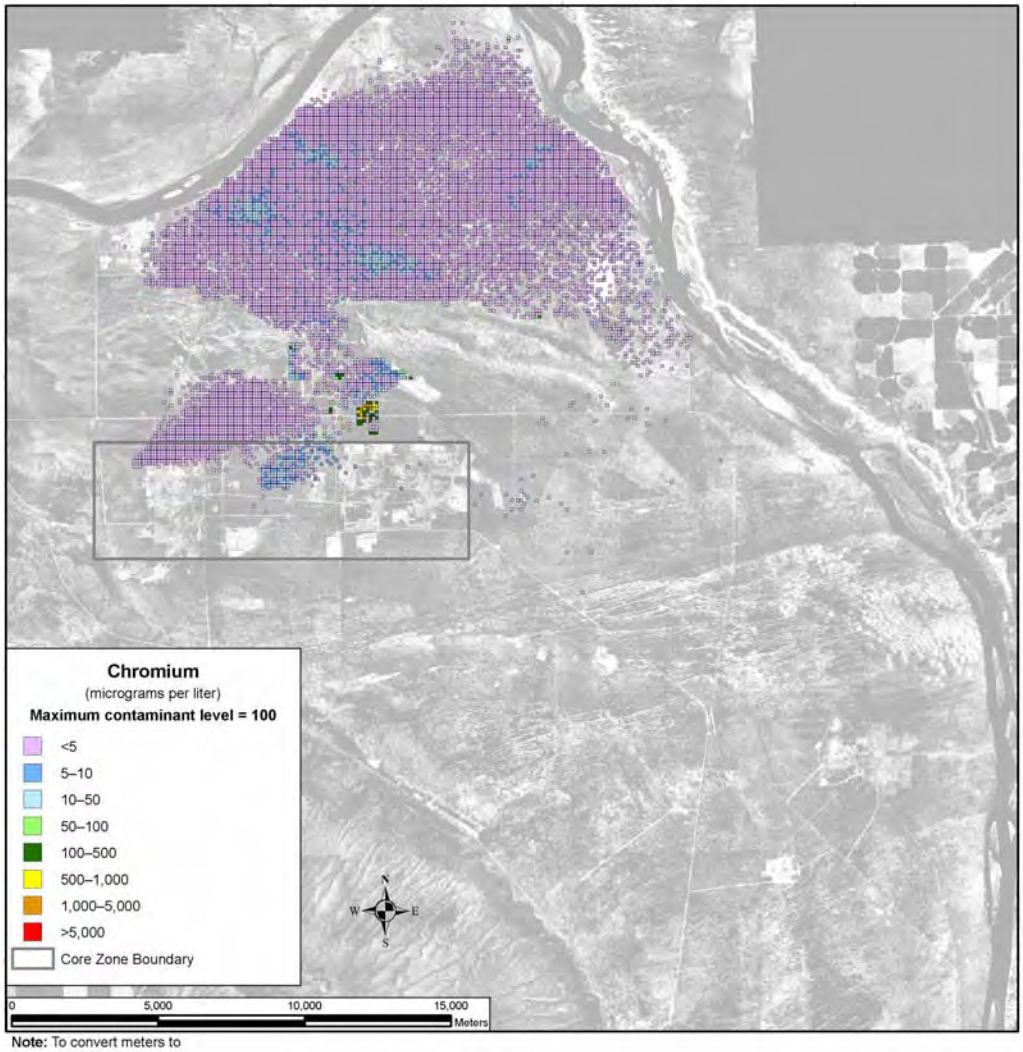
Note: To convert meters to feet, multiply by 3.281

Figure 5–1131. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



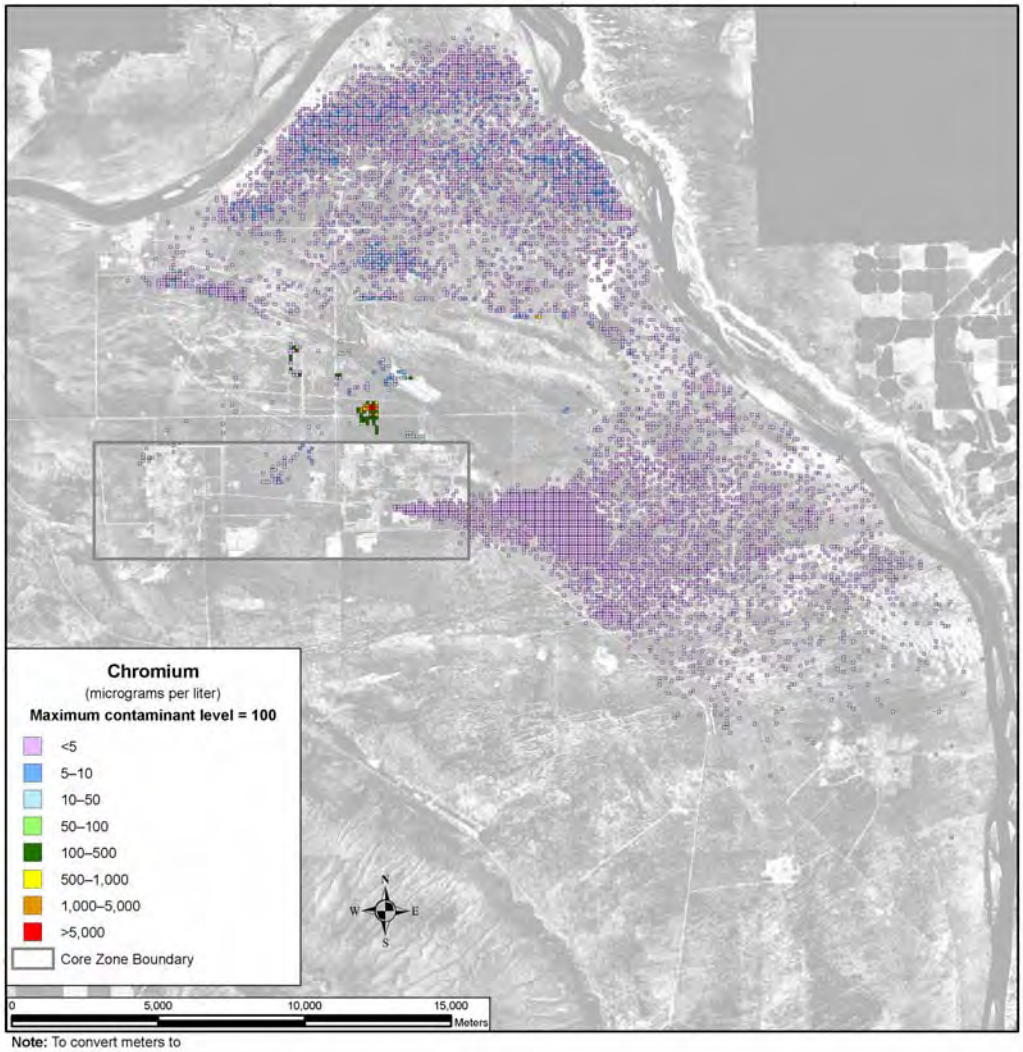
Note: To convert meters to feet, multiply by 3.281

Figure 5–1132. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



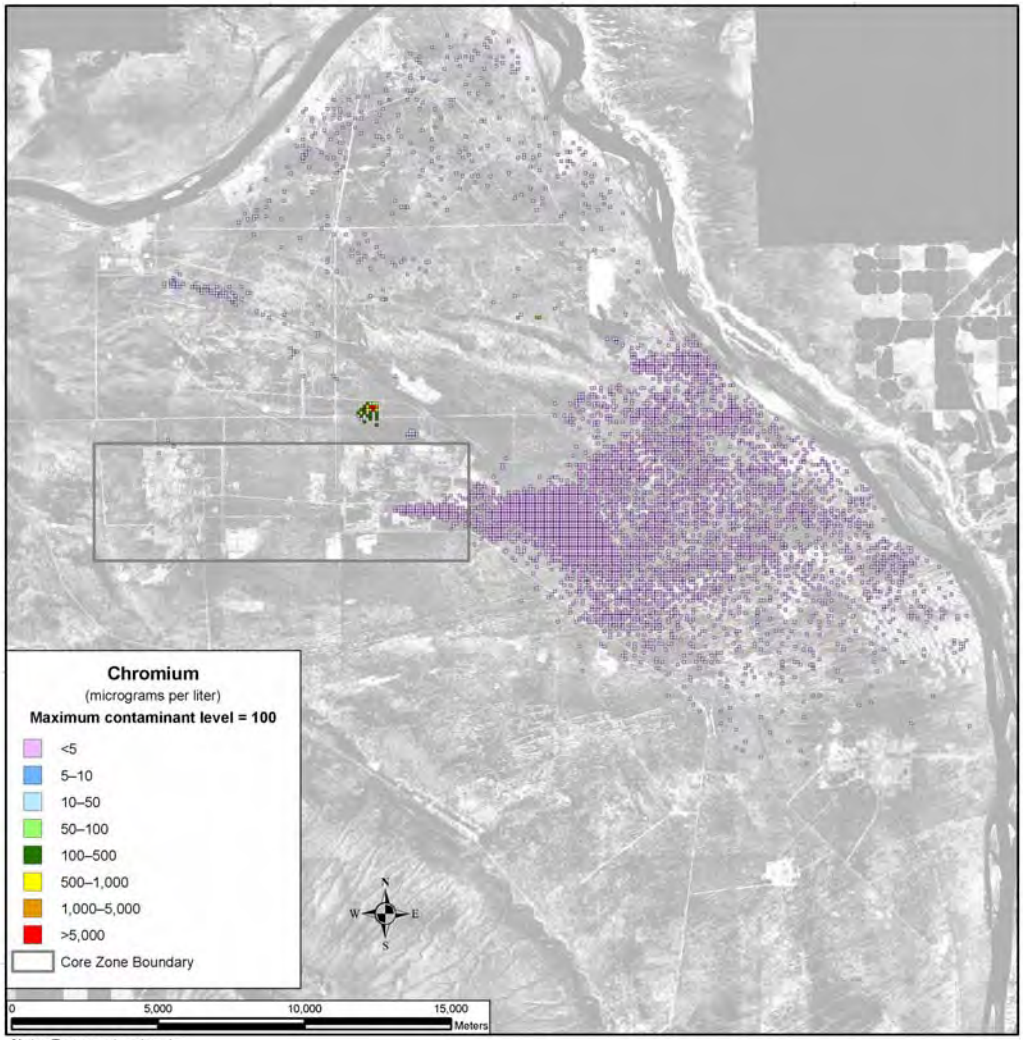
Note: To convert meters to feet, multiply by 3.281

Figure 5–1133. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



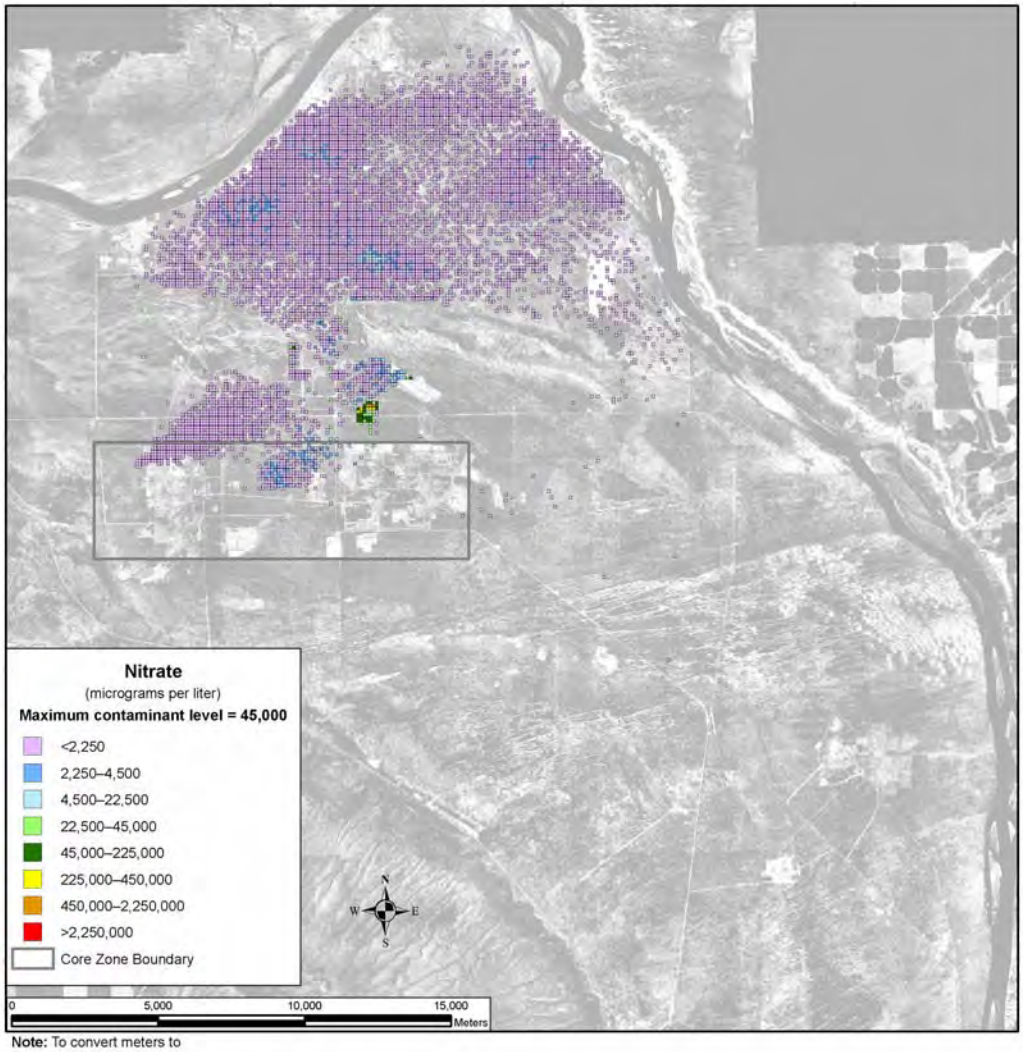
Note: To convert meters to feet, multiply by 3.281

Figure 5–1134. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



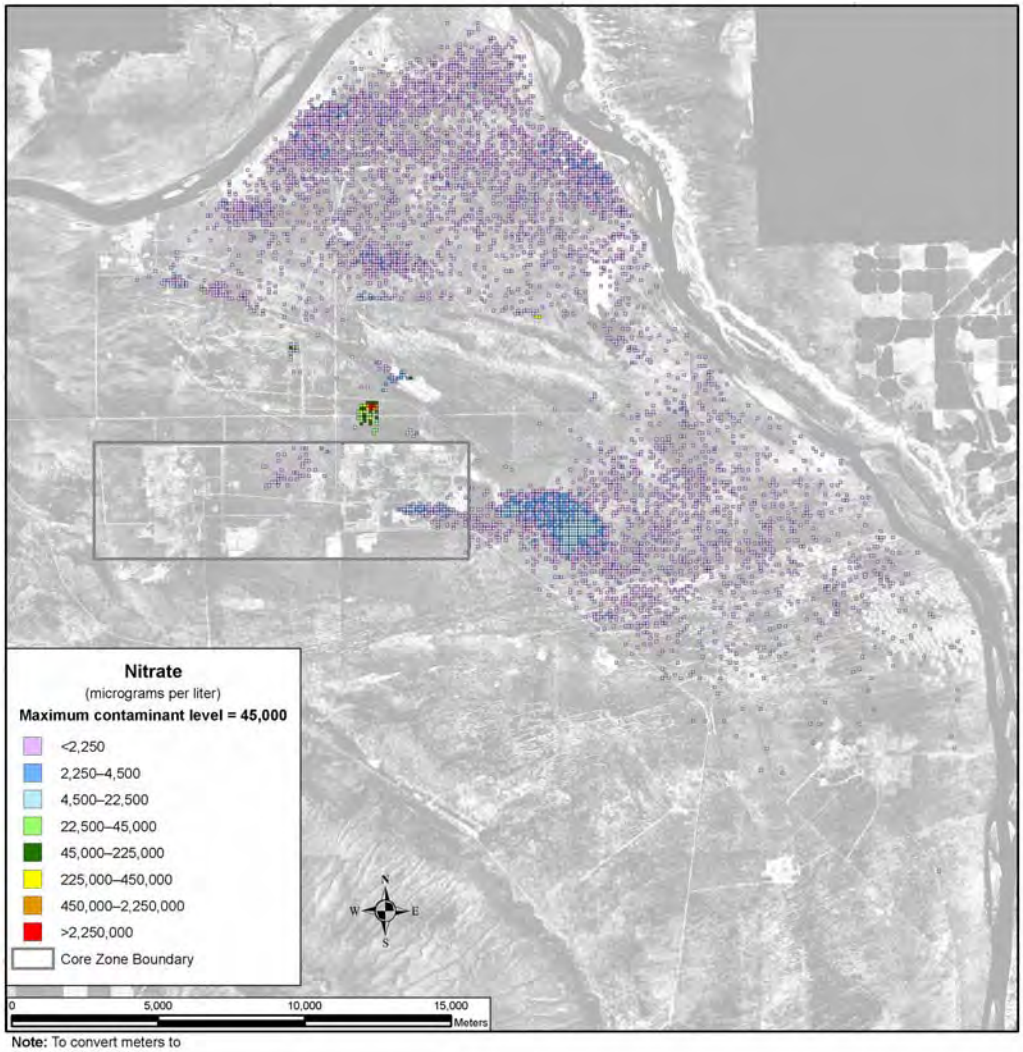
Note: To convert meters to feet, multiply by 3.281

Figure 5–1135. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



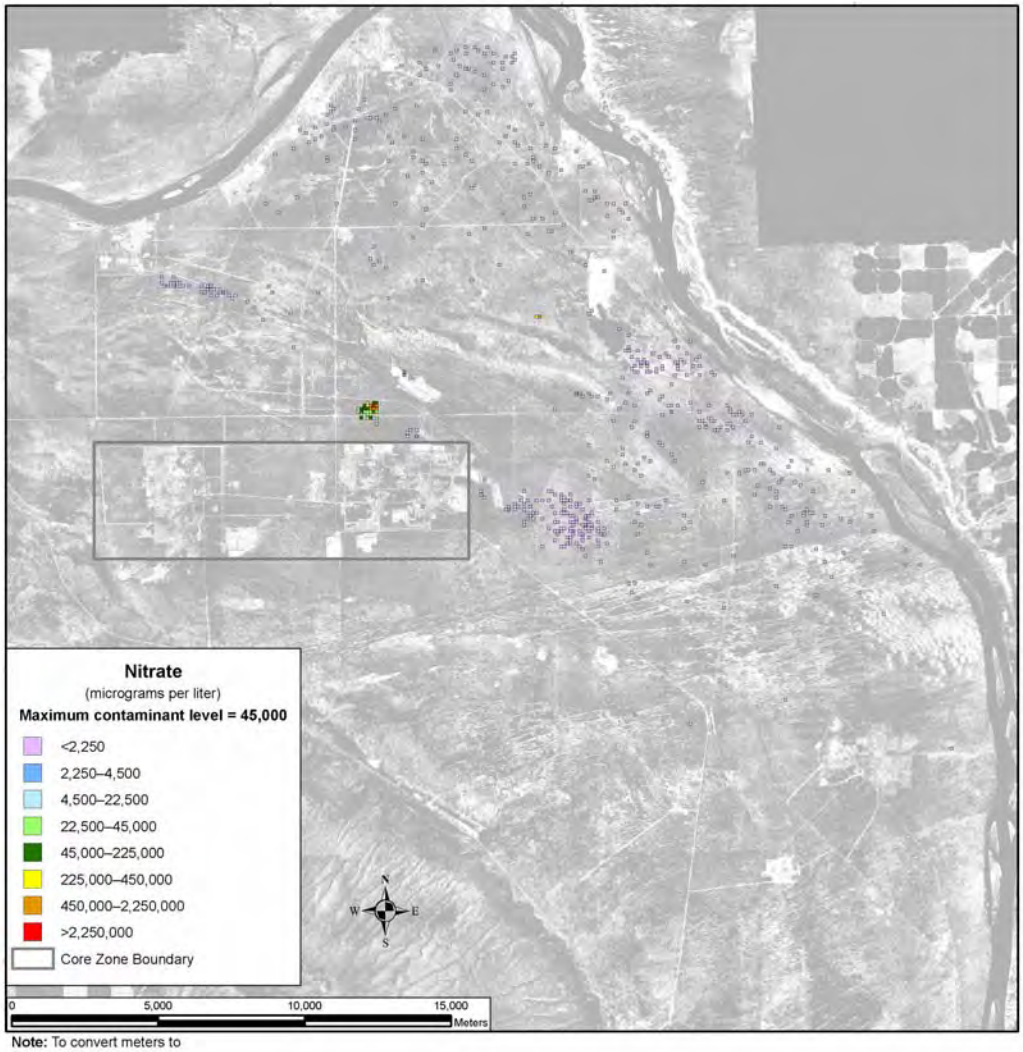
Note: To convert meters to feet, multiply by 3.281

Figure 5–1136. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

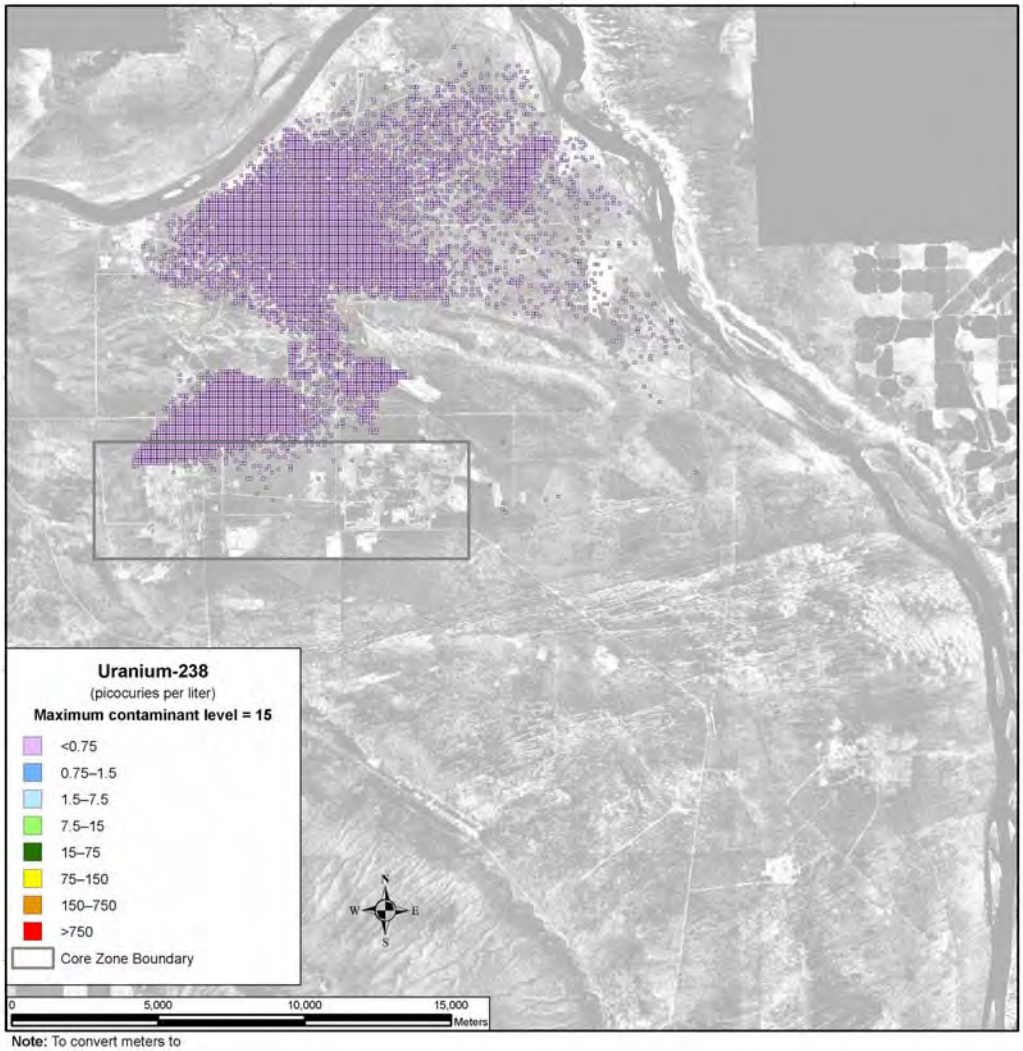
Figure 5–1137. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–1138. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution Year of Groundwater Nitrate Concentration During Calendar Year 11,885

Total uranium and uranium-238 show a different spatial distribution over time. They are not as mobile as the COPCs discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. By CY 11,885, there is a uranium-238 plume extending northeast from IDF-West through Gable Gap (see Figure 5–1139). A total uranium plume extends through Gable Gap from the RPPDF (see Figure 5–1140). Concentrations in all areas of the plumes remain below one-twentieth of the benchmark.



Note: To convert meters to feet, multiply by 3.281

Figure 5–1139. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

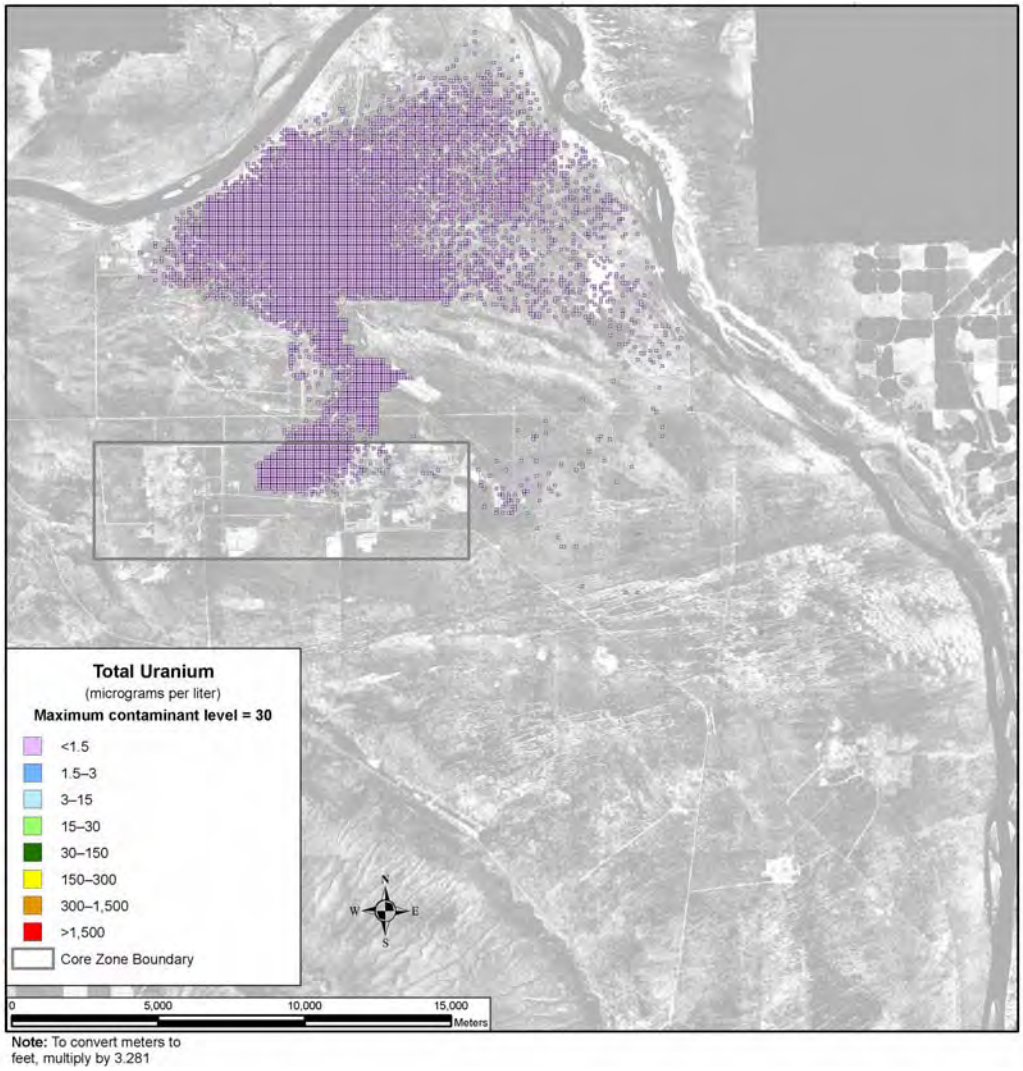


Figure 5–1140. Waste Management Alternative 3, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 3, Disposal Group 3, Option Case, in general, discharges from IDF-West are the predominant contributors; those from IDF-East and the RPPDF are secondary contributors.

Concentrations of iodine-129 and technetium-99 show a sharp rise and fall between CY 2940 and CY 4940 that exceeds the benchmark by an order of magnitude or slightly more. Concentrations of these COPCs continue to decline at a slower rate after CY 4940, reaching a level around an order of magnitude below the benchmark. Chromium and nitrate show a similar rise and fall, but remain about two orders of magnitude below the benchmark.

Uranium-238 and total uranium is limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species remain well below the benchmark at the Core Zone Boundary and the Columbia River throughout the simulation. The peak intensity and area of the contamination plume are near the end of the period of analysis.

5.3.2 Human Health Impacts

Potential human health impacts due to release of radionuclides are estimated as dose and as lifetime risk of incidence of cancer. For long-term performance assessment, radiological dose and risk are estimated consistent with the recommendations of *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, Federal Guidance Report No. 13 (Eckerman et al. 1999), including use of radionuclide-specific dose factors and risk coefficients. Potential human health effects due to the release of chemical constituents include both carcinogenic effects and other forms of toxicity. Impacts of carcinogenic chemicals are estimated as lifetime risk of incidence of cancer. Noncarcinogenic effects are estimated as Hazard Quotient, the ratio of the long-term intake of a single chemical to intake that produces no observable effect, and as Hazard Index, the sum of the Hazard Quotients of a group of chemicals. Further information on the nature of human health effects in response to exposure to radiological and chemical constituents is provided in Appendix K. Screening analysis identified 14 radionuclide and 26 chemical constituents as contributing the greatest risk of adverse impacts. Appendix Q provides more information on the screening analysis, including time of occurrence of peak impacts and constituent- and location-specific impacts under each Tank Closure, FFTF Decommissioning, and Waste Management alternatives.

Four measures of human health impacts are considered in this analysis—lifetime risks of developing cancer from radiological and chemical constituents, dose from radiological constituents, and Hazard Index from chemical constituents. These measures are calculated for each year for 10,000 years for each receptor at seven locations, as appropriate (i.e., LLBG 218-W-5, trenches 31 and 34; IDF-East; IDF-West; the RPPDF; the Core Zone Boundary; the Columbia River nearshore; and the Columbia River surface water). This is a large amount of information that must be summarized to allow interpretation of results. The method chosen is to present dose for the year of maximum dose, risk for the year of maximum risk, and Hazard Index for the year of maximum Hazard Index. This choice is based on regulation of radiological impacts as dose and the analysis results observations that risk due to exposure to chemical constituents is small relative to risk due to exposure to radiological constituents and that peak noncarcinogenic impacts expressed as Hazard Index may occur at times other than that of peak dose.

Impacts on human health over the long time period following stabilization or closure of the waste management disposal facilities would be due primarily to naturally occurring release mechanisms and the degradation of waste forms over time. These releases would involve both radiological and chemical constituents.

The five onsite locations are the barriers of the LLBG 218-W-5, trenches 31 and 34; IDF-East; IDF-West; the RPPDF; the Core Zone Boundary; and the Columbia River nearshore. The two offsite locations are access points to Columbia River surface water near the site and at population centers downstream of the site. Estimates of concentrations of constituents in the Columbia River surface water are used to calculate impacts for both offsite location points of analysis. Total offsite population is 5 million people. Four types of receptor are considered. The first type, a drinking-water well user, uses groundwater as a source of drinking water. The second type, a resident farmer, uses groundwater for drinking-water consumption and irrigation of crops. Garden size and crop yield are assumed adequate to produce approximately 25 percent of average requirements of crops and animal products. The third type, an American Indian resident farmer, also uses groundwater for drinking-water consumption and irrigation of crops. Garden size and crop yield are adequate to produce the entirety of average requirements of crops and animal products. The fourth type, an American Indian hunter-gatherer, is impacted by both groundwater and surface water because he uses surface water for drinking-water consumption and consumes both wild plant materials, which use groundwater, and game animals, which use surface water.

The significance of dose impacts is evaluated by comparison with the 100-millirem-per-year all-exposure modes standard specified for protection of the public and the environment in DOE Order 5400.5, *Radiation Protection of the Public and the Environment*. The level of protection provided for the drinking-water pathway is evaluated by comparison with applicable drinking-water standards presented in Section 5.3.1. Population doses are compared with the total effective dose equivalent from background sources of 365 millirem per year for a member of the population of the United States (NCRP 1987). The significance of noncarcinogenic chemical impacts is evaluated by comparison with a guideline value of unity for Hazard Index.

5.3.2.1 Waste Management Alternative 1: No Action

Under Waste Management Alternative 1, only the wastes currently generated on site at Hanford from non-CERCLA actions would continue to be disposed of in LLBG 218-W-5, trenches 31 and 34. Although the short-term impacts do not address the impacts associated with closure activities for this site, for purposes of analyzing long-term impacts, it is assumed that these trenches will be closed using an RCRA-compliant barrier consistent with the closure plans for these burial grounds. As a result, the non-CERLCA waste disposed of in these trenches from CY 2008 through 2035 would become available for release to the environment.

Potential human health impacts of this alternative are summarized in Tables 5–101 and 5–102. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. In addition, the Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 3.17×10^{-4} person-rem per year for the year of maximum impact. This corresponds to a 1.74×10^{-8} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary is presented in Figure 5–1141. The estimated lifetime risks are relatively low, with a peak of approximately 2×10^{-7}, indicating low rates of release from the disposal trenches.

Table 5–101. Waste Management Alternative 1 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Trenches 31 and 34	4.48×10^{-2}	3.08×10^{-2}	1.39×10^{-6}	0.00	1.39×10^{-6}	1.06×10^{-1}	3.11×10^{-2}	4.40×10^{-6}	1.16×10^{-11}	4.40×10^{-6}
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	7.96×10^{-3}	5.92×10^{-3}	2.53×10^{-7}	0.00	2.53×10^{-7}	1.92×10^{-2}	5.97×10^{-3}	8.13×10^{-7}	2.27×10^{-12}	8.13×10^{-7}
Columbia River Nearshore	1.29×10^{-3}	9.93×10^{-4}	4.12×10^{-8}	0.00	4.12×10^{-8}	3.12×10^{-3}	1.00×10^{-3}	1.32×10^{-7}	3.84×10^{-13}	1.32×10^{-7}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.35×10^{-8}	2.02×10^{-8}	2.69×10^{-12}	7.48×10^{-18}	2.69×10^{-12}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–102. Waste Management Alternative 1 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Trenches 31 and 34	2.09×10^{-1}	4.51×10^{-2}	9.53×10^{-6}	5.33×10^{-7}	9.96×10^{-6}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.83×10^{-2}	8.69×10^{-3}	1.76×10^{-6}	1.04×10^{-7}	1.83×10^{-6}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	6.22×10^{-3}	1.45×10^{-3}	2.86×10^{-7}	1.76×10^{-8}	2.99×10^{-7}	8.02×10^{-6}	2.62×10^{-4}	4.16×10^{-10}	8.81×10^{-9}	9.09×10^{-9}
Off Site										
Columbia River	2.13×10^{-7}	2.90×10^{-6}	8.20×10^{-12}	3.43×10^{-13}	8.49×10^{-12}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

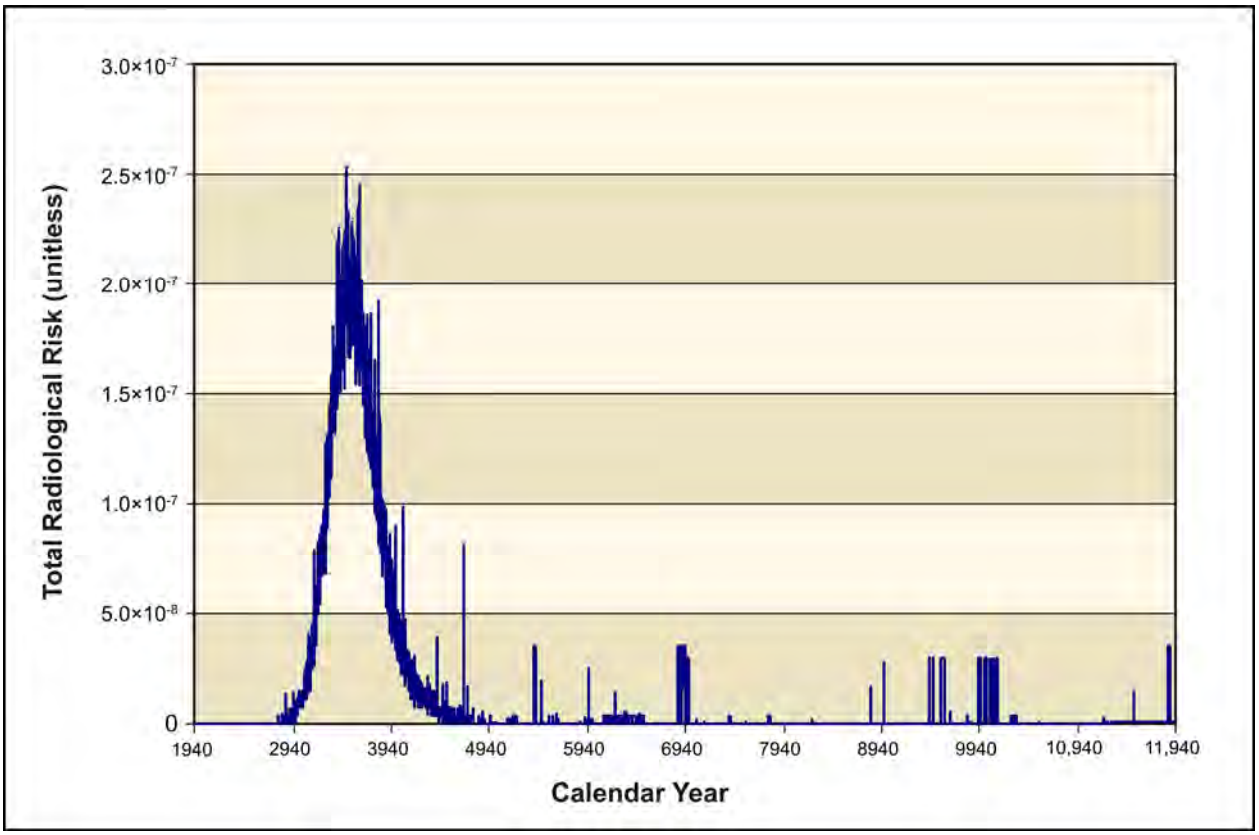


Figure 5–1141. Waste Management Alternative 1 Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only

Under Waste Management Alternative 2, waste from tank treatment operations, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites would be disposed of in IDF-East. Waste from tank farm cleanup activities would be disposed of in the RPPDF. As a result, the waste disposed of in these two facilities would become available for release to the environment. Because different waste types would result from the Tank Closure action alternatives, three disposal groups were considered to account for the different sizes and operational time periods of IDF-East. In addition, within these three disposal groups, subgroups were identified to allow consideration of the different waste types resulting from the Tank Closure alternatives. Potential human health impacts of these subgroups under this alternative are discussed in the following sections.

5.3.2.2.1 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-A

Disposal Group 1, Subgroup 1-A, addresses the waste resulting from Tank Closure Alternative 2B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–103 and 5–104. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. In addition, the Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 3.05×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 1.67×10^{-5} percent of the annual population dose due to

background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and at the Core Zone Boundary are presented in Figures 5–1142 and 5–1143, respectively. Review of the source term inventories (see Appendix D), cumulative release to the unconfined aquifer (see Appendix N), sensitivity analysis (see Appendix N), and estimates of impact presented later in this section support the interpretation that the majority of the impact is due to release of technetium-99 from offsite waste. At the IDF-East Barrier, approximately 90 percent of the risk is attributed to offsite LLW (9×10^{-5}) and approximately 10 percent is attributed to the combination of ETF-generated and tank closure secondary waste (1.3×10^{-5}). Releases from ILAW glass provide a minor contribution to estimated impacts. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1143) show a small peak at CY 3700 due to releases from the RPPDF, while the larger peak at CY 8000 is due to releases from IDF-East.

Table 5–103. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	7.49	2.73×10^{-1}	1.63×10^{-4}	0.00	1.63×10^{-4}	1.34×10^{1}	3.53×10^{-1}	4.42×10^{-4}	1.69×10^{-11}	4.42×10^{-4}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	3.13	1.04×10^{-1}	8.02×10^{-5}	0.00	8.02×10^{-5}	6.24	1.36×10^{-1}	2.45×10^{-4}	8.42×10^{-12}	2.45×10^{-4}
Columbia River Nearshore	2.58	4.78×10^{-2}	4.99×10^{-5}	0.00	4.99×10^{-5}	3.98	6.16×10^{-2}	1.46×10^{-4}	2.93×10^{-12}	1.46×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.10×10^{-5}	1.61×10^{-6}	2.09×10^{-9}	4.26×10^{-17}	2.09×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–104. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	2.35×10^{1}	6.84×10^{-1}	9.26×10^{-4}	7.77×10^{-7}	9.27×10^{-4}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.20×10^{1}	2.65×10^{-1}	5.25×10^{-4}	3.86×10^{-7}	5.26×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	7.36	1.19×10^{-1}	3.09×10^{-4}	1.34×10^{-7}	3.09×10^{-4}	1.47×10^{-2}	9.57×10^{-2}	5.22×10^{-7}	6.72×10^{-8}	5.41×10^{-7}
Off Site										
Columbia River	5.05×10^{-4}	4.21×10^{-3}	1.35×10^{-8}	1.95×10^{-12}	1.35×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not available; Rad.=radiological; yr=year.

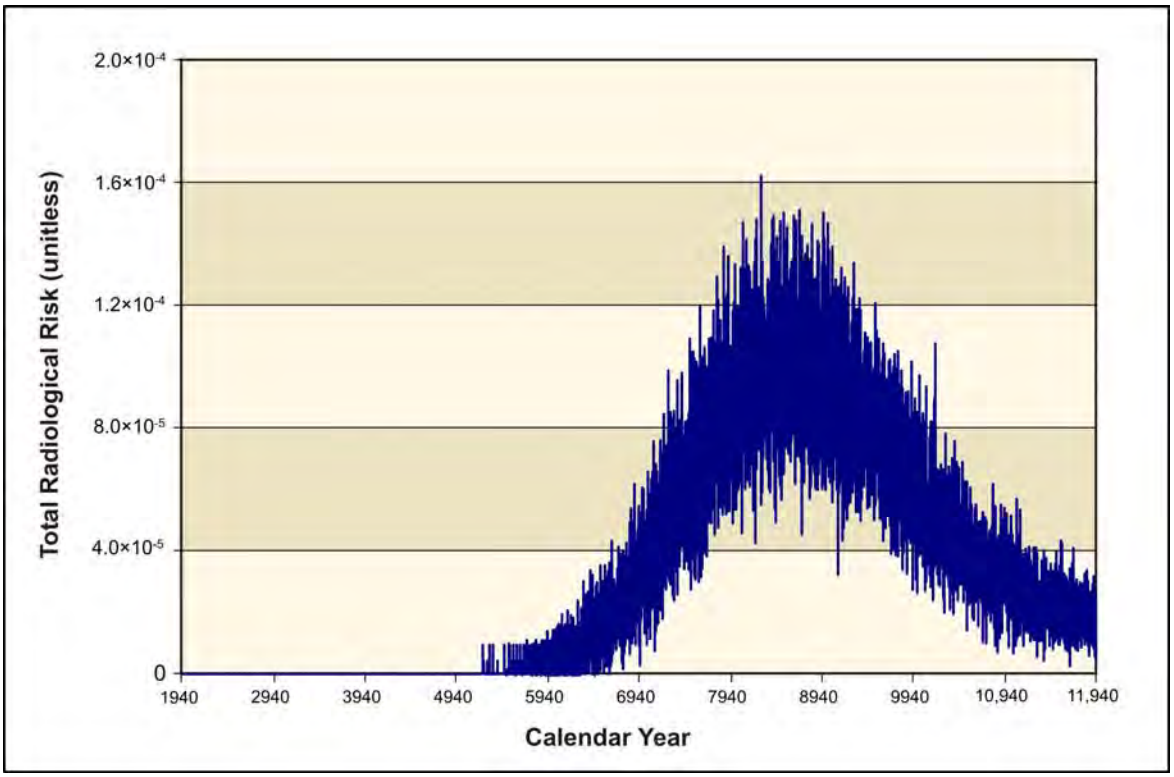


Figure 5–1142. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

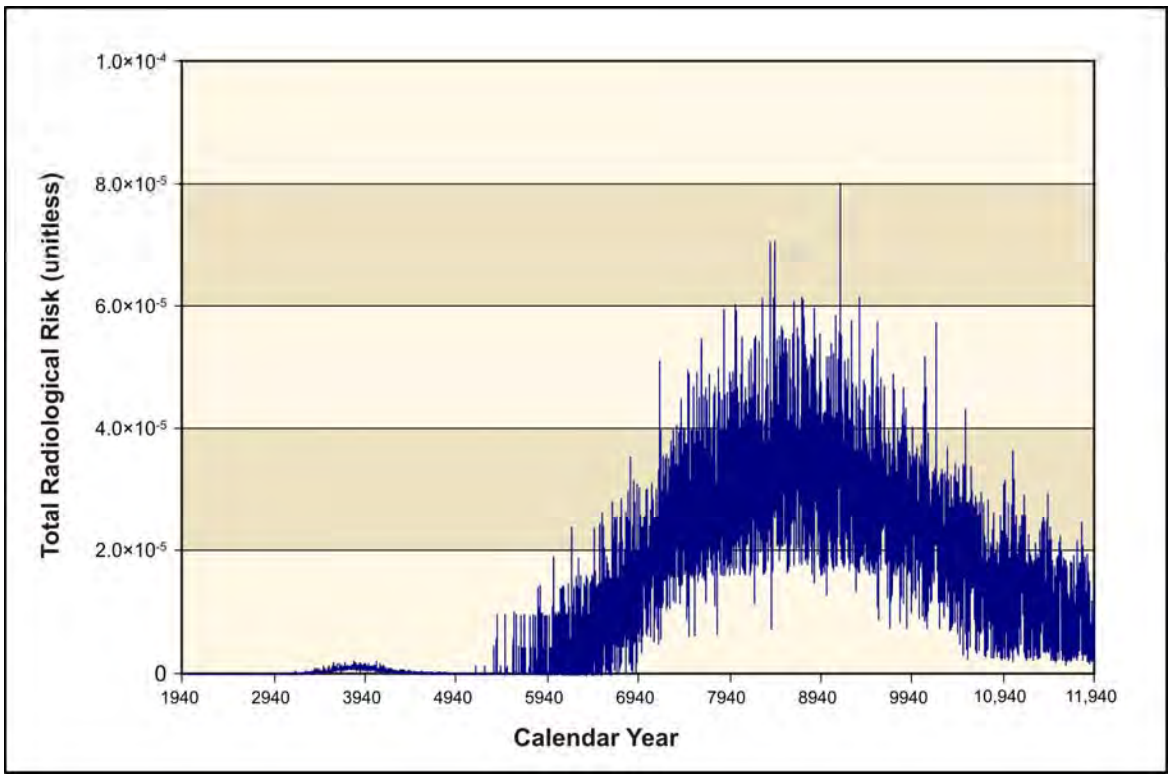


Figure 5–1143. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.2 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-B

Disposal Group 1, Subgroup 1-B, addresses the waste resulting from Tank Closure Alternative 3A, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–105 and 5–106. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. In addition, the Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 3.87×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 2.12×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1144 and 5–1145, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.4×10^{-4}) is distributed among the offsite LLW (9×10^{-5}), the bulk vitrification glass supplemental low-activity waste (LAW) source (4×10^{-5}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the bulk vitrification glass waste is release of technetium-99 from the castable refractory block portion of the waste form package. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1145) comprises a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East.

Table 5–105. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.81	2.66×10^{-1}	2.12×10^{-4}	0.00	2.12×10^{-4}	1.69×10^{1}	3.48×10^{-1}	6.19×10^{-4}	6.93×10^{-12}	6.19×10^{-4}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	3.68	1.06×10^{-1}	8.47×10^{-5}	0.00	8.47×10^{-5}	6.65	1.40×10^{-1}	2.60×10^{-4}	8.42×10^{-12}	2.60×10^{-4}
Columbia River Nearshore	2.77	6.74×10^{-2}	5.54×10^{-5}	0.00	5.54×10^{-5}	4.39	8.82×10^{-2}	1.68×10^{-4}	1.48×10^{-12}	1.68×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	7.75×10^{-5}	1.52×10^{-6}	2.76×10^{-9}	2.10×10^{-17}	2.76×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–106. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.12×10^{1}	6.77×10^{-1}	1.31×10^{-3}	3.18×10^{-7}	1.31×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.27×10^{1}	2.73×10^{-1}	5.58×10^{-4}	3.86×10^{-7}	5.58×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	8.19	1.72×10^{-1}	3.61×10^{-4}	6.77×10^{-8}	3.61×10^{-4}	1.60×10^{-2}	1.36×10^{-1}	5.80×10^{-7}	3.38×10^{-8}	5.97×10^{-7}
Off Site										
Columbia River	5.38×10^{-4}	4.03×10^{-3}	1.51×10^{-8}	9.65×10^{-13}	1.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

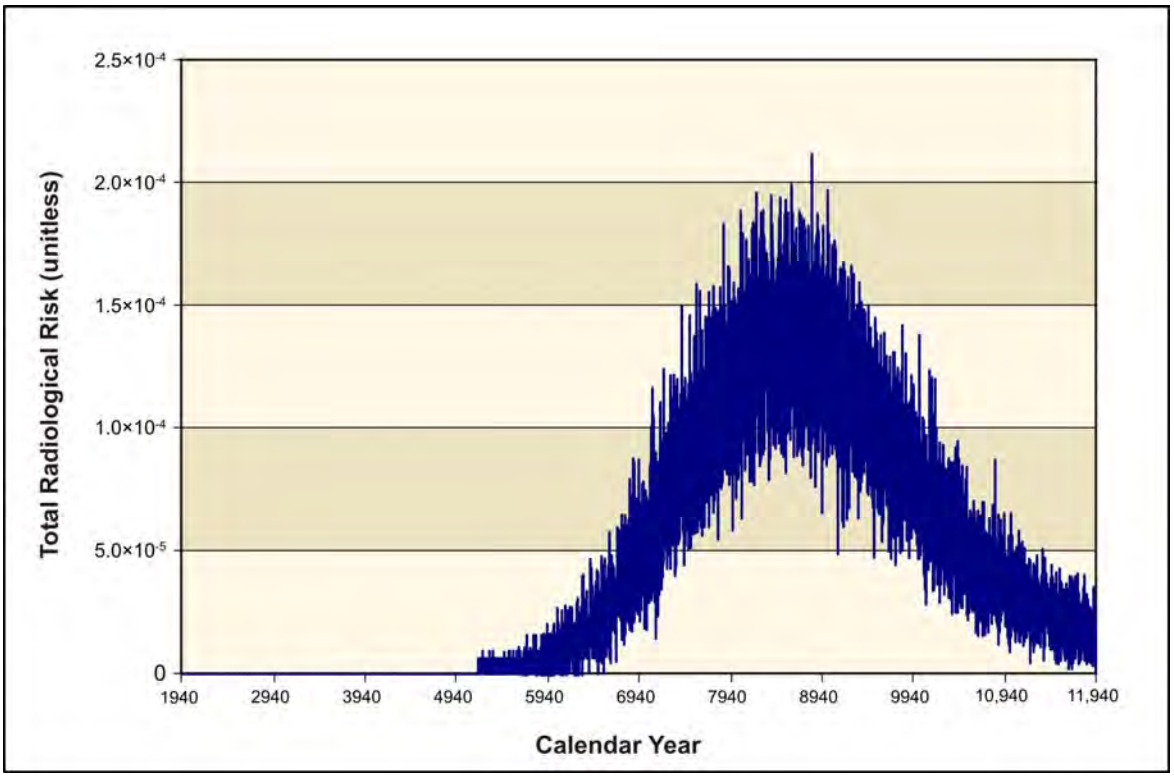


Figure 5–1144. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

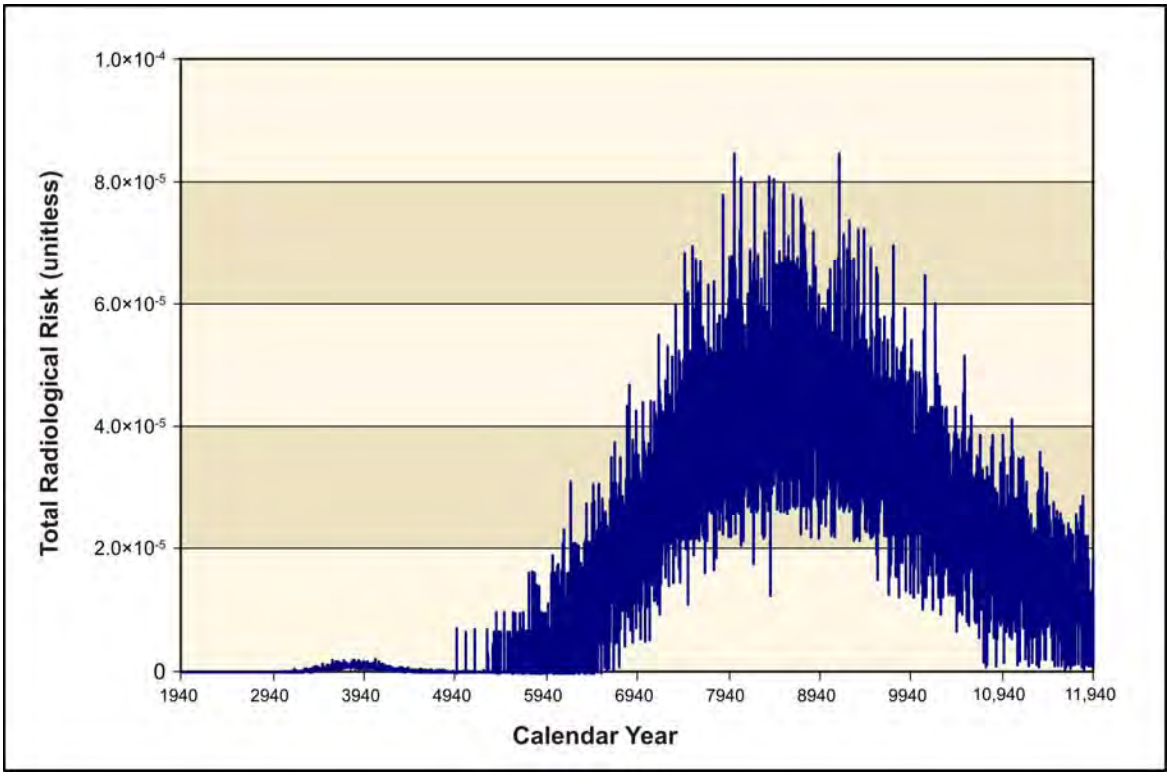


Figure 5–1145. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.3 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-C

Disposal Group 1, Subgroup 1-C, addresses the waste resulting from Tank Closure Alternative 3B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–107 and 5–108. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. However, the Hazard Index guideline would be exceeded due primarily to chromium and nitrate at the IDF-East Barrier, Core Zone Boundary, and Columbia River nearshore for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 5.55×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.04×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1146 and 5–1147, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.8×10^{-4}) is distributed among the offsite LLW (9×10^{-5}), the cast stone supplemental LAW source (8×10^{-5}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the cast stone waste form is release of technetium-99. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1147) comprises a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East.

Table 5–107. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.22×10^{1}	4.86	3.64×10^{-4}	0.00	3.64×10^{-4}	2.79×10^{1}	5.08	1.15×10^{-3}	1.71×10^{-9}	1.15×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	1.59×10^{1}	2.73	5.09×10^{-4}	0.00	5.09×10^{-4}	3.85×10^{1}	2.80	1.64×10^{-3}	1.04×10^{-9}	1.64×10^{-3}
Columbia River Nearshore	4.15	1.24	1.15×10^{-4}	0.00	1.15×10^{-4}	8.97	1.29	3.51×10^{-4}	4.57×10^{-10}	3.51×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.11×10^{-4}	1.91×10^{-5}	4.28×10^{-9}	5.84×10^{-15}	4.28×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–108. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	5.48×10^{1}	7.87	2.48×10^{-3}	7.86×10^{-5}	2.52×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	7.70×10^{1}	4.23	3.55×10^{-3}	4.77×10^{-5}	3.56×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	1.72×10^{1}	1.97	7.53×10^{-4}	2.10×10^{-5}	7.58×10^{-4}	2.54×10^{-2}	6.60×10^{-1}	1.18×10^{-6}	1.05×10^{-5}	1.10×10^{-5}
Off Site										
Columbia River	5.85×10^{-4}	1.80×10^{-2}	1.80×10^{-8}	2.68×10^{-10}	1.82×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

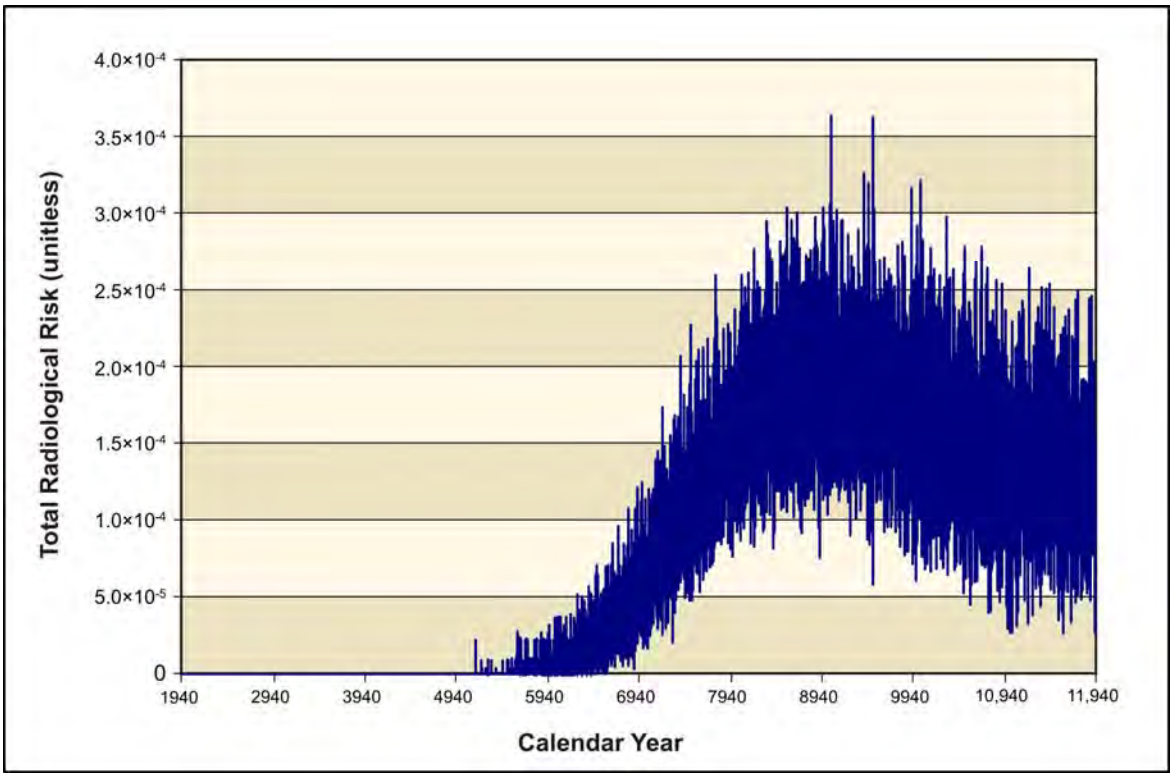


Figure 5–1146. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

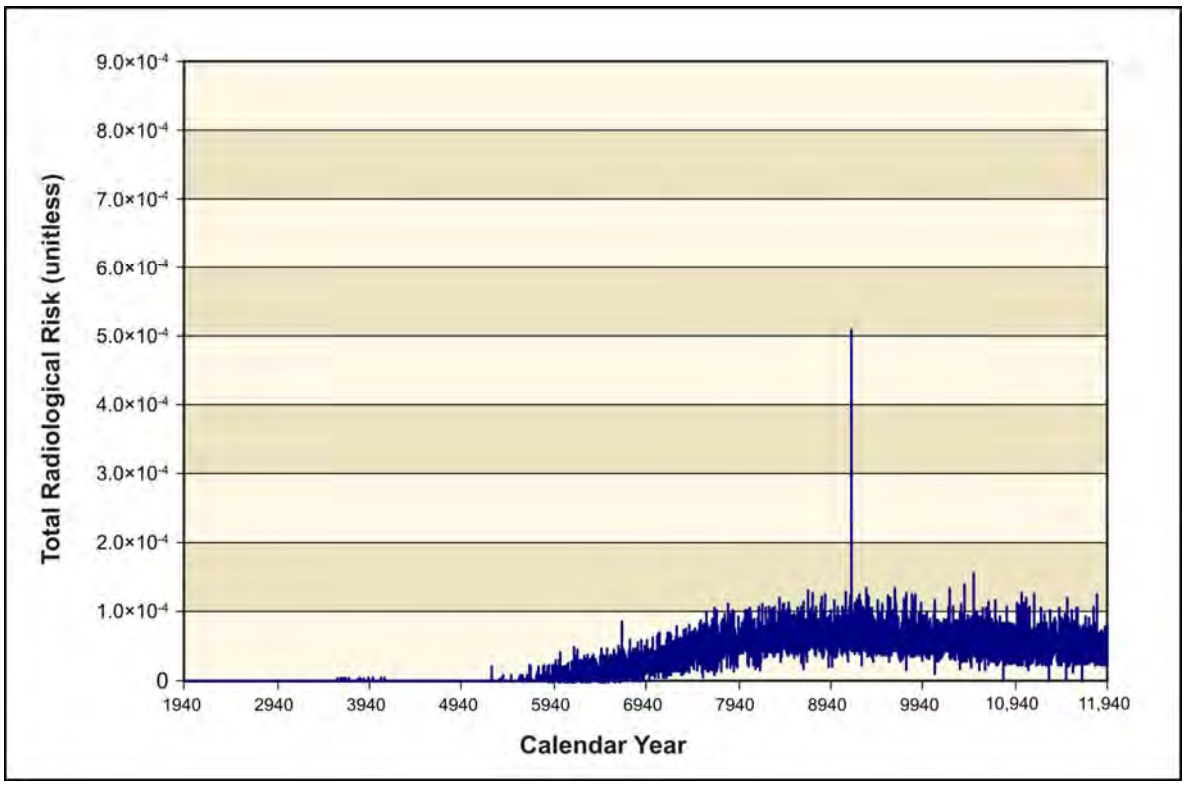


Figure 5–1147. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.4 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-D

Disposal Group 1, Subgroup 1-D, addresses the waste resulting from Tank Closure Alternative 3C, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–109 and 5–110. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would be exceeded at the IDF-East Barrier and the Core Zone Boundary for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would be exceeded due primarily to chromium at the IDF-East Barrier, Core Zone Boundary, and Columbia River nearshore for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 2.40 person-rem per year for the year of maximum impact. This corresponds to a 1.31×10^{-4} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East barrier and the Core Zone Boundary are presented in Figures 5–1148 and 5–1149, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (9.0×10^{-4}) is distributed among the offsite LLW (9×10^{-5}), the steam reforming solids supplemental LAW source (8×10^{-4}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the steam reforming solids is release of technetium-99. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1149) comprises a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East.

Table 5–109. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	5.65×10^{1}	4.30	1.86×10^{-3}	0.00	1.86×10^{-3}	1.40×10^{2}	4.35	6.01×10^{-3}	1.71×10^{-9}	6.01×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	4.42×10^{1}	1.69	1.50×10^{-3}	0.00	1.50×10^{-3}	1.12×10^{2}	1.70	4.91×10^{-3}	6.84×10^{-10}	4.91×10^{-3}
Columbia River Nearshore	1.48×10^{1}	1.12	4.73×10^{-4}	0.00	4.73×10^{-4}	3.58×10^{1}	1.13	1.52×10^{-3}	4.56×10^{-10}	1.52×10^{-3}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.79×10^{-4}	1.69×10^{-5}	2.03×10^{-8}	6.52×10^{-15}	2.03×10^{-8}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–110. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	2.81×10^{2}	6.46	1.31×10^{-2}	7.85×10^{-5}	1.31×10^{-2}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.28×10^{2}	2.50	1.07×10^{-2}	3.14×10^{-5}	1.07×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	7.16×10^{1}	1.66	3.31×10^{-3}	2.09×10^{-5}	3.31×10^{-3}	9.11×10^{-2}	2.88×10^{-1}	4.75×10^{-6}	1.05×10^{-5}	1.18×10^{-5}
Off Site										
Columbia River	1.46×10^{-3}	4.74×10^{-3}	5.94×10^{-8}	2.99×10^{-10}	5.95×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not available; Rad.=radiological; yr=year.

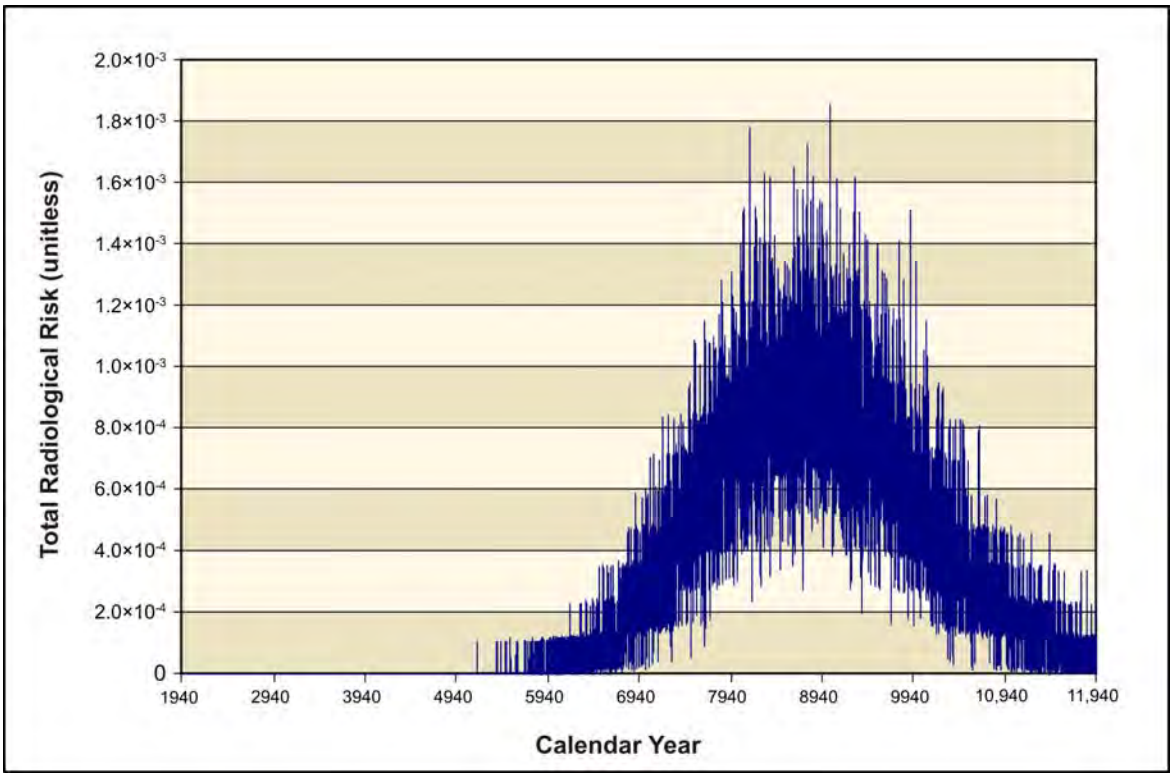


Figure 5–1148. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

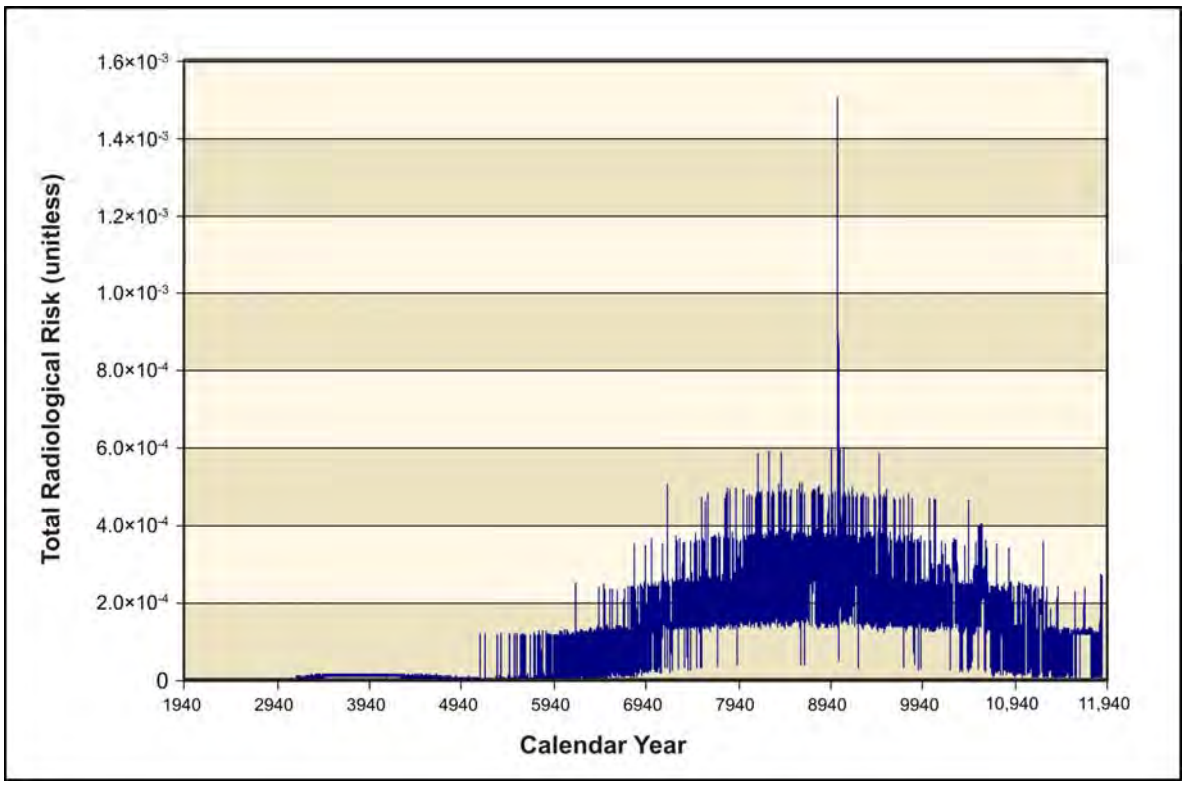


Figure 5–1149. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.5 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-E

Disposal Group 1, Subgroup 1-E, addresses the waste resulting from Tank Closure Alternative 4, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–111 and 5–112. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. The Hazard Index guideline would be exceeded primarily due to chromium at the IDF-East Barrier and the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer. The Hazard Index guideline would also be exceeded primarily due to chromium and nitrate at the Columbia River nearshore location for the American Indian resident farmer. Population dose was estimated as 6.25×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.42×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1150 and 5–1151, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier ($2.2\times \times10^{-4}$) is distributed among the offsite LLW (9×10^{-5}), the combination of ILAW glass and bulk vitrification and cast stone LAW sources (1.2×10^{-4}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the LAW sources is release of technetium-99 from cast stone and the castable refractory block portion of the bulk vitrification glass waste form package. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1151) comprises a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East.

Table 5–111. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.38×10^{1}	2.48	4.10×10^{-4}	0.00	4.10×10^{-4}	3.11×10^{1}	2.59	1.31×10^{-3}	8.78×10^{-10}	1.31×10^{-3}
River Protection Project Disposal Facility	2.15×10^{-1}	5.86×10^{-2}	6.59×10^{-6}	0.00	6.59×10^{-6}	5.03×10^{-1}	5.95×10^{-2}	2.08×10^{-5}	2.30×10^{-11}	2.08×10^{-5}
Core Zone Boundary	5.91	1.02	1.92×10^{-4}	0.00	1.92×10^{-4}	1.45×10^{1}	1.06	6.18×10^{-4}	3.76×10^{-10}	6.18×10^{-4}
Columbia River Nearshore	4.36	6.59×10^{-1}	1.31×10^{-4}	0.00	1.31×10^{-4}	1.01×10^{1}	6.75×10^{-1}	4.13×10^{-4}	2.50×10^{-10}	4.13×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.25×10^{-4}	1.15×10^{-5}	5.05×10^{-9}	3.65×10^{-15}	5.05×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–112. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	6.19×10^{1}	4.01	2.84×10^{-3}	4.03×10^{-5}	2.86×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	9.92×10^{-1}	8.87×10^{-2}	4.51×10^{-5}	1.06×10^{-6}	4.59×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.90×10^{1}	1.62	1.34×10^{-3}	1.72×10^{-5}	1.35×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	1.98×10^{1}	1.02	8.93×10^{-4}	1.15×10^{-5}	8.96×10^{-4}	2.69×10^{-2}	3.40×10^{-1}	1.33×10^{-6}	5.74×10^{-6}	6.22×10^{-6}
Off Site										
Columbia River	6.20×10^{-4}	1.05×10^{-2}	1.94×10^{-8}	1.67×10^{-10}	1.95×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not available; Rad.=radiological; yr=year.

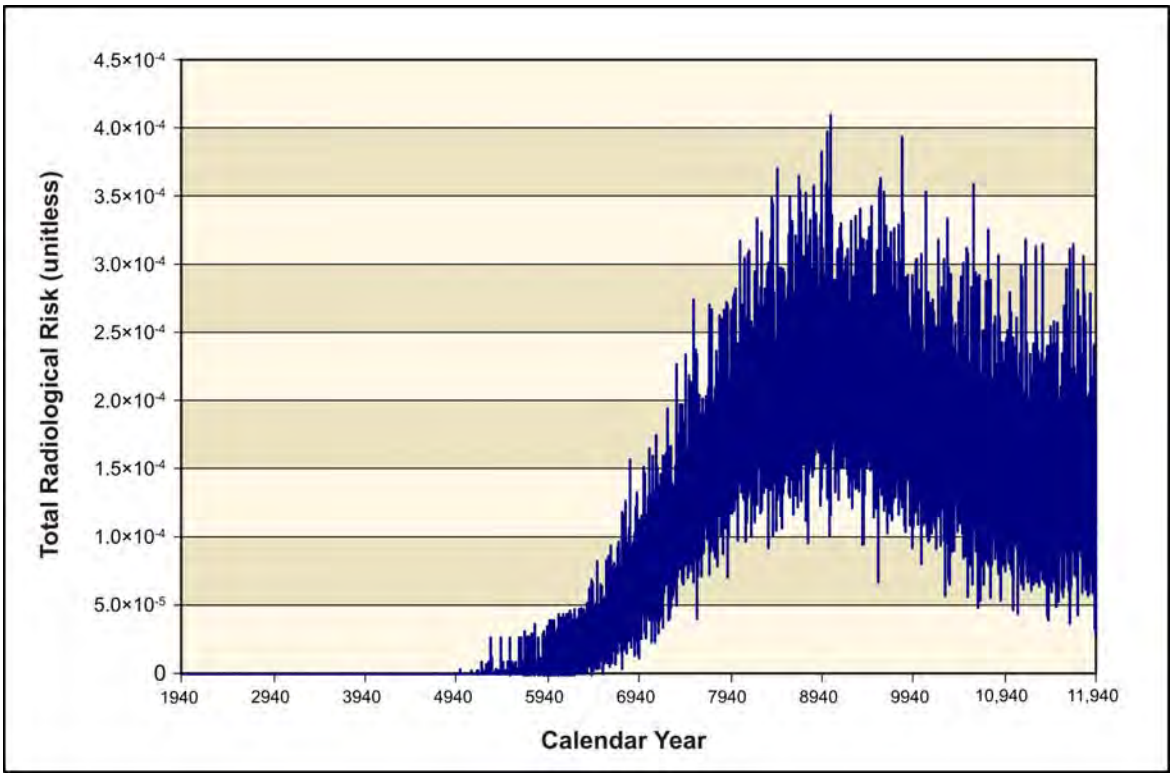


Figure 5–1150. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

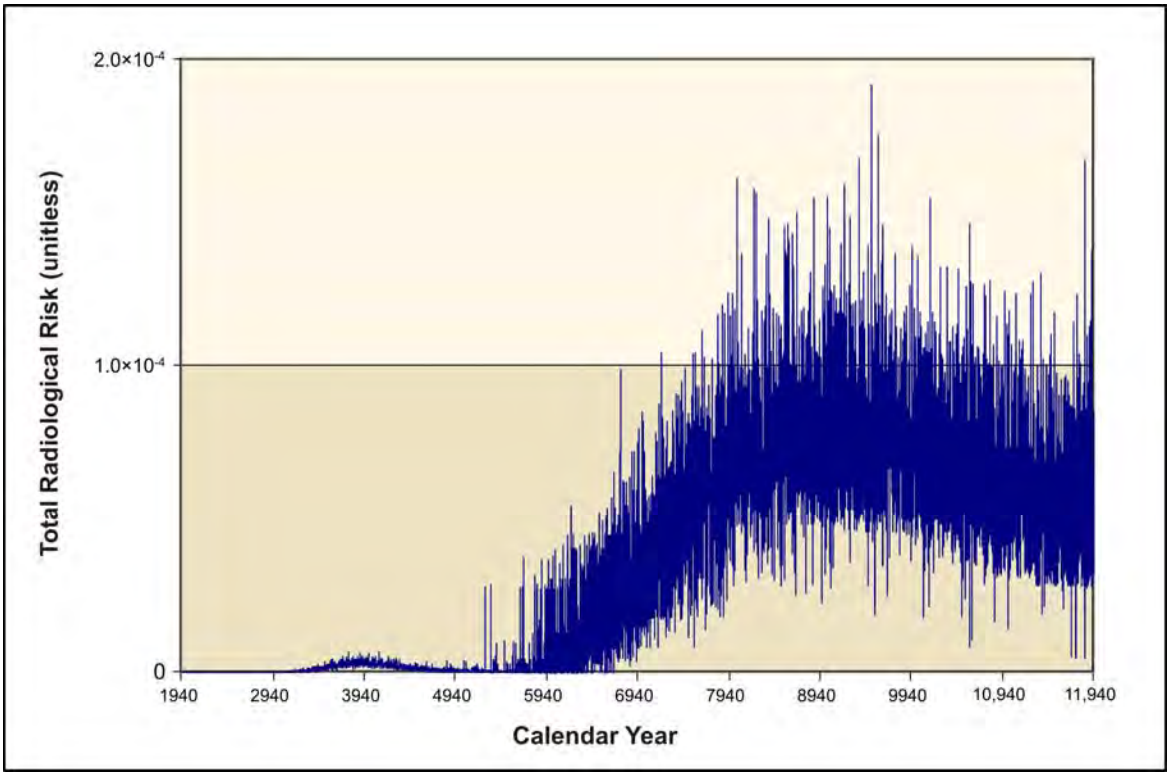


Figure 5–1151. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.6 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-F

Disposal Group 1, Subgroup 1-F, addresses the waste resulting from Tank Closure Alternative 5, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–113 and 5–114. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the IDF-East Barrier, Core Zone Boundary and the Columbia River nearshore locations for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 4.18×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 2.29×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1152 and 5–1153, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.5×10^{-4}) is distributed among the offsite LLW (9×10^{-5}), the combination of ILAW glass and bulk vitrification and cast stone sources (5.0×10^{-5}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the sources is release of technetium-99 from cast stone and the castable refractory block portion of the bulk vitrification glass waste form package. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1153) does not include an early peak, as the RPPDF is not constructed for this alternative, but does include a late peak due to sources at IDF-East.

Table 5–113. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.02×10^{1}	3.51	2.57×10^{-4}	0.00	2.57×10^{-4}	2.05×10^{1}	3.62	7.56×10^{-4}	1.32×10^{-9}	7.56×10^{-4}
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.89	1.47	9.97×10^{-5}	0.00	9.97×10^{-5}	7.70	1.50	3.09×10^{-4}	5.81×10^{-10}	3.09×10^{-4}
Columbia River Nearshore	2.97	1.09	6.15×10^{-5}	0.00	6.15×10^{-5}	4.89	1.10	1.83×10^{-4}	4.32×10^{-10}	1.83×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	8.36×10^{-5}	1.32×10^{-5}	3.10×10^{-9}	4.79×10^{-15}	3.10×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–114. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.80×10^{1}	5.50	1.60×10^{-3}	6.04×10^{-5}	1.63×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.49×10^{1}	2.23	6.64×10^{-4}	2.67×10^{-5}	6.72×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	9.11	1.63	3.93×10^{-4}	1.98×10^{-5}	3.98×10^{-4}	1.73×10^{-2}	3.31×10^{-1}	6.40×10^{-7}	9.90×10^{-6}	1.03×10^{-5}
Off Site										
Columbia River	5.56×10^{4}	6.96×10^{-3}	1.59×10^{-8}	2.20×10^{-10}	1.61×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

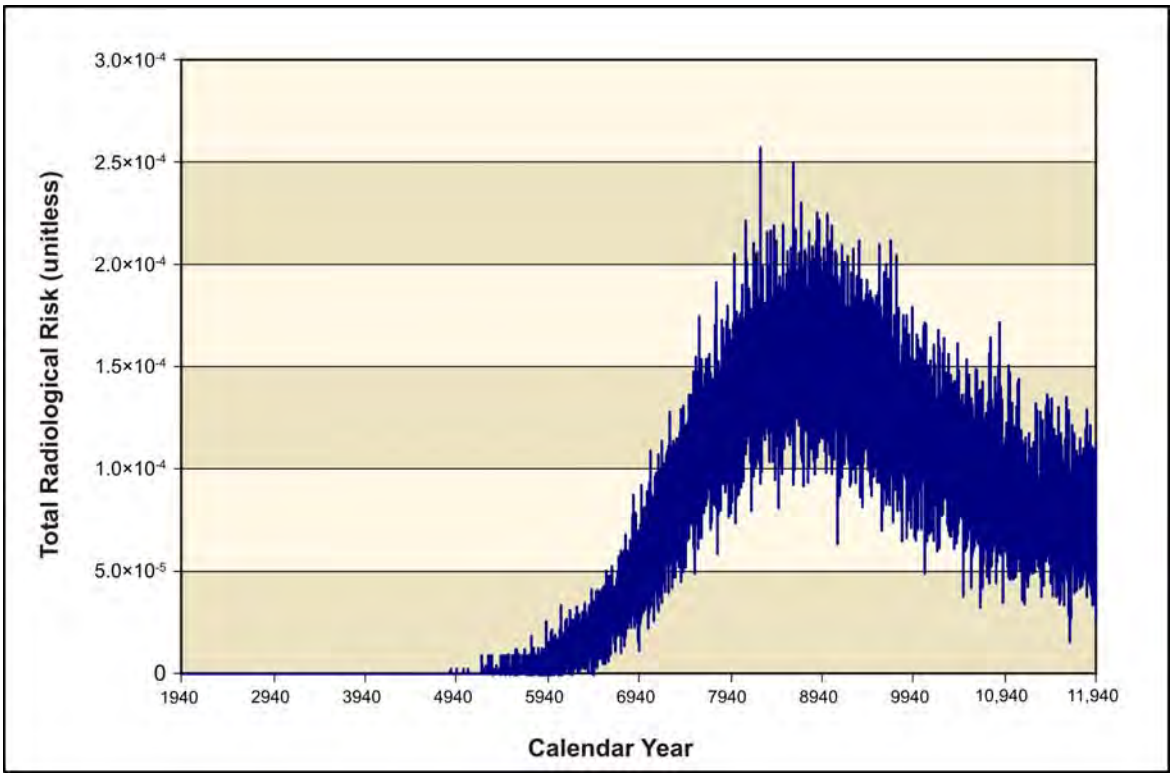


Figure 5–1152. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

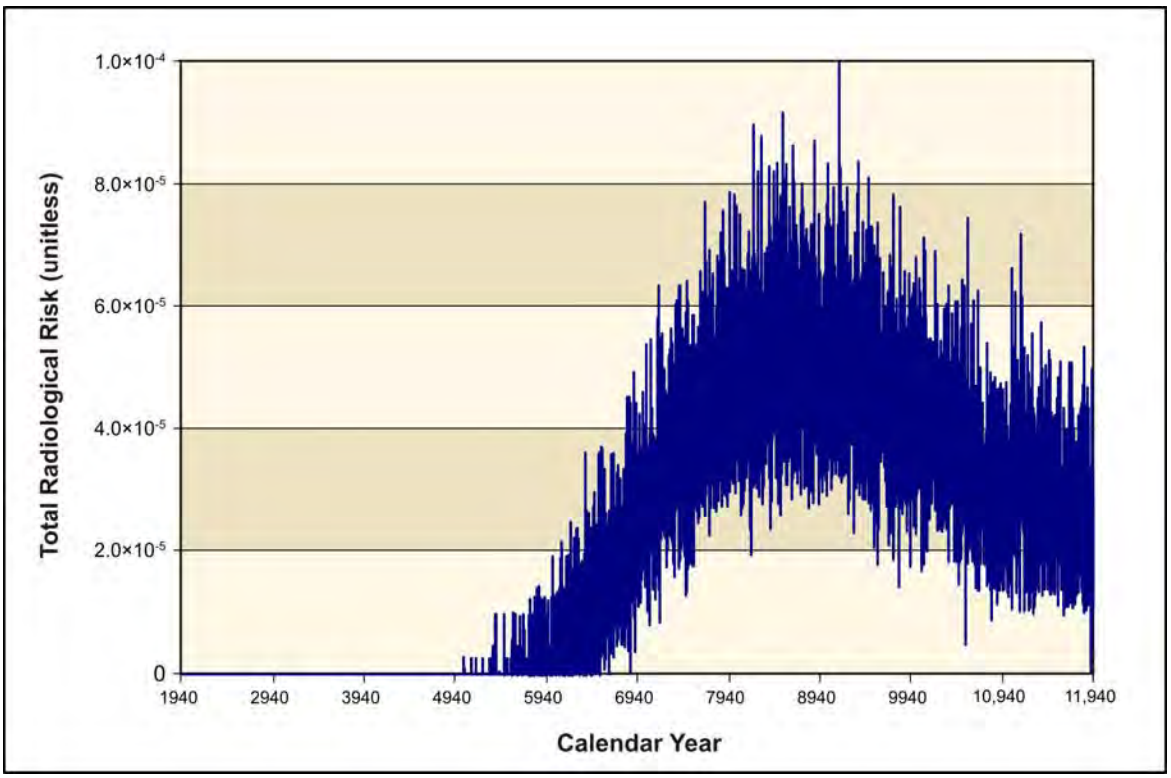


Figure 5–1153. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.7 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 1, Subgroup 1-G

Disposal Group 1, Subgroup 1-G, addresses the waste resulting from Tank Closure Alternative 6C, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–115 and 5–116. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. In addition, the Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 3.06×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 1.68×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1154 and 5–1155, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.0×10^{-4}) is distributed among the offsite LLW (9×10^{-5}) and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for secondary waste sources is release of technetium-99 from tank closure secondary waste and iodine-129 from the combined ETF-generated and tank closure secondary waste sources. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1155) comprises a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East.

Table 5–115. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	7.59	2.68×10^{-1}	1.60×10^{-4}	0.00	1.60×10^{-4}	1.33×10^{1}	3.45×10^{-1}	4.64×10^{-4}	1.52×10^{-11}	4.64×10^{-4}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	3.07	1.04×10^{-1}	7.86×10^{-5}	0.00	7.86×10^{-5}	6.13	1.36×10^{-1}	2.40×10^{-4}	8.42×10^{-12}	2.40×10^{-4}
Columbia River Nearshore	2.61	4.79×10^{-2}	4.98×10^{-5}	0.00	4.98×10^{-5}	3.98	6.17×10^{-2}	1.46×10^{-4}	3.16×10^{-12}	1.46×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.12×10^{-5}	1.61×10^{-6}	2.10×10^{-9}	4.03×10^{-17}	2.10×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–116. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	2.32×10^{1}	6.71×10^{-1}	9.88×10^{-4}	6.96×10^{-7}	9.88×10^{-4}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.17×10^{1}	2.65×10^{-1}	5.14×10^{-4}	3.86×10^{-7}	5.14×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	7.34	1.19×10^{-1}	3.08×10^{-4}	1.45×10^{-7}	3.08×10^{-4}	1.49×10^{-2}	9.61×10^{-2}	5.21×10^{-7}	7.25×10^{-8}	5.40×10^{-7}
Off Site										
Columbia River	5.05×10^{-4}	4.21×10^{-3}	1.34×10^{-8}	1.85×10^{-12}	1.34×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

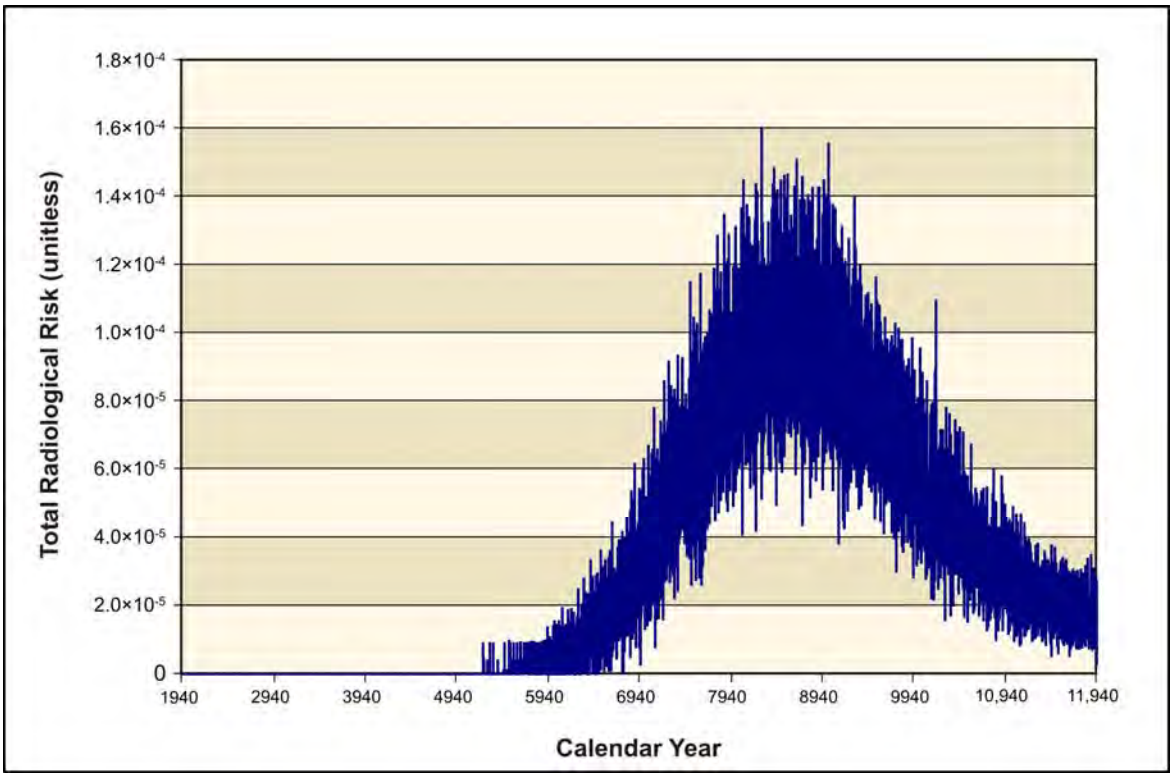


Figure 5–1154. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

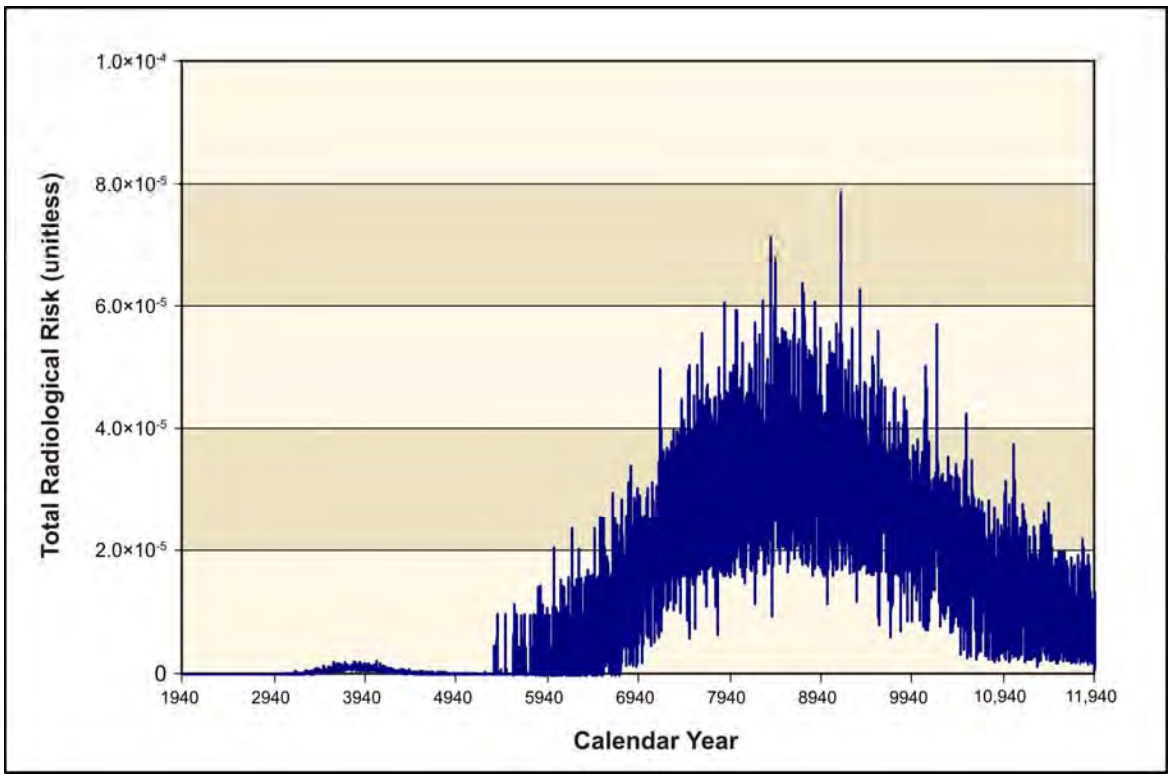


Figure 5–1155. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.8 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 2, Subgroup 2-A

Disposal Group 2, Subgroup 2-A, addresses the waste resulting from Tank Closure Alternative 2A, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–117 and 5–118. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would not be exceeded at any location. In addition, the Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 3.18×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 1.74×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and at the Core Zone Boundary are presented in Figures 5–1156 and 5–1157, respectively. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.2×10^{-4}) includes contributions from offsite LLW (9×10^{-5}), the combination of ETF-generated and tank closure secondary waste (1.3×10^{-5}), and ILAW glass (2.0×10^{-5}); ILAW glass provides a minor contribution to estimated impacts. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary (see Figure 5–1157) does not include an early peak, as the RPPDF is not constructed for this alternative, but does include a late peak due to sources at IDF-East.

Table 5–117. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.12×10^{1}	2.98×10^{-1}	2.32×10^{-4}	0.00	2.32×10^{-4}	1.94×10^{1}	3.86×10^{-1}	6.24×10^{-4}	1.25×10^{-11}	6.24×10^{-4}
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.98	1.05×10^{-1}	8.27×10^{-5}	0.00	8.27×10^{-5}	6.55	1.38×10^{-1}	2.45×10^{-4}	6.51×10^{-12}	2.45×10^{-4}
Columbia River Nearshore	1.92	7.46×10^{-2}	4.52×10^{-5}	0.00	4.52×10^{-5}	3.51	9.76×10^{-2}	1.39×10^{-4}	2.96×10^{-12}	1.39×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.36×10^{-5}	1.64×10^{-6}	2.12×10^{-9}	4.07×10^{-17}	2.12×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–118. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.33×10^{1}	7.47×10^{-1}	1.31×10^{-3}	5.75×10^{-7}	1.31×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.22×10^{1}	2.68×10^{-1}	5.20×10^{-4}	2.99×10^{-7}	5.20×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	6.75	1.91×10^{-1}	2.98×10^{-4}	1.36×10^{-7}	2.99×10^{-4}	1.09×10^{-2}	1.52×10^{-1}	4.71×10^{-7}	6.79×10^{-8}	5.00×10^{-7}
Off Site										
Columbia River	4.89×10^{-4}	4.31×10^{-3}	1.37×10^{-8}	1.87×10^{-12}	1.37×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

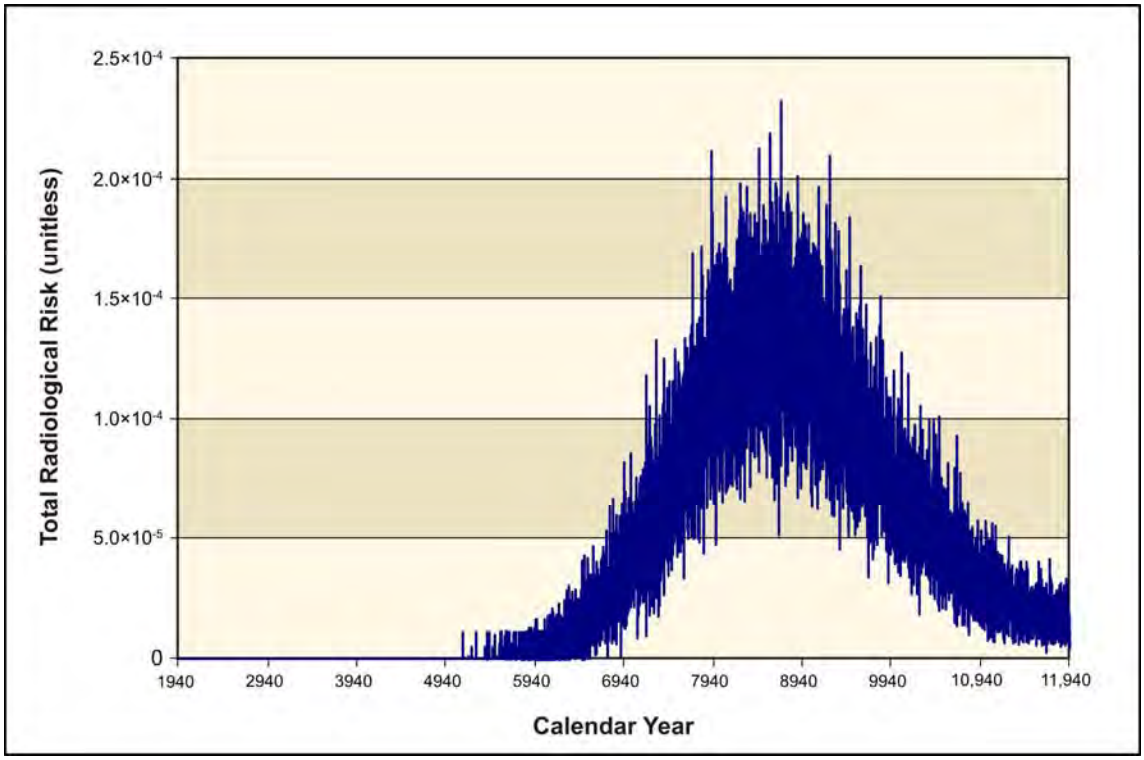


Figure 5–1156. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

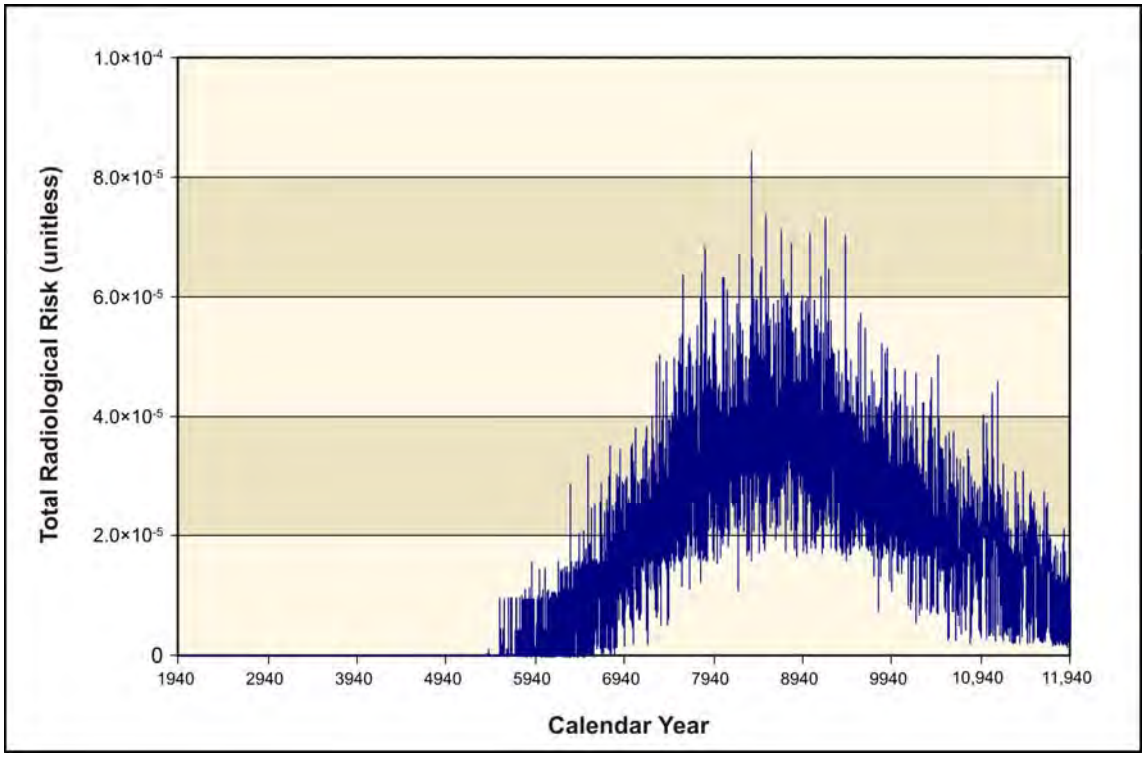


Figure 5–1157. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.9 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 2, Subgroup 2-B

Disposal Group 2, Subgroup 2-B, addresses the waste resulting from Tank Closure Alternative 6B (Base and Option Cases), onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–119 through 5–122. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, nitrate, and total uranium for chemicals. For radionuclides, the dose standard would not be exceeded at any location. For Base Case, the Hazard Index guideline would not be exceeded at any location. For the Option Case, the Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer due primarily to presence of chromium and nitrate. Population dose was estimated for Subgroup 2-B, Base Case, as 3.23×10^{-1} person-rem per year for the year of maximum impact and for Subgroup 2-B, Option Case, as 3.12×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.77×10^{-5} percent and 1.71×10^{-5} percent of the annual population dose due to background exposure for Subgroup 2-B, Base and Option Cases, respectively. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1158 and 5–1159 for the Base Case and in Figures 5–1160 and 5–1161 for the Option Case. The Base and Option Cases differ in the amounts of constituents disposed of at the RPPDF because the Option Case includes removal of the Tank Closure alternative cribs and trenches (ditches). Estimates of impacts for IDF-East are the same for the two cases. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.2×10^{-4}) is distributed primarily among the offsite LLW (9×10^{-5}) and the combined ETF-generated, tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for secondary waste sources is release of technetium-99 from tank closure secondary waste and iodine-129 from the combined ETF-generated and tank closure secondary waste sources. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary for the Base Case (see Figure 5–1159) and the Option Case (see Figure 5–1161) each comprise a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East. The early peak is greater for the Option Case relative to the Base Case due to the inclusion of additional waste from cribs and trenches (ditches).

Table 5–119. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.14×10^{1}	3.21×10^{-1}	2.34×10^{-4}	0.00	2.34×10^{-4}	1.96×10^{1}	4.15×10^{-1}	6.38×10^{-4}	1.27×10^{-11}	6.38×10^{-4}
River Protection Project Disposal Facility	5.92×10^{-1}	5.96×10^{-2}	1.82×10^{-5}	0.00	1.82×10^{-5}	1.39	6.11×10^{-2}	5.75×10^{-5}	2.27×10^{-11}	5.75×10^{-5}
Core Zone Boundary	3.96	1.16×10^{-1}	8.23×10^{-5}	0.00	8.23×10^{-5}	6.52	1.40×10^{-1}	2.43×10^{-4}	4.41×10^{-11}	2.43×10^{-4}
Columbia River Nearshore	1.92	6.48×10^{-2}	4.73×10^{-5}	0.00	4.73×10^{-5}	3.66	8.36×10^{-2}	1.46×10^{-4}	9.08×10^{-12}	1.46×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.43×10^{-5}	1.73×10^{-6}	2.14×10^{-9}	1.23×10^{-16}	2.14×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–120. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.36×10^{1}	8.02×10^{-1}	1.34×10^{-3}	5.81×10^{-7}	1.34×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	2.73	9.24×10^{-2}	1.24×10^{-4}	1.04×10^{-6}	1.25×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.22×10^{1}	2.72×10^{-1}	5.17×10^{-4}	2.02×10^{-6}	5.17×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	7.06	1.61×10^{-1}	3.13×10^{-4}	4.17×10^{-7}	3.13×10^{-4}	1.09×10^{-2}	1.26×10^{-1}	4.93×10^{-7}	2.08×10^{-7}	5.49×10^{-7}
Off Site										
Columbia River	4.90×10^{-4}	4.50×10^{-3}	1.38×10^{-8}	5.63×10^{-12}	1.38×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–121. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.14×10^{1}	3.21×10^{-1}	2.34×10^{-4}	0.00	2.34×10^{-4}	1.96×10^{1}	4.15×10^{-1}	6.38×10^{-4}	1.27×10^{-11}	6.38×10^{-4}
River Protection Project Disposal Facility	6.96×10^{-1}	3.91×10^{-1}	2.16×10^{-5}	0.00	2.16×10^{-5}	1.65	4.38×10^{-1}	6.87×10^{-5}	1.28×10^{-10}	6.87×10^{-5}
Core Zone Boundary	3.96	1.38	8.33×10^{-5}	0.00	8.33×10^{-5}	6.52	1.54	2.70×10^{-4}	3.82×10^{-10}	2.70×10^{-4}
Columbia River Nearshore	1.94	2.29×10^{-1}	4.81×10^{-5}	0.00	4.81×10^{-5}	3.73	2.51×10^{-1}	1.48×10^{-4}	6.67×10^{-11}	1.48×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.46×10^{-5}	3.44×10^{-6}	2.16×10^{-9}	8.31×10^{-16}	2.16×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–122. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.36×10^{1}	8.02×10^{-1}	1.34×10^{-3}	5.82×10^{-7}	1.34×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.26	7.37×10^{-1}	1.49×10^{-4}	5.87×10^{-6}	1.51×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.26×10^{1}	2.56	5.86×10^{-4}	1.75×10^{-5}	5.91×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	7.19	4.12×10^{-1}	3.18×10^{-4}	3.06×10^{-6}	3.20×10^{-4}	1.10×10^{-2}	2.21×10^{-1}	5.01×10^{-7}	1.53×10^{-6}	1.61×10^{-6}
Off Site										
Columbia River	4.93×10^{-4}	5.08×10^{-3}	1.39×10^{-8}	3.81×10^{-11}	1.39×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

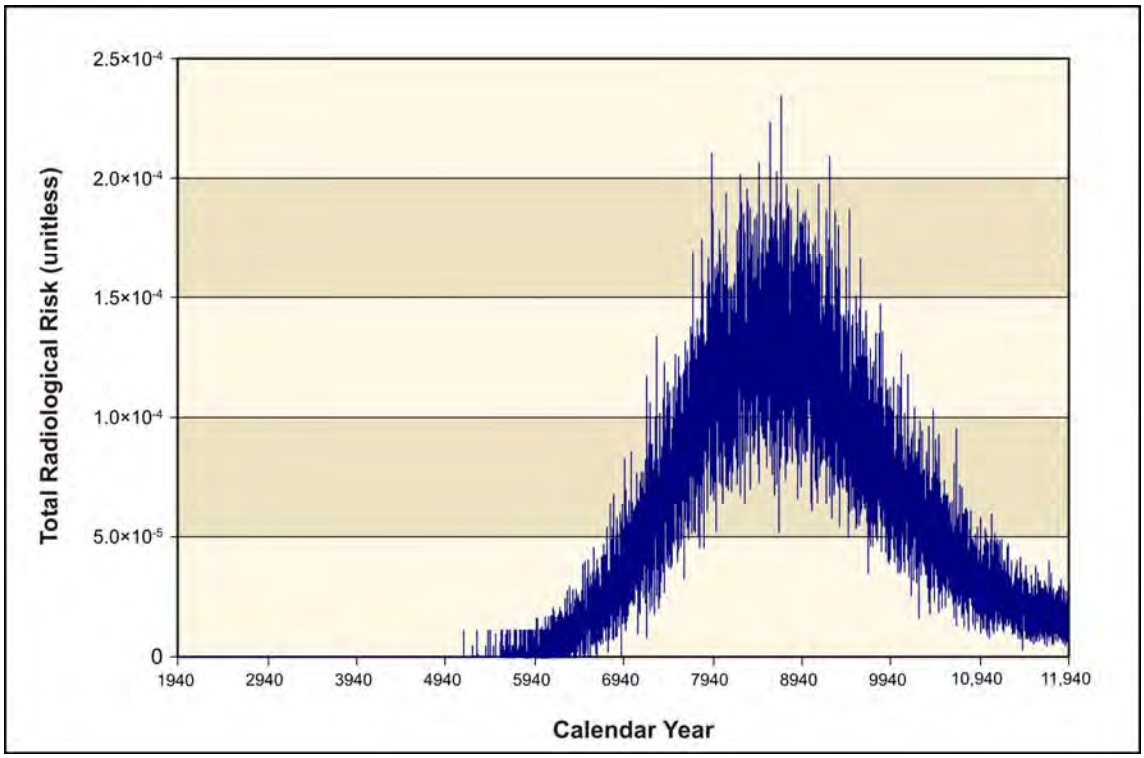


Figure 5–1158. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

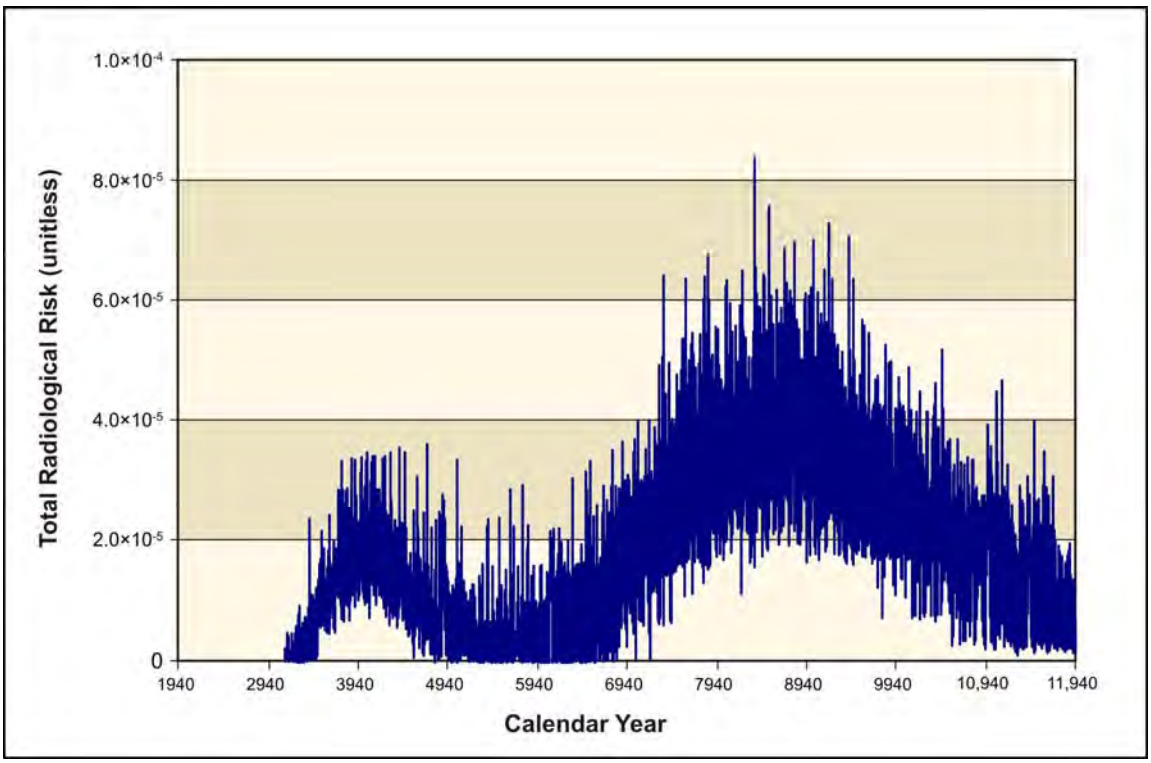


Figure 5–1159. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

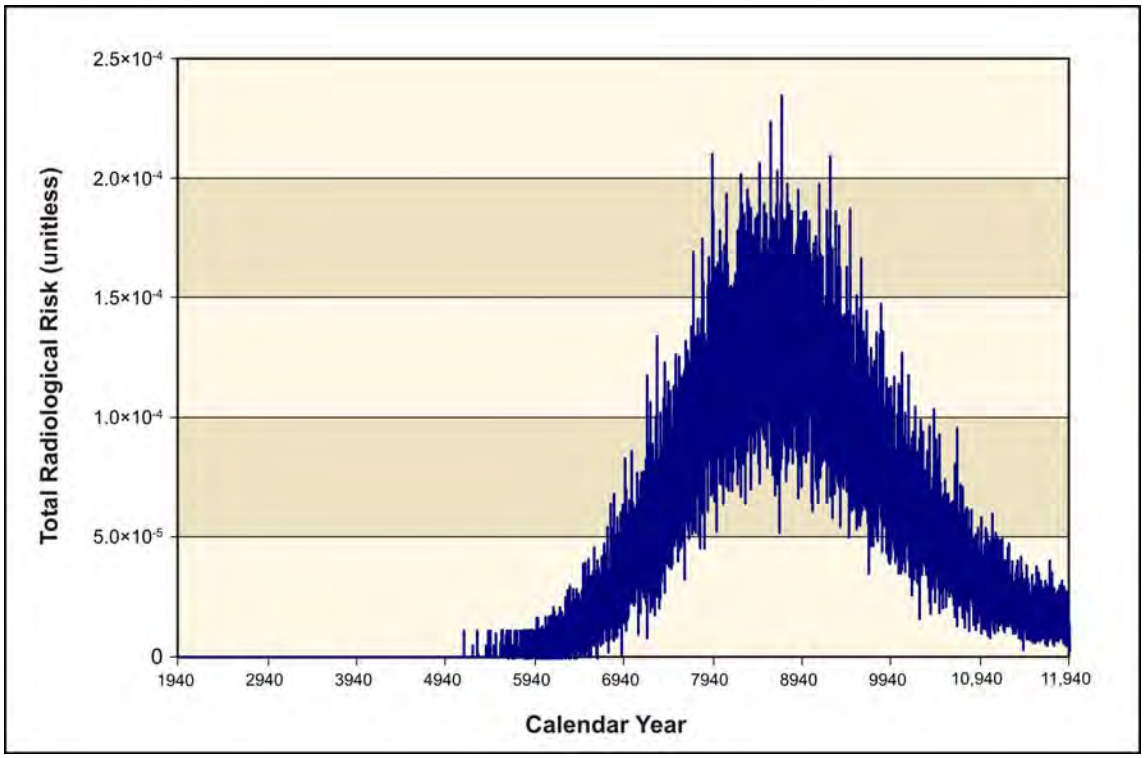


Figure 5–1160. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

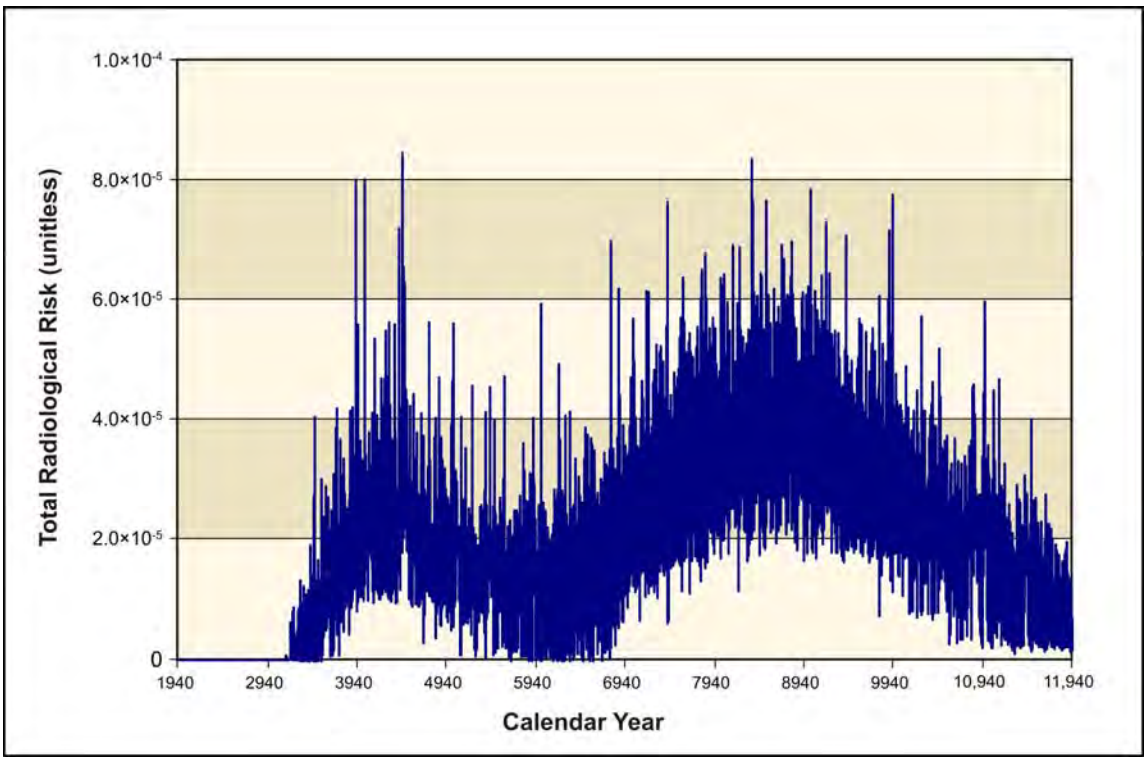


Figure 5–1161. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.2.10 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only, Disposal Group 3

Disposal Group 3 addresses the waste resulting from Tank Closure Alternative 6A (Base and Option Cases), onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this disposal group.

Potential human health impacts of this alternative are summarized in Tables 5–123 through 5–126. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, nitrate, and total uranium for chemicals. For radionuclides, the dose standard would not be exceeded at any location under both Base and Option Cases. For Base Case, the Hazard Index guidelines would not be exceeded at any location. For the Option Case, the Hazard Index guideline would be exceeded at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer due primarily to presence of chromium and nitrate. The Hazard Index would be exceeded for chromium at the Core Zone Boundary under the Option Case. Population dose was estimated for Disposal Group 3, Base Case, as 3.12×10^{-1} person-rem per year for the year of maximum impact and for Disposal Group 3, Option Case, as 3.13×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.71×10^{-5} percent and 1.71×10^{-5} percent of the annual population dose due to background exposure for Disposal Group 3, Base and Option Cases, respectively. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1162 and 5–1163 for the Base Case and in Figures 5–1164 and 5–1165 for the Option Case. The Base and Option Cases differ in the amounts of constituents disposed of at the RPPDF because the Option Case includes removal of the Tank Closure alternative cribs and trenches (ditches). Estimates of impacts for IDF-East are the same for the two cases. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.2×10^{-4}) is distributed primarily among the offsite LLW (9×10^{-5}) and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for secondary waste sources is release of technetium-99 from tank closure secondary waste and iodine-129 from the combined ETF-generated and tank closure secondary waste sources. The time series of radiological risk for the drinking-water well user at the Core Zone Boundary for the Base Case (see Figure 5–1163) and the Option Case (see Figure 5–1165) each comprise a small, early peak due to sources at the RPPDF and a higher, later peak due to sources at IDF-East. The early peak is greater for the Option Case relative to the Base Case due to the inclusion of additional waste from cribs and trenches (ditches).

Table 5–123. Waste Management Alternative 2, Disposal Group 3, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.08×10^{1}	3.07×10^{-1}	2.29×10^{-4}	0.00	2.29×10^{-4}	1.90×10^{1}	4.01×10^{-1}	6.48×10^{-4}	1.20×10^{-11}	6.48×10^{-4}
River Protection Project Disposal Facility	6.35×10^{-1}	5.89×10^{-2}	1.94×10^{-5}	0.00	1.94×10^{-5}	1.48	6.01×10^{-2}	6.15×10^{-5}	2.27×10^{-11}	6.15×10^{-5}
Core Zone Boundary	3.59	1.21×10^{-1}	7.77×10^{-5}	0.00	7.77×10^{-5}	5.99	1.56×10^{-1}	2.42×10^{-4}	4.31×10^{-11}	2.42×10^{-4}
Columbia River Nearshore	2.31	6.81×10^{-2}	6.03×10^{-5}	0.00	6.03×10^{-5}	4.76	8.67×10^{-2}	1.80×10^{-4}	1.21×10^{-11}	1.80×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.24×10^{-5}	1.79×10^{-6}	2.12×10^{-9}	1.23×10^{-16}	2.12×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–124. Waste Management Alternative 2, Disposal Group 3, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.30×10^{1}	7.82×10^{-1}	1.38×10^{-3}	5.52×10^{-7}	1.38×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	2.93	9.04×10^{-2}	1.33×10^{-4}	1.04×10^{-6}	1.33×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.17×10^{1}	3.05×10^{-1}	5.21×10^{-4}	1.98×10^{-6}	5.21×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	8.94	1.65×10^{-1}	3.83×10^{-4}	5.54×10^{-7}	3.84×10^{-4}	1.41×10^{-2}	1.26×10^{-1}	6.28×10^{-7}	2.77×10^{-7}	6.82×10^{-7}
Off Site										
Columbia River	5.26×10^{-4}	4.71×10^{-3}	1.41×10^{-8}	5.64×10^{-12}	1.41×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–125. Waste Management Alternative 2, Disposal Group 3, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.08×10^{1}	3.07×10^{-1}	2.29×10^{-4}	0.00	2.29×10^{-4}	1.90×10^{1}	4.01×10^{-1}	6.48×10^{-4}	1.21×10^{-11}	6.48×10^{-4}
River Protection Project Disposal Facility	7.87×10^{-1}	4.29×10^{-1}	2.45×10^{-5}	0.00	2.45×10^{-5}	1.86	4.69×10^{-1}	7.79×10^{-5}	1.43×10^{-10}	7.79×10^{-5}
Core Zone Boundary	4.10	1.35	8.54×10^{-5}	0.00	8.54×10^{-5}	7.13	1.53	2.42×10^{-4}	4.89×10^{-10}	2.42×10^{-4}
Columbia River Nearshore	2.34	2.29×10^{-1}	6.13×10^{-5}	0.00	6.13×10^{-5}	4.84	2.51×10^{-1}	1.83×10^{-4}	8.04×10^{-11}	1.83×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.25×10^{-5}	3.19×10^{-6}	2.13×10^{-9}	7.90×10^{-16}	2.13×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–126. Waste Management Alternative 2, Disposal Group 3, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.30×10^{1}	7.82×10^{-1}	1.38×10^{-3}	5.53×10^{-7}	1.38×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.70	7.80×10^{-1}	1.69×10^{-4}	6.54×10^{-6}	1.72×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.23×10^{1}	2.59	5.21×10^{-4}	2.24×10^{-5}	5.23×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	9.08	4.11×10^{-1}	3.89×10^{-4}	3.69×10^{-6}	3.89×10^{-4}	1.43×10^{-2}	2.17×10^{-1}	6.38×10^{-7}	1.84×10^{-6}	2.00×10^{-6}
Off Site										
Columbia River	5.28×10^{-4}	5.31×10^{-3}	1.42×10^{-8}	3.62×10^{-11}	1.42×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

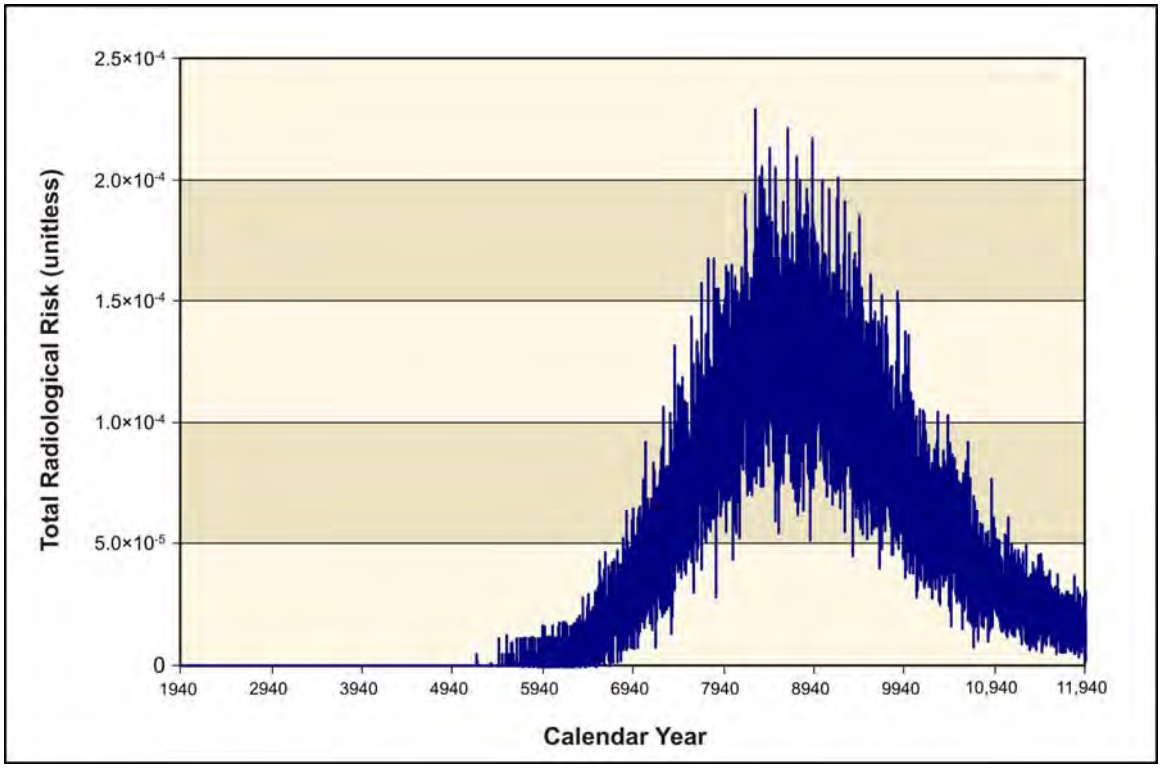


Figure 5–1162. Waste Management Alternative 2, Disposal Group 3, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

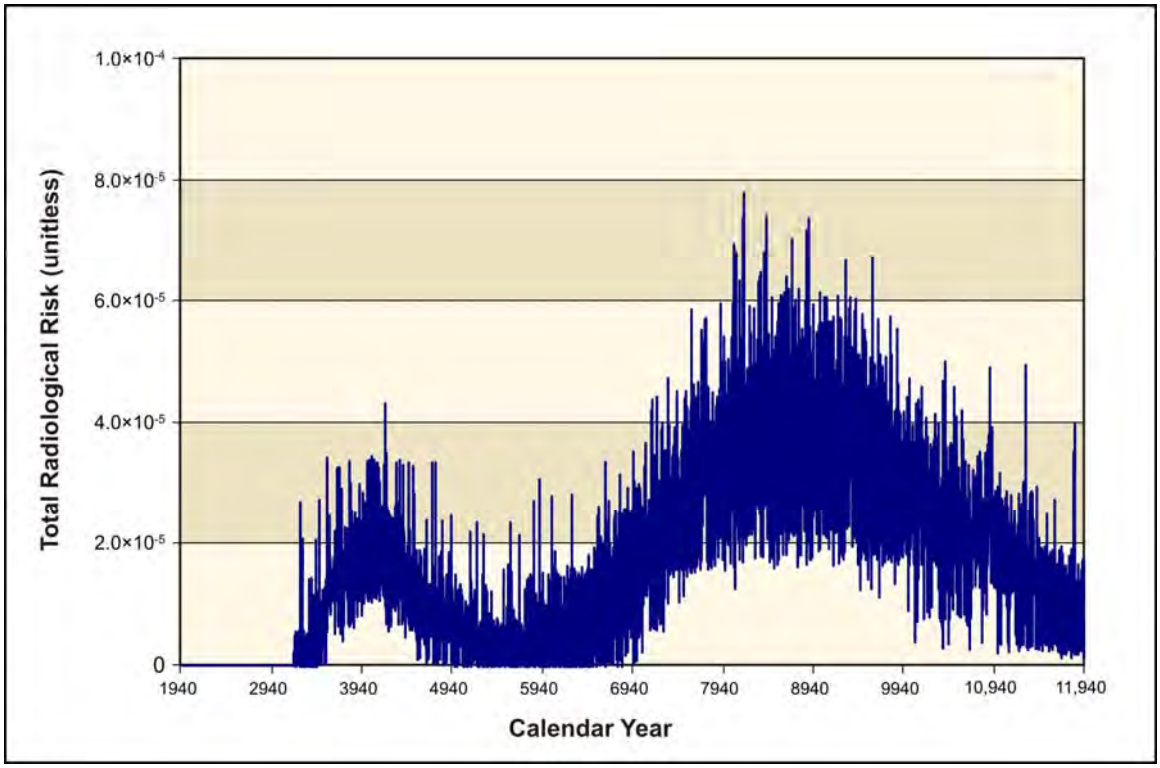


Figure 5–1163. Waste Management Alternative 2, Disposal Group 3, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

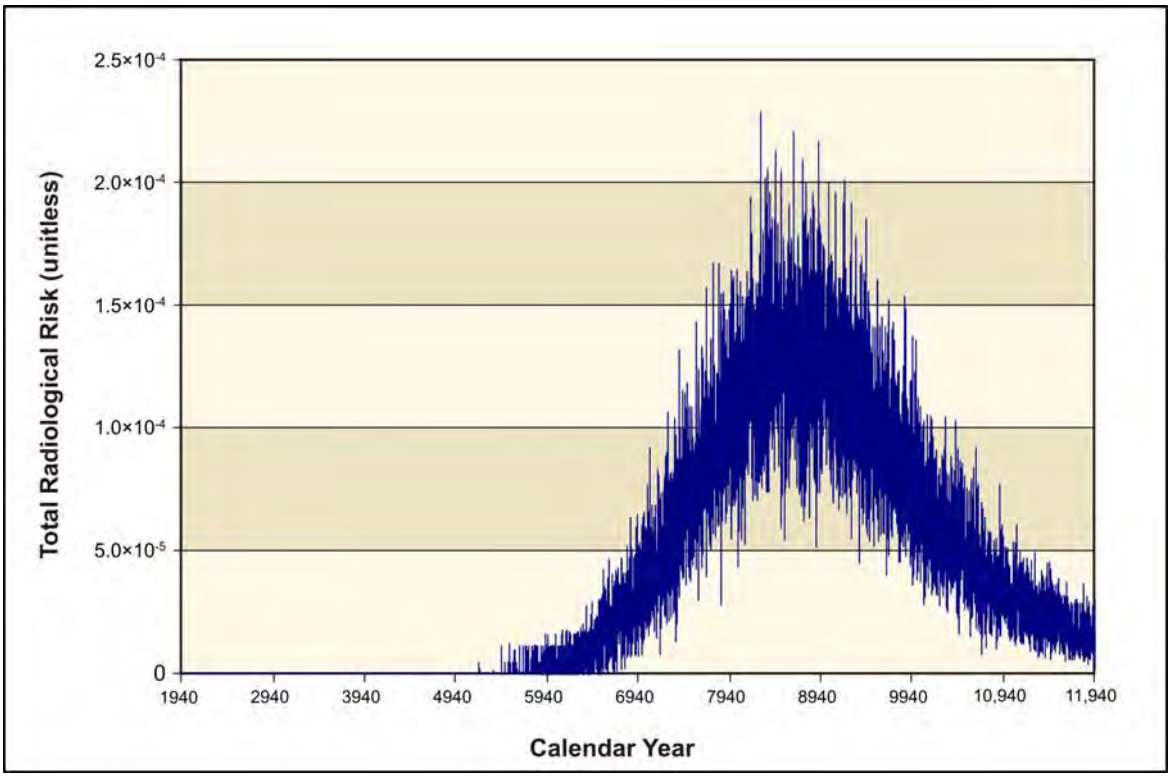


Figure 5–1164. Waste Management Alternative 2, Disposal Group 3, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

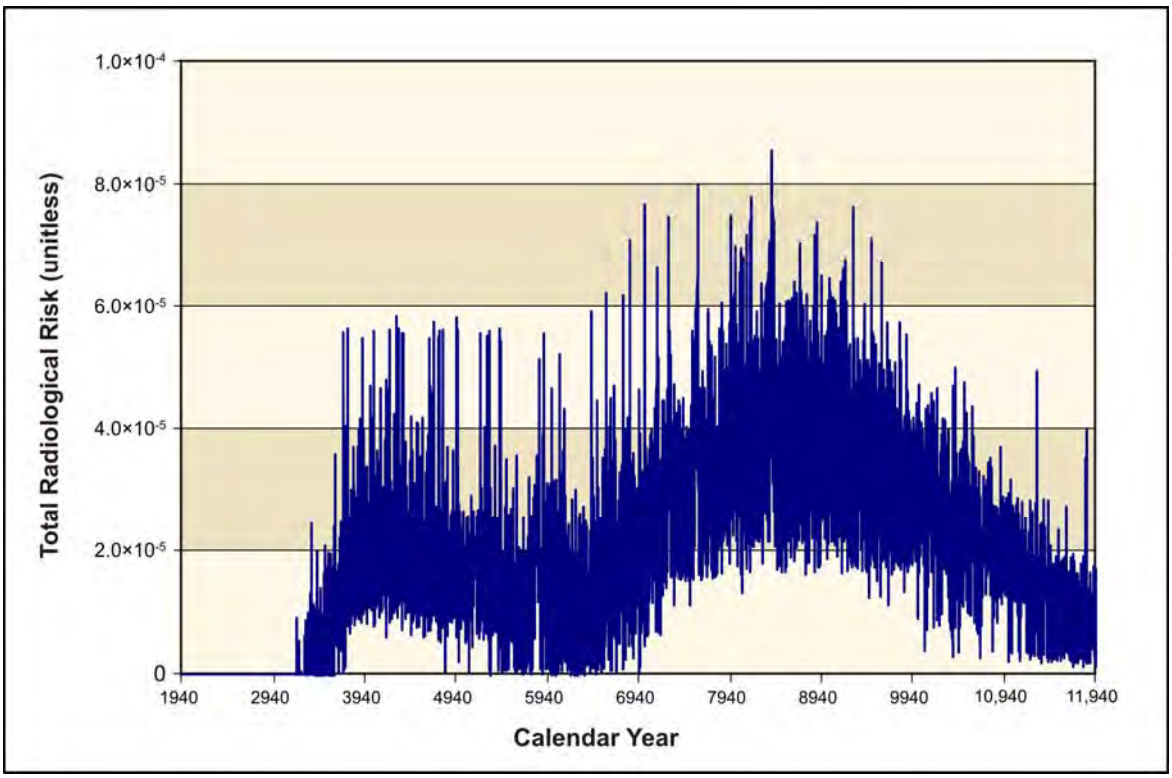


Figure 5–1165. Waste Management Alternative 2, Disposal Group 3, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Under Waste Management Alternative 3, the waste from tank treatment operations would be disposed of in IDF-East, and the waste from onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites would be disposed of in IDF-West. Waste from tank farm cleanup operations would be disposed of in the RPPDF. As a result, the waste disposed of in these three facilities would become available for release to the environment. Because of the different waste types that result from the Tank Closure action alternatives, three disposal groups were considered to account for the different sizes and operational time periods of IDF-East. In addition, within these three disposal groups, subgroups were identified to allow consideration of the different waste types resulting from the Tank Closure alternatives. Potential human health impacts of these subgroups under this alternative are discussed in the following sections.

5.3.2.3.1 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-A

Disposal Group 1, Subgroup 1-A, addresses the waste resulting from Tank Closure Alternative 2B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–127 and 5–128. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are boron and boron compounds, chromium, fluoride, and nitrate; however, the peak chemical hazard is negligible. For radionuclides, the dose standard would be exceeded at the IDF-West boundary for the resident farmer and the American Indian resident farmer. The Hazard Index would not be exceeded at any location. Population dose was estimated as 5.76×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.15×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier, the IDF-West Barrier, and the Core Zone Boundary are presented in Figures 5–1166 through 5–1168, respectively. At the IDF-East Barrier, the peak of the time-averaged lifetime radiological risk (1.3×10^{-5}) is attributed primarily to the combination of ETF-generated and tank closure secondary waste. Releases from ILAW glass contribute a minor portion of the risk. At IDF-West, the peak of the time-averaged lifetime radiological risk (1.5×10^{-3}) is due primarily to release of technetium-99 from offsite LLW. For the time series of risk at the Core Zone Boundary (see Figure 5–1168), the large, early peak at CY 3700, is due to releases from IDF-West, while the lower peak at CY 9900 is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak.

Table 5–127. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.04	2.71×10^{-1}	3.05×10^{-5}	0.00	3.05×10^{-5}	2.35	3.52×10^{-1}	9.59×10^{-5}	1.62×10^{-11}	9.59×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	2.73×10^{1}	1.04×10^{-1}	5.79×10^{-4}	0.00	5.79×10^{-4}	4.75×10^{1}	1.36×10^{-1}	1.66×10^{-3}	1.22×10^{-11}	1.66×10^{-3}
Columbia River nearshore	3.37	4.76×10^{-2}	8.13×10^{-5}	0.00	8.13×10^{-5}	6.44	6.14×10^{-2}	2.41×10^{-4}	2.88×10^{-12}	2.41×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.15×10^{-4}	1.61×10^{-6}	3.77×10^{-9}	3.91×10^{-17}	3.77×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–128. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	4.58	6.82×10^{-1}	2.07×10^{-4}	7.41×10^{-7}	2.07×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.49×10^{1}	2.65×10^{-1}	3.50×10^{-3}	5.58×10^{-7}	3.50×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.20×10^{1}	1.18×10^{-1}	5.12×10^{-4}	1.32×10^{-7}	5.12×10^{-4}	2.00×10^{-2}	9.57×10^{-2}	8.58×10^{-7}	6.61×10^{-8}	8.79×10^{-7}
Off Site										
Columbia River	9.15×10^{-4}	4.21×10^{-3}	2.51×10^{-8}	1.79×10^{-12}	2.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

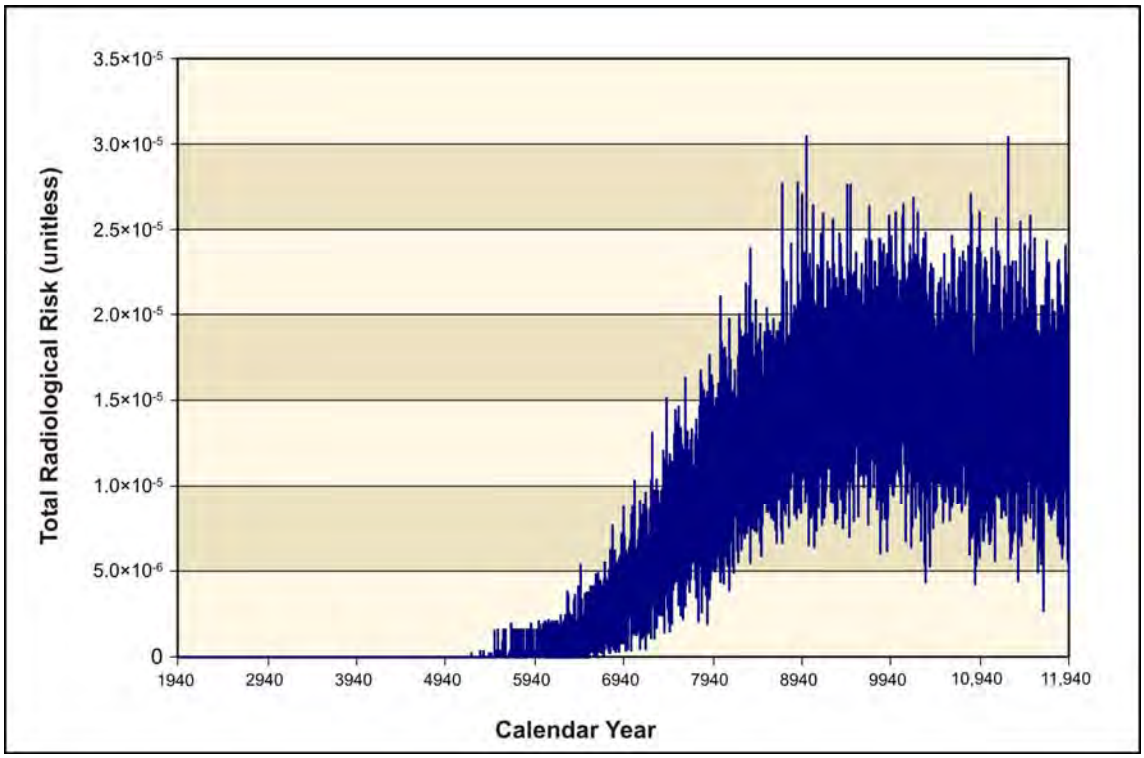


Figure 5–1166. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

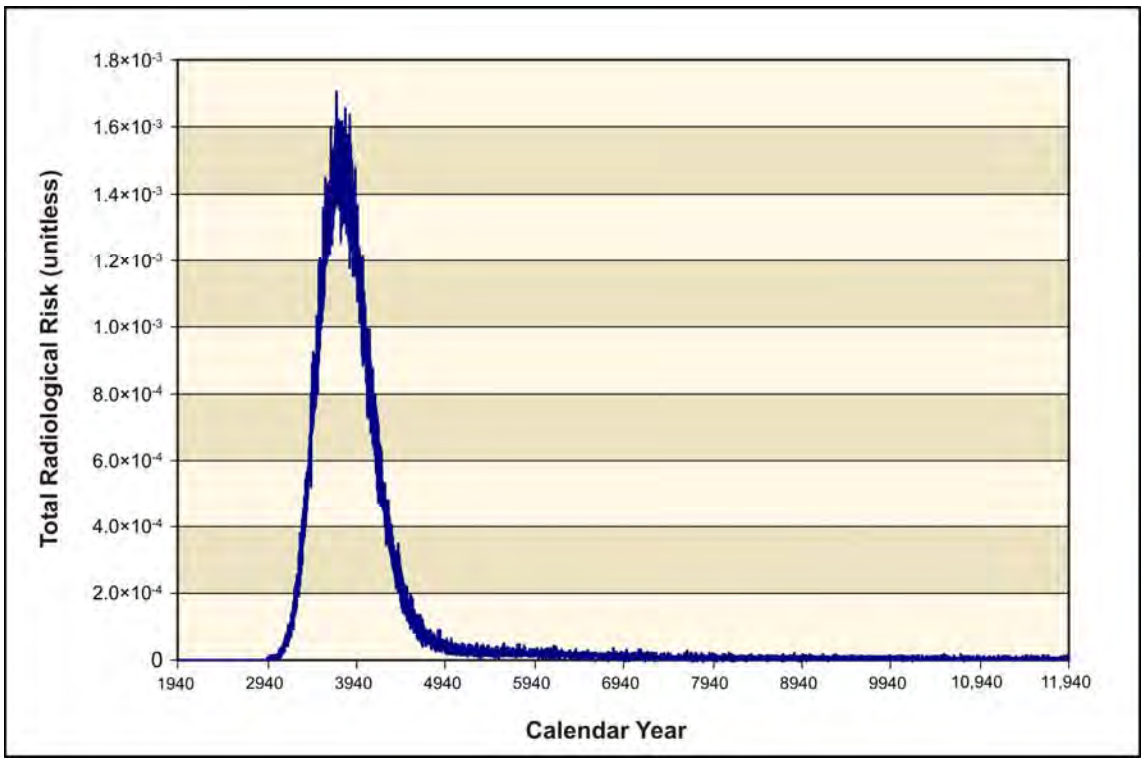


Figure 5–1167. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-West Area Integrated Disposal Facility Barrier

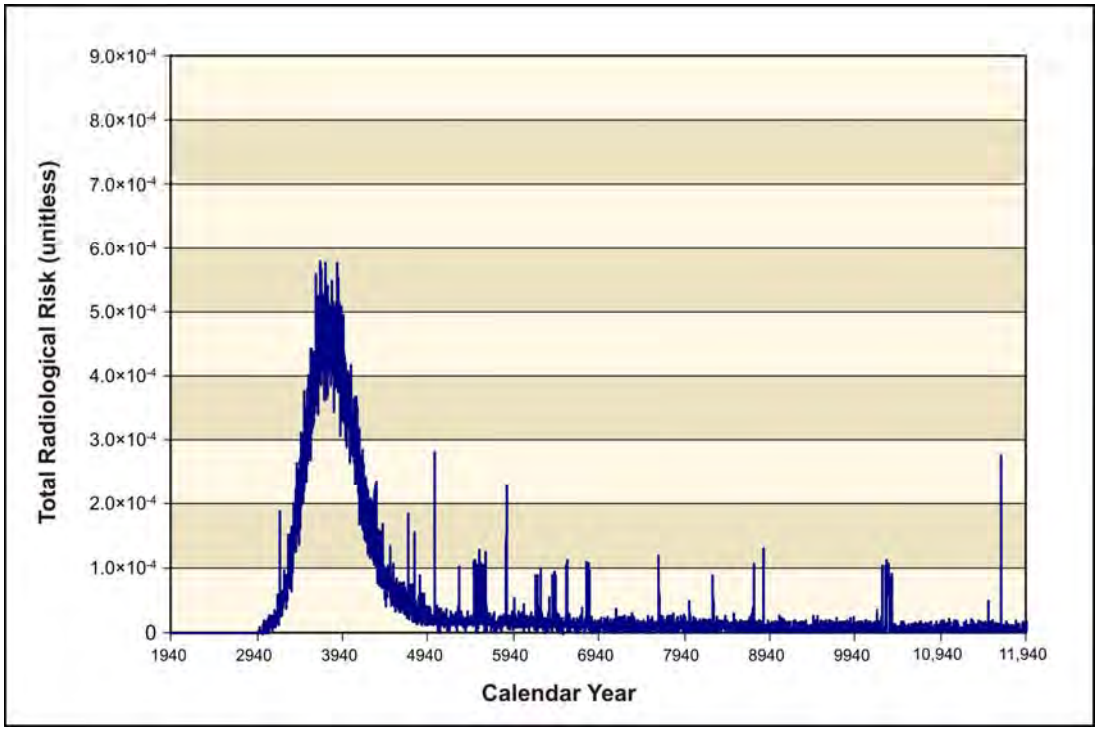


Figure 5–1168. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.2 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-B

Disposal Group 1, Subgroup 1-B, addresses the waste resulting from Tank Closure Alternative 3A, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–129 and 5–130. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are boron and boron compounds, chromium, fluoride, and nitrate; however, the peak chemical hazard is negligible. For radionuclides, the dose standard would be exceeded at the IDF-West boundary for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 5.76×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.15×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1169 and 5–1170, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167, and peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (5.0×10^{-5}) is distributed primarily between the bulk vitrification glass (4×10^{-5}) and the combined ETF-generated and tank closure secondary waste sources (1×10^{-5}). The major contributor to risk for the bulk vitrification glass is release of technetium-99 from the castable refractory block portion of the waste form package. For the time series of risk at the Core Zone Boundary (see Figure 5–1170), the large, early peak at CY 3700, is due to releases from IDF-West, while the low plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak.

Table 5–129. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.00	2.64×10^{-1}	9.88×10^{-5}	0.00	9.88×10^{-5}	7.44	3.45×10^{-1}	3.20×10^{-4}	6.22×10^{-12}	3.20×10^{-4}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	2.73×10^{1}	1.06×10^{-1}	5.79×10^{-4}	0.00	5.79×10^{-4}	4.75×10^{1}	1.39×10^{-1}	1.66×10^{-3}	1.22×10^{-11}	1.66×10^{-3}
Columbia River nearshore	3.37	6.71×10^{-2}	8.13×10^{-5}	0.00	8.13×10^{-5}	6.44	8.79×10^{-2}	2.41×10^{-4}	1.80×10^{-12}	2.41×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.15×10^{-4}	1.51×10^{-6}	3.77×10^{-9}	3.00×10^{-17}	3.77×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–130. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.50×10^{1}	6.74×10^{-1}	6.96×10^{-4}	2.85×10^{-7}	6.96×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.49×10^{1}	2.72×10^{-1}	3.50×10^{-3}	5.58×10^{-7}	3.50×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.20×10^{1}	1.72×10^{-1}	5.12×10^{-4}	8.28×10^{-8}	5.12×10^{-4}	2.00×10^{-2}	1.36×10^{-1}	8.58×10^{-7}	4.14×10^{-8}	8.79×10^{-7}
Off Site										
Columbia River	9.15×10^{-4}	4.03×10^{-3}	2.51×10^{-8}	1.37×10^{-12}	2.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

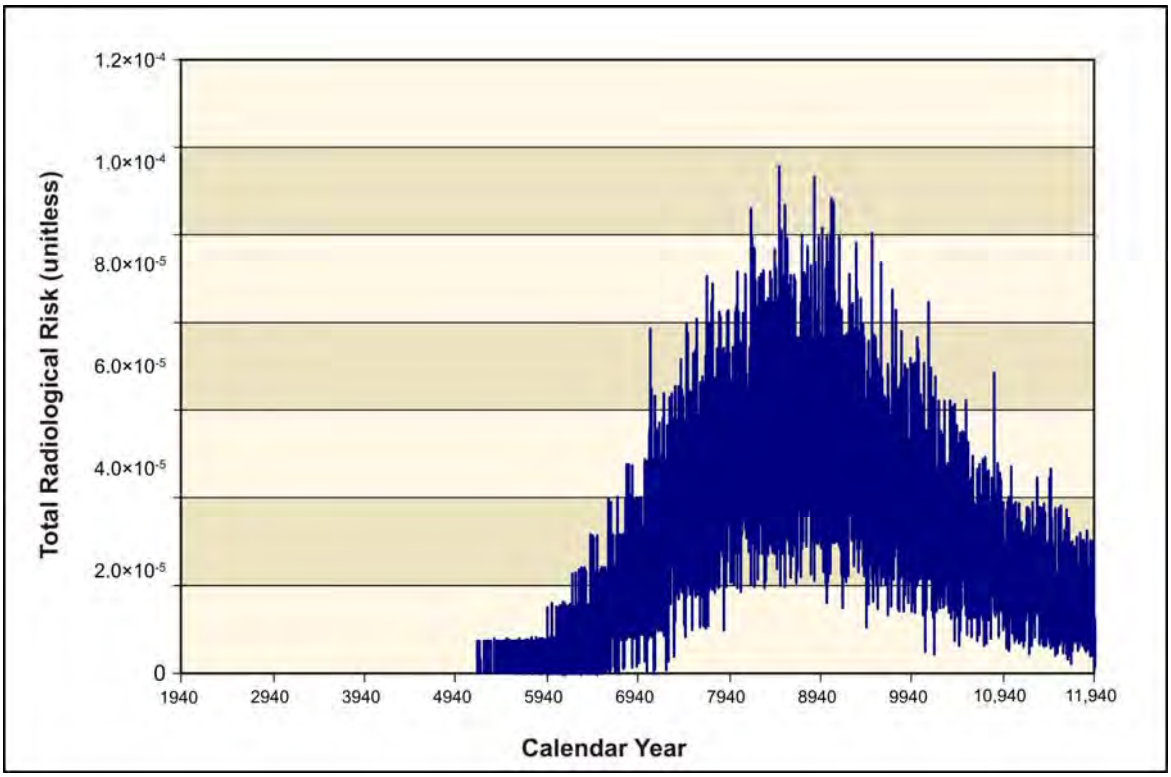


Figure 5–1169. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

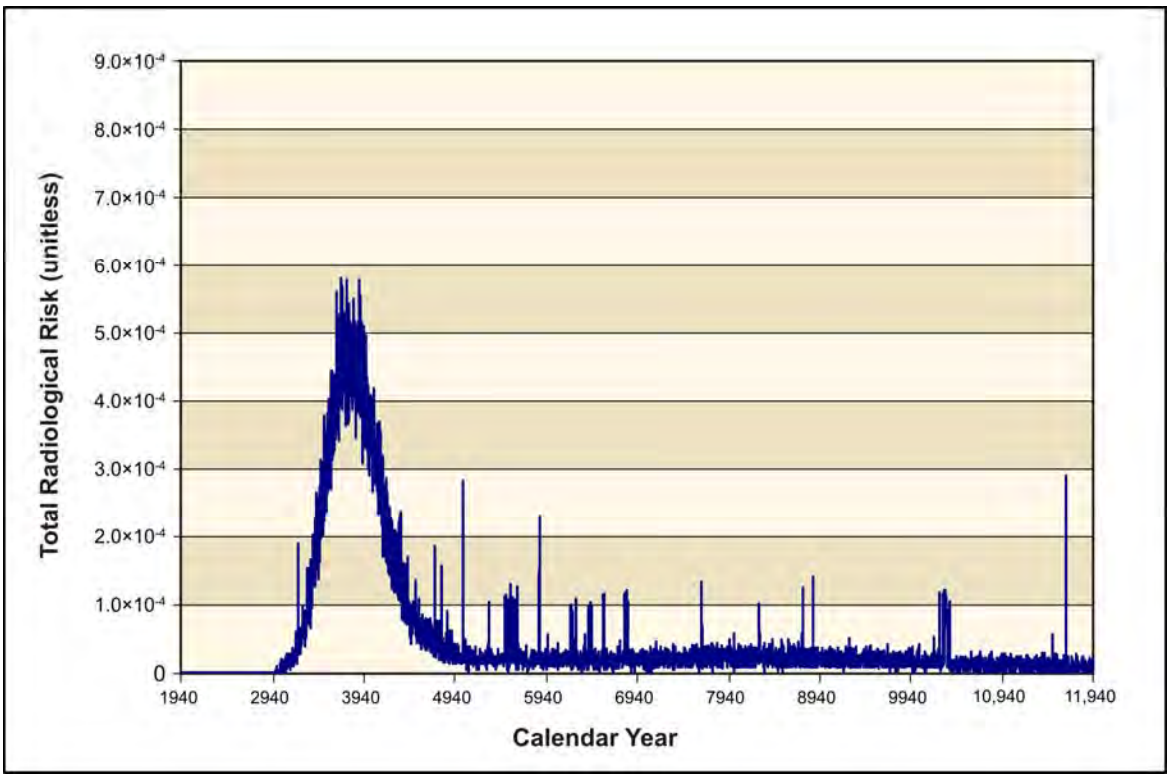


Figure 5–1170. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.3 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-C

Disposal Group 1, Subgroup 1-C, addresses the waste resulting from Tank Closure Alternative 3B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–131 and 5–132. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would be exceeded at the IDF-West Barrier for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the IDF-East Barrier, Core Zone boundary, and Columbia River nearshore for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 5.76×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.15×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1171 and 5–1172, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.3×10^{-4}) is distributed primarily between the cast stone waste (1.2×10^{-4}) and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the cast stone LAW is release of technetium-99. For the time series of risk at the Core Zone Boundary (see Figure 5–1172), the large, early peak at CY 3700 is due to releases from IDF-West, while the low plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak.

Table 5–131. Waste Management Alternative 3, Disposal Group 2, Subgroup 1-C, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.88	4.86	3.03×10^{-4}	0.00	3.03×10^{-4}	2.27×10^{1}	5.08	9.93×10^{-4}	1.71×10^{-9}	9.93×10^{-4}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	2.73×10^{1}	2.73	5.79×10^{-4}	0.00	5.79×10^{-4}	4.75×10^{1}	2.80	1.66×10^{-3}	1.04×10^{-9}	1.66×10^{-3}
Columbia River Nearshore	3.37	1.24	1.06×10^{-4}	0.00	1.06×10^{-4}	8.08	1.29	3.40×10^{-4}	4.57×10^{-10}	3.40×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.15×10^{-4}	1.91×10^{-5}	3.77×10^{-9}	5.84×10^{-15}	3.77×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–132. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	4.61×10^{1}	7.87	2.17×10^{-3}	7.86×10^{-5}	2.20×10^{-3}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.49×10^{1}	4.23	3.50×10^{-3}	4.77×10^{-5}	3.50×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River Nearshore	1.61×10^{1}	1.97	7.37×10^{-4}	2.10×10^{-5}	7.42×10^{-4}	2.06×10^{-2}	6.59×10^{-1}	1.07×10^{-6}	1.05×10^{-5}	1.08×10^{-5}
Off Site										
Columbia River	9.15×10^{-4}	1.80×10^{-2}	2.51×10^{-8}	2.68×10^{-10}	2.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

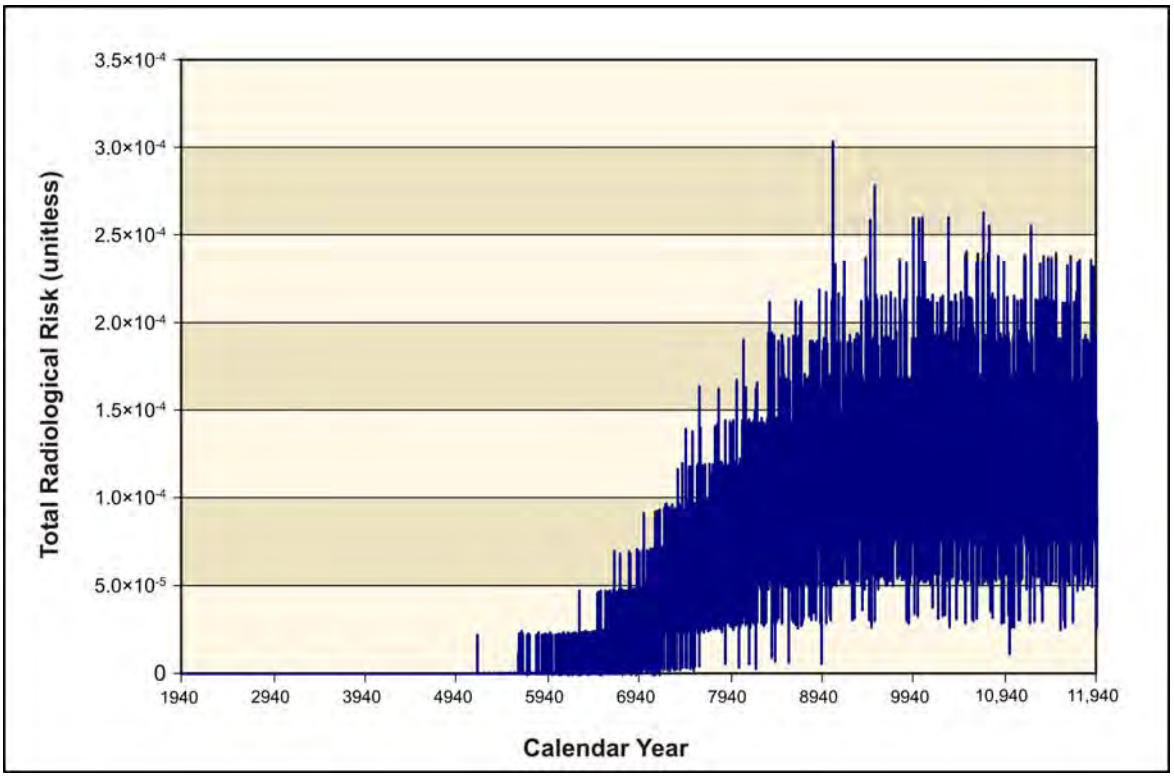


Figure 5–1171. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

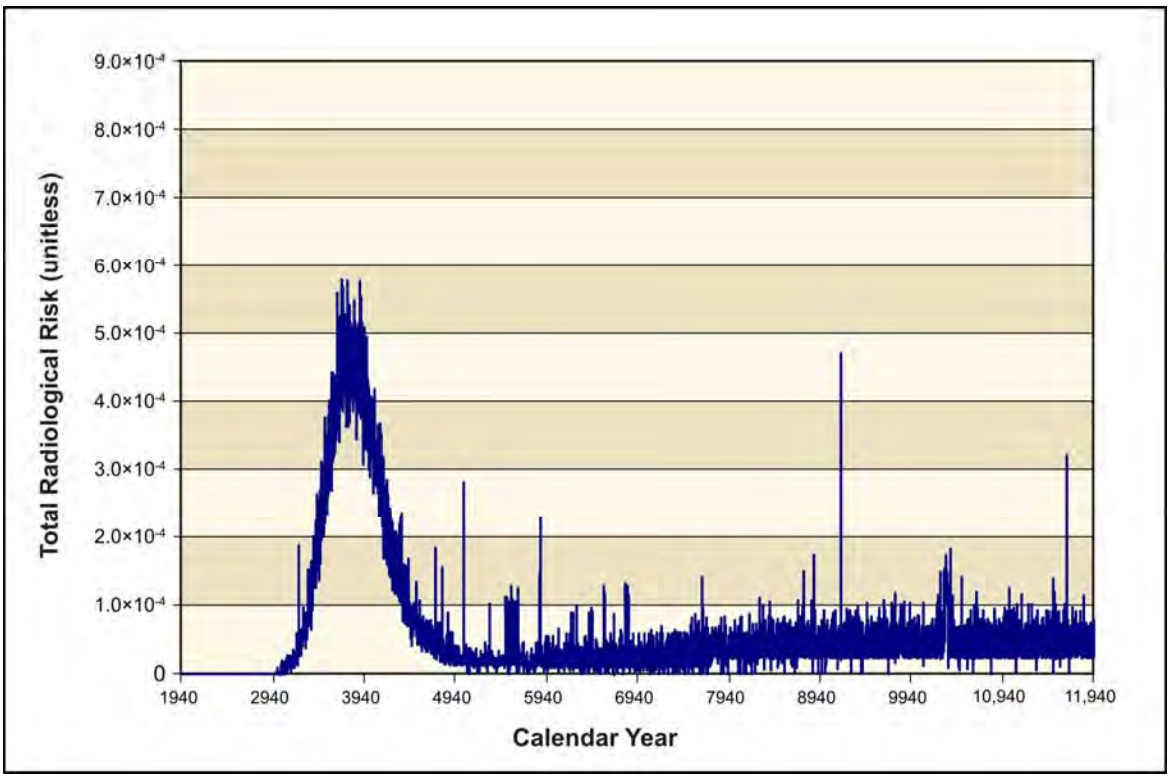


Figure 5–1172. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.4 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-D

Disposal Group 1, Subgroup 1-D addresses the waste resulting from Tank Closure Alternative 3C, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–133 and 5–134. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would be exceeded at the IDF-East Barrier, the IDF-West Barrier, and the Core Zone Boundary for the resident farmer and the American Indian resident farmer. The Hazard Index would be exceeded primarily due to chromium at the IDF-East Barrier, Core Zone Boundary, and Columbia River nearshore location for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 2.24 person-rem per year for the year of maximum impact. This corresponds to a 1.23×10^{-4} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1173 and 5–1174, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (8.0×10^{-4}) is distributed primarily between the steam reforming waste (8.0×10^{-4}) and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the steam reforming waste LAW is release of technetium-99. For the time series of risk at the Core Zone Boundary (see Figure 5–1174), the large, early peak at CY 3700 is due to releases from IDF-West, while the subsequent peak at CY 8000 is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak. While the peak of the series of time-averaged lifetime radiological risk appears on the curve of Figure 5–1174, the peak of the series of instantaneous lifetime radiological risk does not appear in the figure because the upper limit of the risk scale was reduced to facilitate comparison of the peaks attributed to RPPDF and IDF-East.

Table 5–133. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	5.28×10^{1}	4.30	1.78×10^{-3}	0.00	1.78×10^{-3}	1.33×10^{2}	4.35	5.79×10^{-3}	1.71×10^{-9}	5.79×10^{-3}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	4.39×10^{1}	1.69	1.49×10^{-3}	0.00	1.49×10^{-3}	1.12×10^{2}	1.70	4.88×10^{-3}	6.84×10^{-10}	4.88×10^{-3}
Columbia River nearshore	1.40×10^{1}	1.12	4.60×10^{-4}	0.00	4.60×10^{-4}	3.46×10^{1}	1.13	1.49×10^{-3}	4.56×10^{-10}	1.49×10^{-3}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.47×10^{-4}	1.69×10^{-5}	1.94×10^{-8}	6.52×10^{-15}	1.94×10^{-8}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–134. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	2.70×10^{2}	6.46	1.26×10^{-2}	7.85×10^{-5}	1.27×10^{-2}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.27×10^{2}	2.50	1.06×10^{-2}	3.14×10^{-5}	1.06×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	6.96×10^{1}	1.65	3.23×10^{-3}	2.09×10^{-5}	3.24×10^{-3}	8.66×10^{-2}	2.88×10^{-1}	4.59×10^{-6}	1.05×10^{-5}	1.16×10^{-5}
Off Site										
Columbia River	1.14×10^{-3}	4.74×10^{-3}	5.11×10^{-8}	2.99×10^{-10}	5.12×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

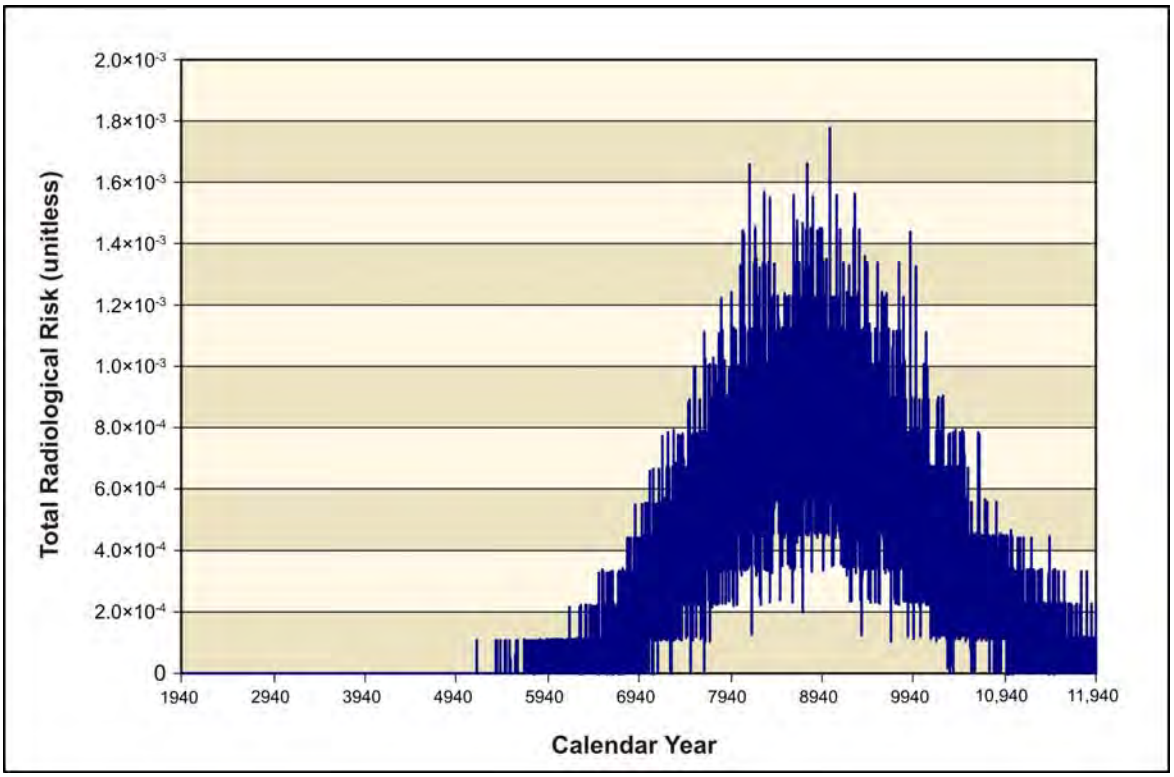


Figure 5–1173. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

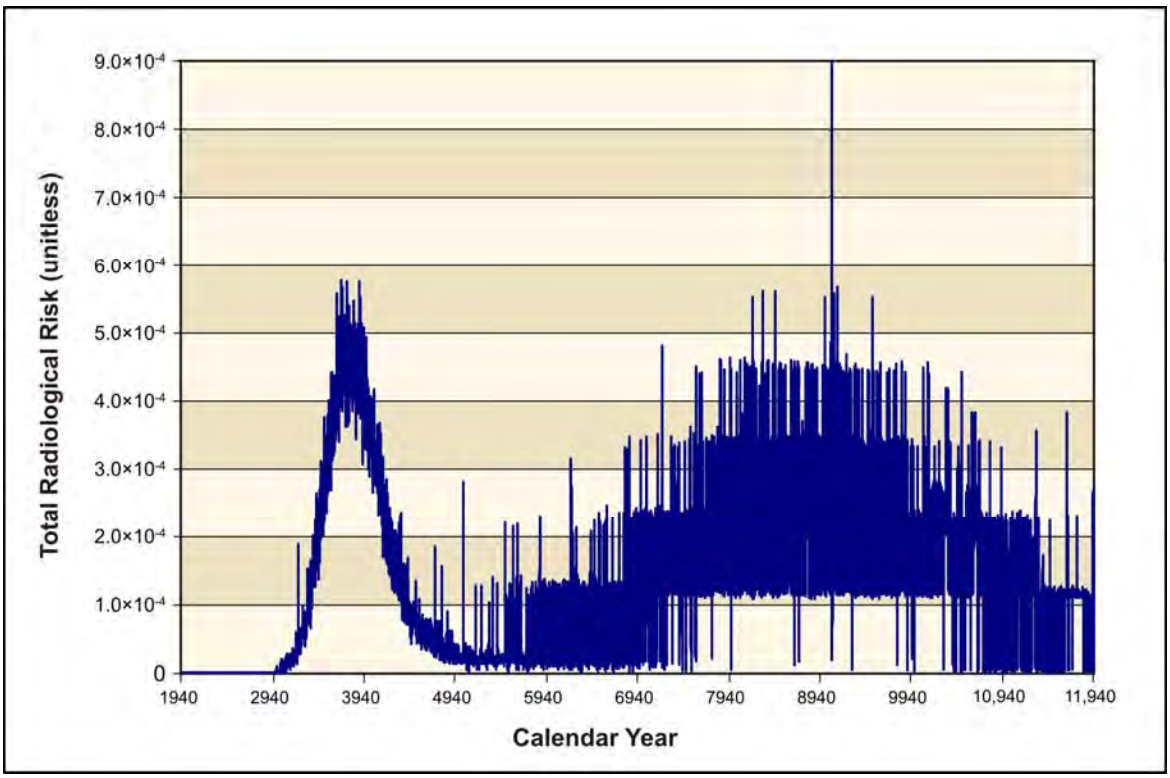


Figure 5–1174. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.5 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-E

Disposal Group 1, Subgroup 1-E, addresses the waste resulting from Tank Closure Alternative 4, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–135 and 5–136. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would be exceeded at the IDF-West Barrier for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the IDF-East Barrier and Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer and at the Columbia River nearshore location for the American Indian resident farmer. Population dose was estimated as 5.79×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.17×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1175 and 5–1176, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167 and peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.5×10^{-4}) is distributed among the combination of ILAW glass, bulk vitrification glass, and cast stone waste (1.2×10^{-4}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the supplemental waste forms is release of technetium-99 from cast stone waste and the castable refractory block portion of the bulk vitrification glass. For the time series of risk at the Core Zone Boundary (see Figure 5–1176), the large, early peak at CY 3700 is due to releases from IDF-West, while the subsequent plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak.

Table 5–135. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	1.01×10^{1}	2.48	3.42×10^{-4}	0.00	3.42×10^{-4}	2.56×10^{1}	2.59	1.12×10^{-3}	8.78×10^{-10}	1.12×10^{-3}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	2.15×10^{-1}	5.86×10^{-2}	6.59×10^{-6}	0.00	6.59×10^{-6}	5.03×10^{-1}	5.95×10^{-2}	2.08×10^{-5}	2.30×10^{-11}	2.08×10^{-5}
Core Zone Boundary	2.73×10^{1}	1.02	5.82×10^{-4}	0.00	5.82×10^{-4}	4.75×10^{1}	1.06	1.67×10^{-3}	3.76×10^{-10}	1.67×10^{-3}
Columbia River nearshore	3.98	6.59×10^{-1}	1.27×10^{-4}	0.00	1.27×10^{-4}	9.62	6.75×10^{-1}	4.08×10^{-4}	2.50×10^{-10}	4.08×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.16×10^{-4}	1.15×10^{-5}	4.44×10^{-9}	3.65×10^{-15}	4.44×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–136. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	5.20×10^{1}	4.00	2.43×10^{-3}	4.03×10^{-5}	2.44×10^{-3}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	9.92×10^{-1}	8.87×10^{-2}	4.51×10^{-5}	1.06×10^{-6}	4.59×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.53×10^{1}	1.62	3.52×10^{-3}	1.72×10^{-5}	3.52×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.92×10^{1}	1.02	8.85×10^{-4}	1.15×10^{-5}	8.87×10^{-4}	2.44×10^{-2}	3.40×10^{-1}	1.27×10^{-6}	5.74×10^{-6}	6.20×10^{-6}
Off Site										
Columbia River	9.18×10^{-4}	1.05×10^{-2}	2.52×10^{-8}	1.67×10^{-10}	2.52×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

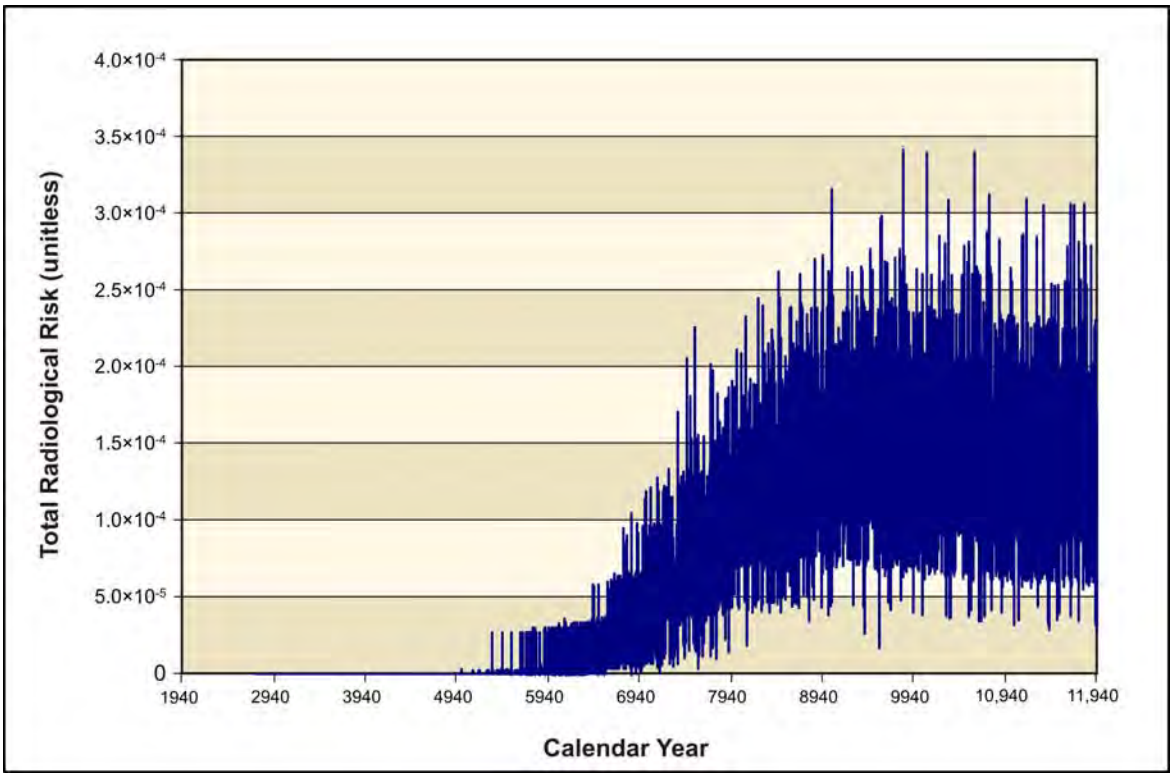


Figure 5–1175. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

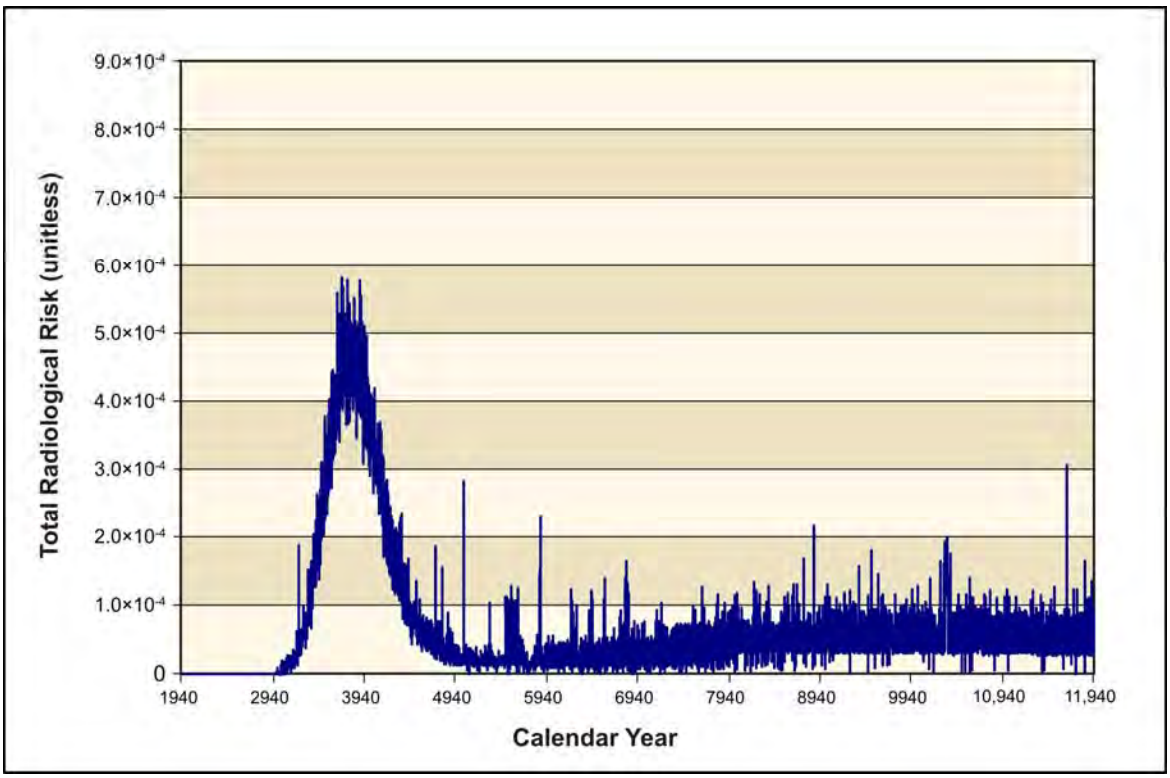


Figure 5–1176. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.6 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-F

Disposal Group 1, Subgroup 1-F, addresses the waste resulting from Tank Closure Alternative 5, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–137 and 5–138. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would be exceeded at the IDF-West Barrier for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the IDF-East Barrier, Core Zone Boundary, and Columbia River nearshore for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 5.74×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.15×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1177 and 5–1178, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (8.0×10^{-5}) is distributed among the combination of ILAW glass, bulk vitrification glass, and cast stone waste (7.0×10^{-5}), and the combined ETF-generated and tank closure secondary waste sources (1.3×10^{-5}). The major contributor to risk for the supplemental waste forms is release of technetium-99 from cast stone waste and the castable refractory block portion of the bulk vitrification glass waste form package. For the time series of risk at the Core Zone Boundary (see Figure 5–1178), the large early peak at CY 3700 is due to releases from IDF-West, while the subsequent plateau extending over the long-term period is due to releases from IDF-East. The RPPDF would not be constructed for this alternative.

Table 5–137. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	4.34	3.51	1.46×10^{-4}	0.00	1.46×10^{-4}	1.09×10^{1}	3.62	4.74×10^{-4}	1.32×10^{-9}	4.74×10^{-4}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.72×10^{1}	1.47	5.78×10^{-4}	0.00	5.78×10^{-4}	4.74×10^{1}	1.50	1.66×10^{-3}	5.81×10^{-10}	1.66×10^{-3}
Columbia River nearshore	3.36	1.09	8.11×10^{-5}	0.00	8.11×10^{-5}	6.42	1.10	2.40×10^{-4}	4.32×10^{-10}	2.40×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.15×10^{-4}	1.32×10^{-5}	3.75×10^{-9}	4.79×10^{-15}	3.75×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–138. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	2.21×10^{1}	5.49	1.03×10^{-3}	6.04×10^{-5}	1.05×10^{-3}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.47×10^{1}	2.23	3.49×10^{-3}	2.67×10^{-5}	3.49×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.20×10^{1}	1.63	5.11×10^{-4}	1.98×10^{-5}	5.11×10^{-4}	2.00×10^{-2}	3.31×10^{-1}	8.57×10^{-7}	9.90×10^{-6}	1.02×10^{-5}
Off Site										
Columbia River	9.13×10^{-4}	6.96×10^{-3}	2.51×10^{-8}	2.20×10^{-10}	2.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

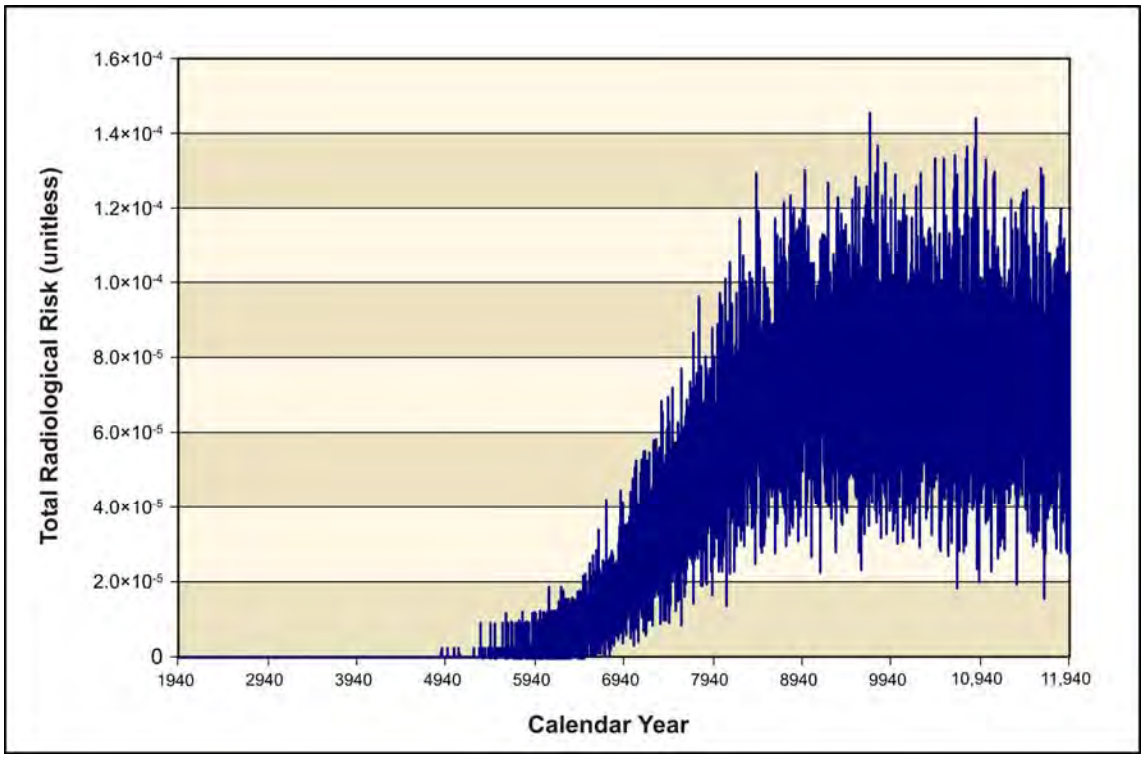


Figure 5–1177. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

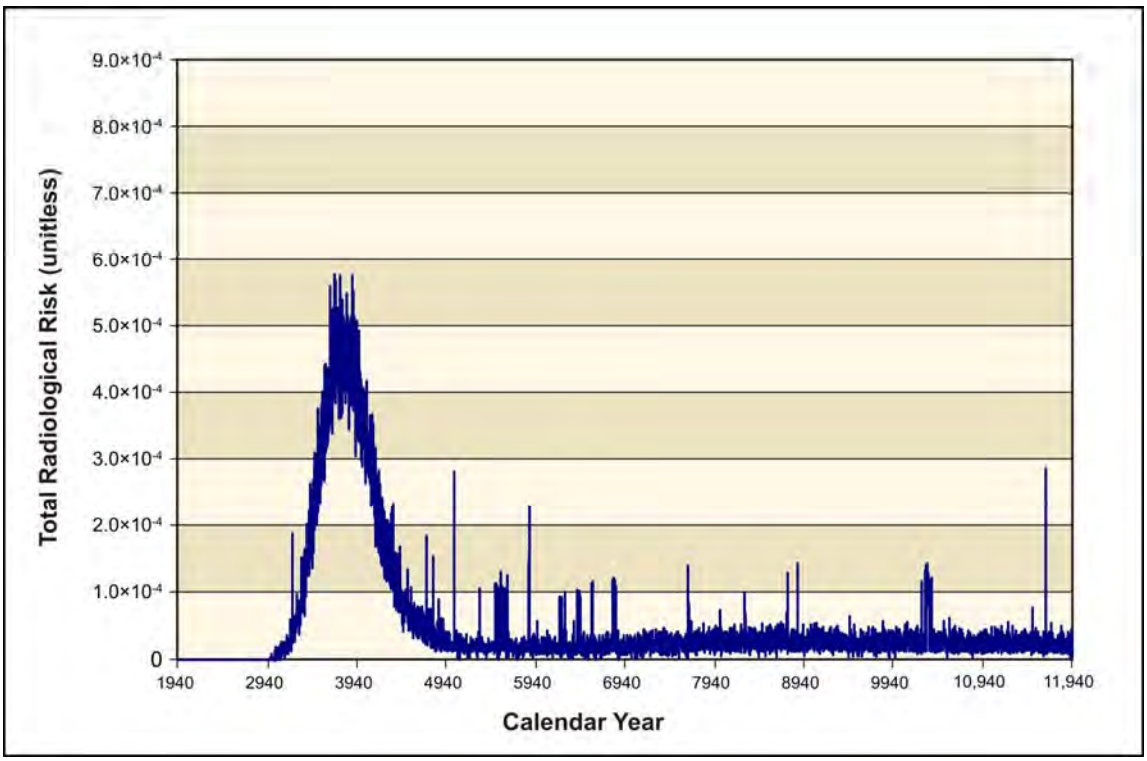


Figure 5–1178. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.7 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 1, Subgroup 1-G

Disposal Group 1, Subgroup 1-G, addresses the waste resulting from Tank Closure Alternative 6C, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–139 and 5–140. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would be exceeded at the IDF-West Barrier for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 5.76×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.15×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1179 and 5–1180, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.3×10^{-5}) is due to release from the combined ETF-generated and tank closure secondary waste sources. The major contributor to risk for these sources is release of technetium-99 and iodine-129. For the time series of risk at the Core Zone Boundary (see Figure 5–1180), the large, early peak at CY 3700 is due to releases from IDF-West, while the subsequent plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak.

Table 5–139. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	9.07×10^{-1}	2.66×10^{-1}	2.70×10^{-5}	0.00	2.70×10^{-5}	2.07	3.43×10^{-1}	8.45×10^{-5}	1.44×10^{-11}	8.45×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.92×10^{-2}	2.19×10^{-2}	2.11×10^{-6}	0.00	2.11×10^{-6}	1.61×10^{-1}	2.25×10^{-2}	6.68×10^{-6}	8.36×10^{-12}	6.68×10^{-6}
Core Zone Boundary	2.73×10^{1}	1.04×10^{-1}	5.79×10^{-4}	0.00	5.79×10^{-4}	4.75×10^{1}	1.36×10^{-1}	1.66×10^{-3}	1.22×10^{-11}	1.66×10^{-3}
Columbia River nearshore	3.37	4.78×10^{-2}	8.13×10^{-5}	0.00	8.13×10^{-5}	6.44	6.16×10^{-2}	2.41×10^{-4}	3.08×10^{-12}	2.41×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.15×10^{-4}	1.61×10^{-6}	3.77×10^{-9}	3.70×10^{-17}	3.77×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–140. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	4.05	6.69×10^{-1}	1.82×10^{-4}	6.61×10^{-7}	1.82×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.18×10^{-1}	3.40×10^{-2}	1.44×10^{-5}	3.83×10^{-7}	1.47×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.49×10^{1}	2.65×10^{-1}	3.50×10^{-3}	5.58×10^{-7}	3.50×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.20×10^{1}	1.19×10^{-1}	5.12×10^{-4}	1.41×10^{-7}	5.12×10^{-4}	2.00×10^{-2}	9.61×10^{-2}	8.58×10^{-7}	7.06×10^{-8}	8.79×10^{-7}
Off Site										
Columbia River	9.15×10^{-4}	4.21×10^{-3}	2.51×10^{-8}	1.70×10^{-12}	2.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

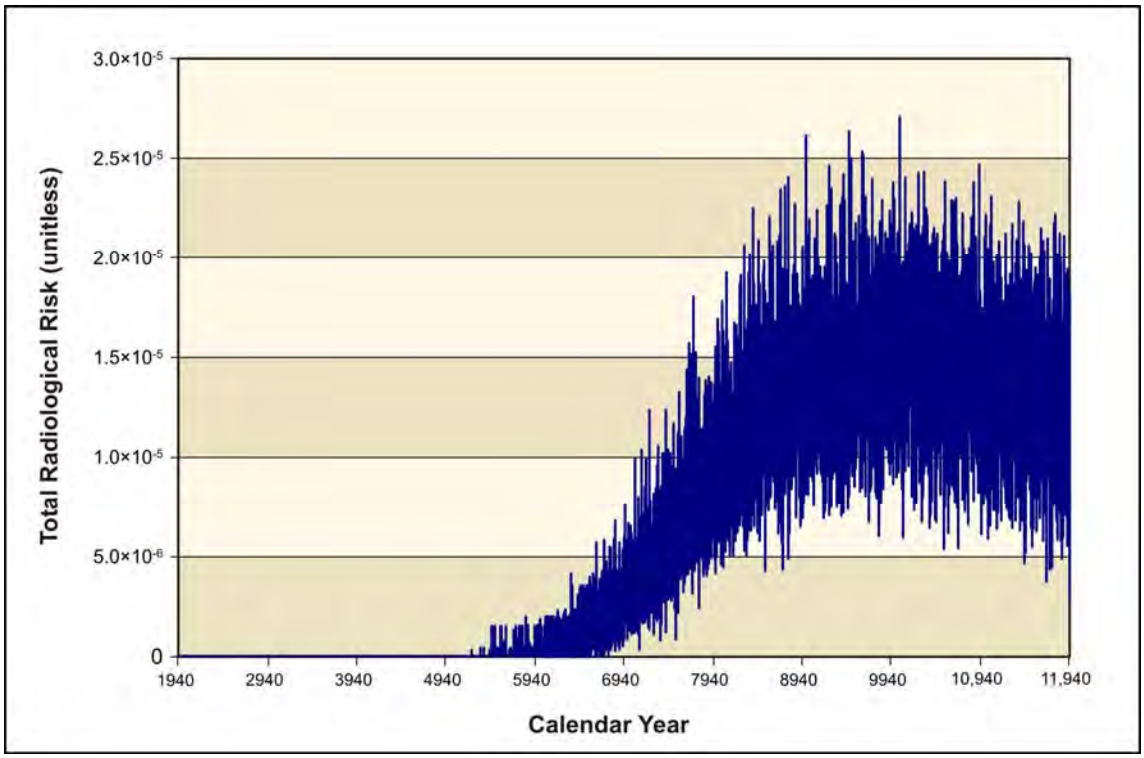


Figure 5–1179. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

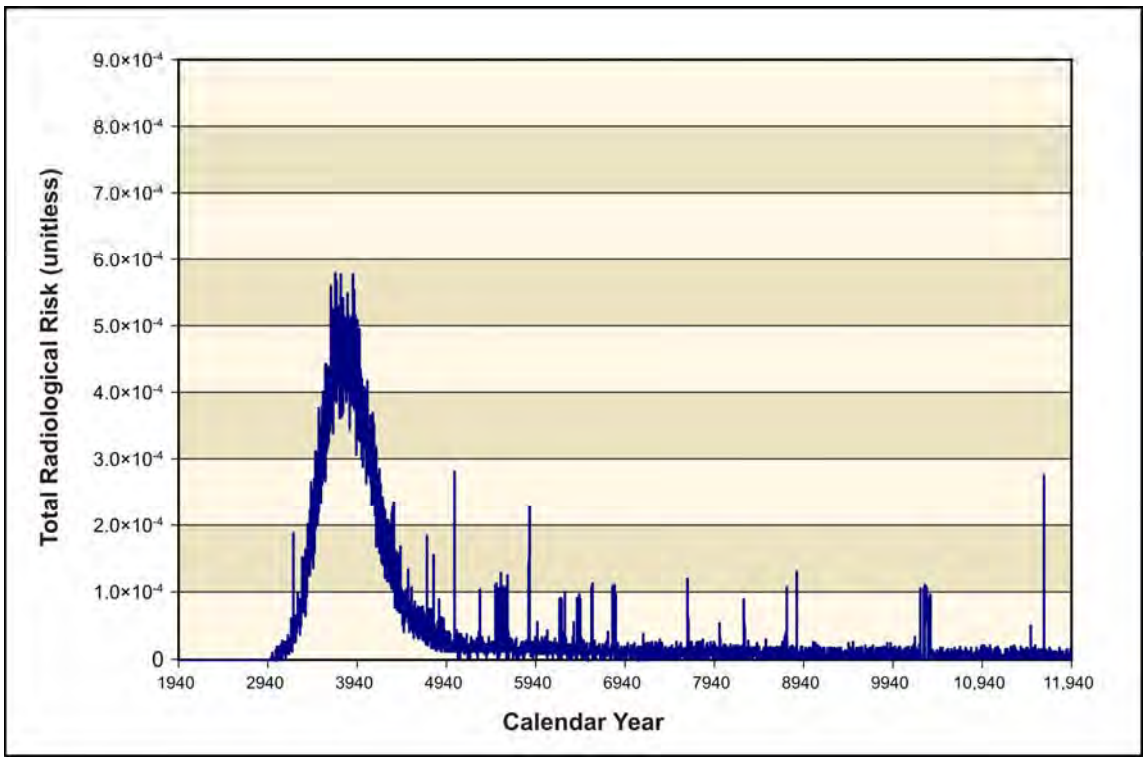


Figure 5–1180. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.8 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 2, Subgroup 2-A

Disposal Group 2, Subgroup 2-A, addresses the waste resulting from Tank Closure Alternative 2A, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–141 and 5–142. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides. For chemicals, the key constituents are boron and boron compounds, chromium, fluoride, and nitrate. For radionuclides, the dose standard would be exceeded at the IDF-West Barrier for the resident farmer and the American Indian resident farmer. The Hazard Index guideline would not be exceeded at any location. Population dose was estimated as 5.74×10^{-1} person-rem per year for the year of maximum impact. This corresponds to a 3.15×10^{-5} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1181 and 5–1182, respectively. At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. The peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.3×10^{-5}) is due to release from the combined ETF-generated and tank closure secondary waste sources. The major contributor to risk for these sources is release of technetium-99 and iodine-129. For the time series of risk at the Core Zone Boundary (see Figure 5–1182), the large, early peak at CY 3700 is due to releases from IDF-West, while the subsequent plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide a minor contribution to the early peak.

Table 5–141. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.64×10^{-1}	2.96×10^{-1}	2.25×10^{-5}	0.00	2.25×10^{-5}	1.74	3.84×10^{-1}	6.91×10^{-5}	1.20×10^{-11}	6.91×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.72×10^{1}	1.05×10^{-1}	5.78×10^{-4}	0.00	5.78×10^{-4}	4.74×10^{1}	1.37×10^{-1}	1.66×10^{-3}	6.29×10^{-12}	1.66×10^{-3}
Columbia River nearshore	3.36	7.45×10^{-2}	8.11×10^{-5}	0.00	8.11×10^{-5}	6.42	9.75×10^{-2}	2.40×10^{-4}	2.81×10^{-12}	2.40×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.15×10^{-4}	1.63×10^{-6}	3.75×10^{-9}	3.77×10^{-17}	3.75×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–142. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.36	7.43×10^{-1}	1.48×10^{-4}	5.49×10^{-7}	1.49×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.47×10^{1}	2.68×10^{-1}	3.49×10^{-3}	2.88×10^{-7}	3.49×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.20×10^{1}	1.90×10^{-1}	5.11×10^{-4}	1.29×10^{-7}	5.11×10^{-4}	2.00×10^{-2}	1.52×10^{-1}	8.57×10^{-7}	6.46×10^{-8}	8.63×10^{-7}
Off Site										
Columbia River	9.13×10^{-4}	4.31×10^{-3}	2.51×10^{-8}	1.73×10^{-12}	2.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

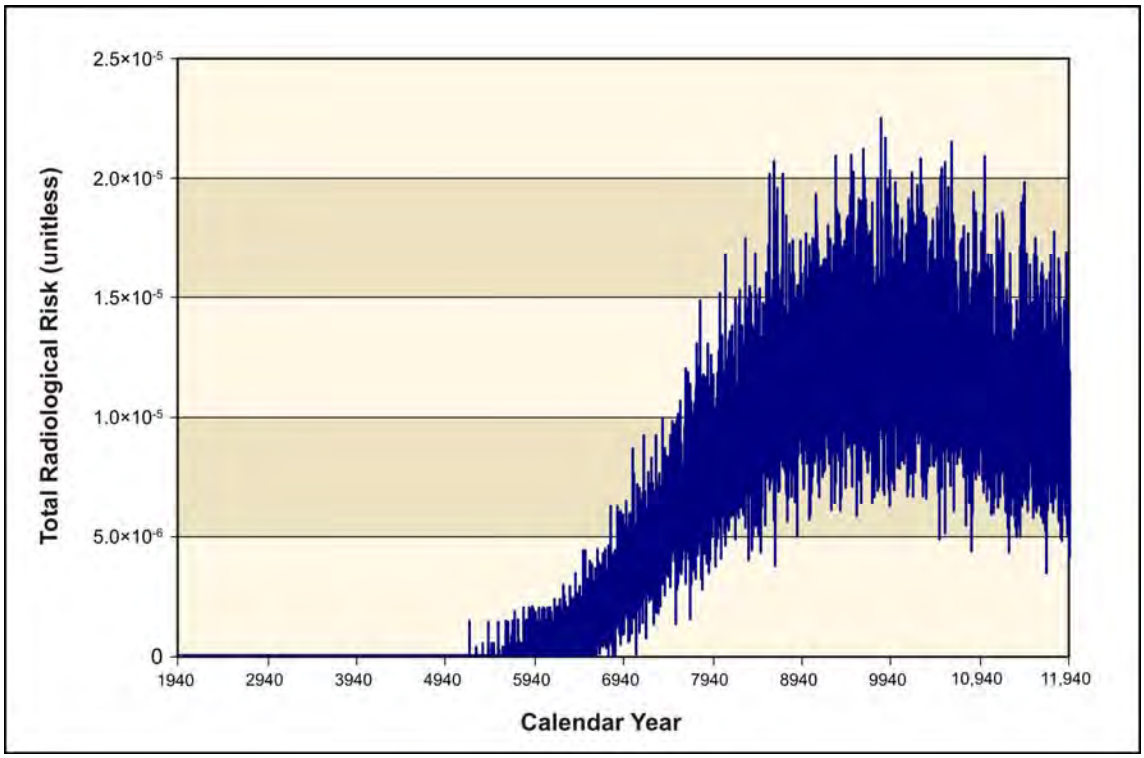


Figure 5–1181. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

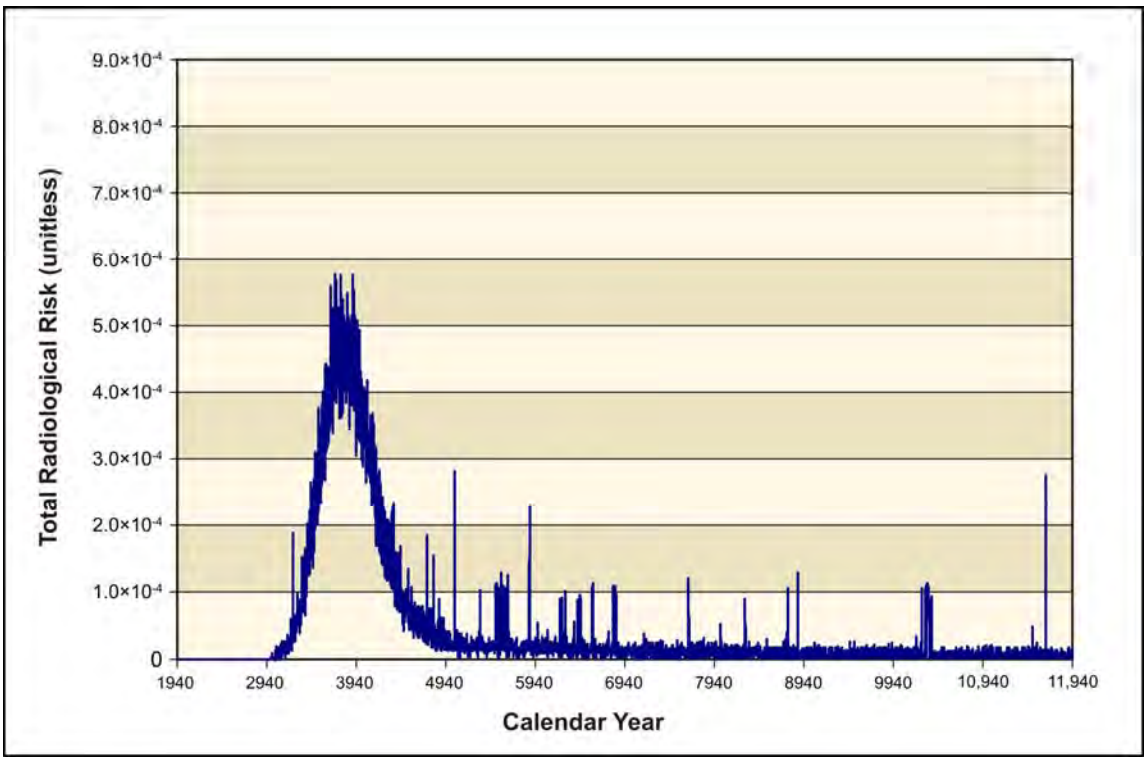


Figure 5–1182. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.9 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 2, Subgroup 2-B

Disposal Group 2, Subgroup 2-B, addresses the waste resulting from Tank Closure Alternative 6B (Base and Option Cases), onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this subgroup.

Potential human health impacts of this alternative are summarized in Tables 5–143 through 5–146. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would be exceeded at IDF-West for the resident farmer and the American Indian resident farmer under both Base and Option Cases. The Hazard Index guideline would not be exceeded at any location. Population dose was estimated for Subgroup 2-B, Base Case, as 6.02×10^{-1} person-rem per year for the year of maximum impact and for Subgroup 2-B, Option Case, as 5.91×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 3.30×10^{-5} percent and 3.24×10^{-5} percent of the annual population dose due to background exposure for Subgroup 2-B, Base and Option Cases, respectively. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1183 and 5–1184 for the Base Case and in Figures 5–1185 and 5–1186 for the Option Case. The Base and Option Cases differ in the amount of constituents disposed of at the RPPDF because the Option Case includes removal of tank closure cribs and trenches (ditches). At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. Under both the Base and Option Cases, the peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.3×10^{-5}) is due to release from the combined ETF-generated and tank closure secondary waste sources. The major contributor to risk for these sources is release of technetium-99 and iodine-129. For the time series of risk at the Core Zone Boundary under the Base Case (see Figure 5–1184) and the Option Case (see Figure 5–1186), the large, early peak at CY 3700 is due to releases from IDF-West, while the subsequent plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide minor contributions to the early peak.

Table 5–143. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.97×10^{-1}	3.18×10^{-1}	2.38×10^{-5}	0.00	2.38×10^{-5}	1.87	4.12×10^{-1}	7.22×10^{-5}	1.20×10^{-11}	7.22×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	5.92×10^{-1}	5.96×10^{-2}	1.82×10^{-5}	0.00	1.82×10^{-5}	1.39	6.11×10^{-2}	5.75×10^{-5}	2.27×10^{-11}	5.75×10^{-5}
Core Zone Boundary	2.76×10^{1}	1.25×10^{-1}	5.92×10^{-4}	0.00	5.92×10^{-4}	4.84×10^{1}	1.39×10^{-1}	1.70×10^{-3}	4.72×10^{-11}	1.70×10^{-3}
Columbia River nearshore	3.53	6.48×10^{-2}	8.35×10^{-5}	0.00	8.35×10^{-5}	6.60	8.35×10^{-2}	2.48×10^{-4}	9.42×10^{-12}	2.48×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.20×10^{-4}	1.72×10^{-6}	3.97×10^{-9}	1.30×10^{-16}	3.97×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–144. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.53	7.98×10^{-1}	1.55×10^{-4}	5.49×10^{-7}	1.55×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	2.73	9.24×10^{-2}	1.24×10^{-4}	1.04×10^{-6}	1.25×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.68×10^{1}	2.71×10^{-1}	3.58×10^{-3}	2.17×10^{-6}	3.58×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.23×10^{1}	1.61×10^{-1}	5.27×10^{-4}	4.32×10^{-7}	5.27×10^{-4}	2.10×10^{-2}	1.26×10^{-1}	8.82×10^{-7}	2.16×10^{-7}	9.86×10^{-7}
Off Site										
Columbia River	9.42×10^{-4}	4.50×10^{-3}	2.59×10^{-8}	5.94×10^{-12}	2.59×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–145. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.97×10^{-1}	3.18×10^{-1}	2.38×10^{-5}	0.00	2.38×10^{-5}	1.87	4.12×10^{-1}	7.22×10^{-5}	1.20×10^{-11}	7.22×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.96×10^{-1}	3.91×10^{-1}	2.16×10^{-5}	0.00	2.16×10^{-5}	1.65	4.38×10^{-1}	6.87×10^{-5}	1.28×10^{-10}	6.87×10^{-5}
Core Zone Boundary	2.77×10^{1}	1.38	5.88×10^{-4}	0.00	5.88×10^{-4}	4.85×10^{1}	1.54	1.67×10^{-3}	3.81×10^{-10}	1.67×10^{-3}
Columbia River nearshore	3.49	2.30×10^{-1}	8.53×10^{-5}	0.00	8.53×10^{-5}	6.74	2.52×10^{-1}	2.53×10^{-4}	6.69×10^{-11}	2.53×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.18×10^{-4}	3.45×10^{-6}	3.96×10^{-9}	8.34×10^{-16}	3.96×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–146. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.53	7.98×10^{-1}	1.55×10^{-4}	5.50×10^{-7}	1.55×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.26	7.37×10^{-1}	1.49×10^{-4}	5.87×10^{-6}	1.51×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.57×10^{1}	2.56	3.51×10^{-3}	1.75×10^{-5}	3.52×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.26×10^{1}	4.13×10^{-1}	5.39×10^{-4}	3.07×10^{-6}	5.40×10^{-4}	2.08×10^{-2}	2.22×10^{-1}	8.93×10^{-7}	1.53×10^{-6}	2.13×10^{-6}
Off Site										
Columbia River	9.32×10^{-4}	5.08×10^{-3}	2.57×10^{-8}	3.82×10^{-11}	2.57×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

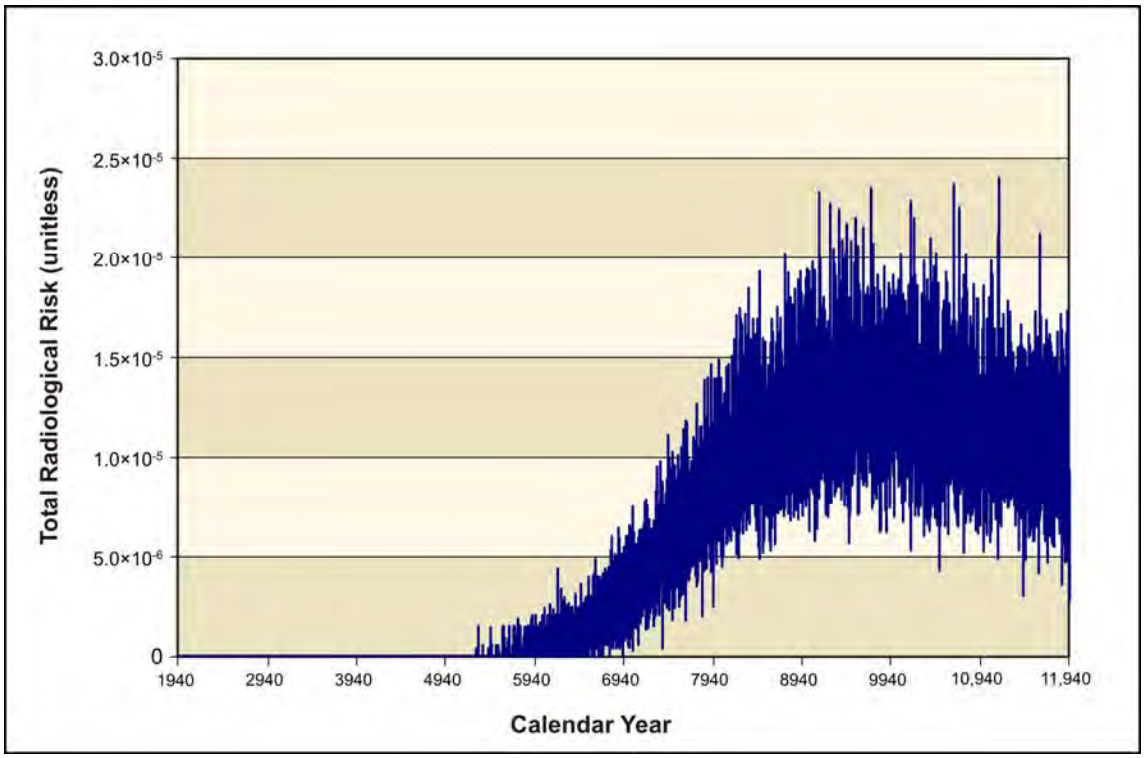


Figure 5–1183. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

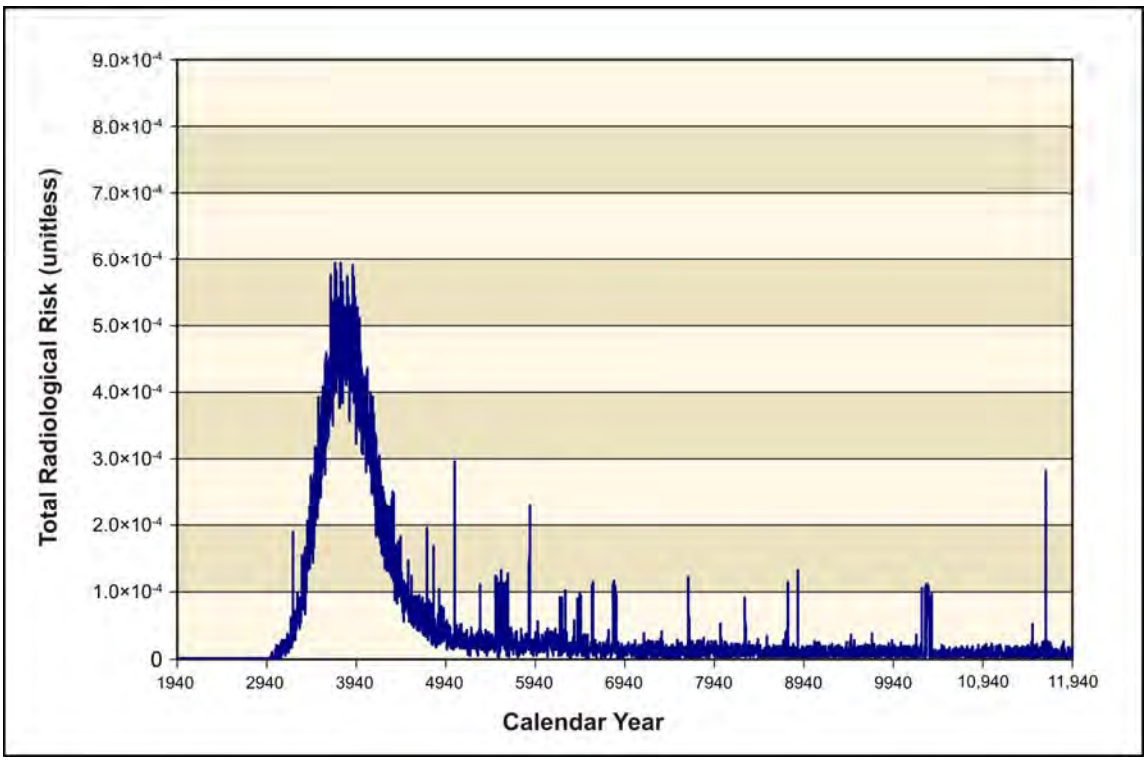


Figure 5–1184. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

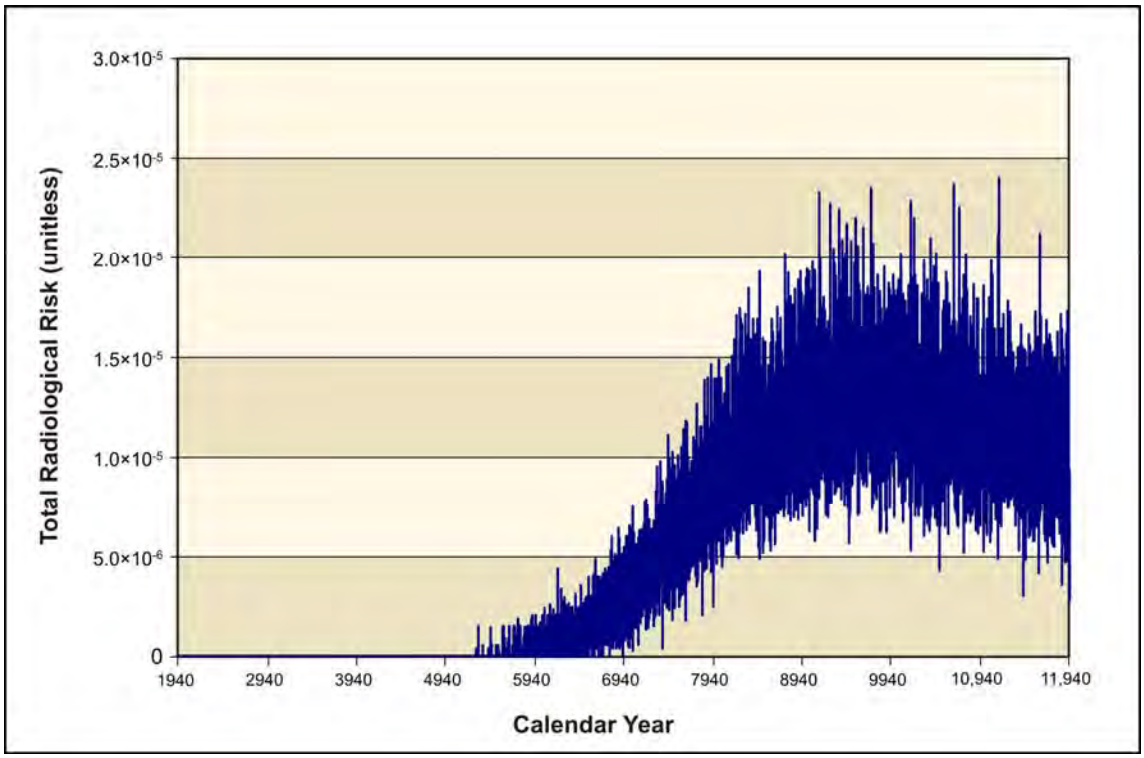


Figure 5–1185. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

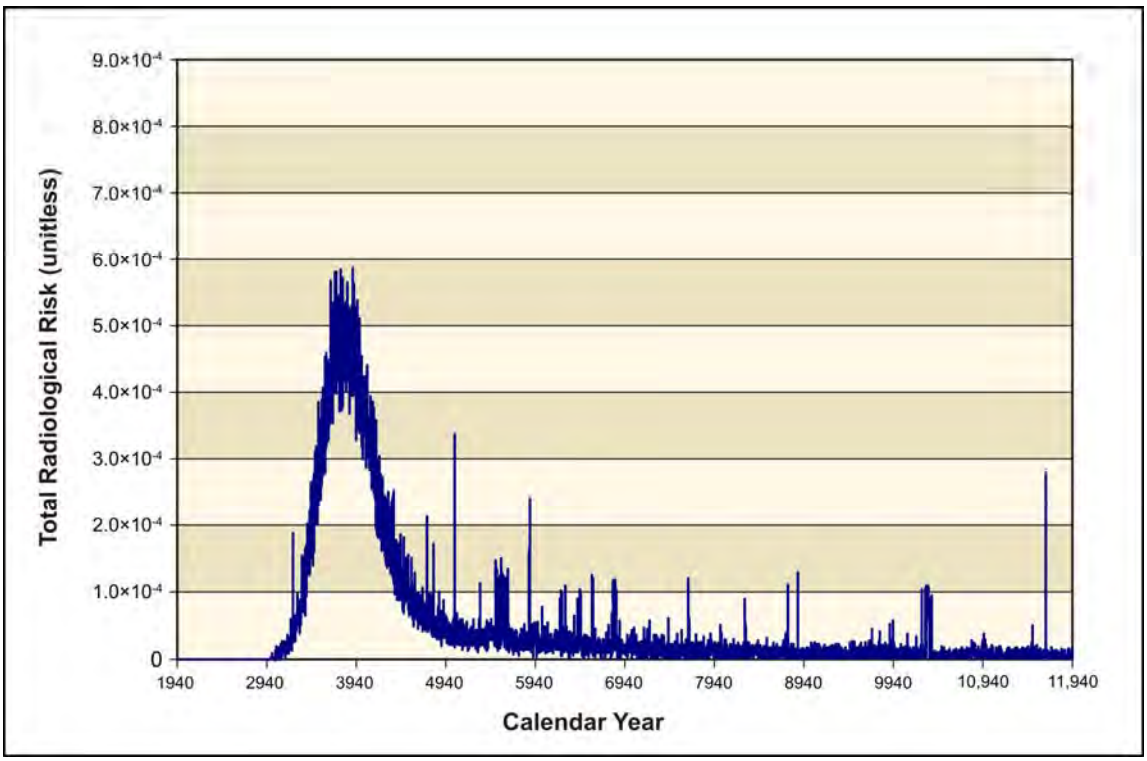


Figure 5–1186. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.2.3.10 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas, Disposal Group 3

Disposal Group 3 addresses the waste resulting from Tank Closure Alternative 6A (Base and Option Cases), onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Table 5–75 provides a listing of the waste types and disposal locations considered under this disposal group.

Potential human health impacts of this alternative are summarized in Tables 5–147 through 5–150. The key constituent contributors to human health risk are technetium-99 and iodine-129 for radionuclides and acetonitrile, boron and boron compounds, chromium, fluoride, and nitrate for chemicals. For radionuclides, the dose standard would be exceeded at IDF-West for the resident farmer and the American Indian resident farmer under both the Base and Option Cases. The Hazard Index guideline would not be exceeded at any location for both the Base and Option Cases. Population dose was estimated for Disposal Group 3, Base Case, as 5.97×10^{-1} person-rem per year for the year of maximum impact and for Disposal Group 3, Option Case, as 5.95×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 3.27×10^{-5} percent and 3.26×10^{-5} percent of the annual population dose due to background exposure for Disposal Group 2, Subgroups 2-B, Base and Option Cases, respectively. The time series of radiological risk for the drinking-water well user at the IDF-East Barrier and the Core Zone Boundary are presented in Figures 5–1187 and 5–1188 for the Base Case and in Figures 5–1189 and 5–1190 for the Option Case. The Base and Option Cases differ in the amount of constituents disposed of at the RPPDF because the Option Case includes removal of tank closure cribs and trenches (ditches). At the IDF-West Barrier, the time sequence of impacts is the same as that presented for Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in Figure 5–1167; peak impacts are due primarily to release of technetium-99 from offsite LLW. For both the Base and Option Cases, the peak of the time-averaged lifetime radiological risk for the drinking-water well user at the IDF-East Barrier (1.3×10^{-5}) is due to release from the combined ETF-generated and tank closure secondary waste sources. The major contributor to risk for these sources is release of technetium-99 and iodine-129. For the time series of risk at the Core Zone Boundary for the Base Case (see Figure 5–1188) and the Option Case (see Figure 5–1190), the large, early peak at CY 3700 is due to releases from IDF-West, while the subsequent plateau extending over the long-term period is due to releases from IDF-East. Releases from the RPPDF would provide minor contributions to the early peak.

Table 5–147. Waste Management Alternative 3, Disposal Group 3, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.62×10^{-1}	3.06×10^{-1}	2.50×10^{-5}	0.00	2.50×10^{-5}	1.91	4.00×10^{-1}	7.89×10^{-5}	1.13×10^{-11}	7.89×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	6.35×10^{-1}	5.89×10^{-2}	1.94×10^{-5}	0.00	1.94×10^{-5}	1.48	6.01×10^{-2}	6.15×10^{-5}	2.27×10^{-11}	6.15×10^{-5}
Core Zone Boundary	2.75×10^{1}	1.20×10^{-1}	6.01×10^{-4}	0.00	6.01×10^{-4}	4.88×10^{1}	1.56×10^{-1}	1.70×10^{-3}	4.57×10^{-11}	1.70×10^{-3}
Columbia River nearshore	3.45	6.80×10^{-2}	8.36×10^{-5}	0.00	8.36×10^{-5}	6.61	8.66×10^{-2}	2.48×10^{-4}	1.25×10^{-11}	2.48×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.19×10^{-4}	1.79×10^{-6}	3.98×10^{-9}	1.27×10^{-16}	3.98×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–148. Waste Management Alternative 3, Disposal Group 3, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.76	7.80×10^{-1}	1.71×10^{-4}	5.16×10^{-7}	1.71×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	2.93	9.04×10^{-2}	1.33×10^{-4}	1.04×10^{-6}	1.33×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.77×10^{1}	3.05×10^{-1}	3.59×10^{-3}	2.10×10^{-6}	3.59×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.24×10^{1}	1.65×10^{-1}	5.27×10^{-4}	5.72×10^{-7}	5.27×10^{-4}	2.05×10^{-2}	1.26×10^{-1}	8.81×10^{-7}	2.86×10^{-7}	9.84×10^{-7}
Off Site										
Columbia River	9.37×10^{-4}	4.71×10^{-3}	2.56×10^{-8}	5.84×10^{-12}	2.56×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–149. Waste Management Alternative 3, Disposal Group 3, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	8.62×10^{-1}	3.06×10^{-1}	2.50×10^{-5}	0.00	2.50×10^{-5}	1.91	4.00×10^{-1}	7.90×10^{-5}	1.13×10^{-11}	7.90×10^{-5}
Integrated Disposal Facility-West	8.08×10^{1}	1.95×10^{-2}	1.70×10^{-3}	0.00	1.70×10^{-3}	1.40×10^{2}	1.96×10^{-2}	4.65×10^{-3}	7.67×10^{-12}	4.65×10^{-3}
River Protection Project Disposal Facility	7.87×10^{-1}	4.29×10^{-1}	2.45×10^{-5}	0.00	2.45×10^{-5}	1.86	4.69×10^{-1}	7.79×10^{-5}	1.43×10^{-10}	7.79×10^{-5}
Core Zone Boundary	2.76×10^{1}	1.36	6.03×10^{-4}	0.00	6.03×10^{-4}	4.85×10^{1}	1.53	1.74×10^{-3}	4.89×10^{-10}	1.74×10^{-3}
Columbia River nearshore	3.58	2.30×10^{-1}	8.69×10^{-5}	0.00	8.69×10^{-5}	6.86	2.51×10^{-1}	2.59×10^{-4}	8.05×10^{-11}	2.59×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.19×10^{-4}	3.20×10^{-6}	3.90×10^{-9}	7.92×10^{-16}	3.90×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–150. Waste Management Alternative 3, Disposal Group 3, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Integrated Disposal Facility-East	3.76	7.80×10^{-1}	1.71×10^{-4}	5.17×10^{-7}	1.71×10^{-4}	N/A	N/A	N/A	N/A	N/A
Integrated Disposal Facility-West	2.46×10^{2}	2.85×10^{-2}	9.65×10^{-3}	3.52×10^{-7}	9.65×10^{-3}	N/A	N/A	N/A	N/A	N/A
River Protection Project Disposal Facility	3.70	7.80×10^{-1}	1.69×10^{-4}	6.54×10^{-6}	1.72×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	8.85×10^{1}	2.59	3.66×10^{-3}	2.24×10^{-5}	3.67×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.29×10^{1}	4.12×10^{-1}	5.52×10^{-4}	3.69×10^{-6}	5.52×10^{-4}	2.10×10^{-2}	2.17×10^{-1}	9.16×10^{-7}	1.85×10^{-6}	2.06×10^{-6}
Off Site										
Columbia River	9.30×10^{-4}	5.31×10^{-3}	2.57×10^{-8}	3.63×10^{-11}	2.57×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

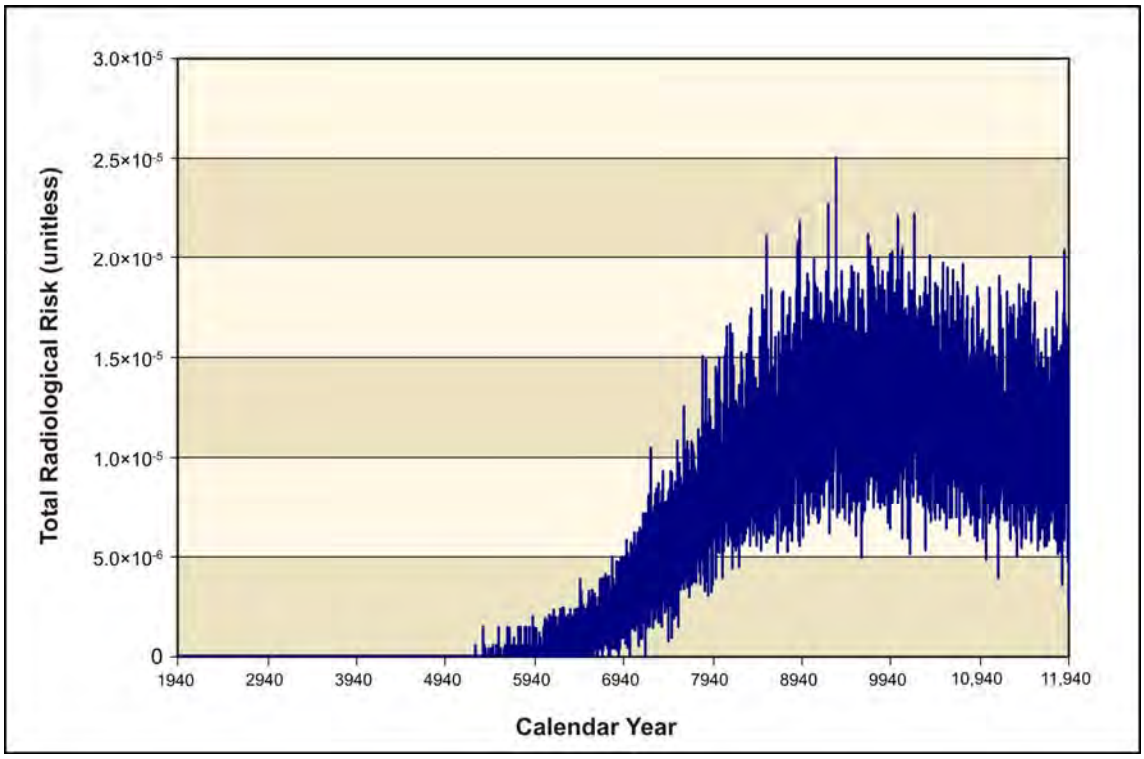


Figure 5–1187. Waste Management Alternative 3, Disposal Group 3, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

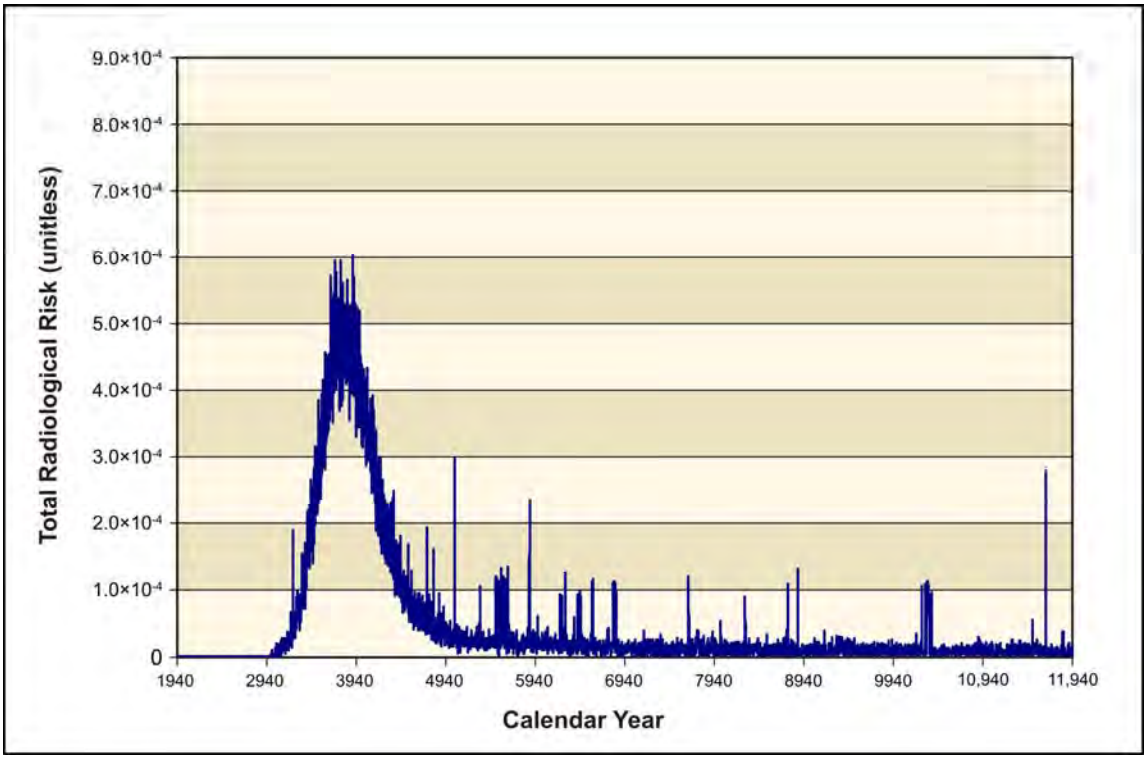


Figure 5–1188. Waste Management Alternative 3, Disposal Group 3, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

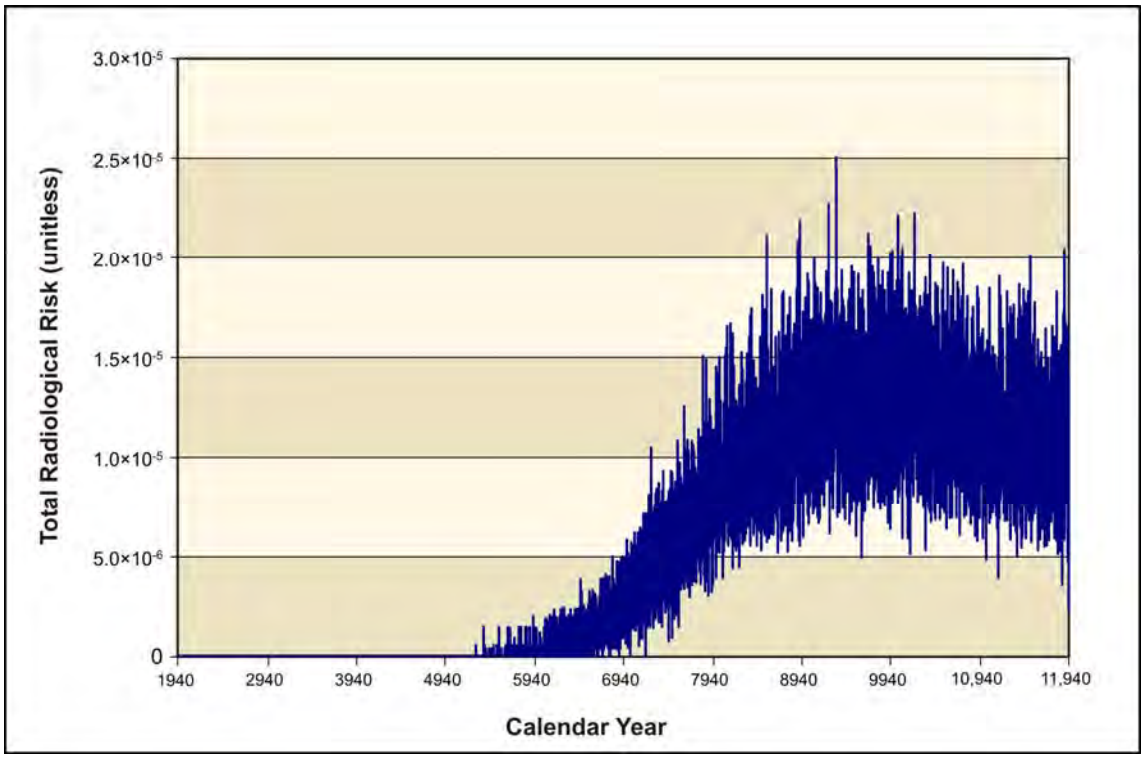


Figure 5–1189. Waste Management Alternative 3, Disposal Group 3, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

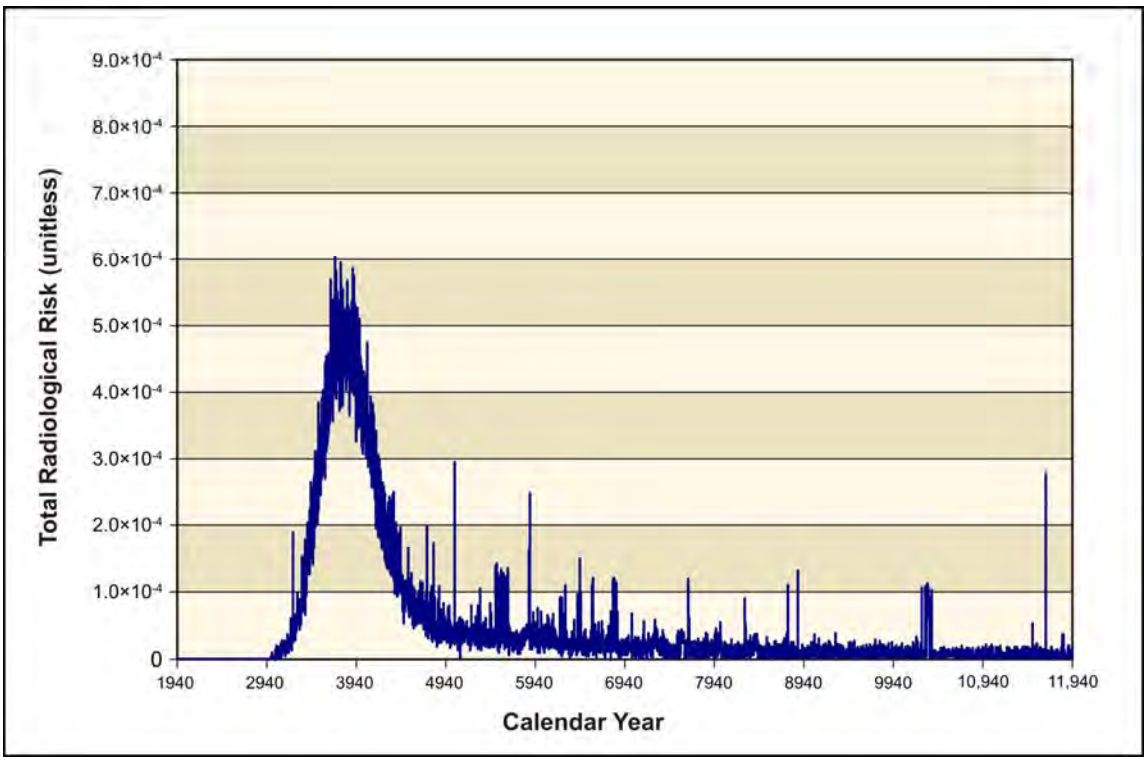


Figure 5–1190. Waste Management Alternative 3, Disposal Group 3, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.3.3 Ecological Risk

This section presents the results of the evaluation of long-term impacts on ecological resources of releases to air and groundwater under the Waste Management alternatives. Risk indices—Hazard Quotient or Hazard Index—were calculated by comparing predicted dose to benchmark dose (see Appendix P). Risk indices could not be calculated for soil-dwelling invertebrates, lizards, toads, or birds for COPCs (organic compounds only) released under the Waste Management alternatives because there are no toxicity reference values for such receptors for these COPCs. Calculated risk indices are for the COPCs with the highest Hazard Quotient or Hazard Index presented for each receptor.

Releases to air and groundwater are expected under all Waste Management alternatives and all disposal group variants under Waste Management Alternatives 2 and 3. The long-term impacts on terrestrial ecological resources of releases to air at Hanford were evaluated at the onsite maximum-exposure location (Core Zone Boundary) and on terrestrial, riparian, and aquatic resources at the offsite maximum-exposure location (Columbia River). Impacts on ecological resources of releases to groundwater were evaluated at the Columbia River.

5.3.3.1 Waste Management Alternative 1: No Action

Predicted emissions of COPCs in air from disposal in LLBG 218-W-5, trenches 31 and 34, under Waste Management Alternative 1, No Action, do not pose a risk to ecological receptors. This No Action Alternative is not expected to result in releases of radionuclides to air. Releases of chemicals to air are expected from ongoing waste management activities (see Section 5.3 and Chapter 2, Section 2.4). The chemical COPC with the largest calculated Hazard Quotient (3.3) is for the mouse exposed to air releases of xylene at the onsite maximum-exposure location (see Table 5–151). There would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air under Waste Management Alternative 1 at the offsite maximum-exposure location (Columbia River). The uncertainty about the risk to terrestrial receptors from chemical COPCs in air releases under *TC & WM EIS* alternatives is discussed in Appendix P (see Section P.2.2)

Predicted emissions of chemical and radiological COPCs in groundwater discharging at the Columbia River do not pose a risk to ecological receptors. The largest risk index (Hazard Quotient is 0.005) for groundwater releases under Waste Management Alternative 1 (see Table 5–152) is that calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 1.

Table 5–151. Waste Management Alternatives – Long-Term Impacts of Chemical COPC Releases to Air on Terrestrial Resources at the Onsite Maximum-Exposure Location

Waste Management Alternative	Maximum Hazard Quotient of Chemical COPC by Receptor			
	Plants	Great Basin Pocket Mouse	Coyote	Mule Deer
	Toluene	Xylene	Xylene	Formaldehyde
1	6.87×10^{-2}	**3.29**	4.18×10^{-1}	4.75×10^{-1}
2, Disposal Group 1	4.74×10^{-1}	$\mathbf{2.59\times10^{1}}$	3.29	1.04×10^{1}
2, Disposal Group 2	3.20	$\mathbf{1.66\times10^{2}}$	2.11×10^{1}	4.81×10^{1}
2, Disposal Group 3	5.65	$\mathbf{2.89\times10^{2}}$	3.67×10^{1}	8.07×10^{1}
3, Disposal Group 1	4.74×10^{-1}	$\mathbf{2.63\times10^{1}}$	3.34	1.12×10^{1}
3, Disposal Group 2	3.20	$\mathbf{1.67\times10^{2}}$	2.12×10^{1}	4.96×10^{1}
3, Disposal Group 3	5.58	$\mathbf{2.89\times10^{2}}$	3.67×10^{1}	8.14×10^{1}

Note: The maximum Hazard Quotient under each alternative is indicated by **bold** text. Results are not available for other terrestrial receptors: side-blotched lizard, mourning dove, western meadowlark, and burrowing owl.

Key: COPC=constituent of potential concern.

5.3.3.2 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only

Predicted emissions of COPCs in air under Waste Management Alternative 2 pose little risk to plants and a moderate risk to mammals at the onsite maximum-exposure location (see Table 5–151). The largest calculated risk indices are for mammals exposed to organic chemicals released in air: formaldehyde for the deer and xylene, toluene, formaldehyde, and benzene for the mouse and coyote, all at the onsite maximum-exposure location. These are summarized below. There would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air under Waste Management Alternative 2 at the offsite maximum-exposure location (Columbia River).

Releases to air and resulting long-term impacts on ecological resources would be similar under Waste Management Alternative 2, Disposal Groups 2 and 3. There would be a slight difference in peak air emissions between Disposal Groups 2 and 3 for operation of IDF-East and the RPPDF. IDF-East and the RPPDF, while the same size, would operate for a longer period of time under Disposal Group 3. This would result in higher cumulative emissions of all COPCs under Disposal Group 3 as compared to Disposal Group 2, with a somewhat greater long-term impact on ecological resources of air releases under Disposal Group 3.

5.3.3.2.1 Waste Management Alternative 2, Disposal Group 1

Predicted emissions of COPCs in air under Waste Management Alternative 2, Disposal Group 1 (Subgroups 1-A through 1-G), pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location only. The calculated Hazard Quotient for deer is 10 for formaldehyde under Waste Management Alternative 2, Disposal Group 1 (see Table 5–151). The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene (26) and formaldehyde (17) for the mouse at the onsite maximum-exposure location. Risk indices were not calculated separately for the air emissions under the different subgroups of Waste Management Alternative 2, Disposal Group 1 (i.e., Subgroups 1-A through 1-G).

Table 5–152. Waste Management Alternatives – Long-Term Impacts of Contaminant Releases to Groundwater on Aquatic and Riparian Resources at the Columbia River

Waste Management Alternative	Maximum Hazard Quotient or Hazard Index of Chemical or Radiological COPC by Receptor						
	Benthic Invertebrate	Muskrat	Spotted Sandpiper	Raccoon	Least Weasel	Bald Eagle	Aquatic Biota/Salmonids
	Chromium	Chromium	Chromium	Chromium	Nitrate	Chromium	Chromium
1	7.15×10^{-5}	2.80×10^{-6}	4.85×10^{-4}	5.87×10^{-5}	9.10×10^{-6}	7.47×10^{-6}	**4.72×10^{-3}**
2, DG 1-A	5.45×10^{-4}	2.13×10^{-5}	3.70×10^{-3}	4.48×10^{-4}	1.32×10^{-2}	5.15×10^{-5}	**2.69×10^{-2}**
2, DG 1-B	2.75×10^{-4}	1.07×10^{-5}	1.86×10^{-3}	2.25×10^{-4}	1.30×10^{-2}	2.58×10^{-5}	**1.33×10^{-2}**
2,,DG 1-C	8.51×10^{-2}	3.33×10^{-3}	5.77×10^{-1}	6.99×10^{-2}	5.72×10^{-2}	7.72×10^{-3}	**3.69**
2, DG 1-D	8.48×10^{-2}	3.32×10^{-3}	5.75×10^{-1}	6.97×10^{-2}	1.50×10^{-2}	7.97×10^{-3}	**4.12**
2, DG 1-E	4.66×10^{-2}	1.82×10^{-3}	3.16×10^{-1}	3.83×10^{-2}	3.28×10^{-2}	4.40×10^{-3}	**2.30**
2, DG 1-F	8.03×10^{-2}	3.14×10^{-3}	5.45×10^{-1}	6.60×10^{-2}	2.19×10^{-2}	7.01×10^{-3}	**3.02**
2, DG 1-G	5.88×10^{-4}	2.30×10^{-5}	3.99×10^{-3}	4.83×10^{-4}	1.32×10^{-2}	5.34×10^{-5}	**2.54×10^{-2}**
2, DG 2-A	5.51×10^{-4}	2.15×10^{-5}	3.74×10^{-3}	4.52×10^{-4}	1.39×10^{-2}	5.11×10^{-5}	**2.57×10^{-2}**
2, DG 2-B, Base	1.69×10^{-3}	6.61×10^{-5}	1.15×10^{-2}	1.39×10^{-3}	1.43×10^{-2}	1.56×10^{-4}	**7.74×10^{-2}**
2, DG 2-B, Option	1.24×10^{-2}	4.85×10^{-4}	8.41×10^{-2}	1.02×10^{-2}	1.66×10^{-2}	1.12×10^{-3}	**5.25×10^{-1}**
2, DG 3, Base	2.25×10^{-3}	8.79×10^{-5}	1.52×10^{-2}	1.85×10^{-3}	1.49×10^{-2}	1.92×10^{-4}	**7.77×10^{-2}**
2, DG 3, Option	1.50×10^{-2}	5.85×10^{-4}	1.02×10^{-1}	1.23×10^{-2}	1.73×10^{-2}	1.27×10^{-3}	**4.99×10^{-1}**
3, DG 1-A	5.37×10^{-4}	2.10×10^{-5}	3.64×10^{-3}	4.41×10^{-4}	1.32×10^{-2}	4.96×10^{-5}	**2.47×10^{-2}**
3, DG 1-B	3.36×10^{-4}	1.31×10^{-5}	2.28×10^{-3}	2.76×10^{-4}	1.30×10^{-2}	3.31×10^{-5}	**1.89×10^{-2}**
3, DG 1-C	8.51×10^{-2}	3.33×10^{-3}	5.77×10^{-1}	6.99×10^{-2}	5.72×10^{-2}	7.72×10^{-3}	**3.69**
3, DG 1-D	8.48×10^{-2}	3.32×10^{-3}	5.75×10^{-1}	6.96×10^{-2}	1.50×10^{-2}	7.96×10^{-3}	**4.12**
3, DG 1-E	4.66×10^{-2}	1.82×10^{-3}	3.16×10^{-1}	3.83×10^{-2}	3.28×10^{-2}	4.40×10^{-3}	**2.30**
3, DG 1-F	8.03×10^{-2}	3.14×10^{-3}	5.45×10^{-1}	6.59×10^{-2}	2.19×10^{-2}	7.01×10^{-3}	**3.02**
3, DG 1-G	5.73×10^{-4}	2.24×10^{-5}	3.89×10^{-3}	4.71×10^{-4}	1.32×10^{-2}	5.11×10^{-5}	**2.34×10^{-2}**
3, DG 2-A	5.24×10^{-4}	2.05×10^{-5}	3.55×10^{-3}	4.30×10^{-4}	1.39×10^{-2}	4.82×10^{-5}	**2.38×10^{-2}**
3, DG 2-B, Base	1.75×10^{-3}	6.85×10^{-5}	1.19×10^{-2}	1.44×10^{-3}	1.43×10^{-2}	1.63×10^{-4}	**8.18×10^{-2}**
3, DG 2-B, Option	1.25×10^{-2}	4.87×10^{-4}	8.45×10^{-2}	1.02×10^{-2}	1.66×10^{-2}	1.12×10^{-3}	**5.26×10^{-1}**
3, DG 3, Base	2.32×10^{-3}	9.07×10^{-5}	1.57×10^{-2}	1.91×10^{-3}	1.49×10^{-2}	1.98×10^{-4}	**8.03×10^{-2}**
3, DG 3, Option	1.50×10^{-2}	5.86×10^{-4}	1.02×10^{-1}	1.23×10^{-2}	1.73×10^{-2}	1.27×10^{-3}	**5.00×10^{-1}**

Note: The maximum Hazard Quotient under each alternative is indicated by **bold** text.

Key: Base=Base Case; COPC=constituent of potential concern; DG=Disposal Group; Option=Option Case.

There would be no risk of long-term impacts on ecological resources from releases to groundwater under Waste Management Alternative 2, Disposal Group 1, Subgroups 1-A through 1-G. The largest risk index (Hazard Quotient is 4.1) is for groundwater releases under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D (see Table 5–152), calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This Hazard Quotient is 3 orders of magnitude greater than under Waste Management Alternative 1. The Hazard Quotient for chromium is within the margin of error resulting from the uncertainties in the estimated exposure and toxicity. No other risk indices exceeded 1. This indicates no risk to ecological receptors from chromium or other chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 2, Disposal Group 1.

5.3.3.2.2 Waste Management Alternative 2, Disposal Group 2

Predicted emissions of COPCs in air under Waste Management Alternative 2, Disposal Group 2, pose a greater probability of adverse impact on ecological receptors at the onsite maximum-exposure location than under Waste Management Alternative 2, Disposal Group 1 (see Table 5–151). The calculated Hazard Quotient for deer is nearly 50 for formaldehyde under Waste Management Alternative 2, Disposal Group 2, as compared to 10 under Waste Management Alternative 2, Disposal Group 1. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene (166) and formaldehyde (79.6) for the mouse at the onsite maximum-exposure location. Risk indices were not calculated separately for the air emissions under the different subgroups of Waste Management Alternative 2, Disposal Group 2 (i.e., Subgroups 2-A and 2-B).

There would be no risk of long-term impacts on ecological resources from releases to groundwater under Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A or 2-B. The largest risk index (Hazard Quotient is 0.53) is for groundwater releases under Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B (see Table 5–152), calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 2, Disposal Group 2.

5.3.3.2.3 Waste Management Alternative 2, Disposal Group 3

Predicted emissions of COPCs in air under Waste Management Alternative 2, Disposal Group 3, pose a greater probability of adverse impact on ecological receptors at the onsite maximum-exposure location than under Waste Management Alternative 2, Disposal Group 2. The calculated Hazard Quotient for deer is 81 for formaldehyde under Waste Management Alternative 2, Disposal Group 3 (see Table 5–151). The largest Hazard Quotients for the release of chemical COPCs to air were predicted for the mouse exposed to xylene (289) and formaldehyde (134) at the onsite maximum-exposure location.

There would be no risk of long-term impacts on ecological resources from releases to groundwater under Waste Management Alternative 2, Disposal Group 3. The largest risk index (Hazard Quotient is 0.5) is for groundwater releases under Waste Management Alternative 2, Disposal Group 3 (see Table 5–152), calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 2, Disposal Group 3.

5.3.3.3 Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas

Predicted emissions of COPCs in air under Waste Management Alternative 3 pose little risk to plants and a moderate risk to mammals at the onsite maximum-exposure location (see Table 5–151). These results are discussed below. There would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air under Waste Management Alternative 3 at the offsite maximum-exposure location (Columbia River).

Releases to air and resulting long-term impacts on ecological resources at the onsite maximum-exposure location would be similar under Waste Management Alternative 3, Disposal Groups 2 and 3. There would be a slight difference in peak air emissions between Disposal Groups 2 and 3 for operation of an IDF and the RPPDF. An IDF and the RPPDF, while the same size, operate for a longer period of time under Waste Management Alternative 3, Disposal Group 3. This would result in higher cumulative emissions of COPCs and slightly lower peak emissions of others (e.g., formaldehyde and ammonia under Disposal Group 3 as compared to Disposal Group 2), with only minor differences in long-term impacts on ecological resources of air releases.

5.3.3.3.1 Waste Management Alternative 3, Disposal Group 1

Predicted emissions of COPCs in air under Waste Management Alternative 3, Disposal Group 1, pose a slightly greater probability of adverse impact on ecological receptors at the onsite maximum-exposure location than under Waste Management Alternative 2, Disposal Group 1 (see Table 5–151). The calculated Hazard Quotient for deer is 11 for formaldehyde under Waste Management Alternative 3, Disposal Group 1, as compared to 10 under Waste Management Alternative 2, Disposal Group 1. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene (26) and formaldehyde (18.5) for the mouse at the onsite maximum-exposure location. Risk indices were not calculated separately for the air emissions under the different subgroups of Waste Management Alternative 3, Disposal Group 1 (i.e., Subgroups 1-A through 1-G).

There would be no risk of long-term impacts on ecological resources from releases to groundwater under Waste Management Alternative 3, Disposal Group 1, Subgroups 1-A through 1-G. The largest risk index (Hazard Quotient is 4.1) is for groundwater releases under Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D (see Table 5–152), calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This Hazard Quotient is 3 orders of magnitude greater than under Waste Management Alternative 1. The Hazard Quotient for chromium is within the margin of error resulting from the uncertainties in the estimated exposure and toxicity. No other risk indices exceeded 1. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 3, Disposal Group 1.

5.3.3.3.2 Waste Management Alternative 3, Disposal Group 2

Predicted emissions of COPCs in air under Waste Management Alternative 3, Disposal Group 2, pose a greater probability of adverse impact on ecological receptors at the onsite maximum-exposure location than under Waste Management Alternative 3, Disposal Group 1, and a slightly greater probability of impact than under Waste Management Alternative 2, Disposal Group 2 (see Table 5–151). The calculated Hazard Quotient for deer is 50 for formaldehyde under Waste Management Alternative 3, Disposal Group 2, as compared to 11 under Waste Management Alternative 3, Disposal Group 1, and 48 under Waste Management Alternative 2, Disposal Group 2. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene (167) and formaldehyde (82) for the mouse at the onsite maximum-exposure location. Risk indices were not calculated separately for the air emissions under the different variants of Waste Management Alternative 3, Disposal Group 2 (i.e., Subgroups 2-A and 2-B).

There would be no risk of long-term impacts on ecological resources from releases to groundwater under Waste Management Alternative 3, Disposal Group 2, Subgroups 2-A or 2-B. The largest risk index (Hazard Quotient is 0.53) is for groundwater releases under Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B (see Table 5–152), calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 3, Disposal Group 2.

5.3.3.3.3 Waste Management Alternative 3, Disposal Group 3

Predicted emissions of COPCs in air under Waste Management Alternative 3, Disposal Group 3, pose a greater probability of adverse impact on ecological receptors at the onsite maximum-exposure location than under Waste Management Alternative 3, Disposal Group 2. The calculated Hazard Quotient for deer is 81 for formaldehyde under Waste Management Alternative 3, Disposal Group 3, as compared to 50 under Waste Management Alternative 3, Disposal Group 2 (see Table 5–151). The calculated formaldehyde Hazard Quotient under Waste Management Alternative 3, Disposal Group 3, is the maximum risk index for the mule deer under all alternatives (see Appendix P, Table P–5). The chemical COPCs with the largest calculated Hazard Quotients for air release are xylene (289) and formaldehyde (135) for the mouse at the onsite maximum-exposure location.

There would be no risk of long-term impacts on ecological resources from releases to groundwater under Waste Management Alternative 3, Disposal Group 3. The largest risk index (Hazard Quotient is 0.5) is for groundwater releases under Waste Management Alternative 3, Disposal Group 3 (see Table 5–152), calculated for exposure of salmonids and aquatic biota to chromium in surface water at the Columbia River. This indicates no risk to ecological receptors from chemical or radiological COPCs released to groundwater at Hanford under Waste Management Alternative 3, Disposal Group 3.

5.3.4 Environmental Justice

Sections 5.3.1 and 5.3.2 evaluate groundwater impacts and associated potential long-term human health effects under the Waste Management alternatives. Receptors analyzed with a potential for environmental justice concerns include a resident farmer, an American Indian resident farmer, and an American Indian hunter-gatherer. The hypothetical resident farmer, which could represent a low-income population, and American Indian resident farmer were both assumed to use only groundwater for drinking water ingestion and crop irrigation. While only a portion of the food consumed by the resident farmer was assumed to come from crops and animal products exposed to contaminated groundwater, all of the food consumed by the American Indian resident farmer was assumed to be exposed to contaminated groundwater. The American Indian hunter-gatherer was assumed to have a subsistence consumption pattern that differs from the American Indian resident farmer. The American Indian hunter-gatherer does not cultivate crops but gathers food from indigenous plants, harvests fish from the Columbia River, and is exposed to a combination of surface water and groundwater. Given these assumptions, the two American Indian receptors would be most at risk from contaminated groundwater. These receptors were used to develop exposure scenarios at several on- and offsite locations identified in Appendix Q, Section Q.3.3.1. Long-term human health impacts of waste management actions would be greatest under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D. Radiological releases under this alternative would result in the doses at the IDF-East Barrier and the Core Zone Boundary exceeding regulatory limits for the resident farmer and the American Indian resident farmer. None of the hypothetical receptors at the RPPDF Barrier, the Columbia River nearshore, or the Columbia River surface-water location would be exposed to a dose in excess of regulatory limits. Nonradiological releases under this alternative would result in exceedance of the Hazard Index for chromium at the IDF-East Barrier, Core Zone Boundary, and Columbia River nearshore for the resident farmer and the American Indian resident farmer. The analysis determined that the greatest impact of any alternative on long-term human health could result in radiological doses in excess of regulatory limits and chemical exposures with a Hazard Index greater than 1 for receptors located on site at the IDF-East Barrier, Core Zone Boundary, or Columbia River nearshore. There are no such onsite receptors currently at Hanford. The onsite exposure scenarios do not currently exist and have never existed during Hanford operations. Therefore, the estimated high health risks for past years are hypothetical risks only; no persons were ever exposed at these levels. While it is possible for these receptors scenarios to develop in the future, none are expected for the foreseeable future because the Core Zone is designated as Industrial-Exclusive, the Columbia River nearshore is designated as Preservation (Hanford Reach National Monument), and the area between them is designated as

Preservation (DOE 1999). It is unlikely, therefore, that any of the Waste Management alternatives would pose a disproportionately high and adverse long-term human health risk to the American Indian population at offsite locations. The greatest risk would be to the American Indian resident farmer at the IDF-East Barrier. During the year of peak dose, this receptor would receive a radiological dose of 281 millirem. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index greater than 1. The greatest risk in such a situation would be to the American Indian resident farmer. The adverse impacts would also be applicable to non–American Indian receptors at the same locations, but to a lesser extent.

5.4 COMBINATION OF ALTERNATIVES

The potential long-term environmental and human health impacts associated with implementation of alternatives and options for (1) Hanford SST system waste retrieval, treatment, and closure (i.e., tank closure), (2) decommissioning of FFTF and auxiliary facilities (i.e., FFTF decommissioning), and (3) management of waste from other Hanford activities and limited volumes from other DOE sites (i.e., waste management) are presented separately in Sections 5.1, 5.2, and 5.3, respectively. The individual Tank Closure, FFTF Decommissioning, and Waste Management alternatives and options, as applicable, are described in detail in Chapter 2. This section presents the potential long-term, combined impacts to air and groundwater on key resource indicators of implementing selected alternatives and options associated with the three sets of proposed actions.

Key resource indicators have been selected from the total range of impact measures presented for each resource area or discipline (analyzed elsewhere in this chapter) to focus on those measures providing the most meaningful and useful assessment of potential impact. As presented in this section, the combined impact analyses provide a basis for determining the potential peak and/or total impact on an environmental resource area or human health indicator associated with implementation of alternatives and options from each set of proposed actions analyzed in this EIS.

Several hundred impact scenarios could result from the potential combinations of the 11 Tank Closure, 3 FFTF Decommissioning, and 3 Waste Management alternatives when factored with their associated option cases and waste disposal groups. For purposes of analysis, the following combinations of alternatives were chosen to represent key points along the range of actions and associated overall impacts that could result from full implementation of the three sets of proposed actions.

- Alternative Combination 1: all No Action Alternatives

- Alternative Combination 2: Tank Closure Alternative 2B (Expanded WTP Vitrification; Landfill Closure); FFTF Decommissioning Alternative 2 (Entombment) with the Idaho Option for Disposition of RH-SCs and the Hanford Reuse Option for Disposition of Bulk Sodium; and Waste Management Alternative 2 (Disposal in IDF, 200-East Area Only) with Disposal Group 1, Subgroup 1-A.

- Alternative Combination 3: Tank Closure Alternative 6B (All Vitrification with Separations; Clean Closure), Base Case; FFTF Decommissioning Alternative 3 (Removal) with the Idaho Option for Disposition of RH-SCs and the Hanford Reuse Option for Disposition of Bulk Sodium; and Waste Management Alternative 2 (Disposal in IDF, 200-East Area Only) with Disposal Group 2. Subgroup 2-B.

Alternative Combination 1 represents the potential short-term impacts of minimal DOE action and the greatest long-term impacts with respect to groundwater. Alternative Combination 2 is a midrange case representative of DOE's Preferred Alternative(s), as addressed in Chapter 2, Section 2.12. Alternative Combination 3 would result in maximum reasonably foreseeable short-term impacts (in terms of the

intensity of the potential impact) on most resource areas and therefore represents, on the whole, a combination that would result in maximum potential short-term impacts, but would likely have the lowest long-term impacts on groundwater. For some resource areas, a combination that included Tank Closure Alternative 6A, Option Case, would result in maximum impacts. Selection of these three alternative combinations for detailed analysis in this EIS is done only to establish overall impact-level reference cases for stakeholders and decisionmakers to consider and does not preclude the selection and implementation of different combinations of the various alternatives in support of final agency decisions.

5.4.1 Groundwater

5.4.1.1 Alternative Combination 1

This section describes the results of the long-term groundwater impacts analysis for Alternative Combination 1, which comprises Tank Closure Alternative 1, FFTF Decommissioning Alternative 1, and Waste Management Alternative 1. The focus is the combined long-term groundwater impacts of these alternatives. More-detailed discussion of the individual impacts is provided in Sections 5.1.1, 5.2.1, and 5.3.1.

This discussion of long-term impacts is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers were obtained from the combination of the COPC drivers for the three individual alternatives that compose the alternative combination. They fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. The other COPCs that were analyzed do not significantly contribute to risk or hazard during the period of analysis because of limited inventory, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Alternative Combination 1 in terms of total amount of COPCs released to the vadose zone, to groundwater, and to the Columbia River. Releases of radionuclides are totaled in curies; chemicals in kilograms. Both are totaled over the 10,000-year period of analysis.

Table 5–153 lists the releases to the vadose zone for the COPC drivers. For Alternative Combination 1, the releases to the vadose zone are controlled by inventory; the entire inventory from all sources was released to the vadose zone during the period of analysis. The releases to the vadose zone for Alternative Combination 1 are dominated by sources associated with Tank Closure Alternative 1; releases from FFTF decommissioning and waste management sources account for less than 1 percent of the total. This result suggests that the long-term impacts of Alternative Combination 1 would closely match the long-term impacts of Tank Closure Alternative 1.

Table 5–153. Alternative Combination 1 Release to Vadose Zone for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 1	5.75×10^{4}	4.78×10^{1}	2.58×10^{4}	9.38×10^{2}	6.94×10^{5}	9.74×10^{7}	6.32×10^{5}
FFTF Decommissioning Alternative 1	2.29	0.00	2.72×10^{1}	0.00	5.72×10^{-3}	0.00	2.79×10^{-2}
Waste Management Alternative 1	3.52×10^{3}	1.32×10^{-3}	1.21	7.35×10^{-1}	1.80×10^{2}	2.98×10^{3}	9.47×10^{-1}
Total	6.10×10^{4}	4.78×10^{1}	2.59×10^{4}	9.39×10^{2}	6.94×10^{5}	9.74×10^{7}	6.32×10^{5}

Key: COPC=constituent of potential concern.

Table 5–154 lists the releases to groundwater for the COPC drivers. In addition to the inventory consideration discussed in the previous paragraph, releases to groundwater are controlled by the transport properties of the COPC drivers and the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone. For tritium, that amount is attenuated by radioactive decay during transit through the vadose zone. About 55 percent of the tritium released to the vadose zone reaches the unconfined aquifer. For uranium-238 and total uranium, the amount released to groundwater is lower than that released to the vadose zone because of retardation. Less than 5 percent of the uranium-238 and total uranium released to the vadose zone reaches the unconfined aquifer during the period of analysis.

Table 5–154. Alternative Combination 1 Release to Groundwater for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 1	3.23×10^{4}	4.65×10^{1}	2.51×10^{4}	2.57×10^{1}	6.34×10^{5}	9.40×10^{7}	2.86×10^{4}
FFTF Decommissioning Alternative 1	5.30×10^{-3}	0.00	2.67×10^{1}	0.00	5.61×10^{-3}	0.00	2.35×10^{-2}
Waste Management Alternative 1	1.76×10^{3}	1.31×10^{-3}	1.21	3.09×10^{-5}	1.77×10^{2}	2.94×10^{3}	4.39×10^{-5}
Total	3.41×10^{4}	4.65×10^{1}	2.51×10^{4}	2.57×10^{1}	6.34×10^{5}	9.40×10^{7}	2.86×10^{4}

Key: COPC=constituent of potential concern.

Table 5–155 lists the releases to the Columbia River for the COPC drivers. Releases to the Columbia River are controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate) the amount released to Columbia River is essentially equal to that released to groundwater. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 3 percent of the tritium released to groundwater reaches the Columbia River. For uranium-238 and total uranium, the amount released to the Columbia River is lower than the release to groundwater because of retardation in the aquifer. Overall, about 25 percent of the amount released to groundwater during the period of analysis reaches the Columbia River.

Table 5–155. Alternative Combination 1 Release to the Columbia River for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	**Iodine-129**	**Technetium-99**	**Uranium-238**	**Chromium**	**Nitrate**	**Total Uranium**
Tank Closure Alternative 1	8.68×10^{2}	4.54×10^{1}	2.46×10^{4}	6.26	6.52×10^{5}	9.42×10^{7}	6.87×10^{3}
FFTF Decommissioning Alternative 1	3.15×10^{-4}	0.00	2.72×10^{1}	0.00	5.73×10^{-3}	0.00	2.20×10^{-2}
Waste Management Alternative 1	0.00	1.28×10^{-3}	1.18	2.67×10^{-6}	1.75×10^{2}	2.90×10^{3}	3.50×10^{-6}
Total	8.68×10^{2}	4.54×10^{1}	2.46×10^{4}	6.26	6.52×10^{5}	9.42×10^{7}	6.87×10^{3}

Key: COPC= constituent of potential concern.

ANALYSIS OF CONCENTRATION VERSUS TIME

This section describes the impacts of Alternative Combination 1 in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to aid to interpreting data with a significant amount of random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration trend was level, and the concentrations were near the benchmark. The benchmark concentration for each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–156 lists the maximum concentrations for the COPCs at the peak year at the Core Zone Boundary and the Columbia River nearshore.

Figure 5–1191 shows concentration versus time for tritium. Note that for visual clarity, the time period shown on this figure is from CY 1940 through CY 5940 rather than the full 10,000-year period of analysis. Concentrations at the Core Zone Boundary exceed the benchmark concentration by about two orders of magnitude for a short period of time during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River nearshore peak at about an order of magnitude lower than the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates the groundwater concentration, and tritium is essentially not a factor at times later than CY 2100.

Table 5–156. Alternative Combination 1 Maximum COPC Concentrations in the Peak Year at the Core Zone Boundary and Columbia River Nearshore

Contaminant	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter			
Hydrogen-3 (tritium)	**2,860,000**	1,720	20,000
	(1956)	(1998)	
Technetium-99	**350,000**	**5,230**	900
	(3837)	(4032)	
Iodine-129	**682**	**13**	1
	(3801)	(4411)	
Uranium isotopes	**1,070**	6	15
(includes uranium-233, -234, -235, -238)	(11,683)	(11,918)	
Chemical in micrograms per liter			
Acetonitrile	**121**	9	100
	(3338)	(3285)	
Chromium	**28,700**	**165**	100
	(1956)	(4019)	
Dichloromethane	0.0	0.0	5
	(1940)	(1940)	
Fluoride	1	0	4,000
	(3661)	(4592)	
Nitrate	**13,400,000**	23,500	45,000
	(1956)	(3911)	
Total uranium	**1,220**	8	30
	(11,648)	(11,591)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern

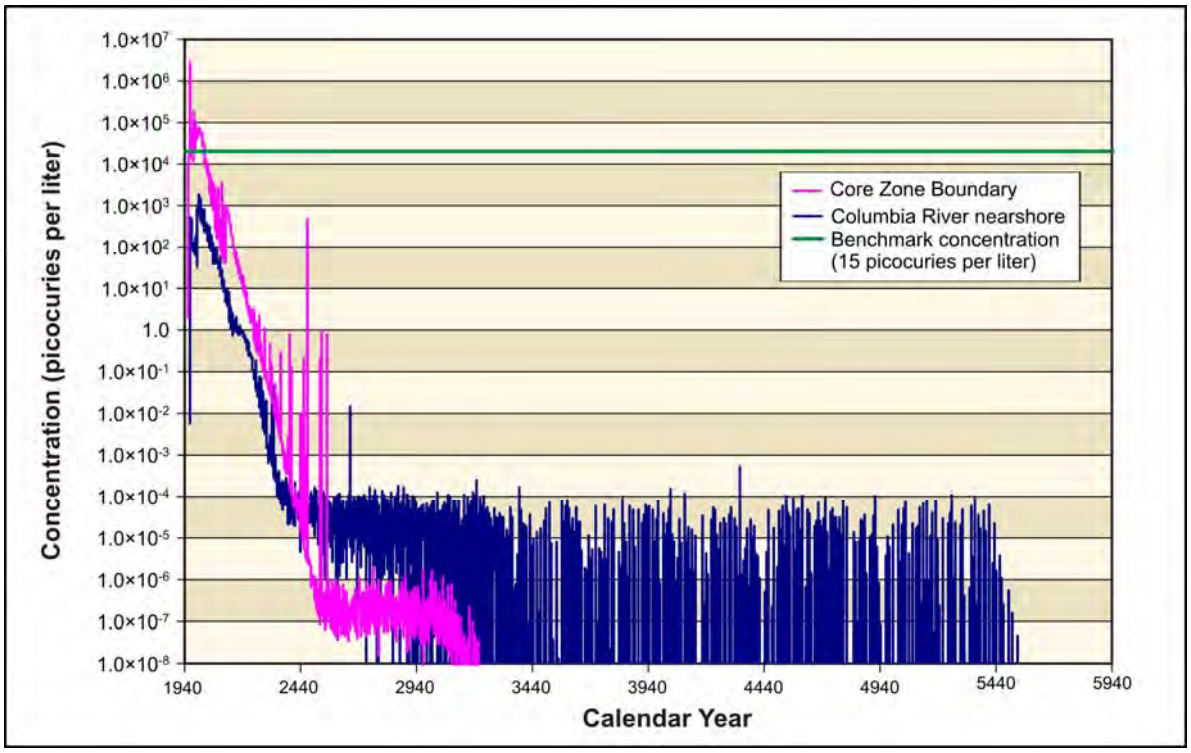


Figure 5–1191. Alternative Combination 1 Hydrogen-3 (Tritium) Concentration Versus Time

Figures 5–1192 through 5–1195 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Groundwater concentrations of iodine-129 exceed benchmark concentrations by more than two orders of magnitude during the first several thousand years of the analysis period. During this time, groundwater concentrations at the Columbia River nearshore exceed the benchmark concentration by about an order of magnitude. Later in the analysis period, the concentrations at the Core Zone Boundary exceed the benchmark by about an order of magnitude, and are of the same order of magnitude as the benchmark at the Columbia River nearshore. Technetium-99, chromium, and nitrate concentrations show a similar curve, with chromium and nitrate concentrations at the Columbia River nearshore dropping below the benchmark concentrations.

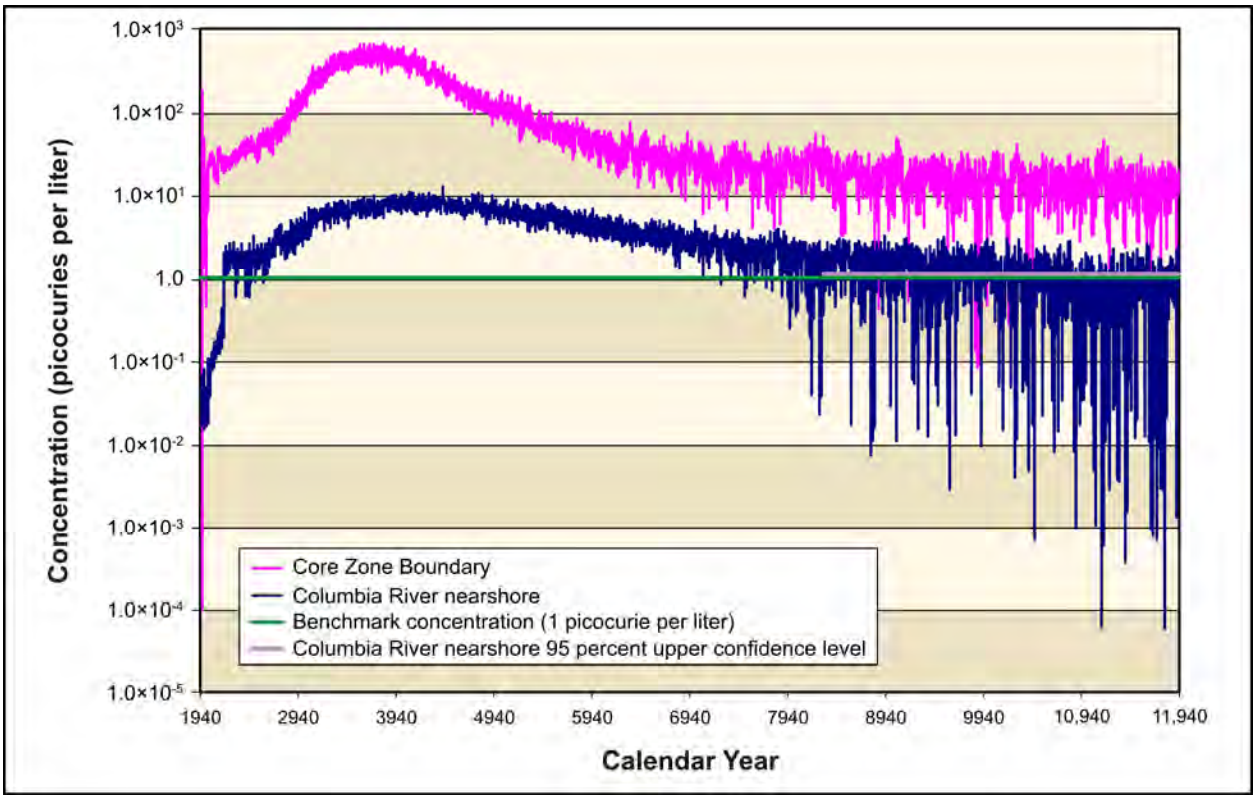


Figure 5–1192. Alternative Combination 1 Iodine-129 Concentration Versus Time

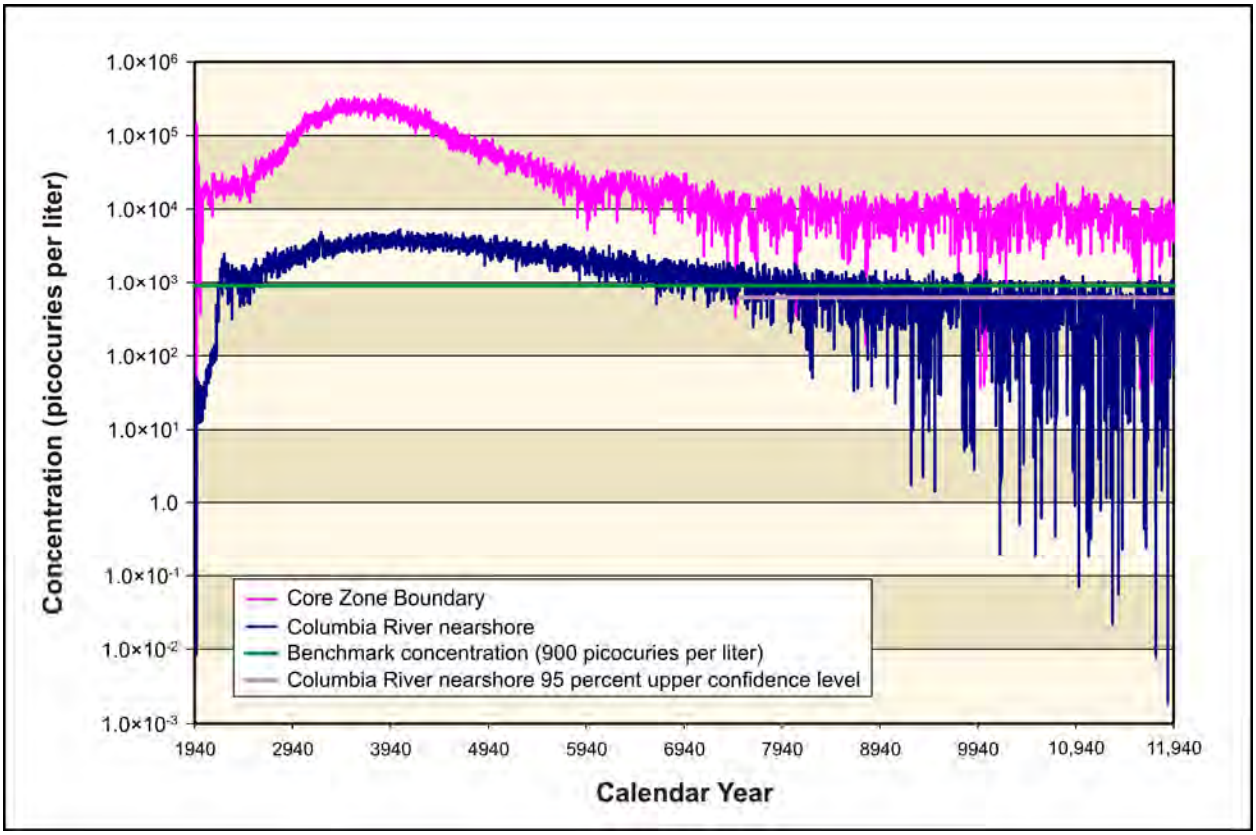


Figure 5–1193. Alternative Combination 1 Technetium-99 Concentration Versus Time

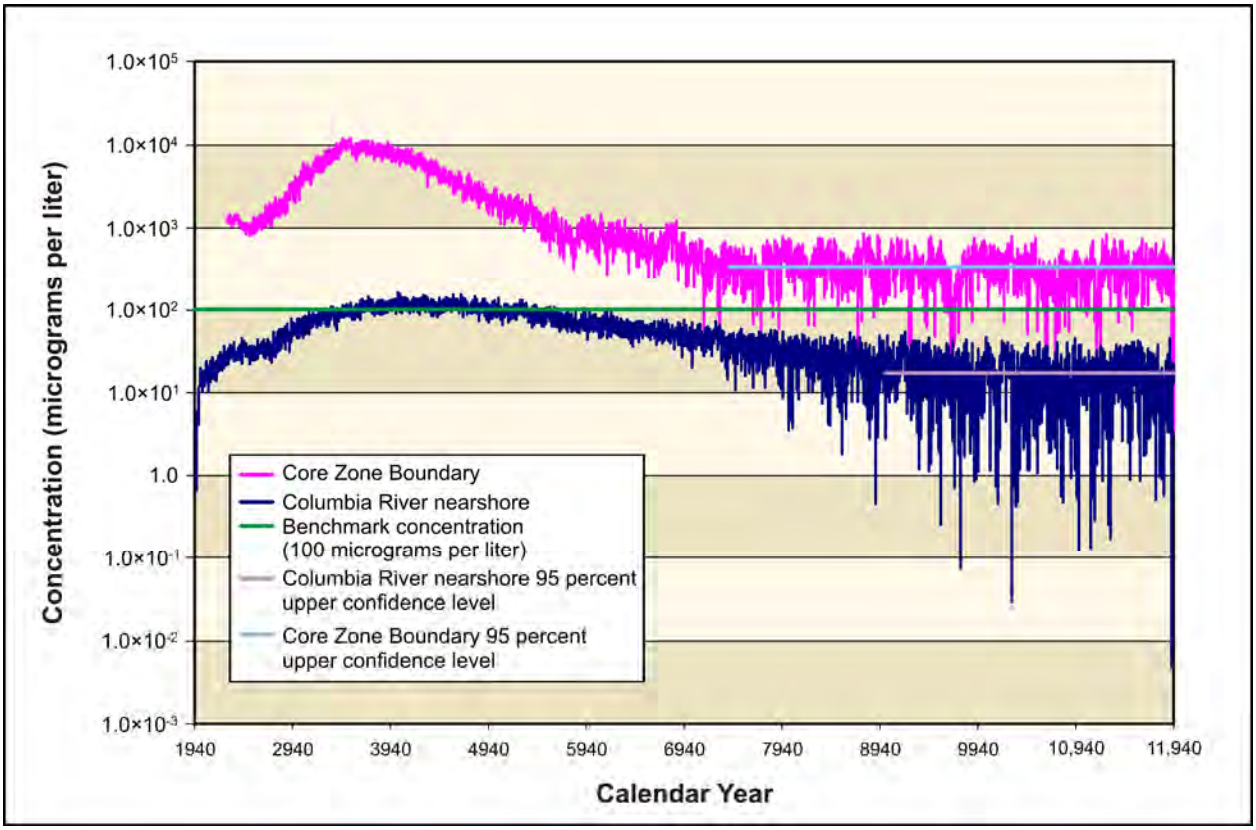


Figure 5–1194. Alternative Combination 1 Chromium Concentration Versus Time

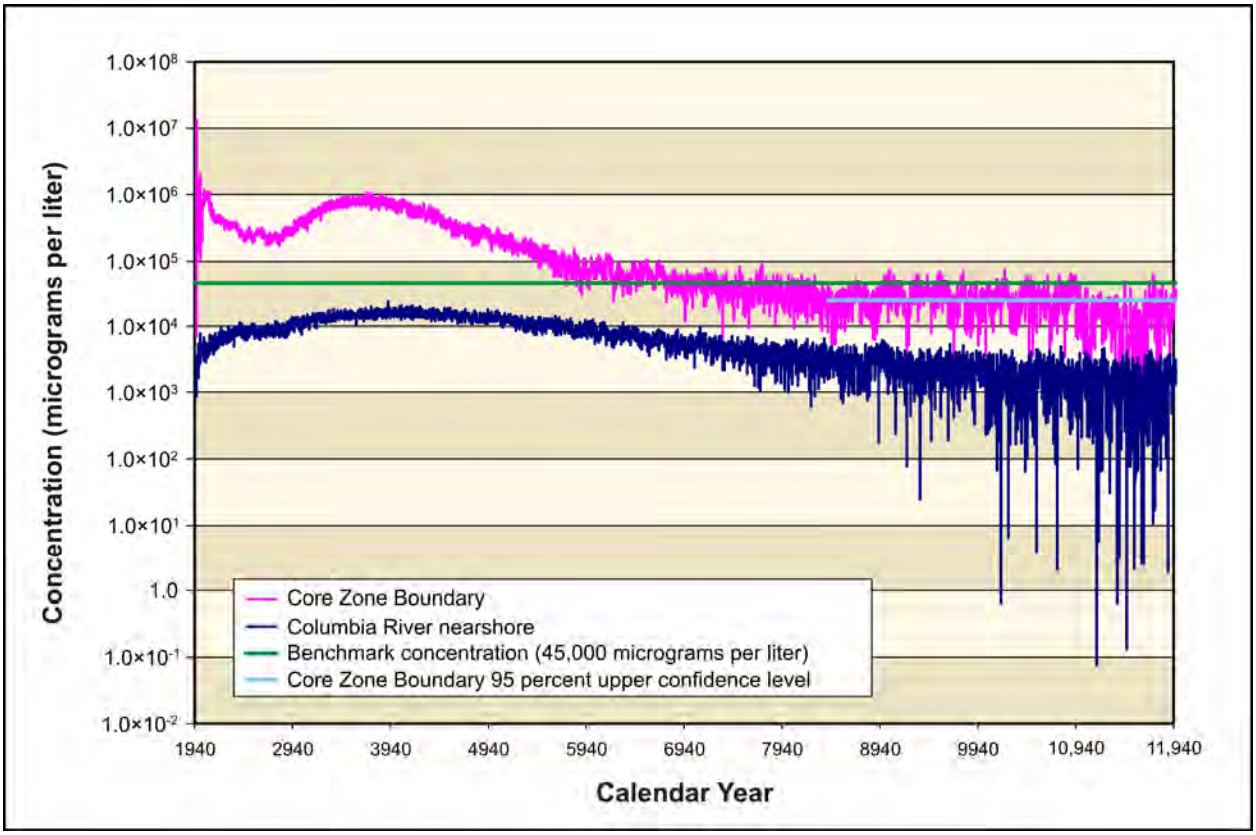


Figure 5–1195. Alternative Combination 1 Nitrate Concentration Versus Time

Figures 5–1196 and 5–1197 show concentration versus time for uranium-238 and total uranium. Concentrations of uranium-238 and total uranium rise throughout the period of analysis. The travel times of these COPCs from the source locations to the Core Zone Boundary and the Columbia River are retarded relative to the conservative tracers by about a factor of seven. After about 5,000 years, concentrations of both uranium-238 and total uranium approach the benchmark concentration at the Core Zone Boundary, and continue to rise until the end of the period of analysis, when they exceed the benchmark concentration by about a factor of 30. Groundwater concentrations at the Columbia River nearshore rise throughout the period of analysis, nearing the benchmark concentration by CY 11,940.

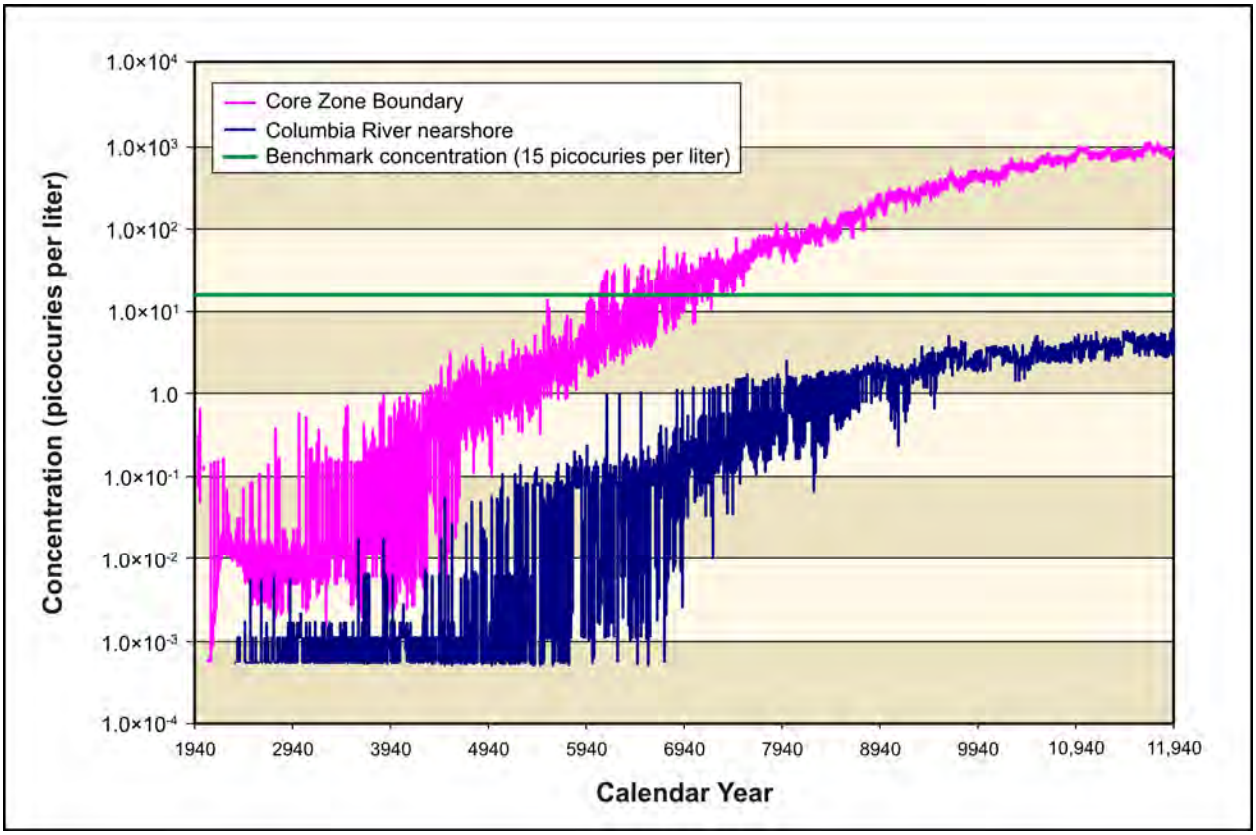


Figure 5–1196. Alternative Combination 1 Uranium-238 Concentration Versus Time

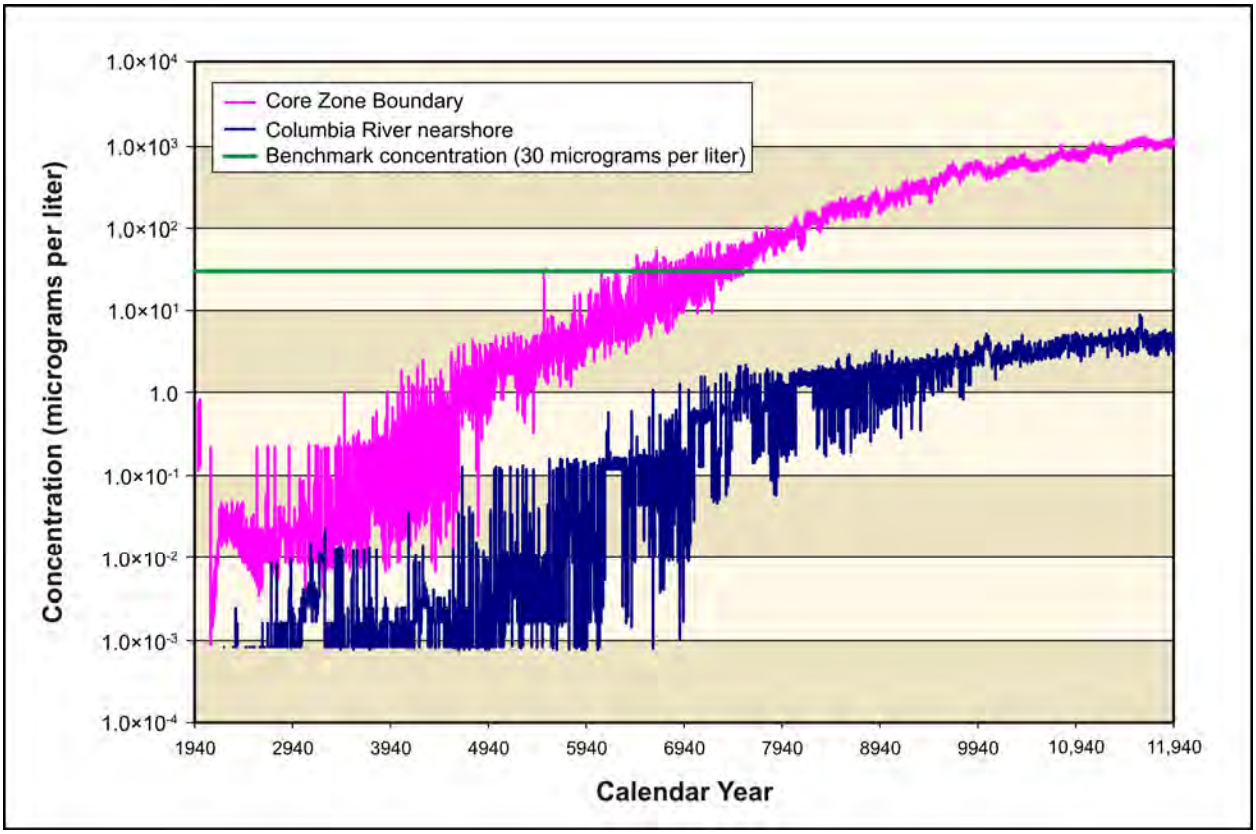
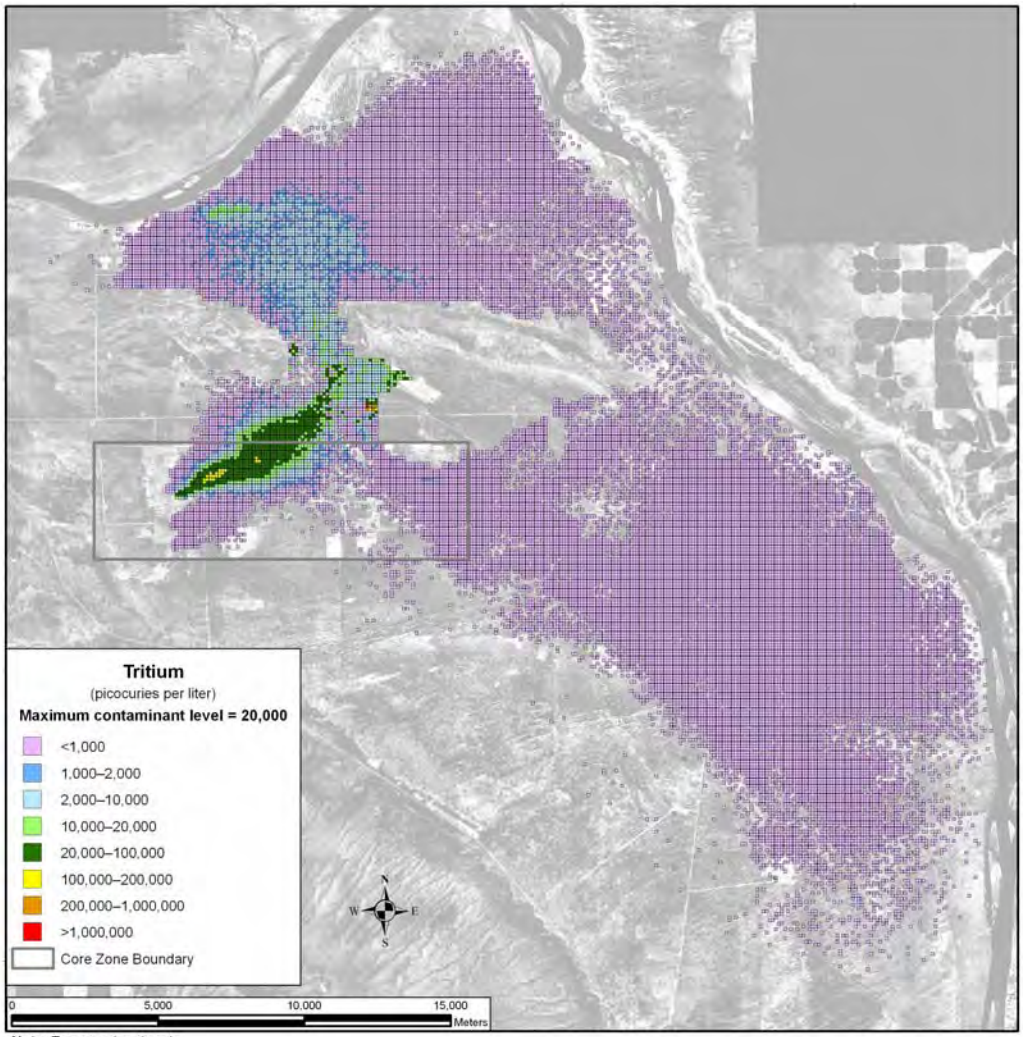


Figure 5–1197. Alternative Combination 1 Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section describes the impacts of Alternative Combination 1 in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations lower than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

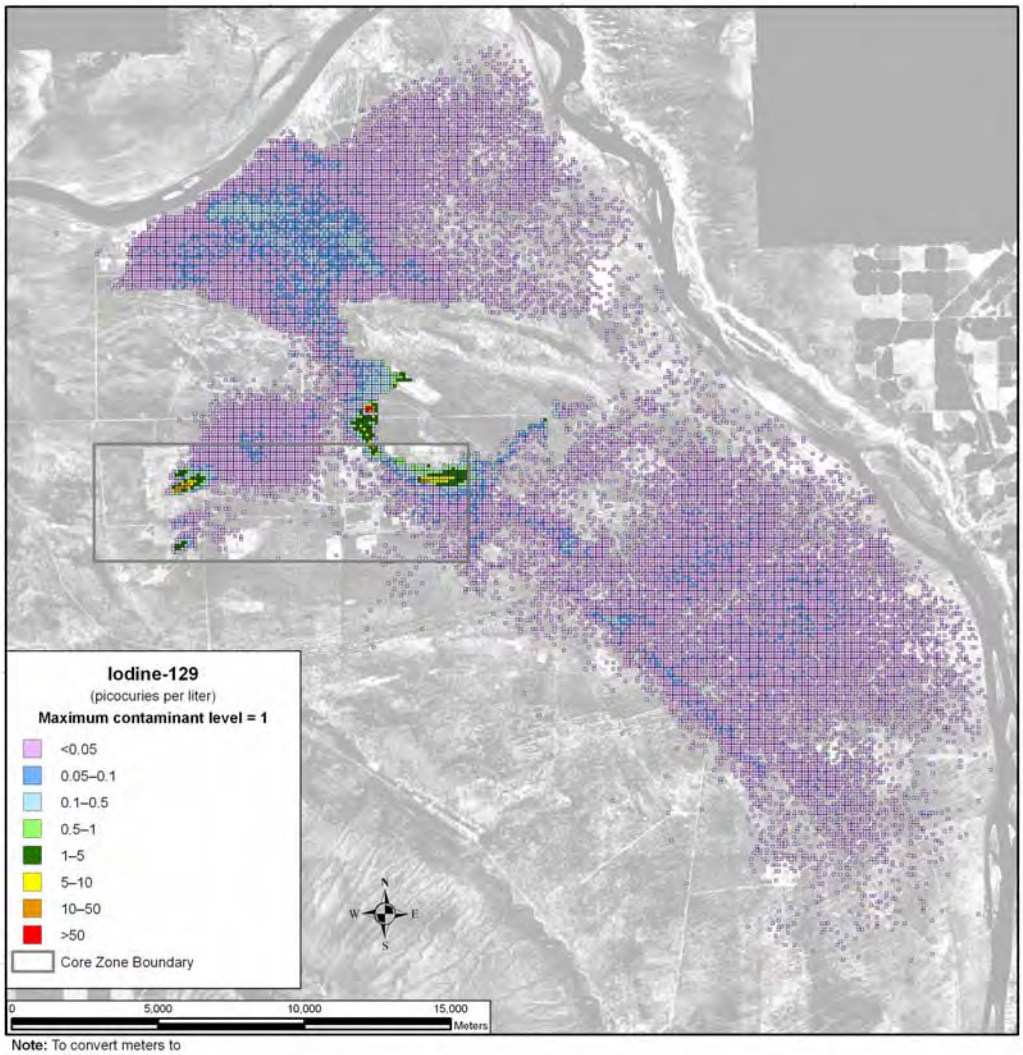
Figure 5–1198 shows the spatial distribution of groundwater concentrations of tritium during CY 2005. Releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crossing the Core Zone Boundary, and extending toward Gable Gap. Peak concentrations in this plume are about 10 to 20 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135.



Note: To convert meters to feet, multiply by 3.281

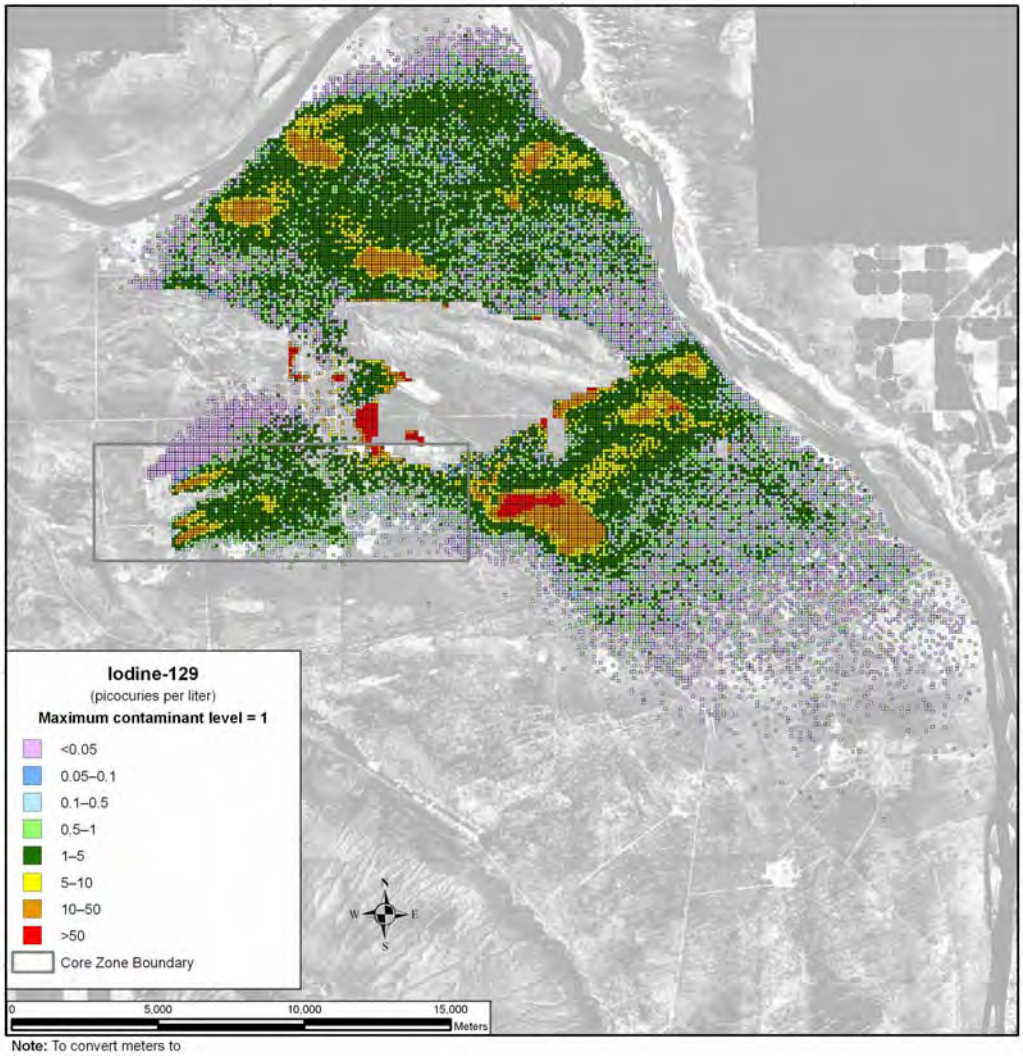
Figure 5–1198. Alternative Combination 1 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

Figure 5–1199 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005. Releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceed the benchmark concentration associated with the T Barrier, B Barrier, and A Barrier. Peak concentrations in this plume are about 10 to 50 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Around CY 3890, releases from other tank farm sources create a large plume exceeding the benchmark, extending from the tank farm barriers to the Columbia River (see Figure 5–1200). A secondary plume from trenches 31 and 34 (Waste Management Alternative 1 sources) can also be seen in the 200-West Area. By CY 7140, most of the mass in the plume reaches the Columbia River, with only isolated pockets of high-concentration areas where the groundwater flow velocities are extremely low (see Figure 5–1201). Figure 5–1202 shows the total area for which groundwater concentrations of iodine-129 exceed the benchmark concentration as a function of time. The area of exceedance peaks between CY 3240 and CY 4540, driven primarily by releases from other tank farm sources. Figures 5–1203 through 5–1206 show the spatial distribution at the same three times and the total area of exceedance versus time for technetium-99. The spatial distribution of technetium-99 is similar to that of iodine-129. The other conservative tracers, chromium (see Figures 5–1207 through 5–1209) and nitrate (see Figures 5–1210 through 5–1212) show similar spatial distributions.



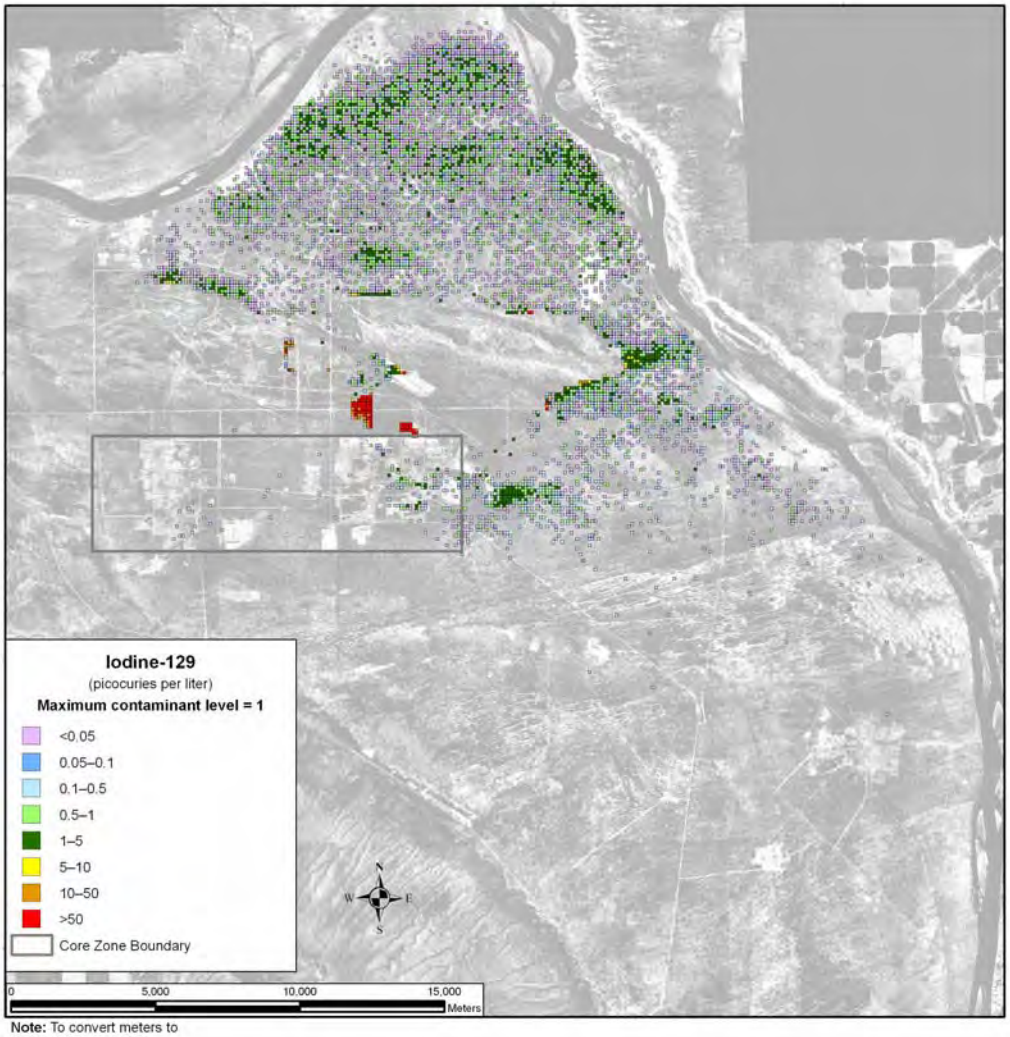
Note: To convert meters to feet, multiply by 3.281

Figure 5–1199. Alternative Combination 1 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005



Note: To convert meters to feet, multiply by 3.281

Figure 5–1200. Alternative Combination 1 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1201. Alternative Combination 1 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

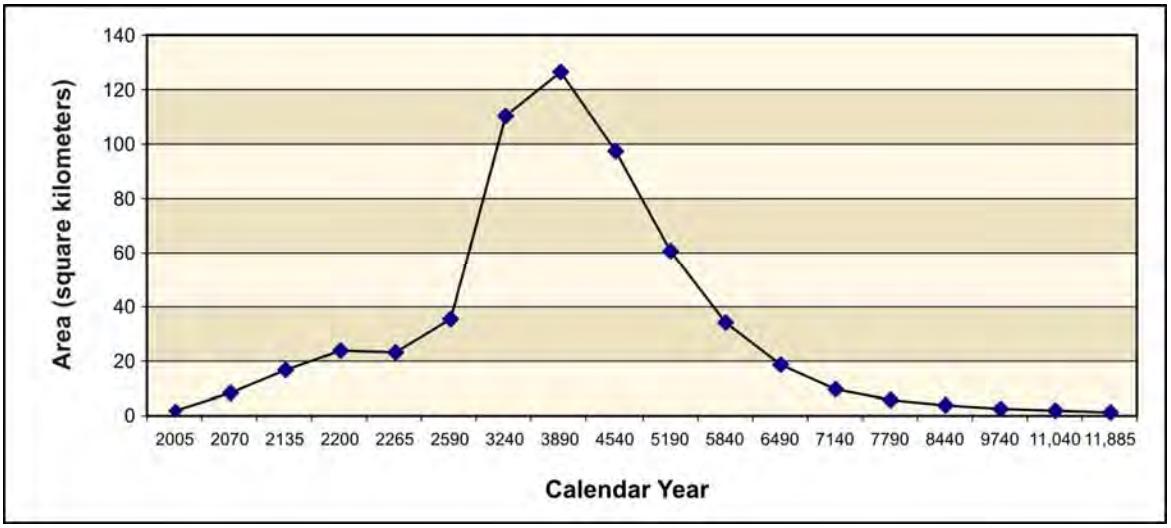
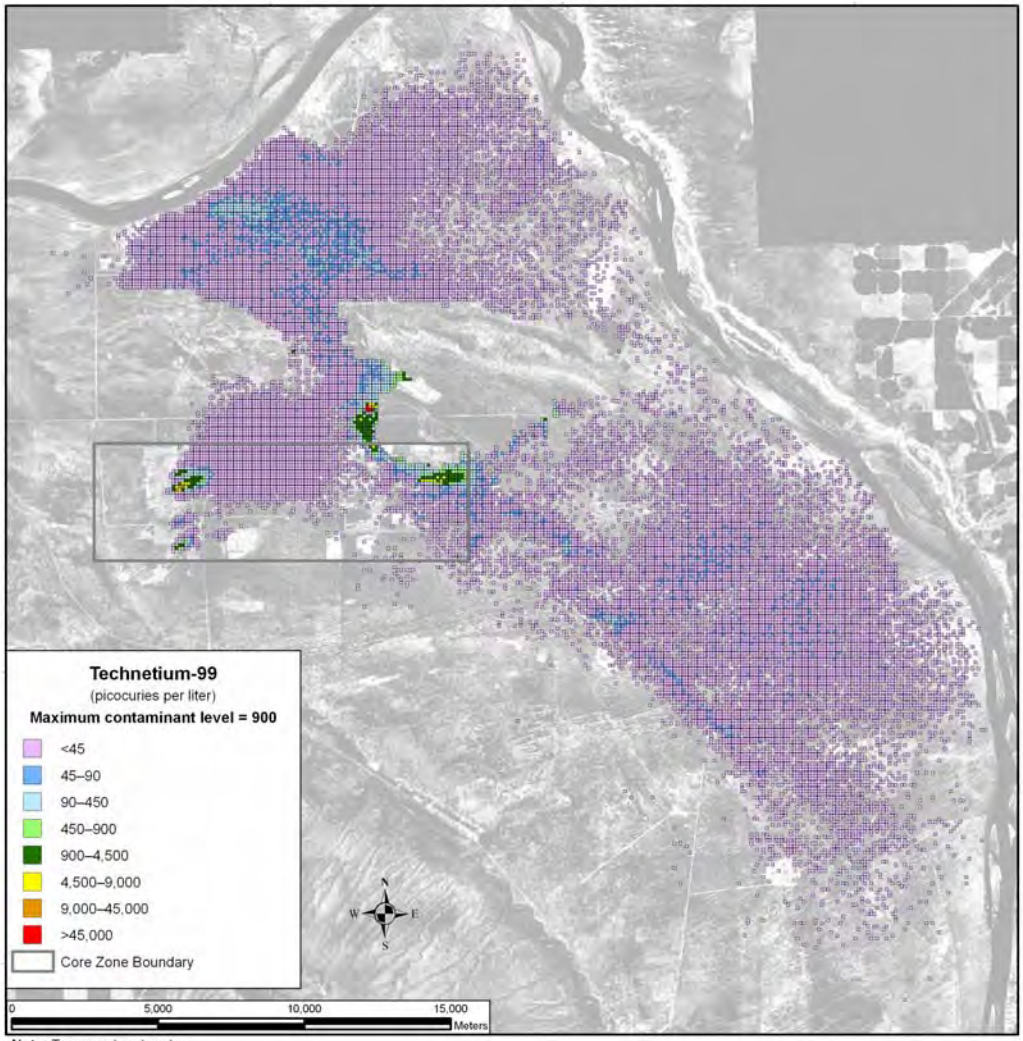
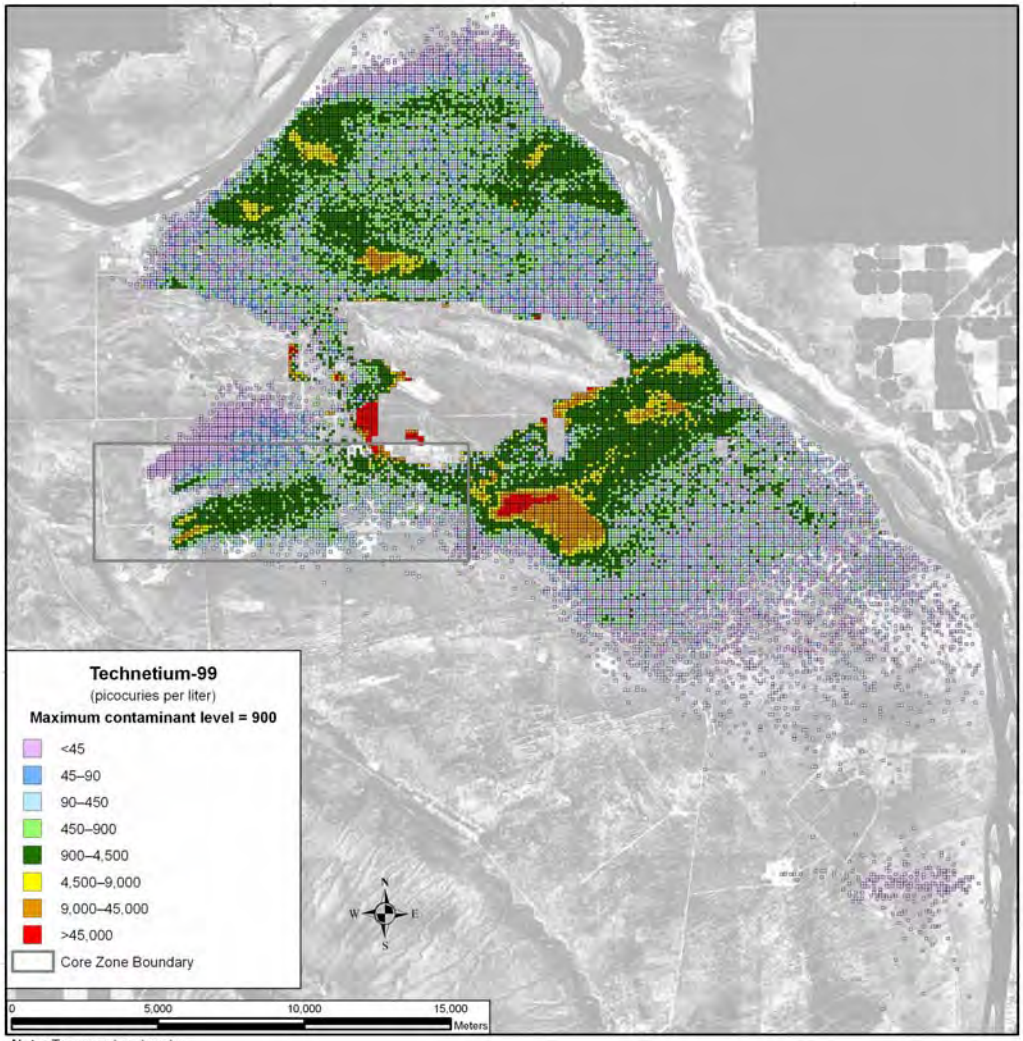


Figure 5–1202. Alternative Combination 1 Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time



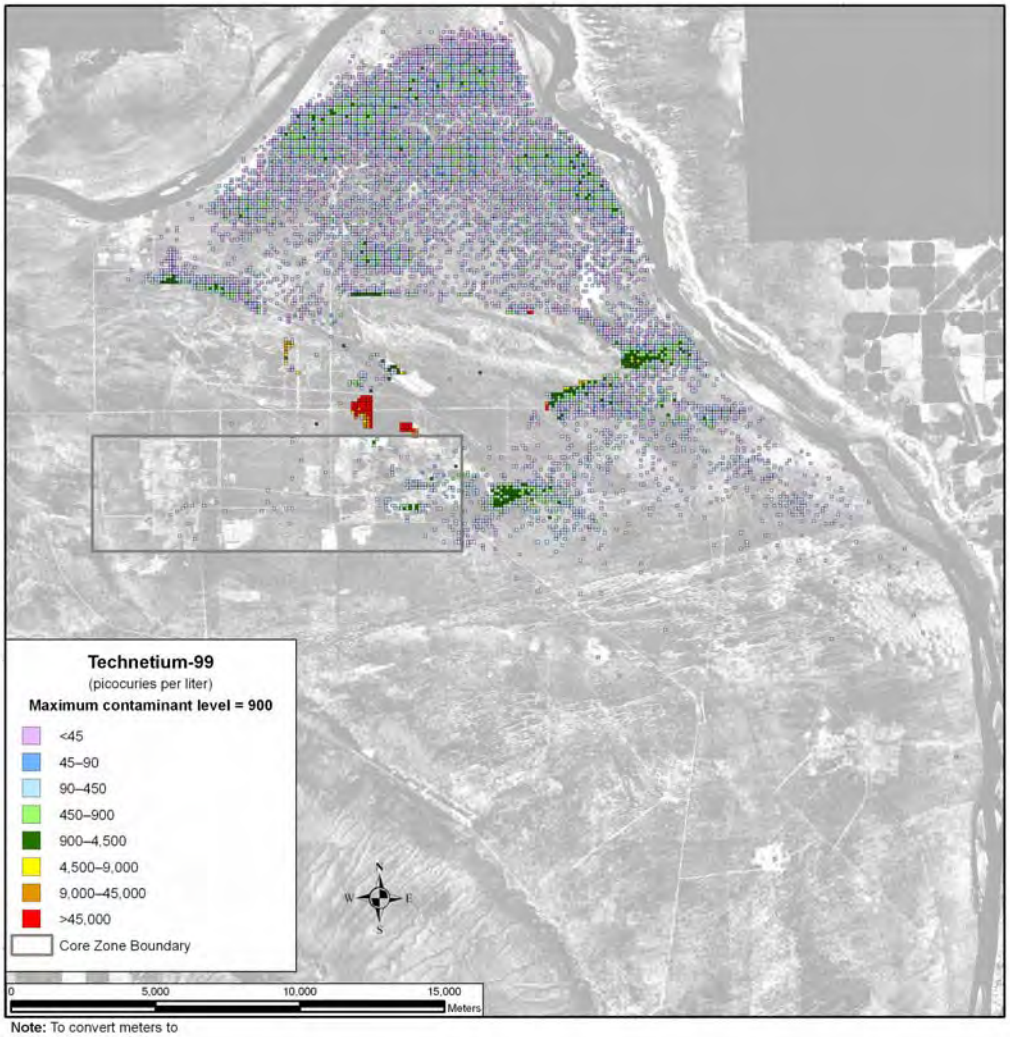
Note: To convert meters to feet, multiply by 3.281

Figure 5–1203. Alternative Combination 1 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005



Note: To convert meters to feet, multiply by 3.281

Figure 5–1204. Alternative Combination 1 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1205. Alternative Combination 1 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140

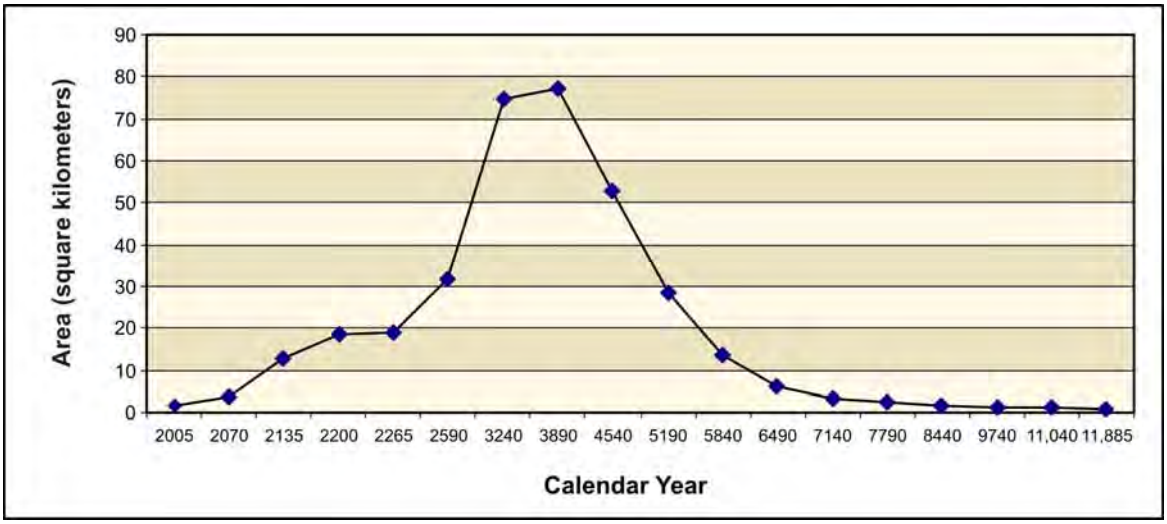
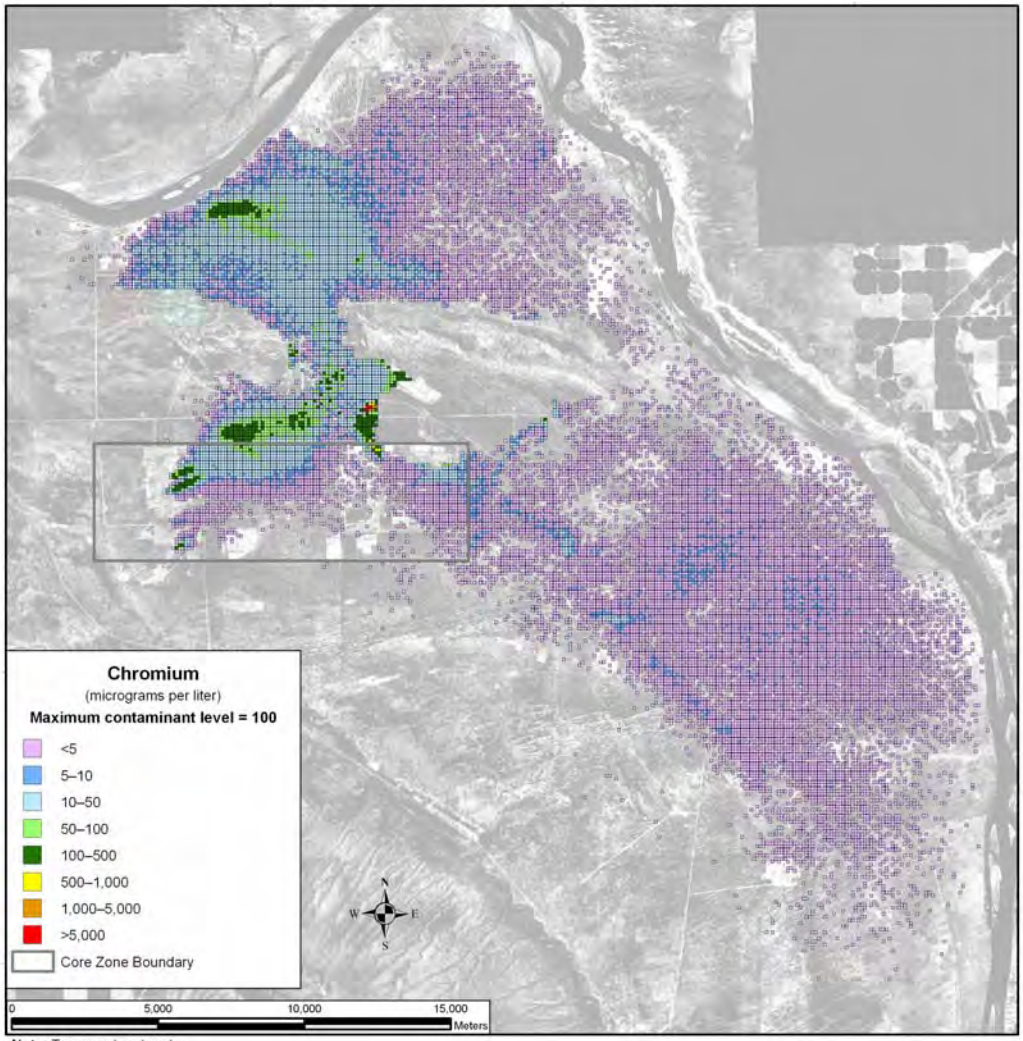
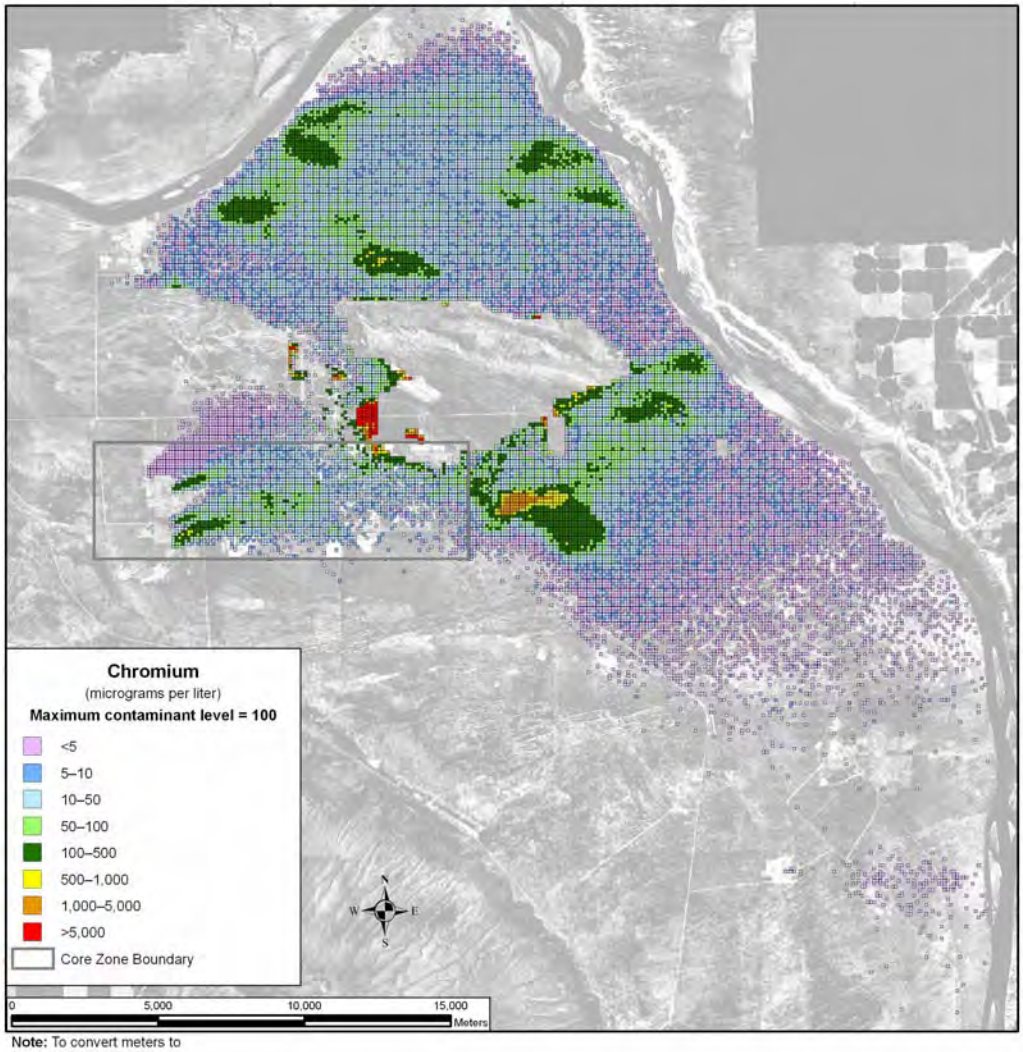


Figure 5–1206. Alternative Combination 1 Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time



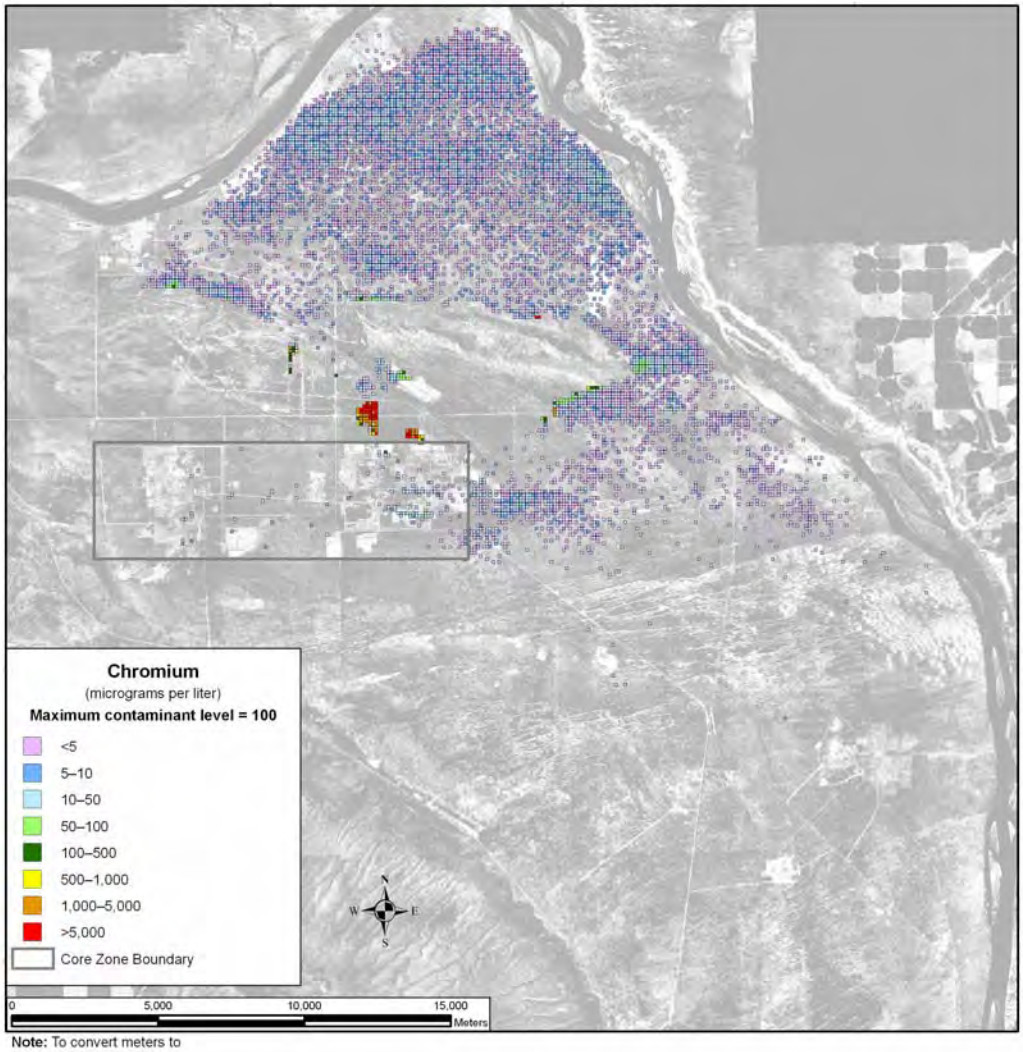
Note: To convert meters to feet, multiply by 3.281

Figure 5–1207. Alternative Combination 1 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005



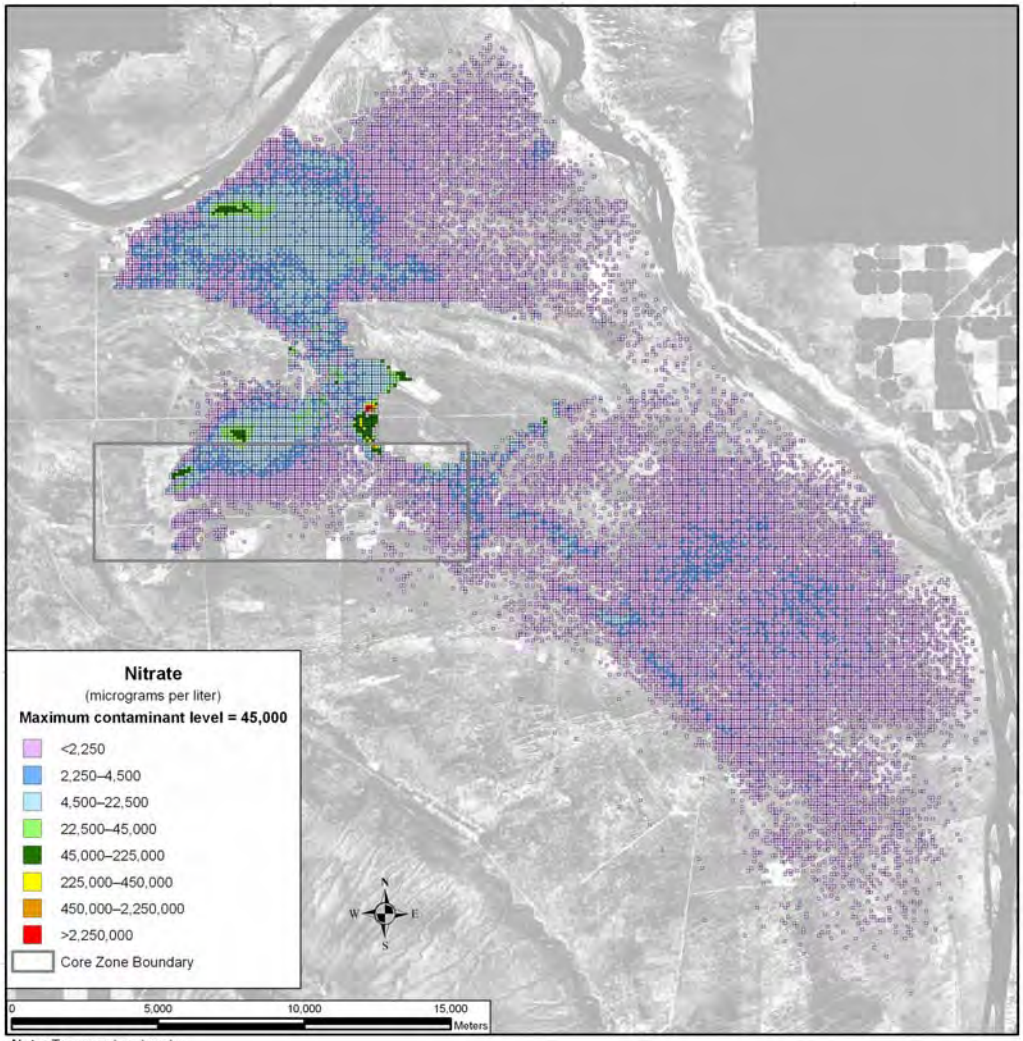
Note: To convert meters to feet, multiply by 3.281

Figure 5–1208. Alternative Combination 1 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



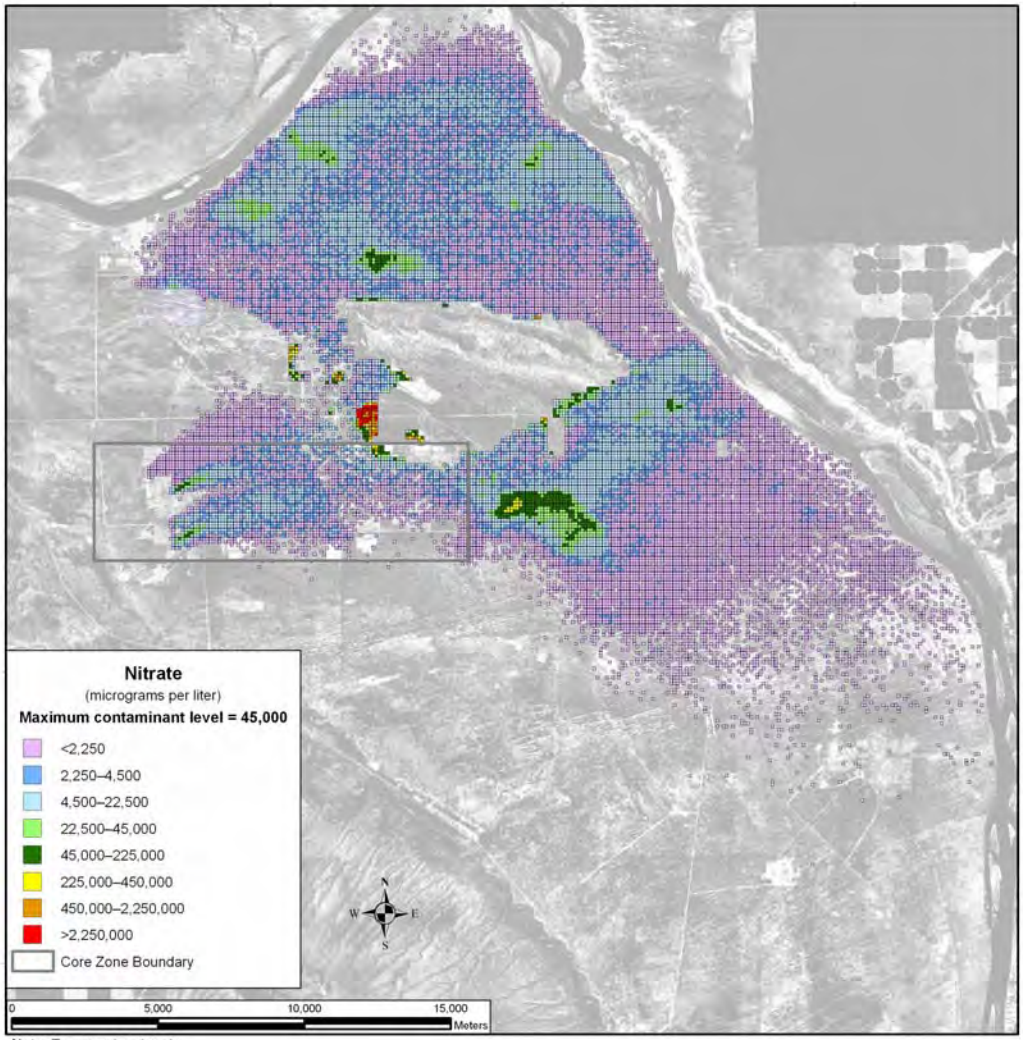
Note: To convert meters to feet, multiply by 3.281

Figure 5–1209. Alternative Combination 1 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



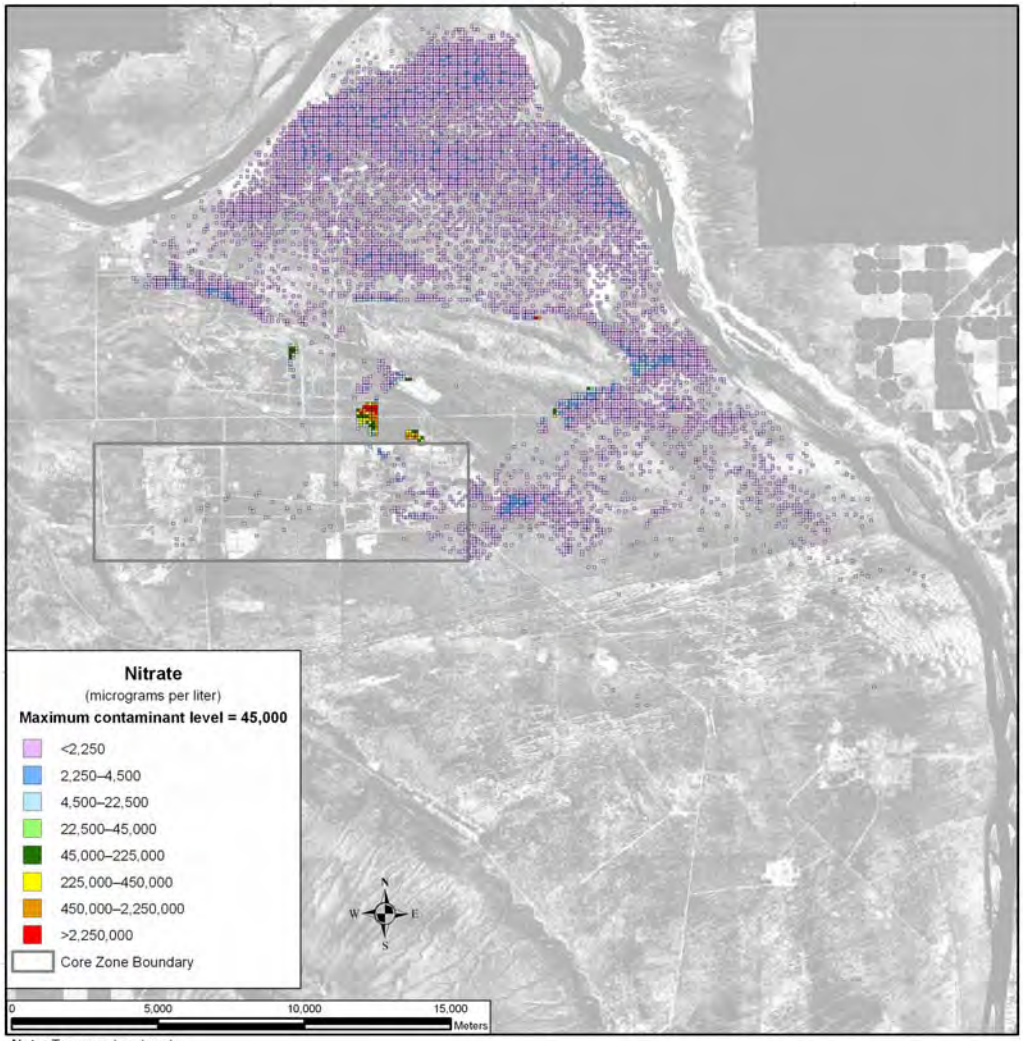
Note: To convert meters to feet, multiply by 3.281

Figure 5–1210. Alternative Combination 1 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005



Note: To convert meters to feet, multiply by 3.281

Figure 5–1211. Alternative Combination 1 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1212. Alternative Combination 1 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

Uranium-238 and total uranium show a different spatial distribution over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–1213 shows the distribution of uranium-238 during CY 2135. There is a small plume associated with cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark and contained within the Core Zone Boundary. By CY 3890 (see Figure 5–1214), the area of the plume has grown, but there are no significant increases in peak concentration. At CY 11,885 (see Figure 5–1215), the greatest development of the plume during the analysis period is seen, resulting primarily from releases from other tank farm sources. Figure 5–1216 shows the total area for which groundwater concentrations of uranium-238 exceed the benchmark concentration as a function of time. The area of exceedance is largest near the end of the period of analysis. Figures 5–1217 through 5–1219 show the corresponding spatial distribution for total uranium.

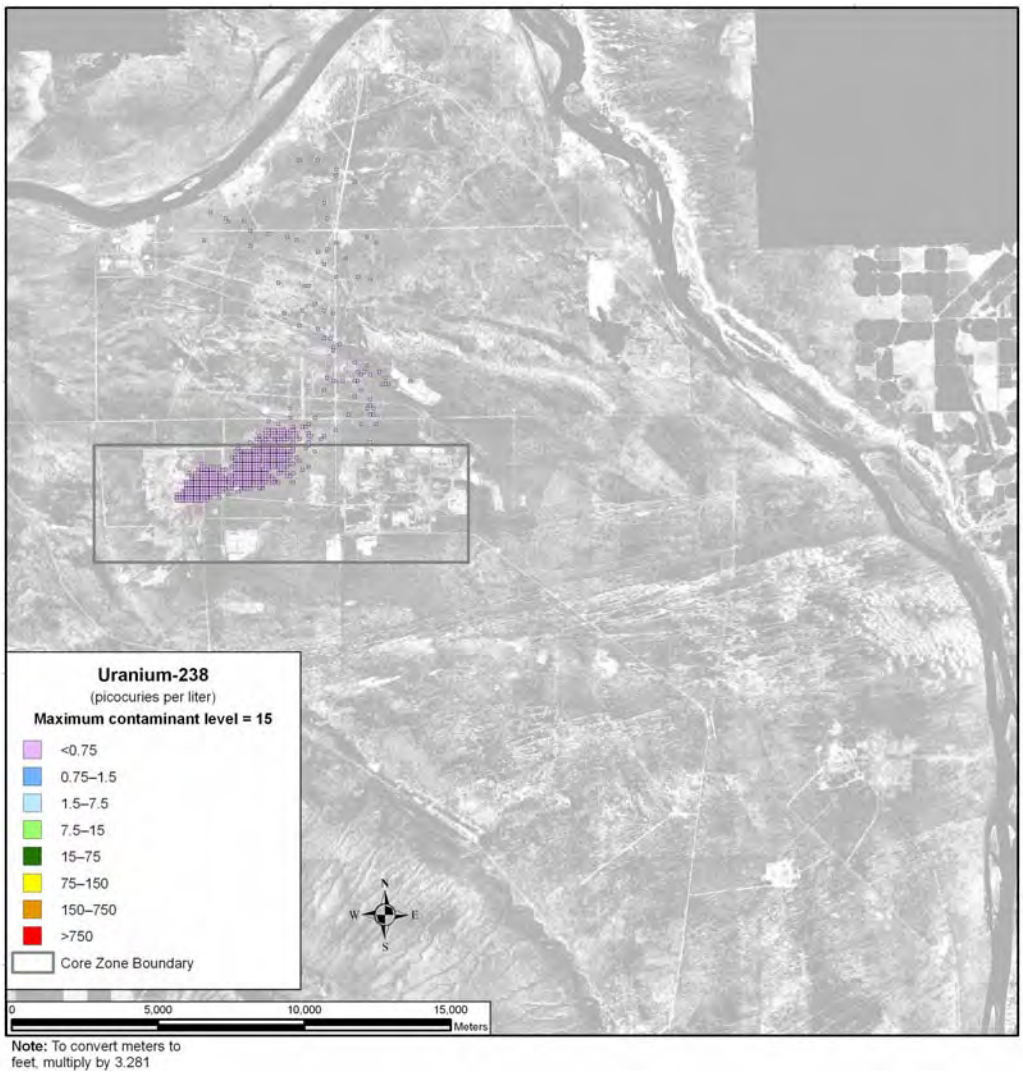
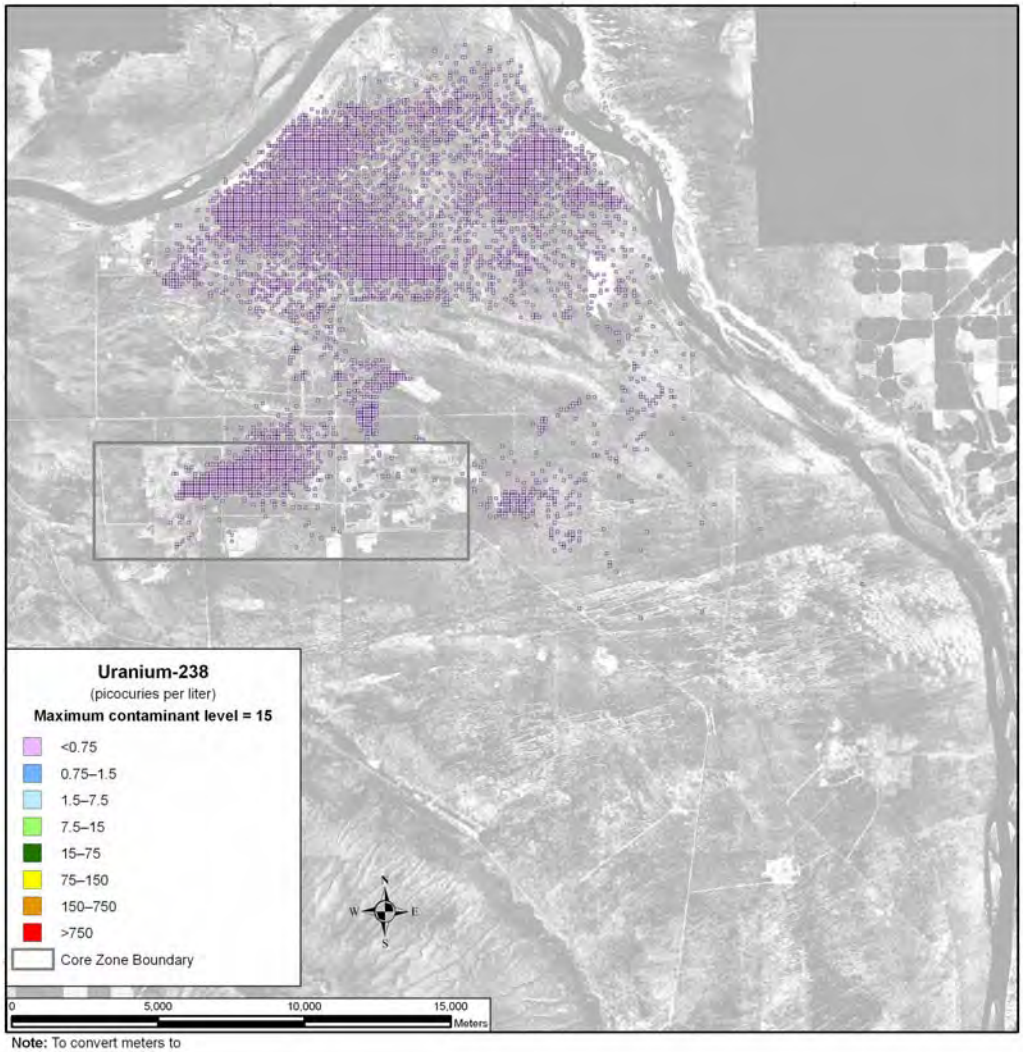
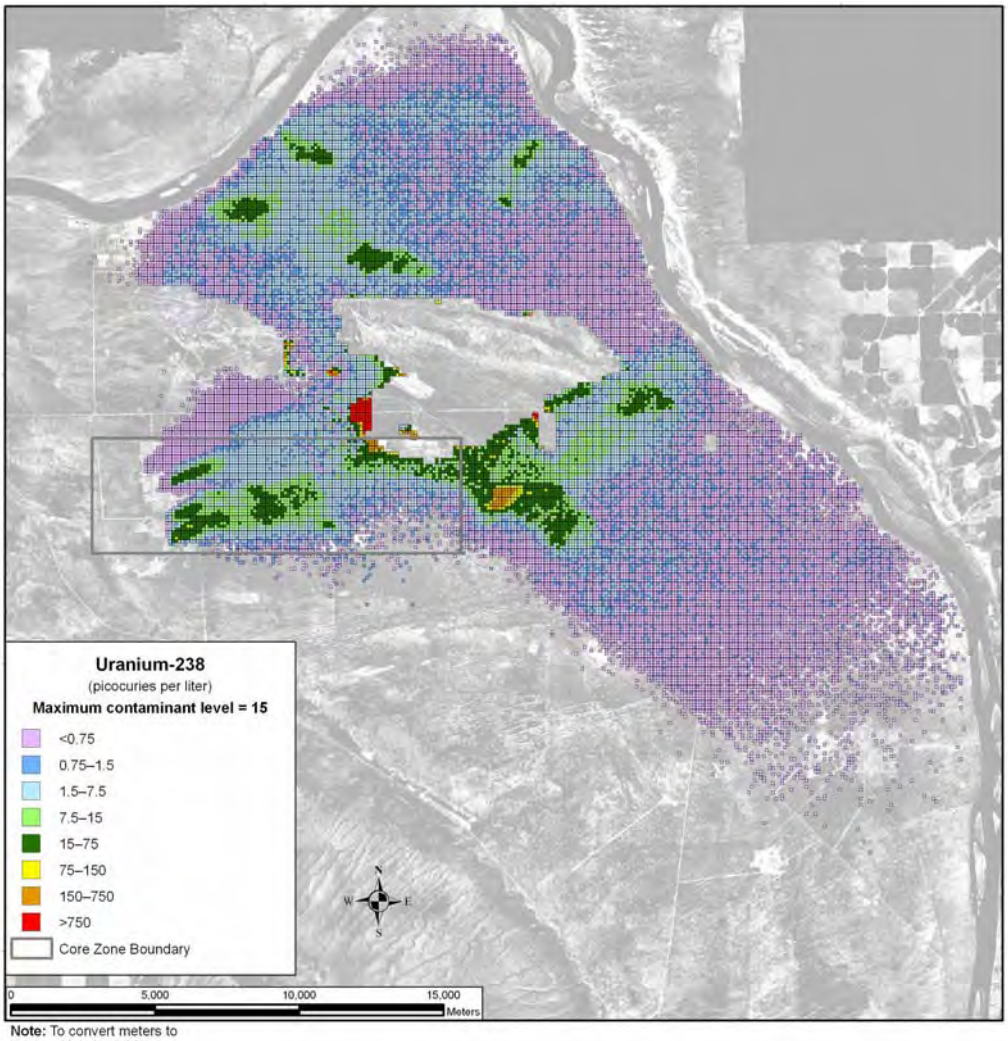


Figure 5–1213. Alternative Combination 1 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281

Figure 5–1214. Alternative Combination 1 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1215. Alternative Combination 1 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

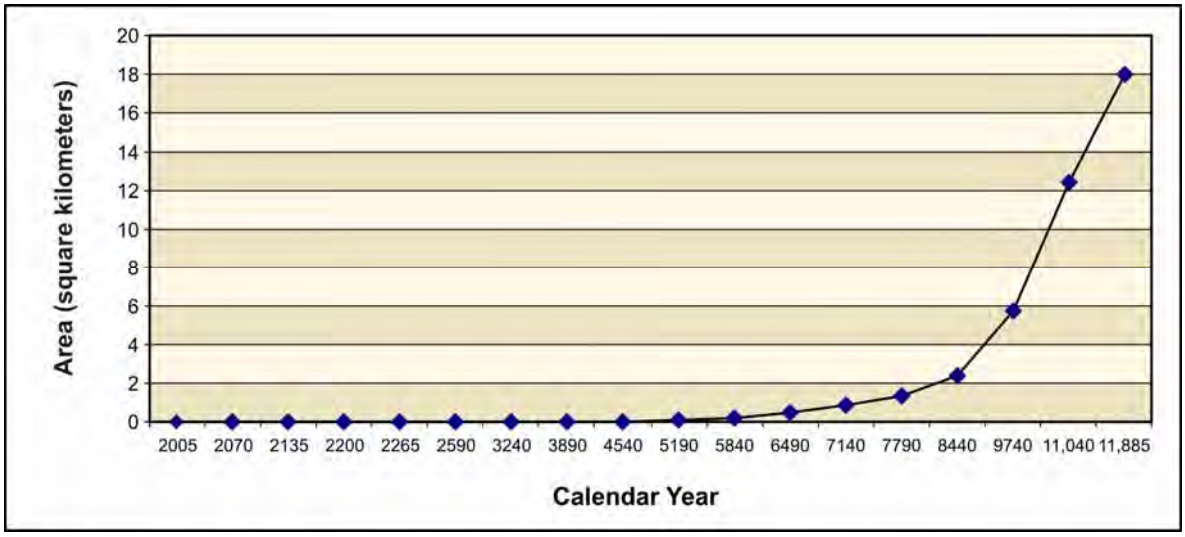
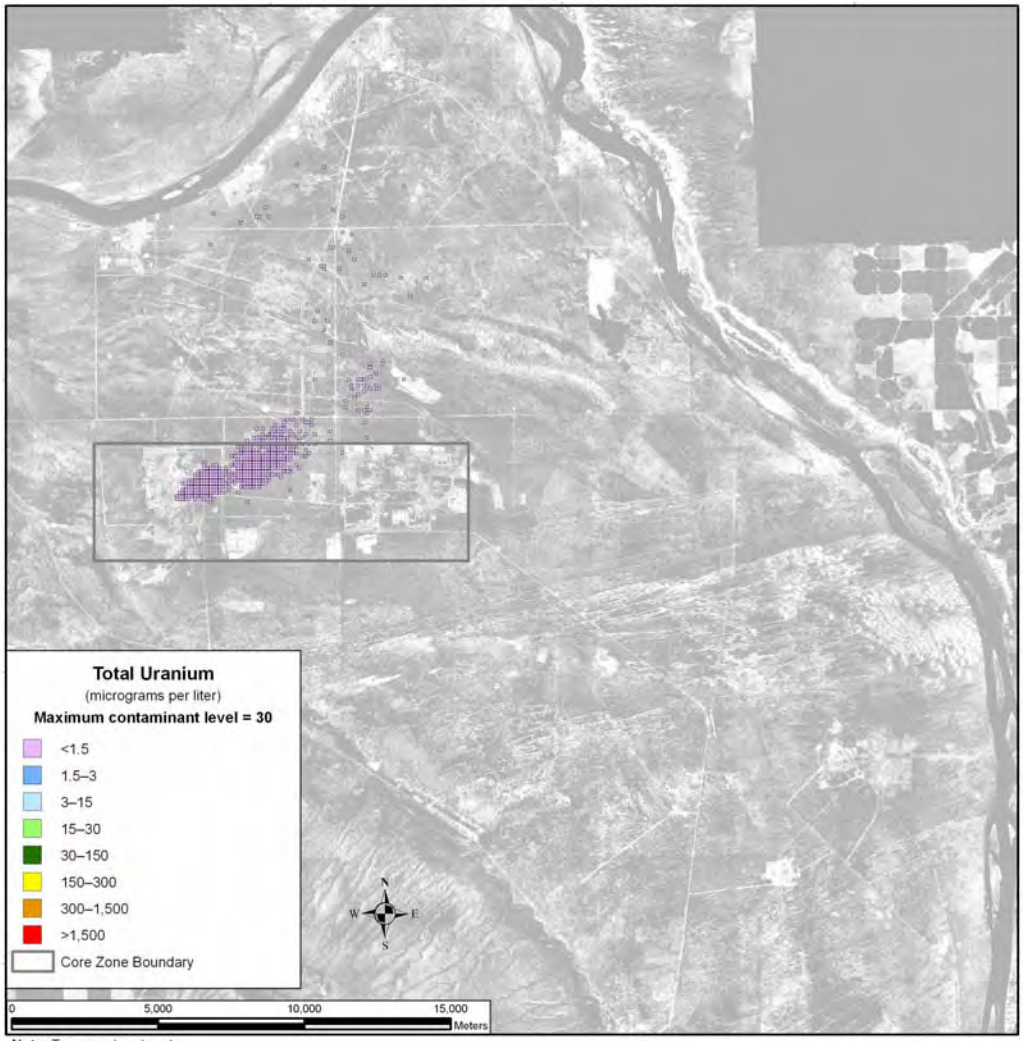
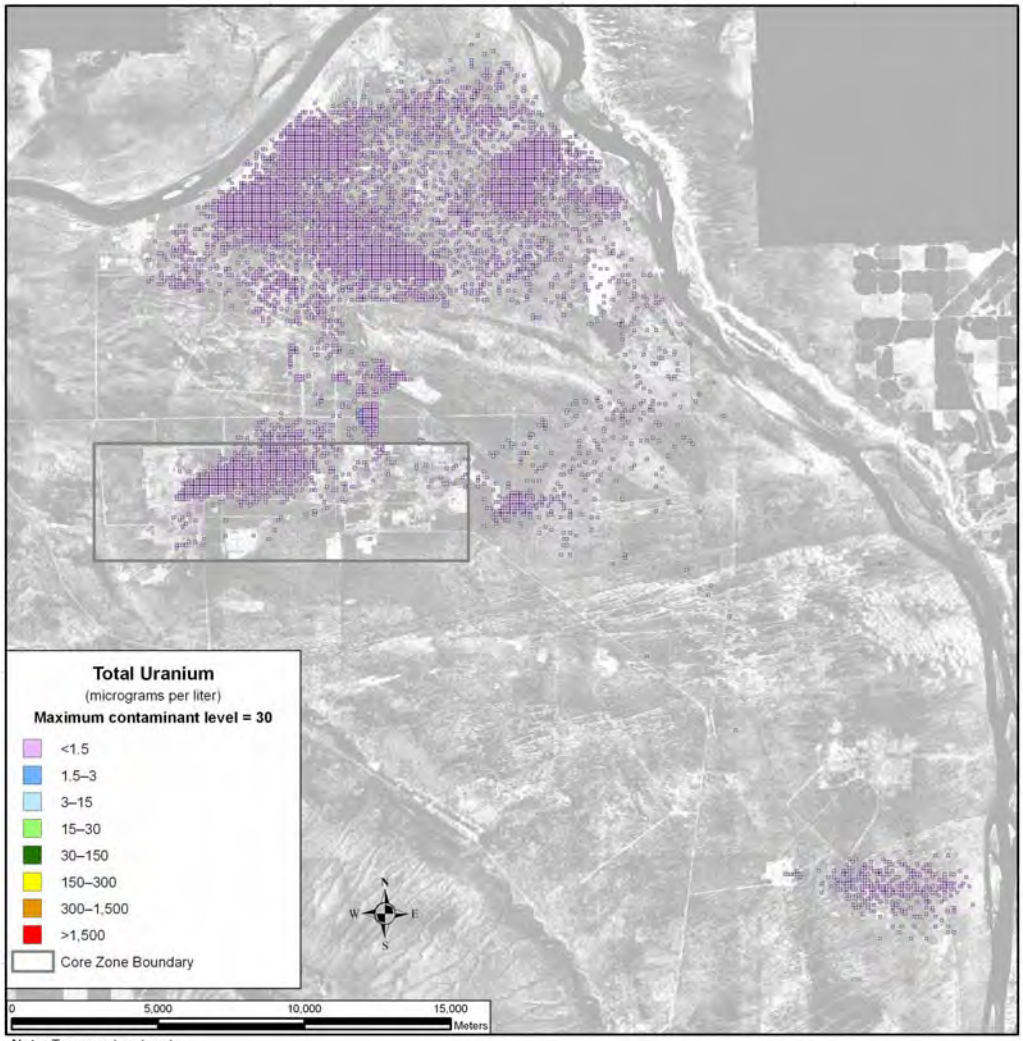


Figure 5–1216. Alternative Combination 1 Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time



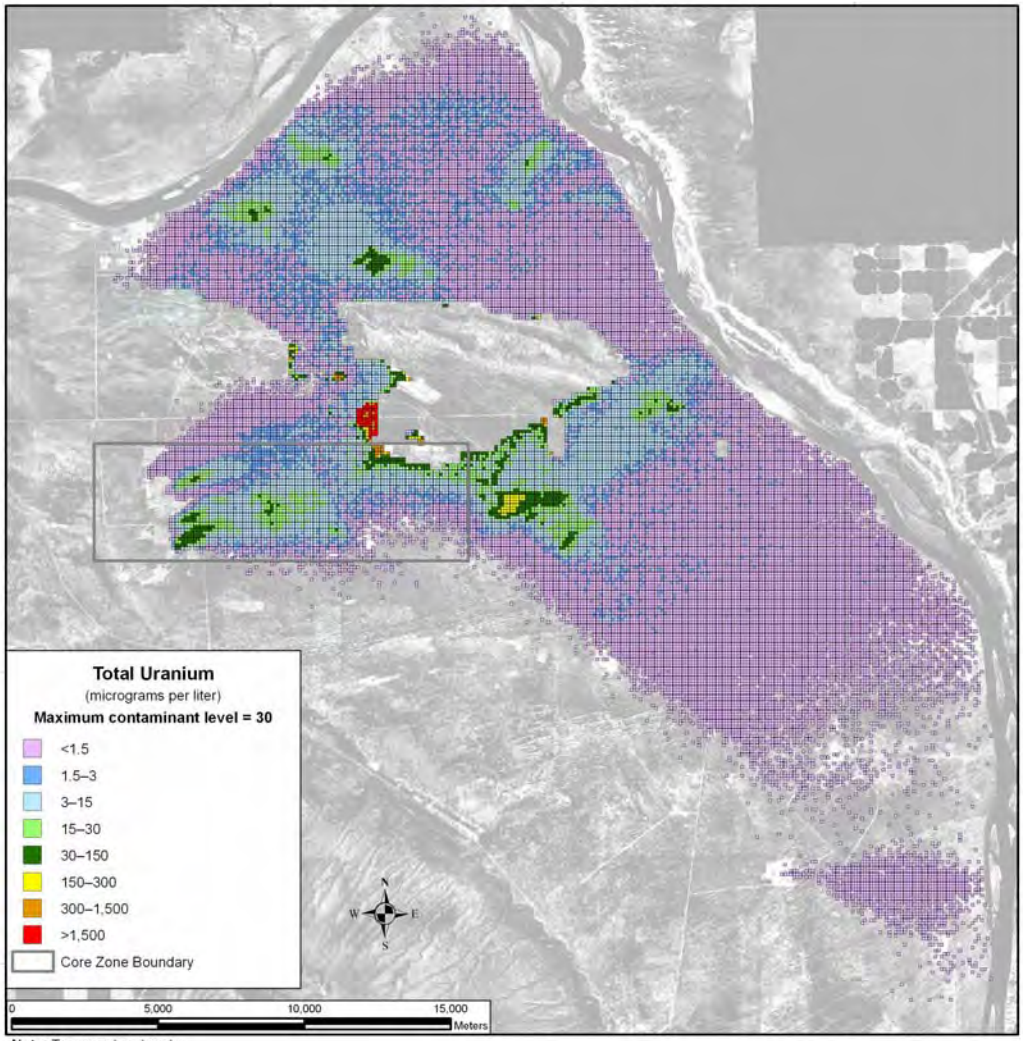
Note: To convert meters to feet, multiply by 3.281

Figure 5–1217. Alternative Combination 1 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281

Figure 5–1218. Alternative Combination 1 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1219. Alternative Combination 1 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

The long-term impacts of Alternative Combination 1 are dominated by sources under Tank Closure Alternative 1. In particular, the inventory remaining in the tank farms is the predominant contributor. Discharges to cribs and trenches (ditches) and leaks during the past-practice period are a secondary contributor. Contributions from Waste Management Alternative 1 and FFTF Decommissioning Alternative 1 sources account for well below 1 percent of the total amount released to the environment.

For the conservative tracers, concentrations at the Core Zone Boundary exceed benchmark standards by two to three orders of magnitude during most of the period of analysis. Concentrations at the Columbia River nearshore are about two orders of magnitude lower. The intensities and areas of these groundwater plumes peak between CY 3200 and CY 4000.

For tritium, concentrations at the Core Zone Boundary exceed the benchmark by about three orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River approach the benchmark during this time. Attenuation by radioactive decay is a predominant mechanism

that limits the intensity and duration of groundwater impacts by tritium. After CY 2100, tritium impacts are essentially negligible.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species exceed the benchmark at the Core Zone Boundary beyond CY 6000, and approach the benchmark at the Columbia River after CY 10,000. The intensity is highest and the area of the contamination plume largest near the end of the period of analysis.

5.4.1.2 Alternative Combination 2

This section describes the results of the long-term groundwater impacts analysis for Alternative Combination 2, which comprises Tank Closure Alternative 2B, FFTF Decommissioning Alternative 2, and Waste Management Alternative 2. The focus is the combined long-term groundwater impacts of these alternatives. More-detailed discussion of the individual impacts is provided in Sections 5.1.1, 5.2.1, and 5.3.1.

This discussion of long-term impacts is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers were obtained from the combination of the COPC drivers for the three individual alternatives that compose the alternative combination. They fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short lived. The half-life of tritium is 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. The other COPCs that were analyzed do not significantly contribute to risk or hazard during the period of analysis because of limited inventory, limited rates of release (i.e., retention in waste form), high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Alternative Combination 2 in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals in kilograms. Both are totaled over the 10,000-year period of analysis.

Table 5–157 lists the release to the vadose zone for the COPC drivers. For Alternative Combination 2, the release to the vadose zone is controlled by a combination of inventory and waste form. For tank closure and FFTF decommissioning sources, the entire inventory is released to the vadose zone during the period of analysis. For some waste management sources (e.g., ILAW glass), some of the inventory is not released to the vadose zone during the 10,000-year period of analysis because of retention in the waste form. The release to the vadose zone for Alternative Combination 2 is dominated by sources associated with Tank Closure Alternative 2B for tritium, uranium-238, chromium, nitrate, and total uranium. For these COPC drivers, releases from FFTF decommissioning and waste management sources account for less than 25 percent of the total. For iodine-129 and technetium-99, release to the vadose zone is dominated by waste management sources, in particular by offsite waste disposed of in IDF-East. Offsite waste accounts for over 93 percent of the total release to the vadose zone for iodine-129 and over 83 percent of the total release to the vadose zone for technetium-99.

Table 5–157. Alternative Combination 2 Release to Vadose Zone for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 2B Base	4.60×10^{4}	1.51	8.67×10^{2}	4.54×10^{1}	1.00×10^{5}	2.70×10^{7}	4.13×10^{4}
FFTF Decommissioning Alternative 2	1.73×10^{-5}	0.00	2.72×10^{1}	0.00	0.00	0.00	0.00
Waste Management Alternative 2 Disposal Group 1, Subgroup 1-A	6.27×10^{4}	1.80×10^{1}	2.39×10^{3}	3.17×10^{2}	2.97×10^{3}	9.05×10^{6}	2.65×10^{3}
Total	1.09×10^{5}	1.95×10^{1}	3.28×10^{3}	3.63×10^{2}	1.03×10^{5}	3.61×10^{7}	4.40×10^{4}

Key: COPC=constituent of potential concern.

Table 5–158 lists the release to groundwater for the COPC drivers. In addition to the inventory and waste form considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Note that delayed release to the vadose zone (i.e., retention in the waste form) can enhance retention in the vadose zone because contaminant mass released into the vadose zone near the end of the 10,000-year period of analysis may not reach the water table. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater ranges from 100 percent down to 80 percent of the amount released to the vadose zone. For tritium, the amount released to groundwater is attenuated by radioactive decay during transit through the vadose zone. About 70 percent of the tritium released to the vadose zone reaches the unconfined aquifer. For uranium-238 and total uranium, the amount released to groundwater is lower than that of the release to the vadose zone because of retardation. Less than 7 percent of the uranium-238 and total uranium released to the vadose zone reaches the unconfined aquifer during the period of analysis.

Table 5–158. Alternative Combination 2 Release to Groundwater Zone for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 2B Base	3.23×10^{4}	1.51	8.61×10^{2}	2.91	1.04×10^{5}	2.80×10^{7}	2.96×10^{3}
FFTF Decommissioning Alternative 2	2.58×10^{-8}	0.00	2.62×10^{1}	0.00	0.00	0.00	0.00
Waste Management Alternative 2 Disposal Group 1 Subgroup 1-A	0.00	1.64×10^{1}	2.10×10^{3}	3.02×10^{-10}	2.89×10^{3}	9.03×10^{6}	5.14×10^{-5}
Total	3.23×10^{4}	1.79×10^{1}	2.99×10^{3}	2.91	1.06×10^{5}	3.70×10^{7}	2.96×10^{3}

Key: COPC=constituent of potential concern.

Table 5–159 lists the release to the Columbia River for the radiological risk drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 3 percent of the tritium released to groundwater reaches the Columbia River. For uranium-238 and total uranium, the amount released to the Columbia River is less than that released to groundwater because of retardation in the aquifer. Overall, about 30 percent of the amount released to groundwater during the period of analysis reaches the Columbia River.

Table 5–159. Alternative Combination 2 Release to Columbia River for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 2B Base	8.70×10^{2}	1.45	8.37×10^{2}	8.46×10^{-1}	1.03×10^{5}	2.78×10^{7}	8.54×10^{2}
FFTF Decommissioning Alternative 2	0.00	0.00	2.72×10^{1}	0.00	0.00	0.00	0.00
Waste Management Alternative 2 Disposal Group 1 Subgroup 1-A	0.00	1.59×10^{1}	2.04×10^{3}	0.00	2.80×10^{3}	8.89×10^{6}	3.77×10^{-6}
Total	8.70×10^{2}	1.74×10^{1}	2.90×10^{3}	8.46×10^{-1}	1.06×10^{5}	3.67×10^{7}	8.54×10^{2}

Key: COPC=constituent of potential concern.

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Alternative Combination 2 in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to aid to interpreting data with a significant amount random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration trend was level, and the concentrations were near the benchmark. The benchmark concentration for each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–160 lists the maximum concentrations for the COPCs at the peak year at the Core Zone Boundary and the Columbia River nearshore.

Table 5–160. Alternative Combination 2 Maximum COPC Concentrations in the Peak Year at the Core Zone Boundary and Columbia River Nearshore

Contaminant	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter			
Hydrogen-3 (Tritium)	**2,820,000**	1,280	20,000
	(1956)	(1994)	
Technetium-99	**144,000**	699	900
	(1956)	(9454)	
Iodine-129	**187**	**7**	1
	(1956)	(8700)	
Uranium isotopes (includes uranium-233, -234, -235, -238)	**73**	1	15
	(11,691)	(11,871)	
Chemical in micrograms per liter			
Acetonitrile	1	0	100
	(3829)	(4021)	
Chromium	**28,000**	34	100
	(1956)	(2695)	
Fluoride	1	0	4,000
	(7258)	(8913)	
Nitrate	**12,900,000**	8,580	45,000
	(1956)	(2450)	
Total uranium	**103**	1	30
	(11,683)	(11,146)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern.

Figure 5–1220 shows concentration versus time for tritium. Note that for visual clarity, the time period shown on this figure is from CY 1940 through CY 2540 rather than for the full 10,000-year period of analysis. Concentrations at the Core Zone Boundary exceed the benchmark concentration by about two orders of magnitude for a short period of time during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River peak at about an order of magnitude lower than the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor at times later than CY 2100.

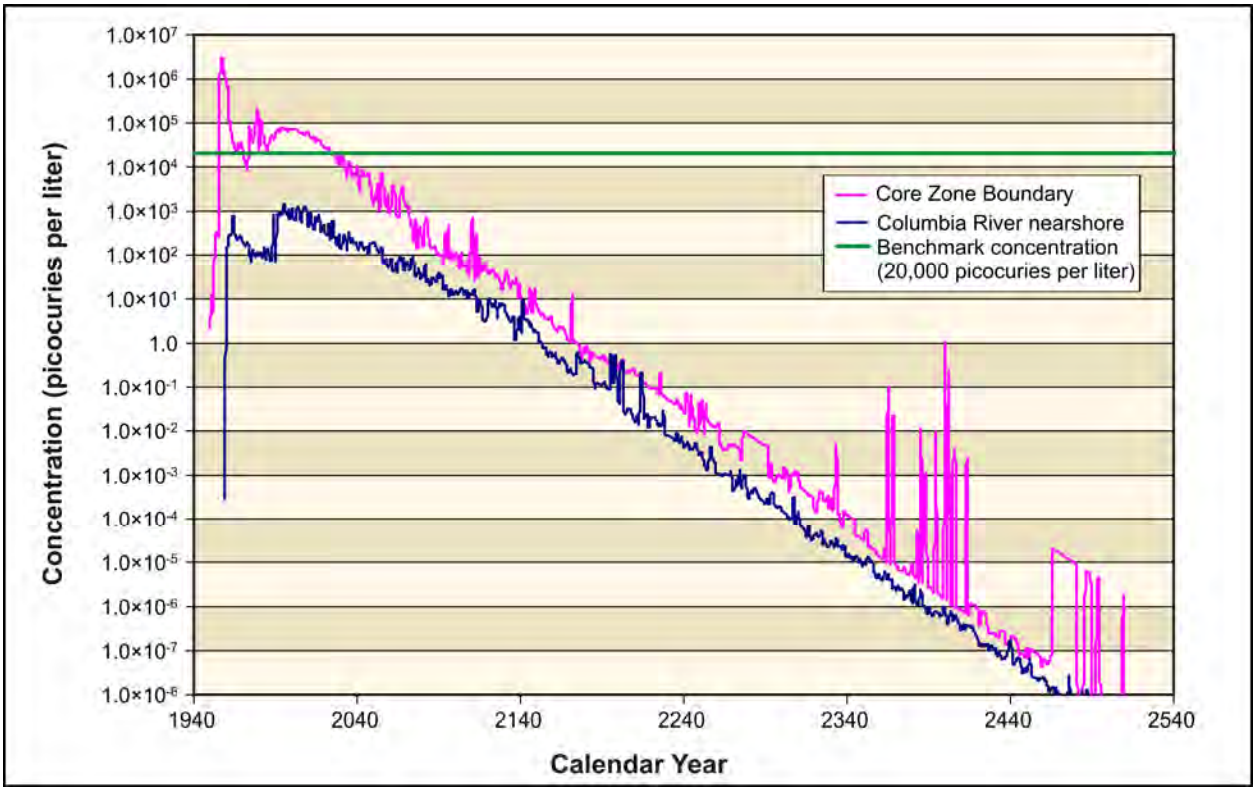


Figure 5–1220. Alternative Combination 2 Hydrogen-3 (Tritium) Concentration Versus Time

Figures 5–1221 and 5–1222 show concentration versus time for chromium and nitrate, the conservative tracers that are not affected by retention in the waste forms. Groundwater concentrations of chromium exceed benchmark concentrations by an order of magnitude during the first several thousand years of the analysis. During this time, groundwater concentrations at the Columbia River nearshore are below, but within an order of magnitude of, the benchmark concentration. During later times in the analysis, the concentrations at the Core Zone Boundary and the Columbia River nearshore are below the benchmark by about one and two orders of magnitude, respectively. Nitrate shows a similar concentration pattern with respect to time. For iodine-129 and technetium-99, the behavior during the first 4,000 years is similar to that of chromium and nitrate (see Figures 5–1223 and 5–1224). After CY 6000, the effects of delayed release from waste management sources are seen. For iodine-129, the post–CY 6000 concentrations at the Core Zone Boundary and the Columbia River nearshore are above, but within an order of magnitude of, the benchmark concentration. For technetium-99 the corresponding concentrations are below, but within an order of magnitude of, the benchmark concentration.

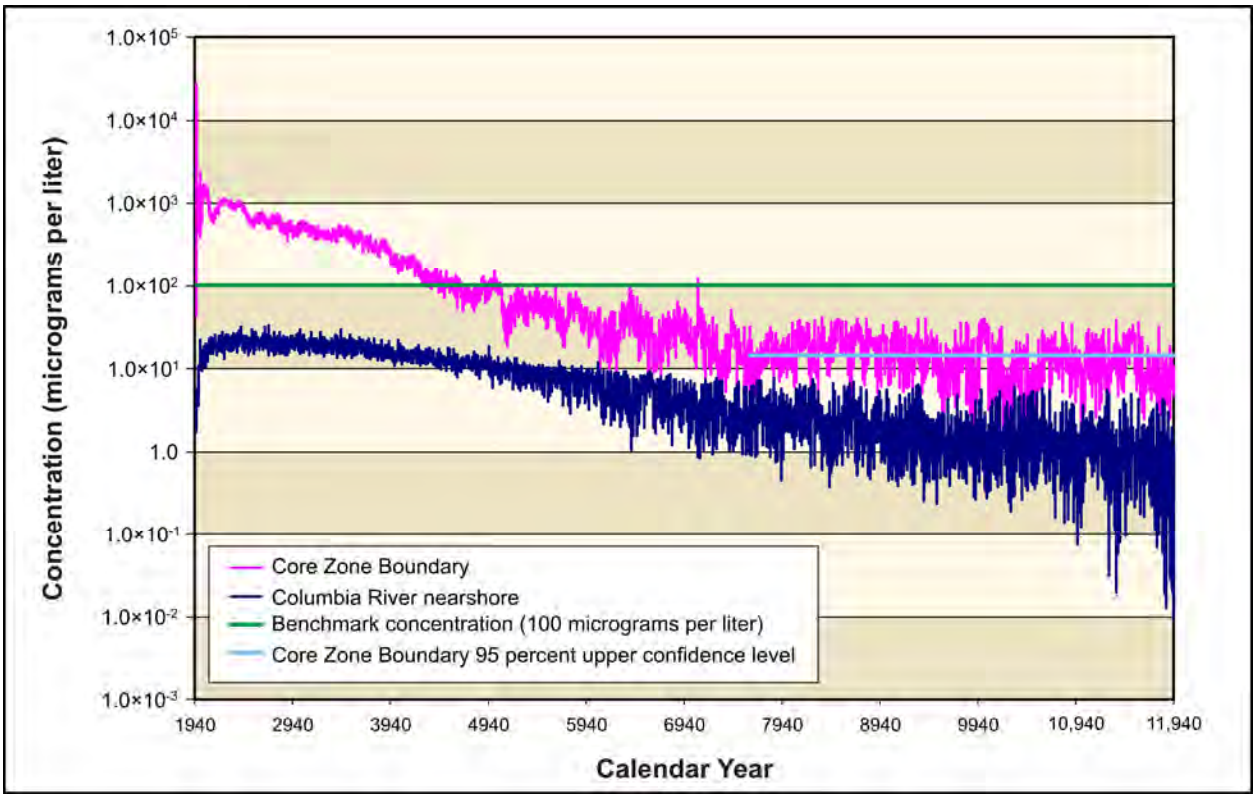


Figure 5–1221. Alternative Combination 2 Chromium Concentration Versus Time

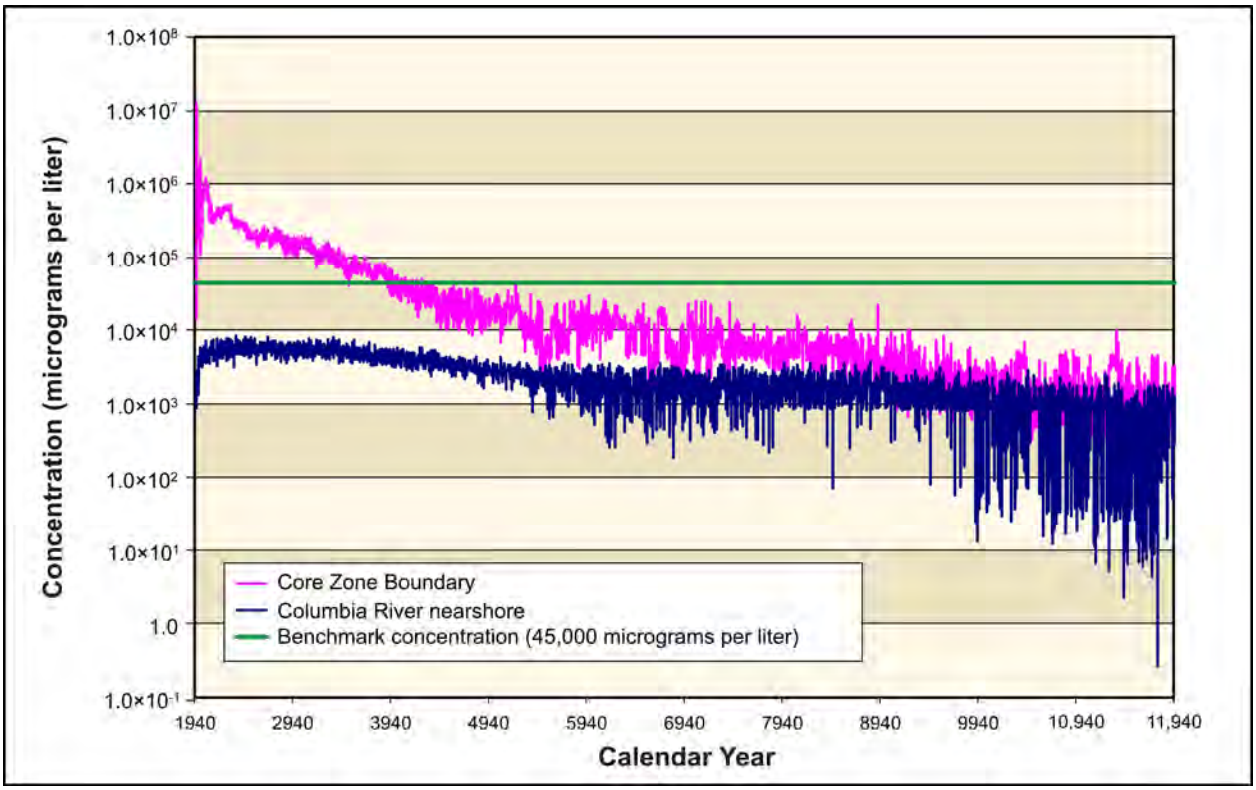


Figure 5–1222. Alternative Combination 2 Nitrate Concentration Versus Time

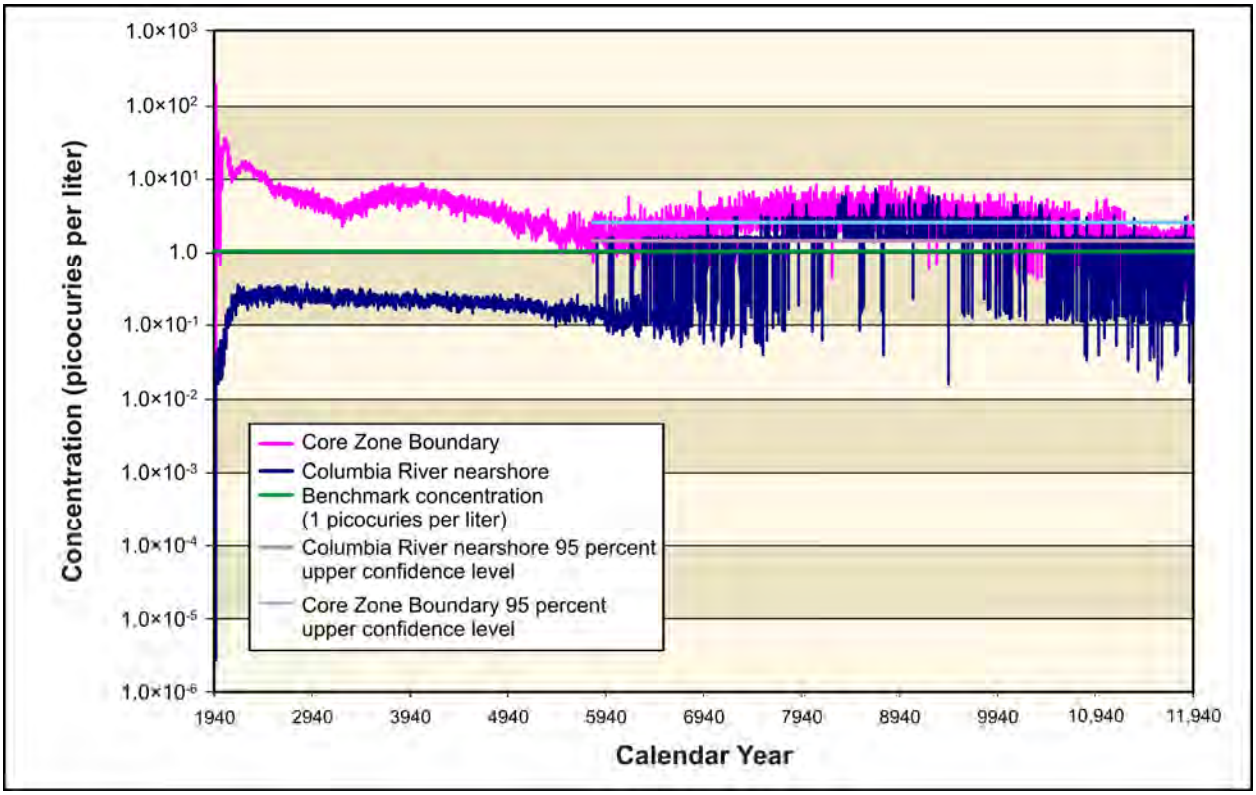


Figure 5–1223. Alternative Combination 2 Iodine-129 Concentration Versus Time

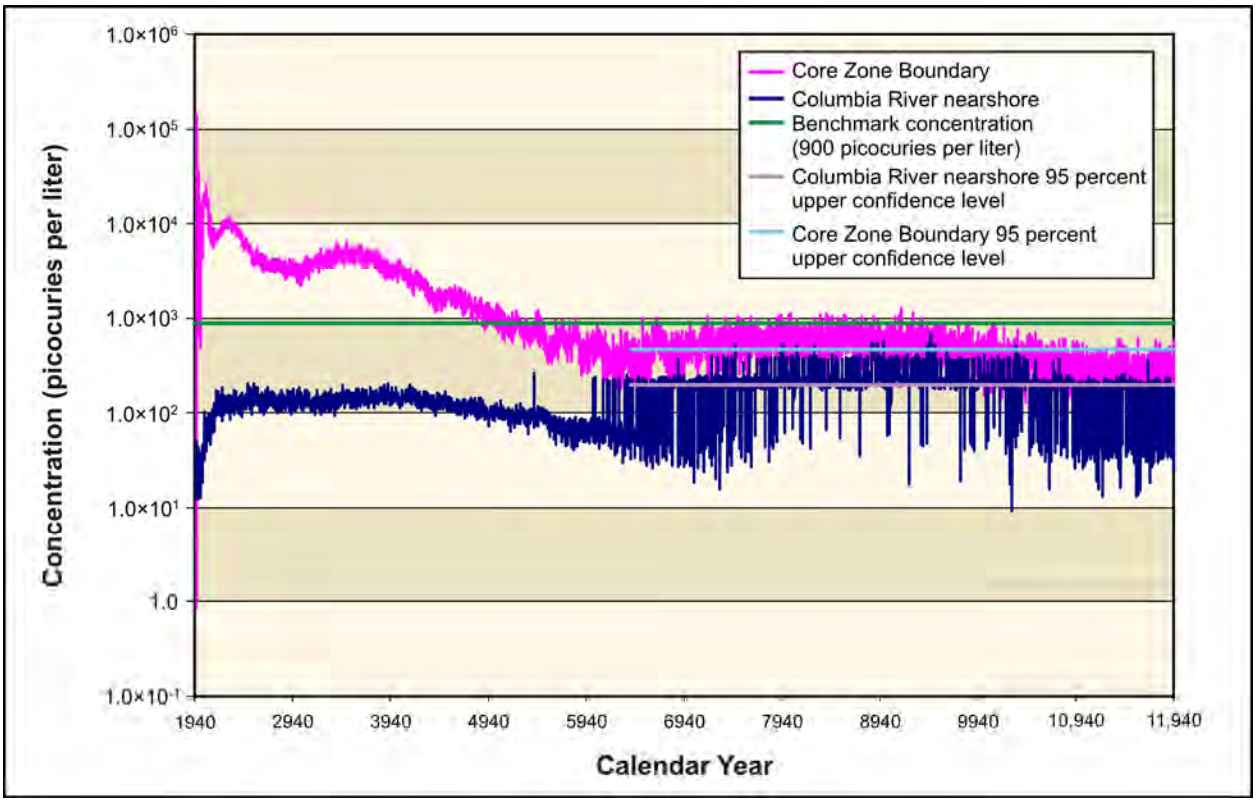


Figure 5–1224. Alternative Combination 2 Technetium-99 Concentration Versus Time

Figures 5–1225 and 5–1226 show concentration versus time for uranium-238 and total uranium. These concentrations rise throughout the period of analysis. The travel times of these COPCs from the source locations to the Core Zone Boundary and the Columbia River are retarded relative to the conservative tracers by a factor of about seven. After about 8,000 years, concentrations of both uranium-238 and total uranium are near the benchmark concentration at the Core Zone Boundary, and continue to rise until the end of the period of analysis, when they exceed the benchmark concentration by a factor of about three to five. Groundwater concentrations at the Columbia River nearshore rise throughout the period of analysis, but remain more than an order of magnitude below the benchmark concentration by CY 11,940.

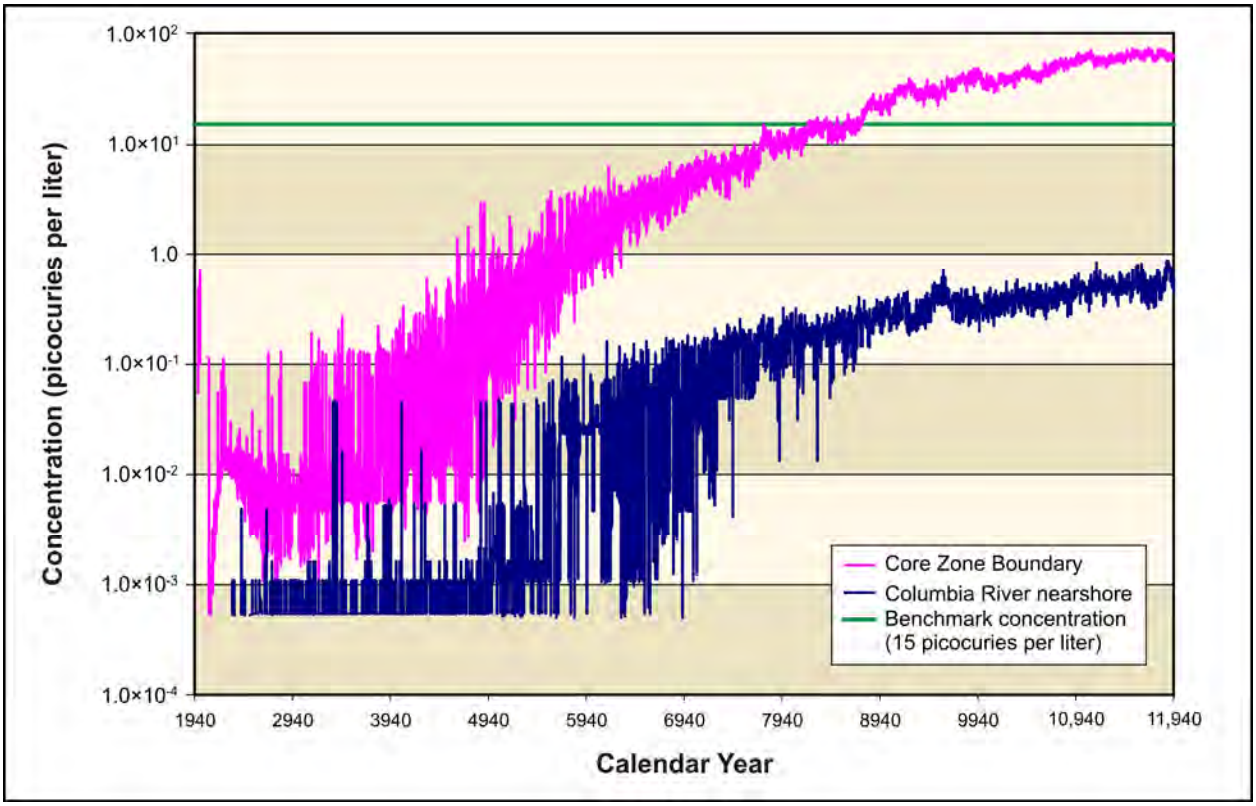


Figure 5–1225. Alternative Combination 2 Uranium-238 Concentration Versus Time

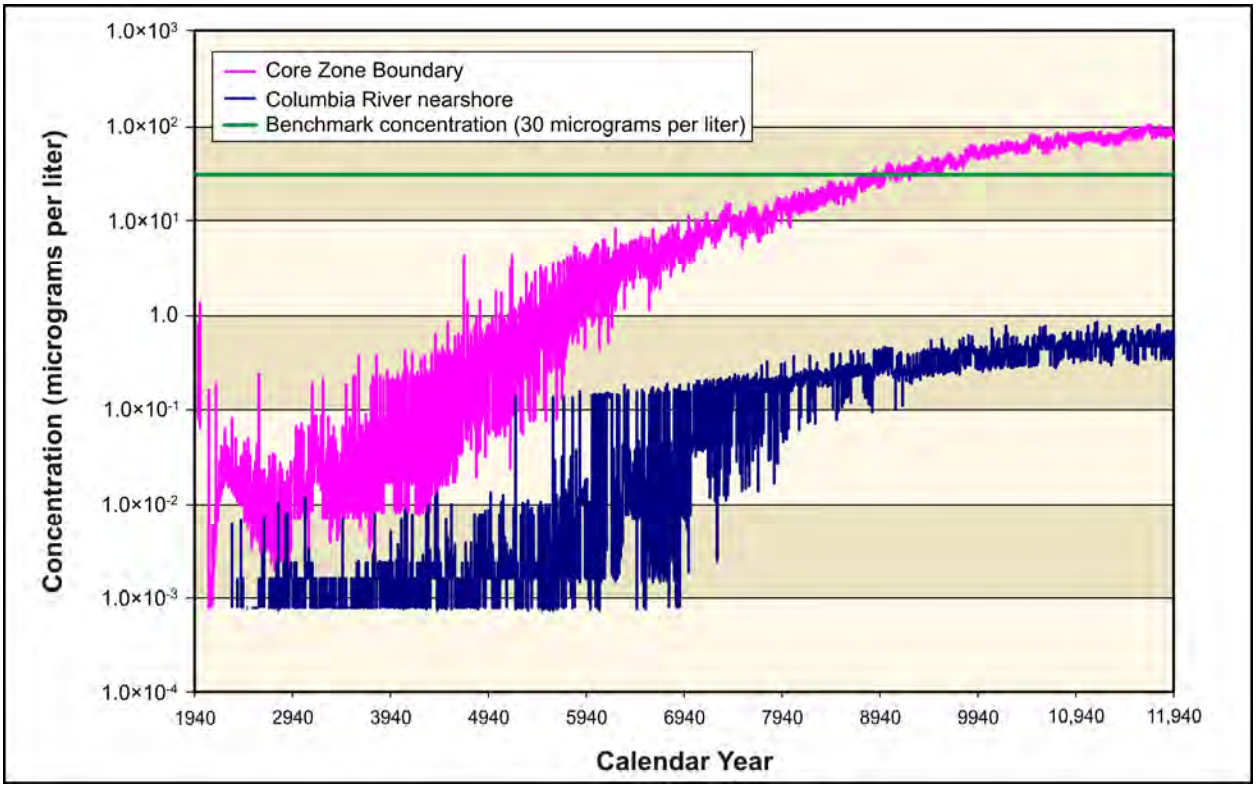


Figure 5–1226. Alternative Combination 2 Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Alternative Combination 2, in terms of the spatial distribution of groundwater concentrations at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations lower than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–1227 shows the spatial distribution of groundwater concentration for tritium during CY 2005. Releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crossing the Core Zone Boundary, and extending toward Gable Gap. Peak concentrations in this plume are about 10 to 20 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135.

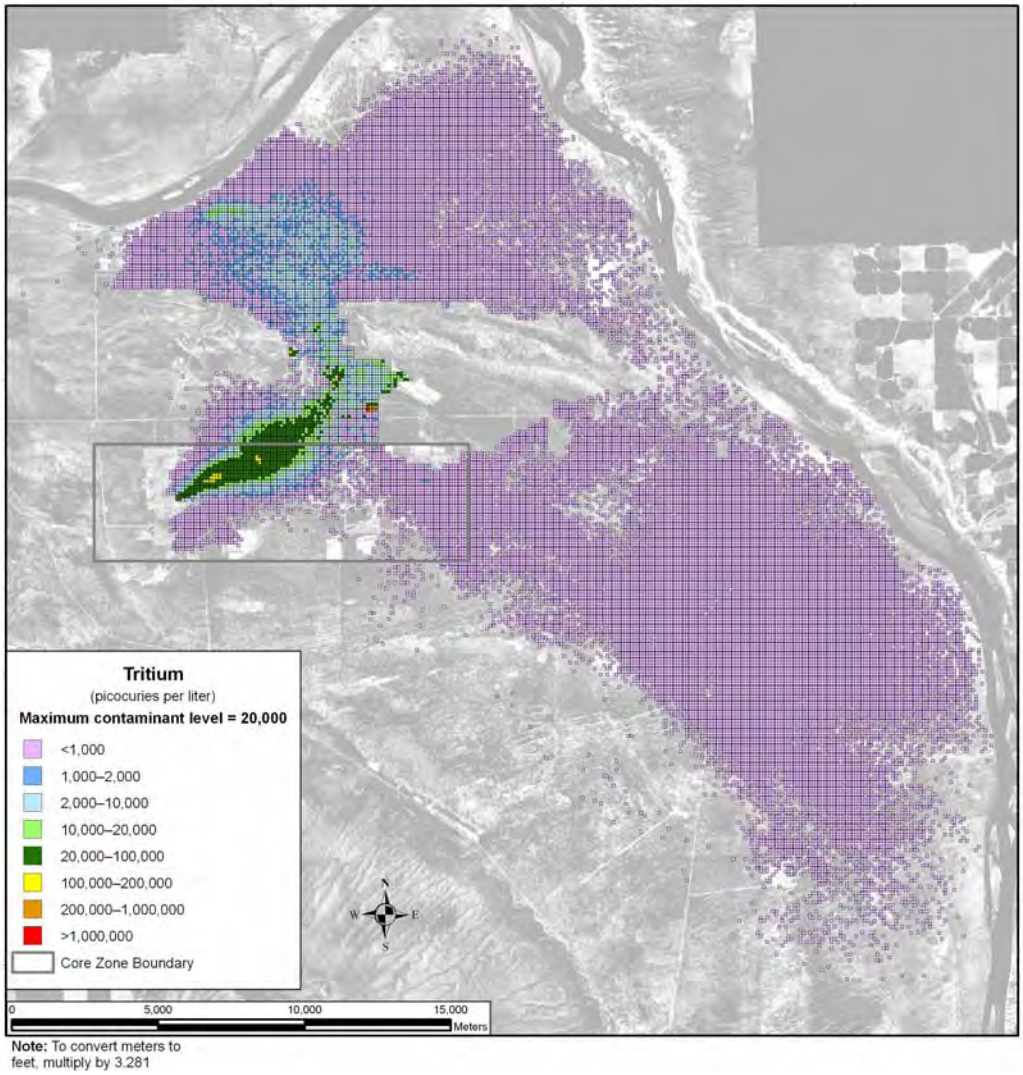
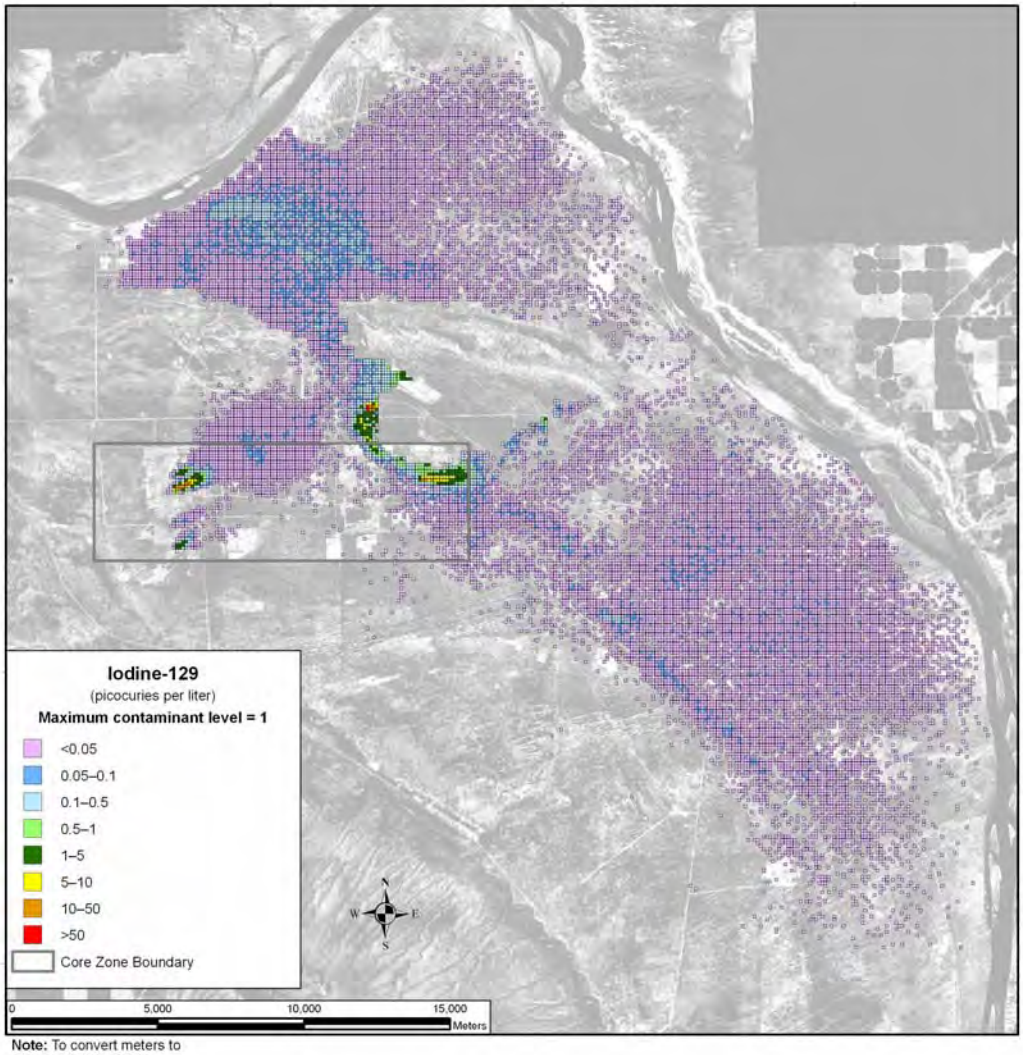


Figure 5–1227. Alternative Combination 2 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

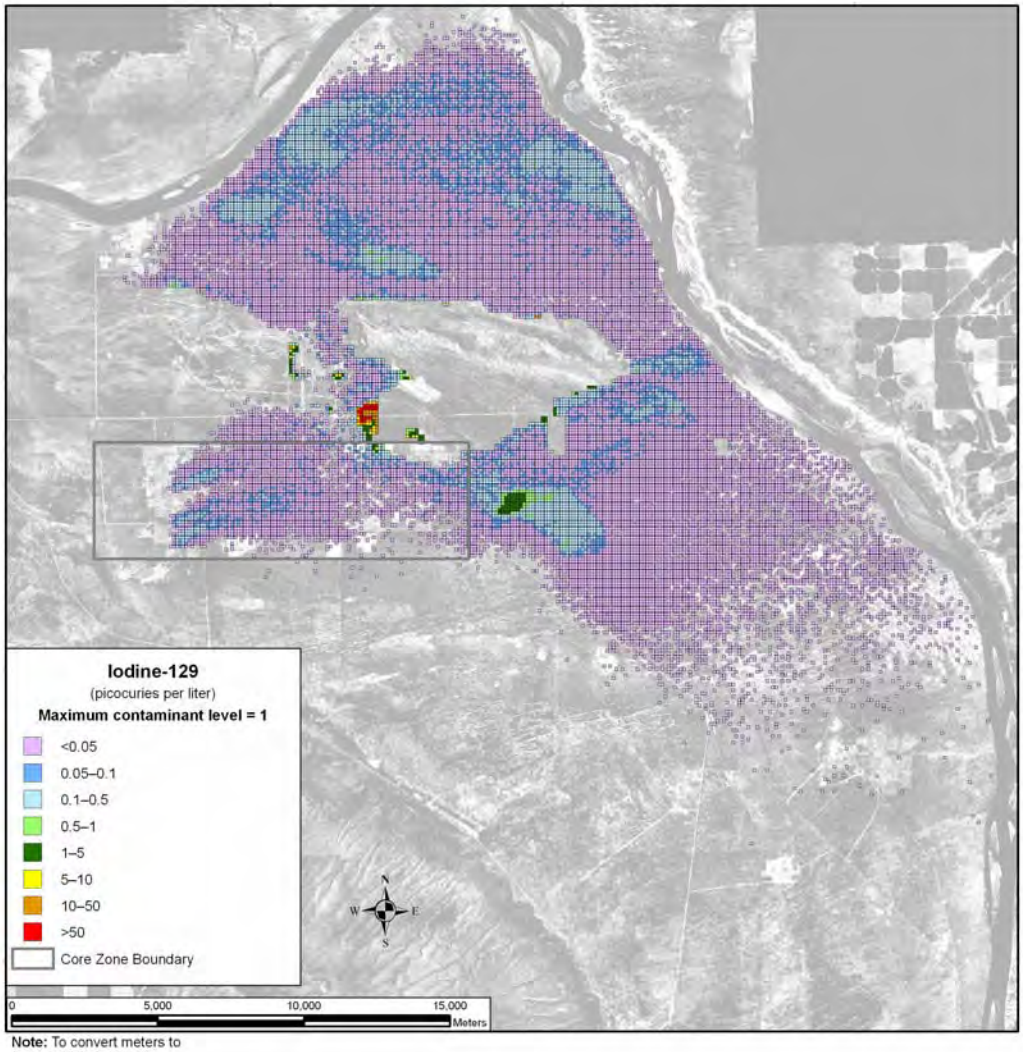
Figure 5–1228 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005. Releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceed the benchmark concentration associated with the T Barrier, B Barrier, and A Barrier. Peak concentrations in this plume are about 10 to 50 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Around CY 3890, releases from other tank farm sources create a rather small plume that exceeds, but is within an order of magnitude of, the benchmark concentration just east of the Core Zone Boundary (see Figure 5–1229). A comparison of this result against the corresponding distribution for Alternative Combination 1 (see Figure 5–1200) illustrates the reduction in impacts resulting from the retrieval of other tank farm sources and, secondarily, from landfill closure. By CY 7140, the groundwater concentration distribution is driven primarily by waste management sources at IDF-East (see Figure 5–1230). The impact is characterized by a plume east of the Core Zone Boundary that exceeds the benchmark concentration by more than an order of magnitude. Because of retention in the waste forms, this impact lasts until the end of the 10,000-year period of analysis (see Figure 5–1231). Figure 5–1232 shows the total area for which groundwater concentrations of iodine-129 exceed the benchmark concentration as a function of time. Again, a comparison of this result with the corresponding distribution for Alternative Combination 1 (see Figure 5–1202) illustrates the reduction of impacts resulting from retrieval of other tank farm sources (around CY 4000), but also

the increase in impacts associated with waste management sources, primarily offsite waste (around CY 9000). Figures 5–1233 through 5–1237 show the spatial distribution at the same four times and the total area of exceedance versus time for technetium-99. The spatial distribution of technetium-99 is similar to that of iodine-129. The other conservative tracers, chromium (see Figures 5–1238 through 5–1241) and nitrate (see Figures 5–1242 through 5–1244) show similar spatial distributions.



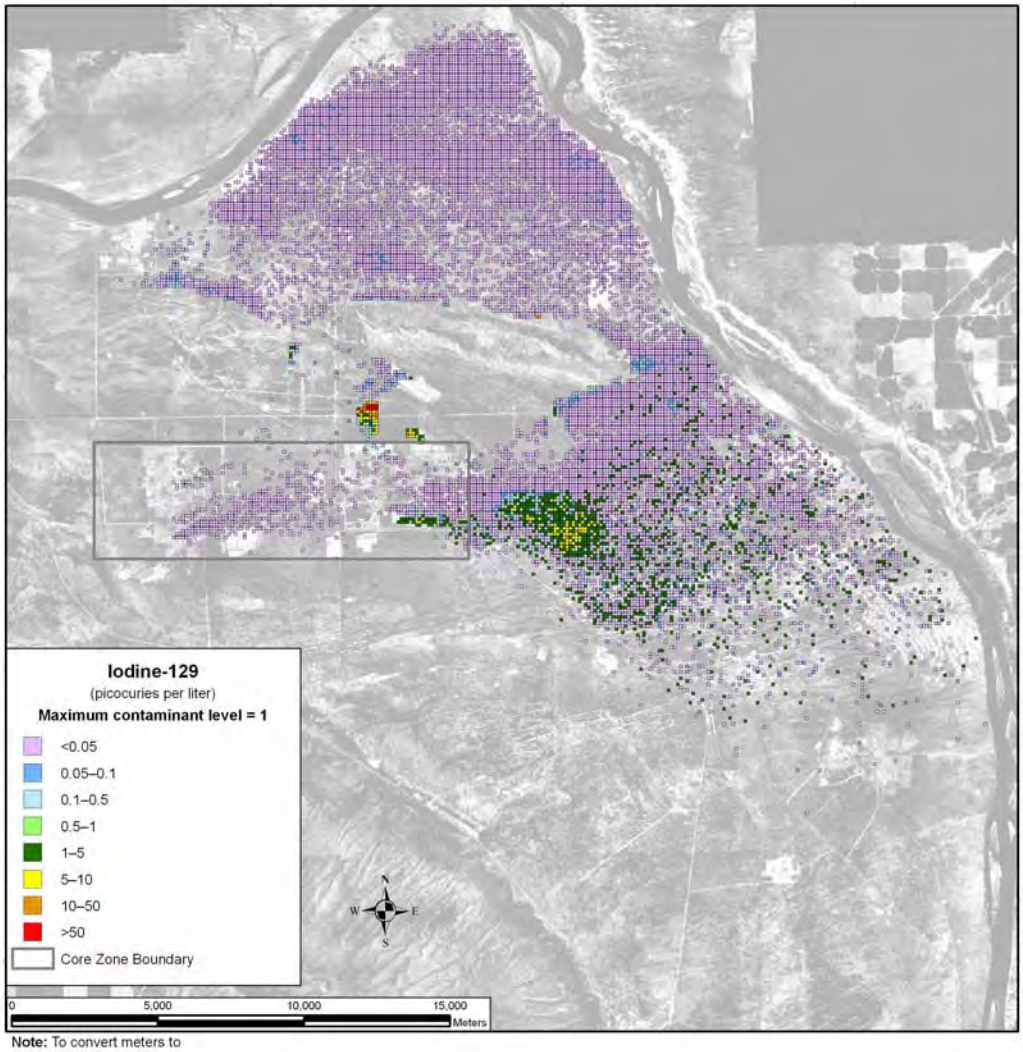
Note: To convert meters to feet, multiply by 3.281

Figure 5–1228. Alternative Combination 2 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005



Note: To convert meters to feet, multiply by 3.281

Figure 5–1229. Alternative Combination 2 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1230. Alternative Combination 2 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140

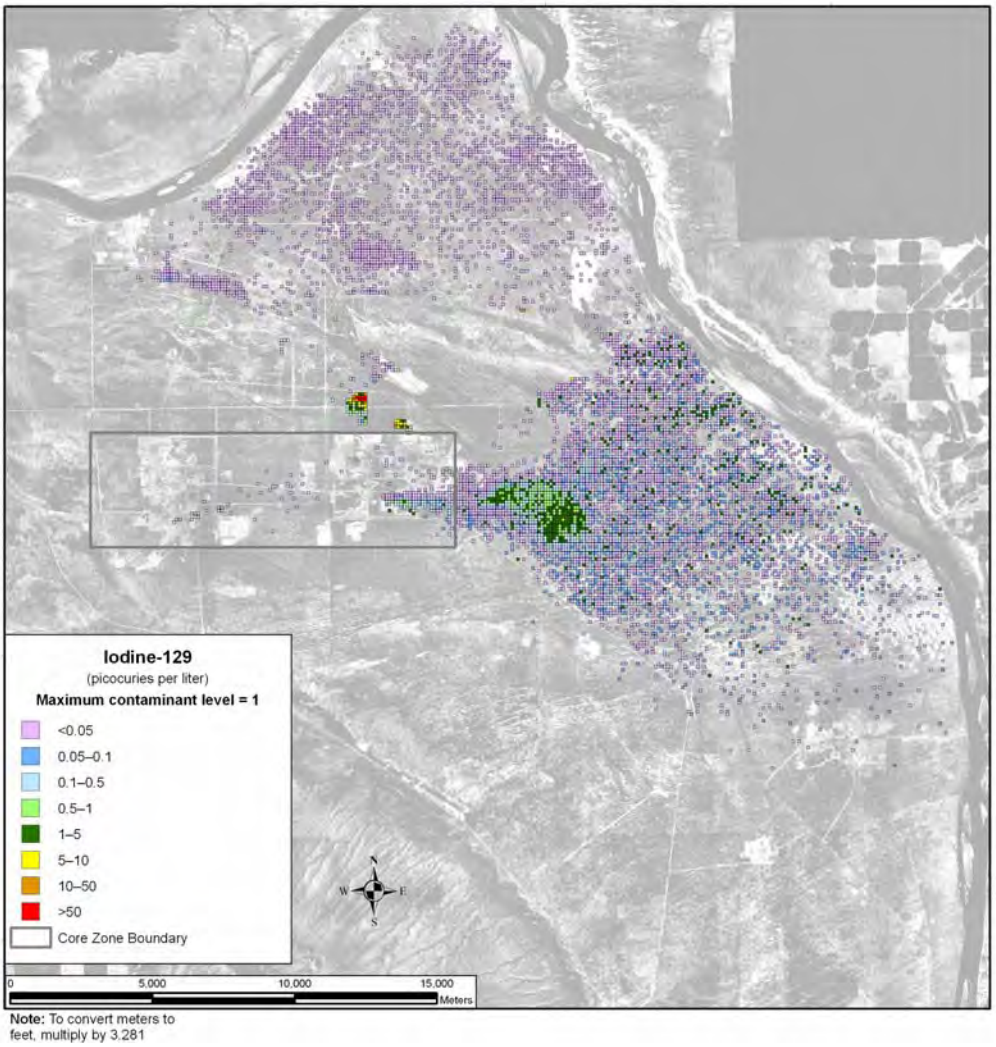


Figure 5–1231. Alternative Combination 2 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

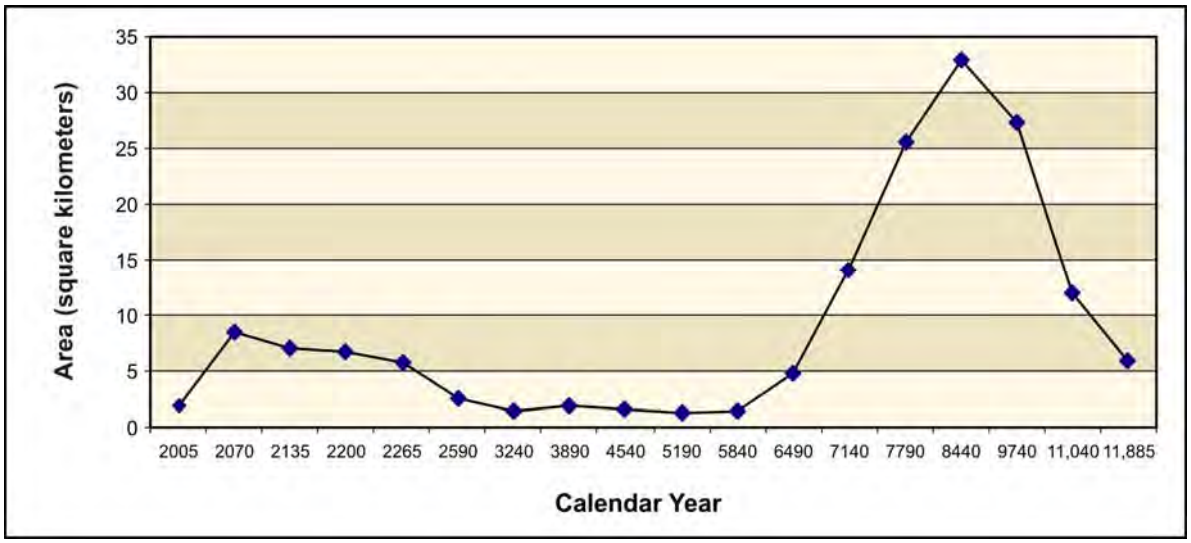
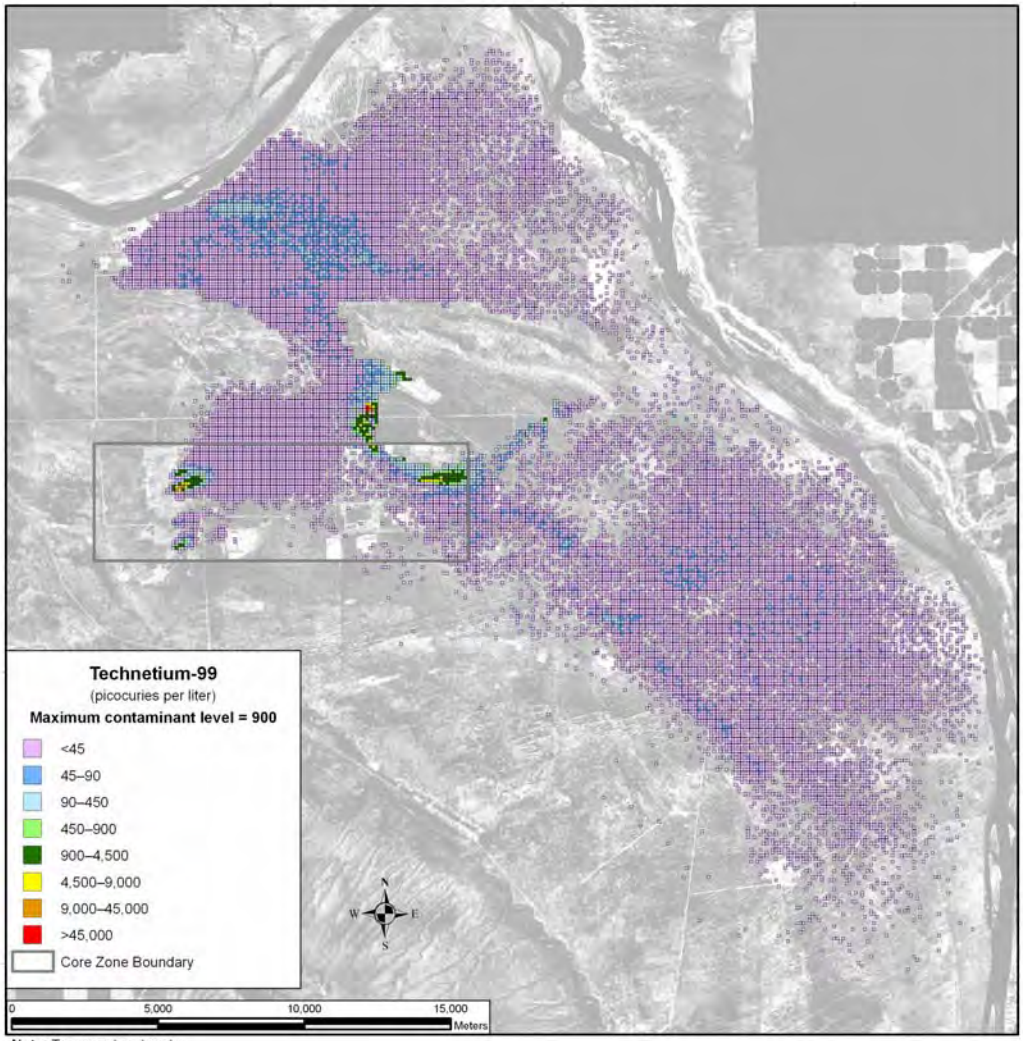
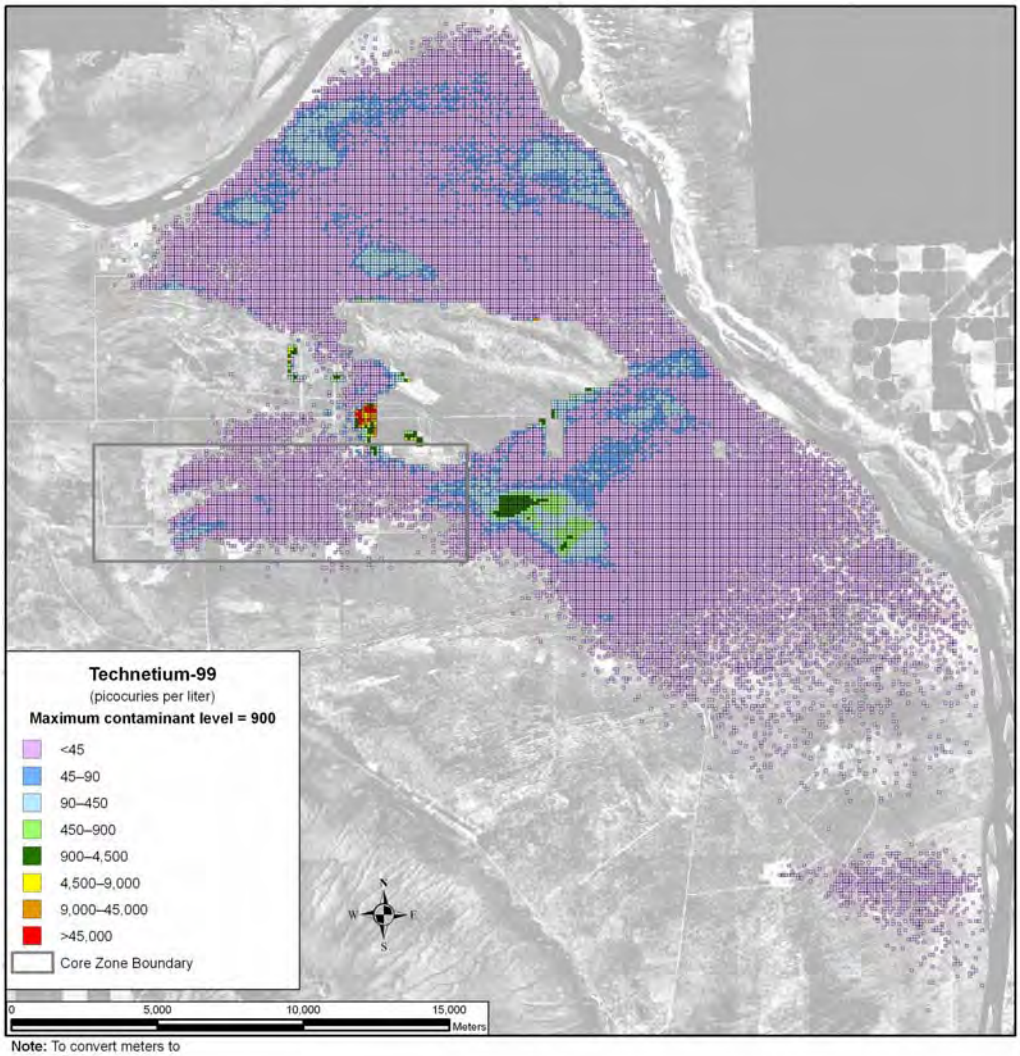


Figure 5–1232. Alternative Combination 2 Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time



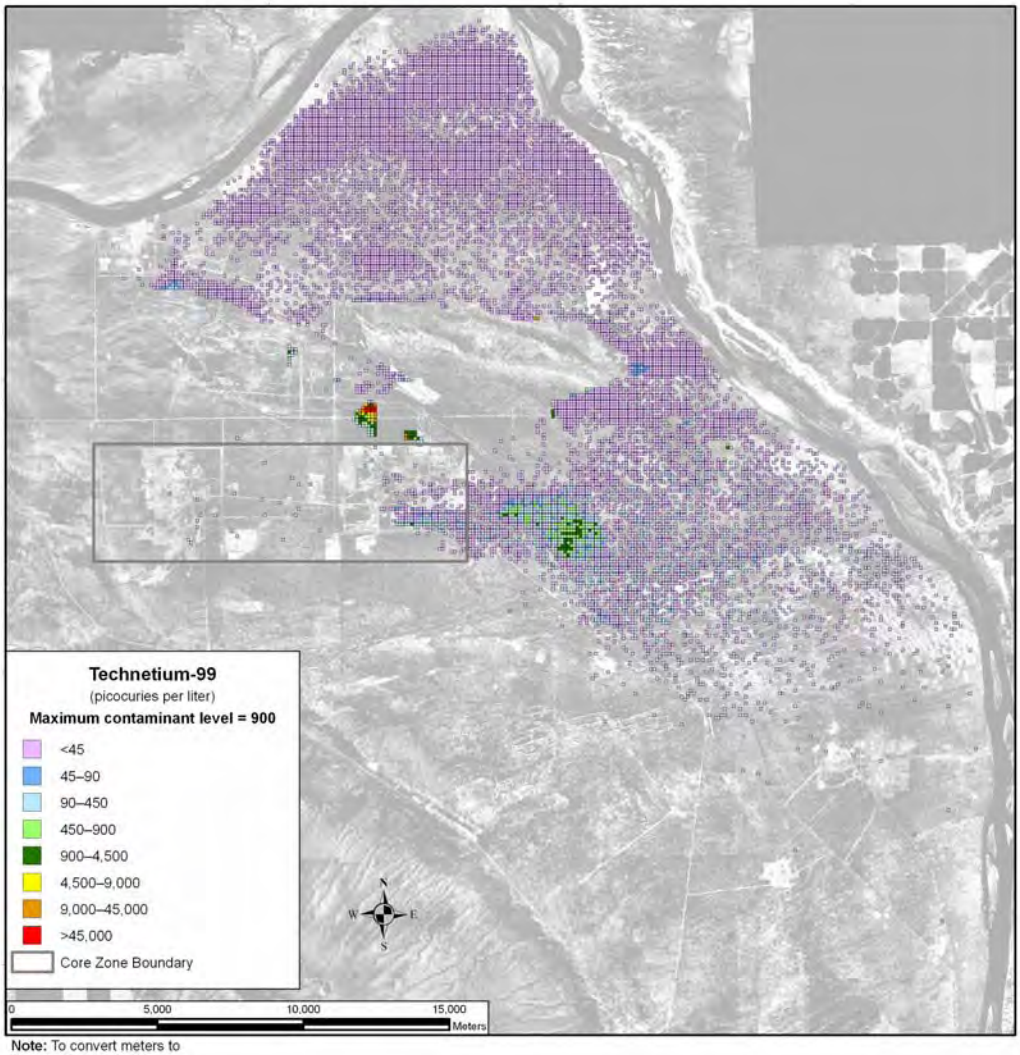
Note: To convert meters to feet, multiply by 3.281

Figure 5–1233. Alternative Combination 2 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005



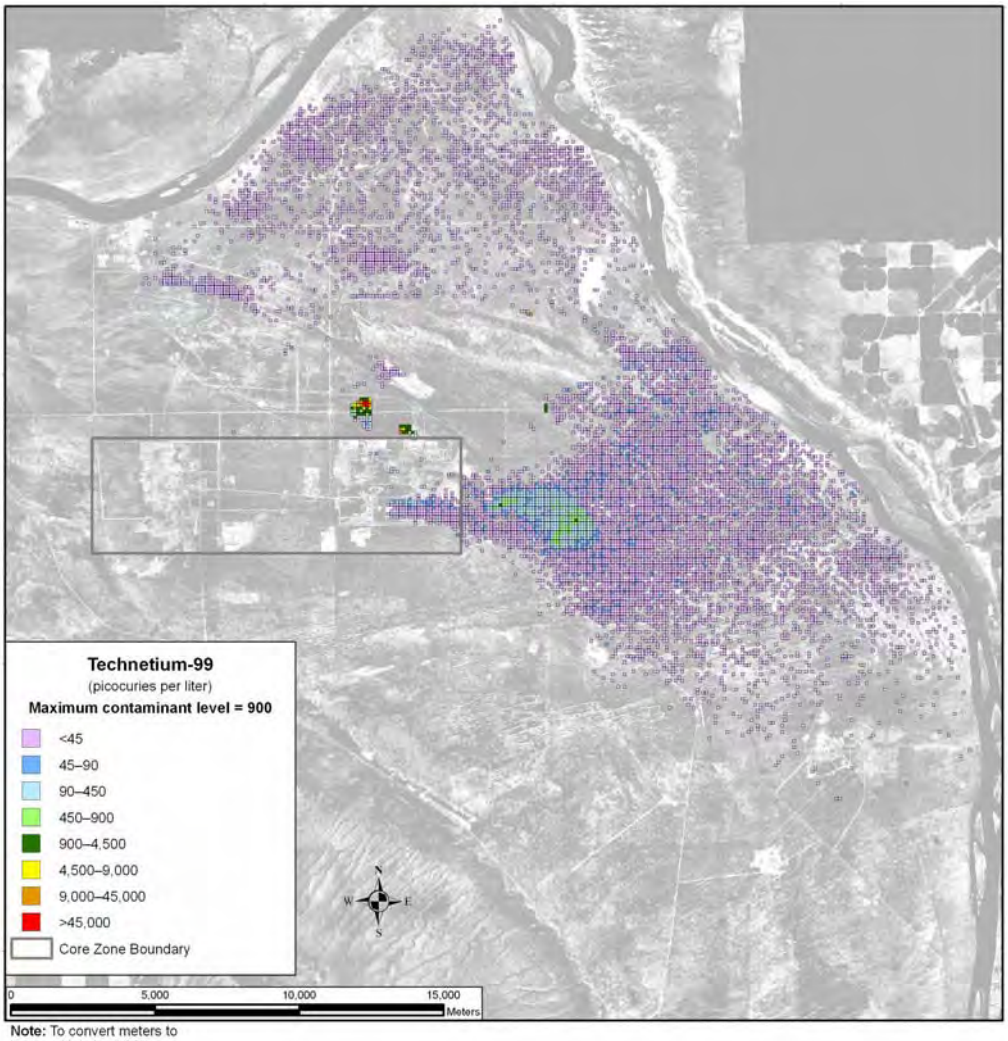
Note: To convert meters to feet, multiply by 3.281

Figure 5–1234. Alternative Combination 2 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1235. Alternative Combination 2 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–1236. Alternative Combination 2 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

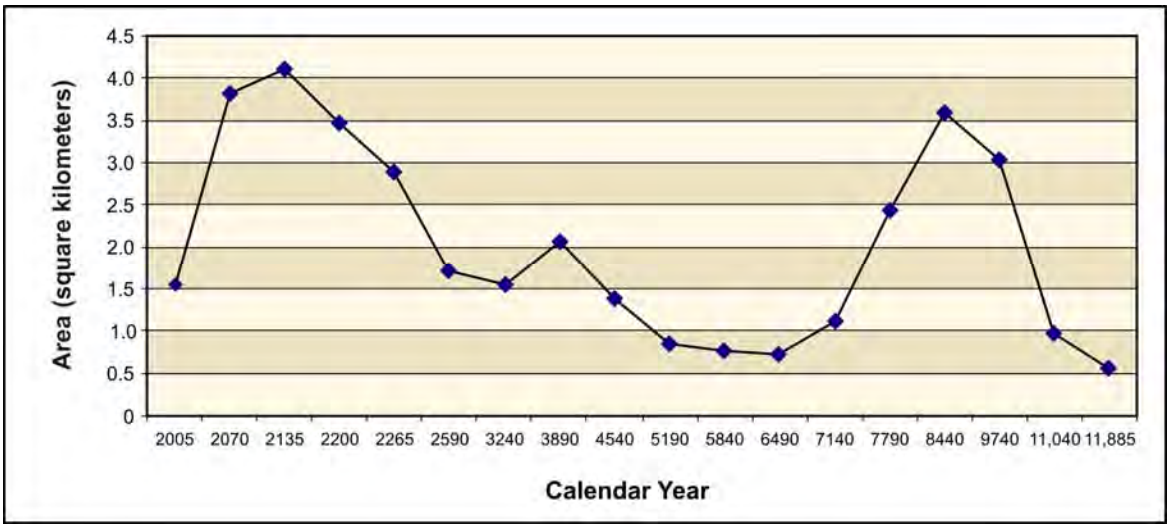
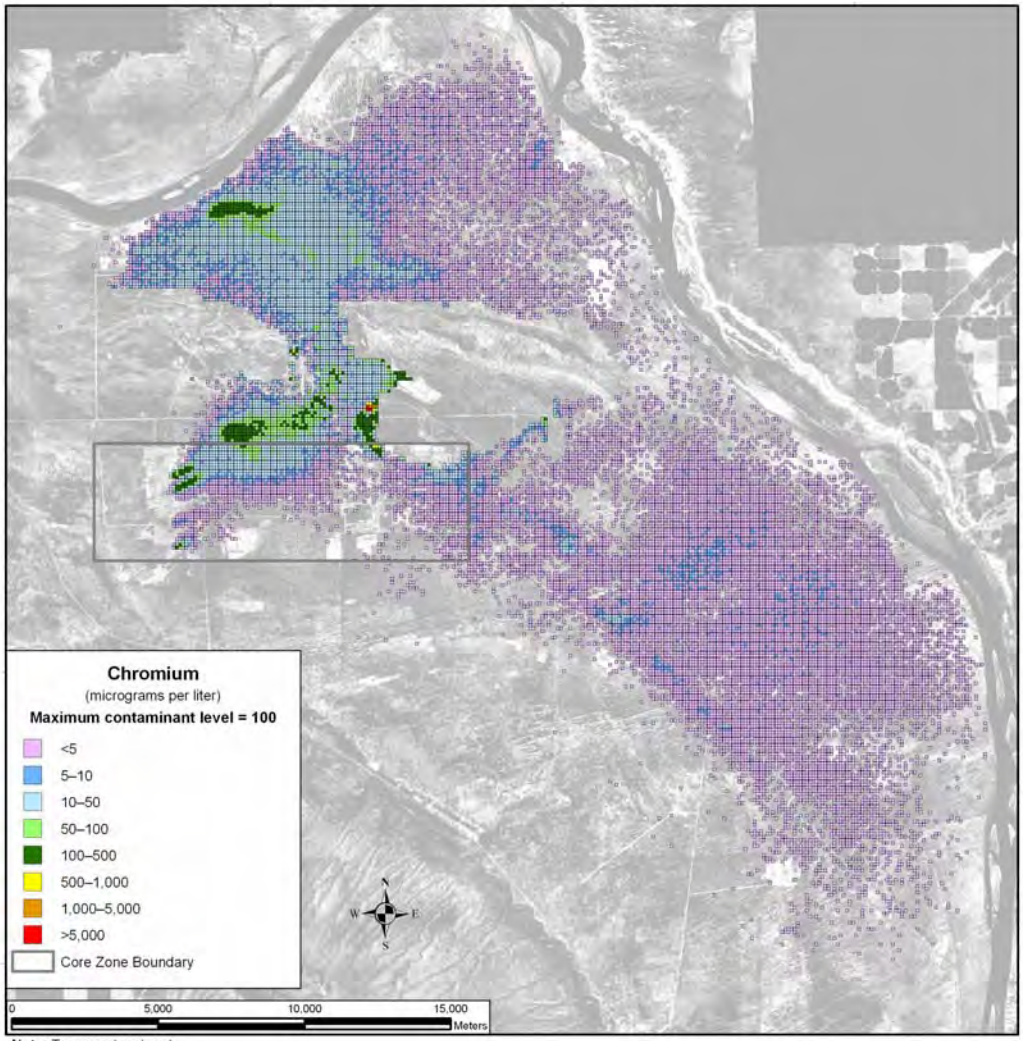
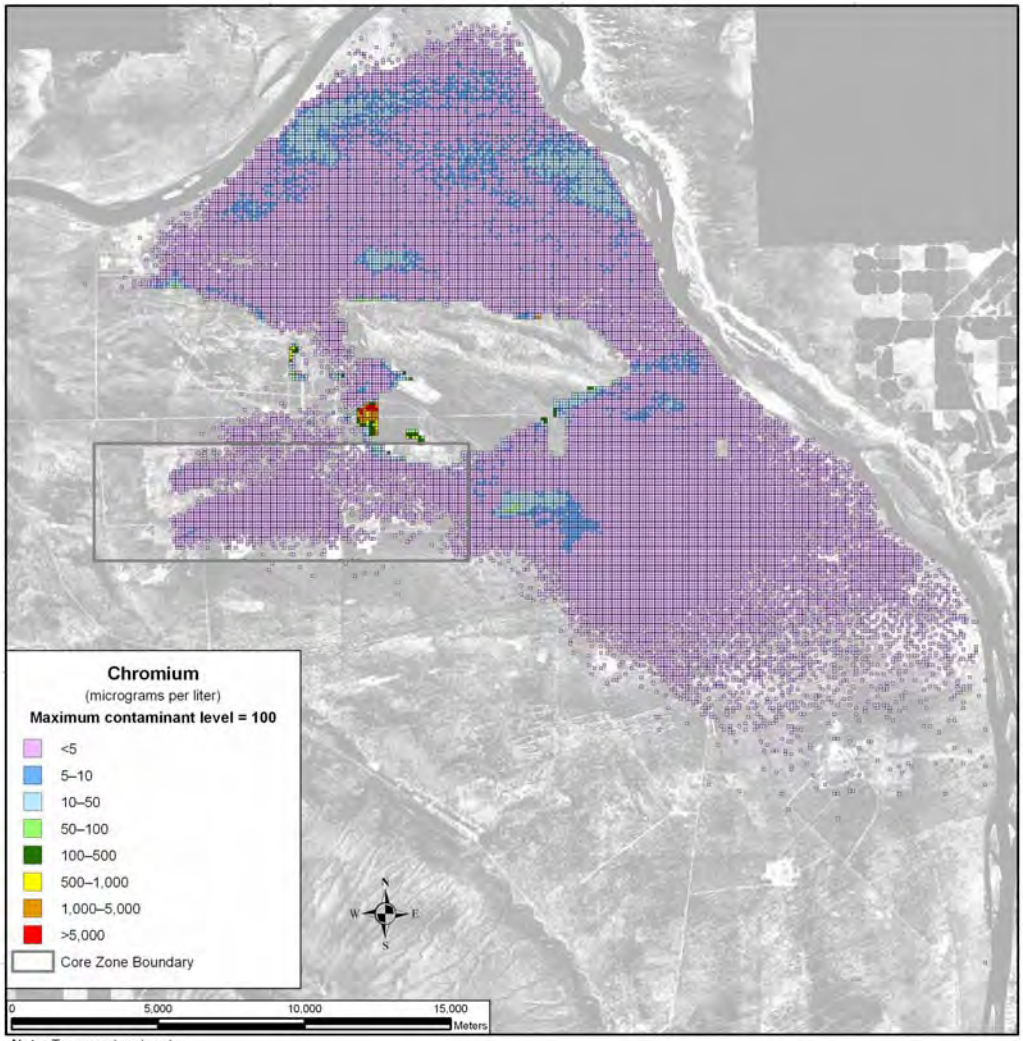


Figure 5–1237. Alternative Combination 2 Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time



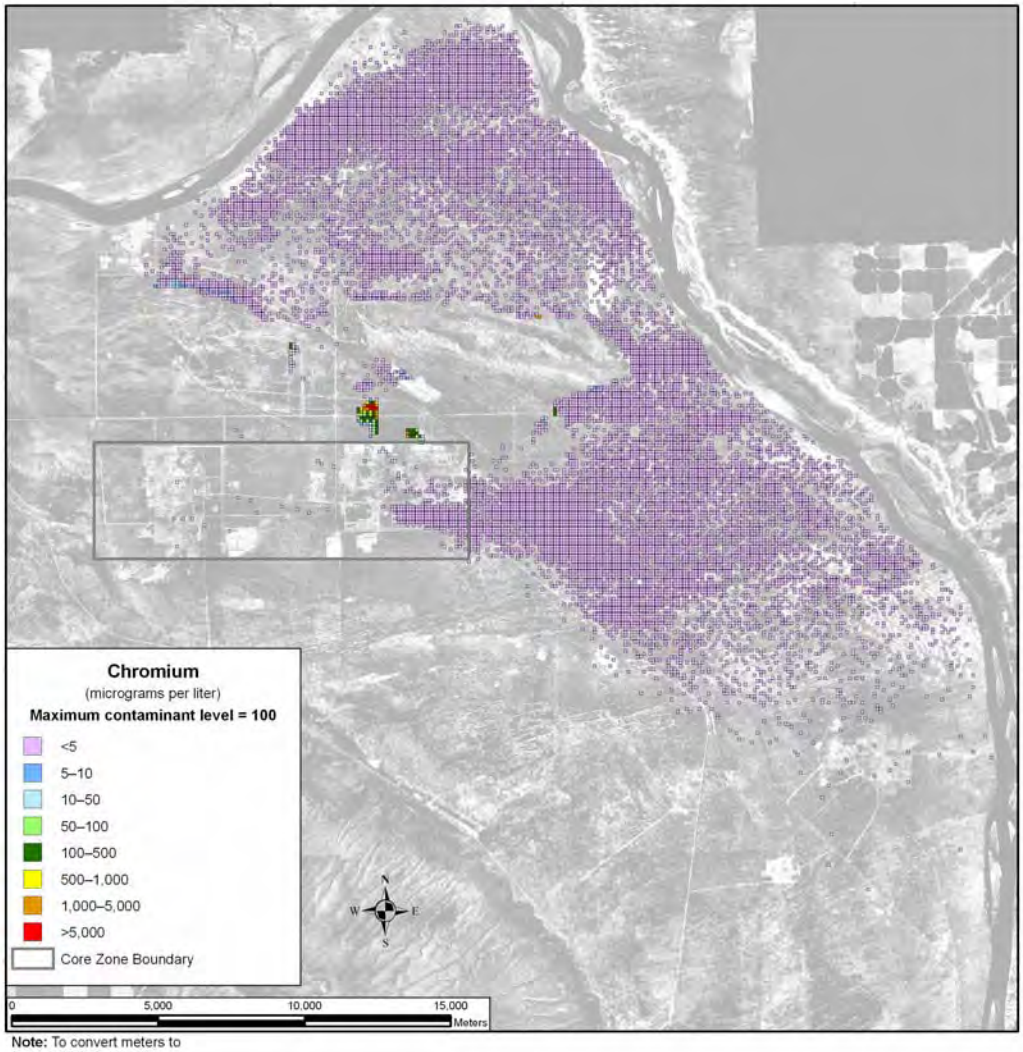
Note: To convert meters to feet, multiply by 3.281

Figure 5–1238. Alternative Combination 2 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005



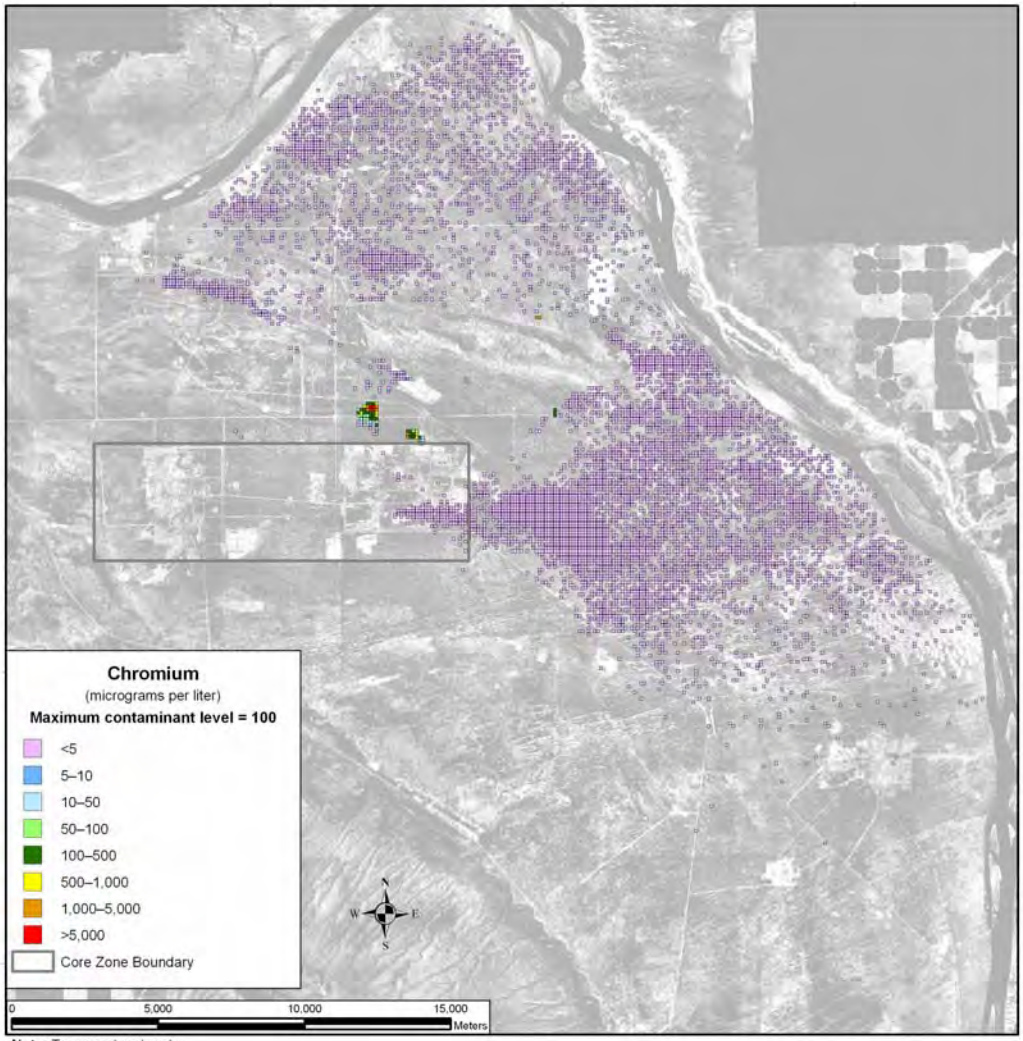
Note: To convert meters to feet, multiply by 3.281

Figure 5–1239. Alternative Combination 2 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



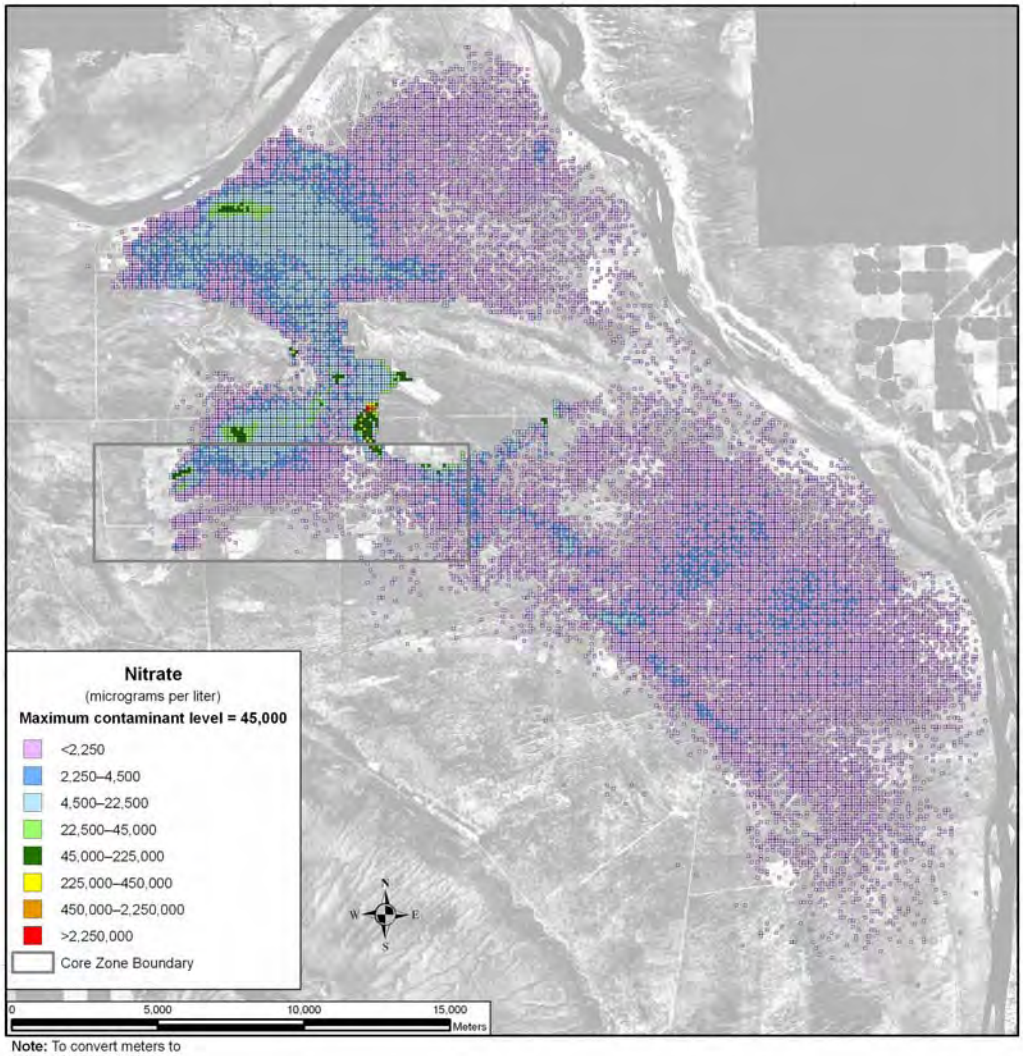
Note: To convert meters to feet, multiply by 3.281

Figure 5–1240. Alternative Combination 2 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



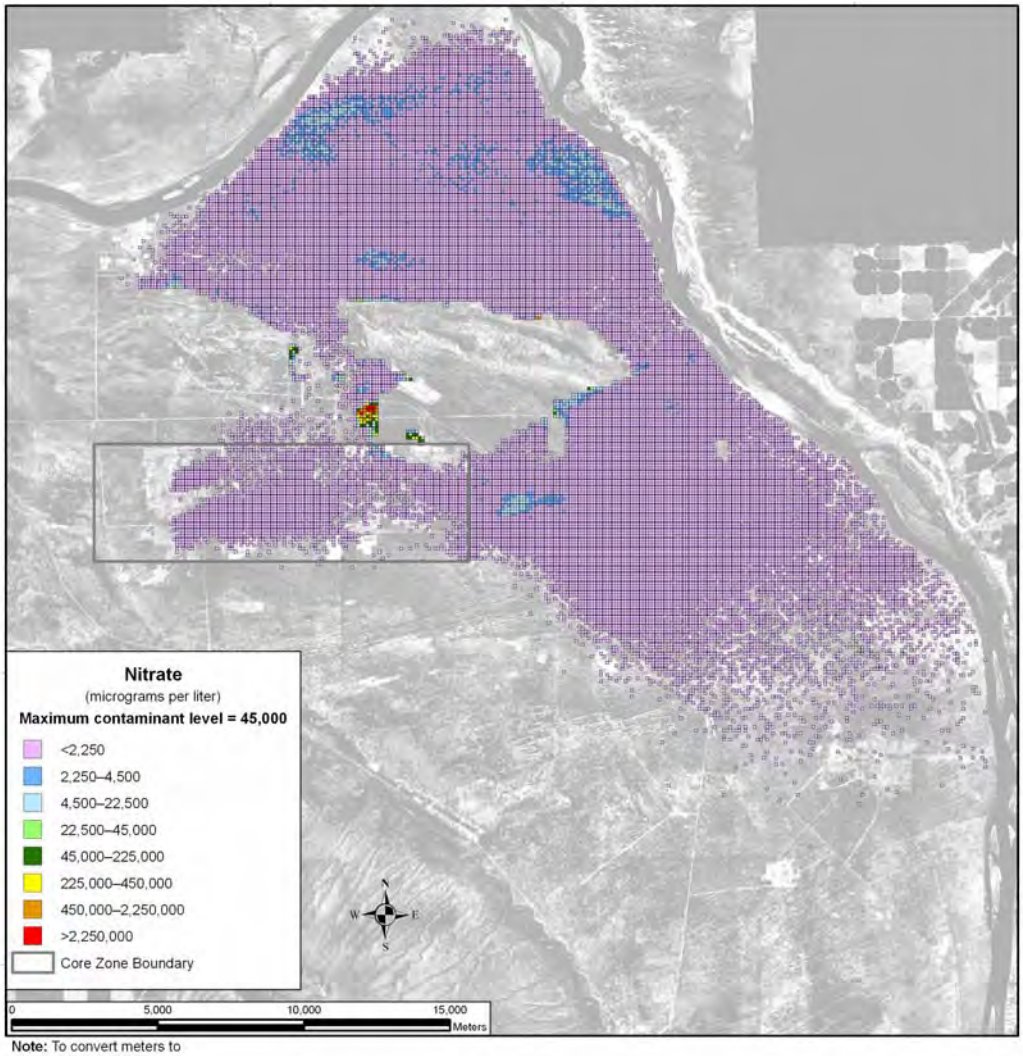
Note: To convert meters to feet, multiply by 3.281

Figure 5–1241. Alternative Combination 2 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



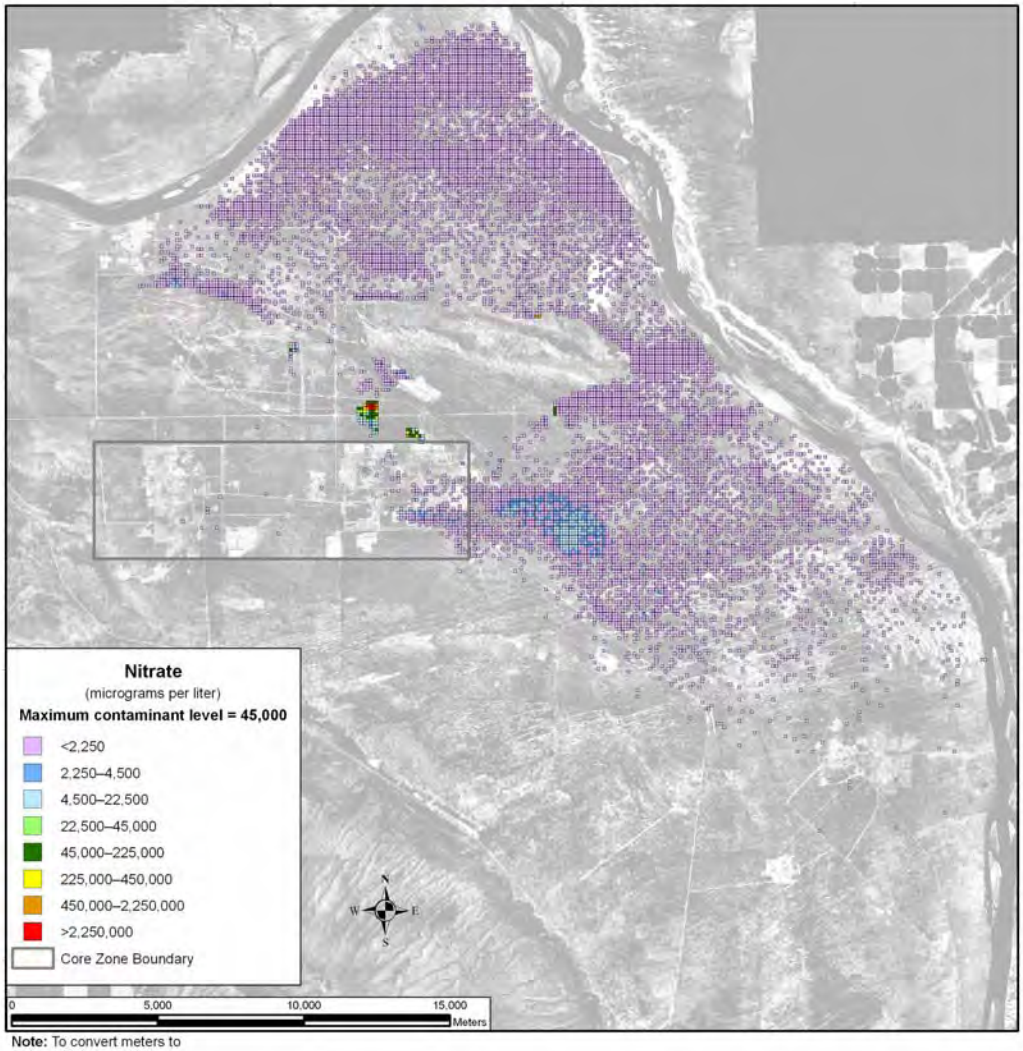
Note: To convert meters to feet, multiply by 3.281

Figure 5–1242. Alternative Combination 2 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005



Note: To convert meters to feet, multiply by 3.281

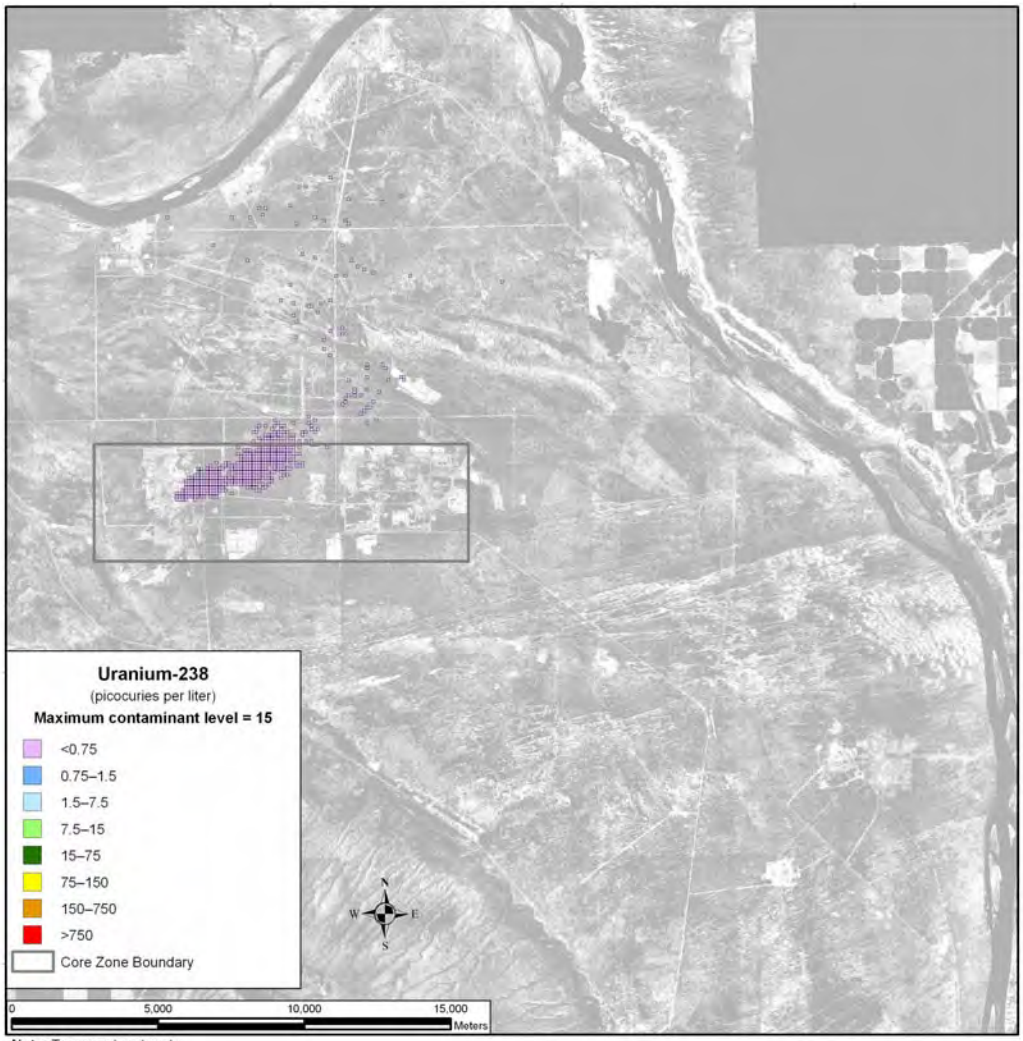
Figure 5–1243. Alternative Combination 2 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

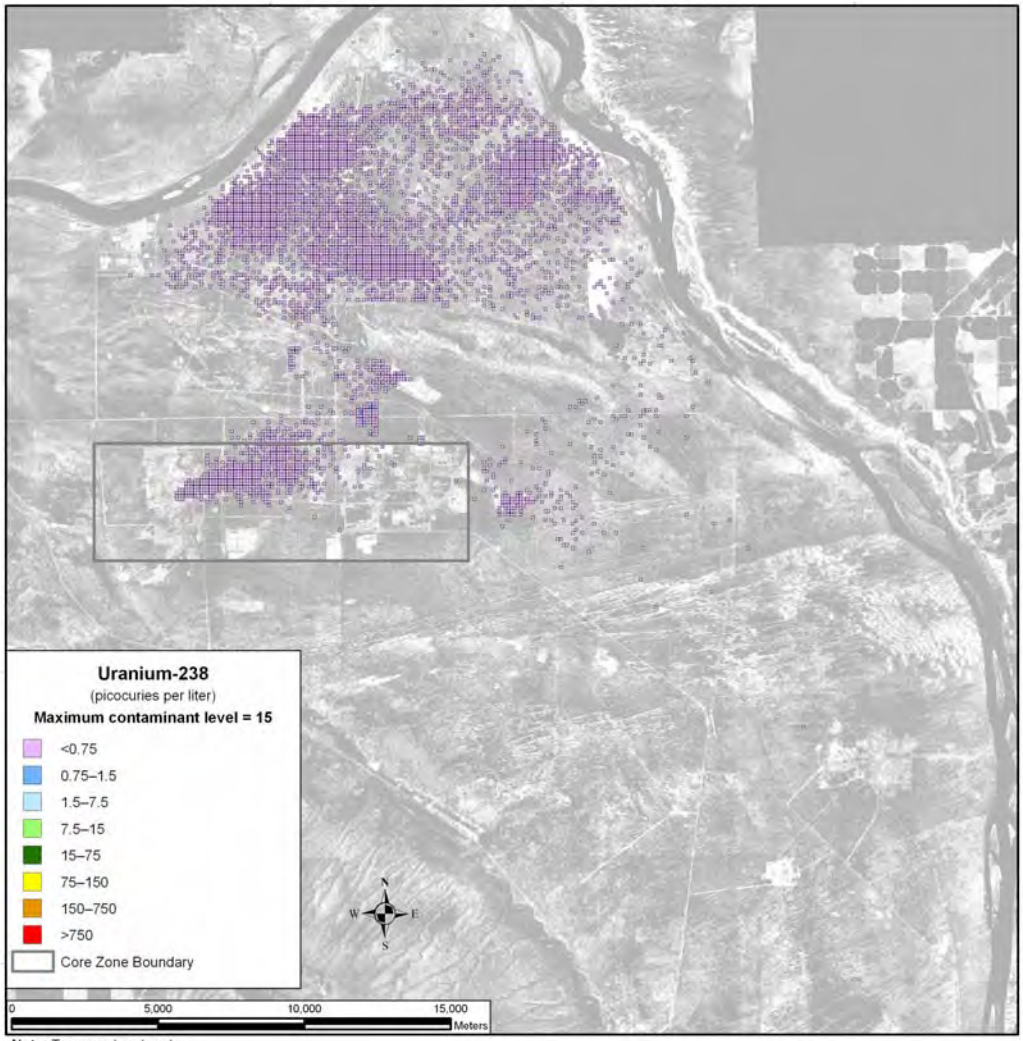
Figure 5–1244. Alternative Combination 2 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140

Uranium-238 and total uranium show different spatial distributions over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–1245 shows the distribution of uranium-238 during CY 2135. There is a small plume associated with cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark and contained within the Core Zone Boundary. By CY 3890 (see Figure 5–1246), the area of the plume has grown, but there are no significant increases in peak concentration. At CY 11,885 (see Figure 5–1247), the greatest development of the plume during the analysis period is seen. Figure 5–1248 shows the total area for which groundwater concentrations of uranium-238 exceed the benchmark concentration as a function of time. The area of exceedance is largest near the end of the period of analysis. Figures 5–1249 through 5–1251 show the corresponding spatial distribution for total uranium.



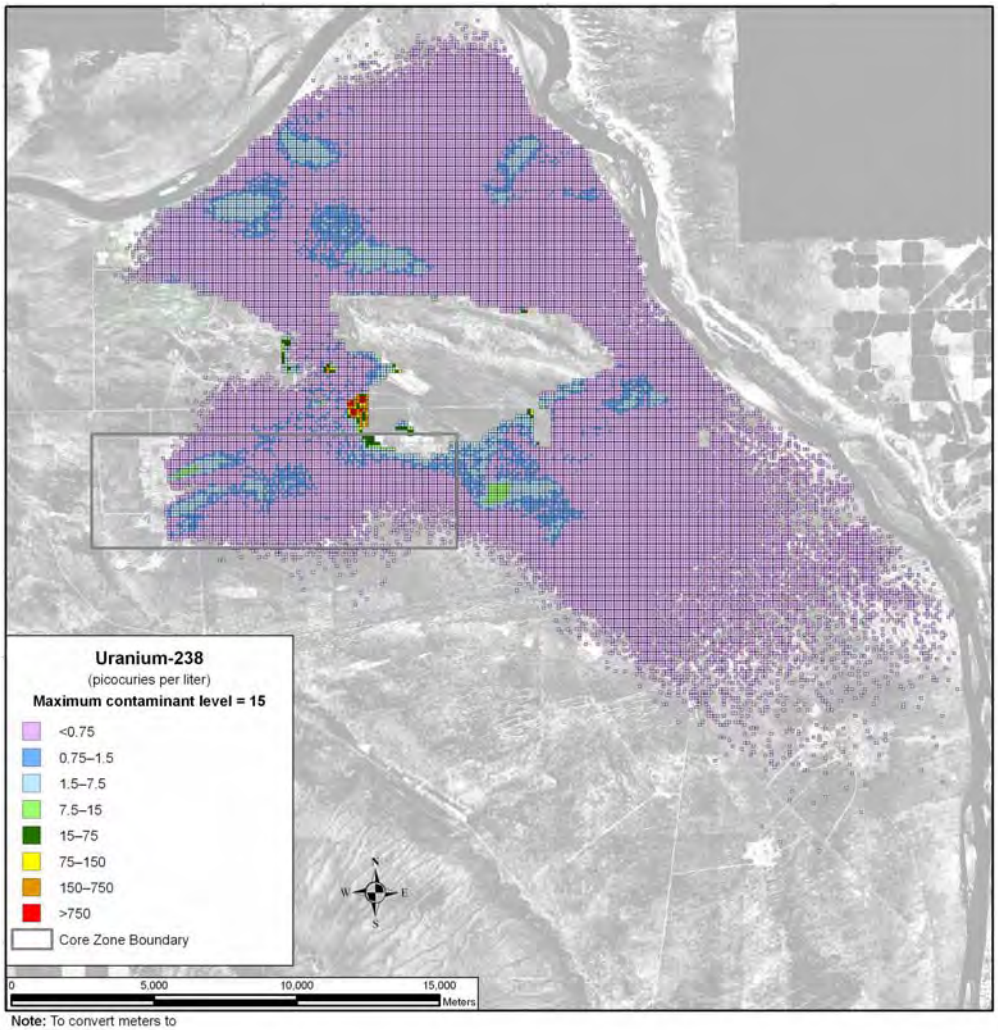
Note: To convert meters to feet, multiply by 3.281

Figure 5–1245. Alternative Combination 2 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281

Figure 5–1246. Alternative Combination 2 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1247. Alternative Combination 2 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

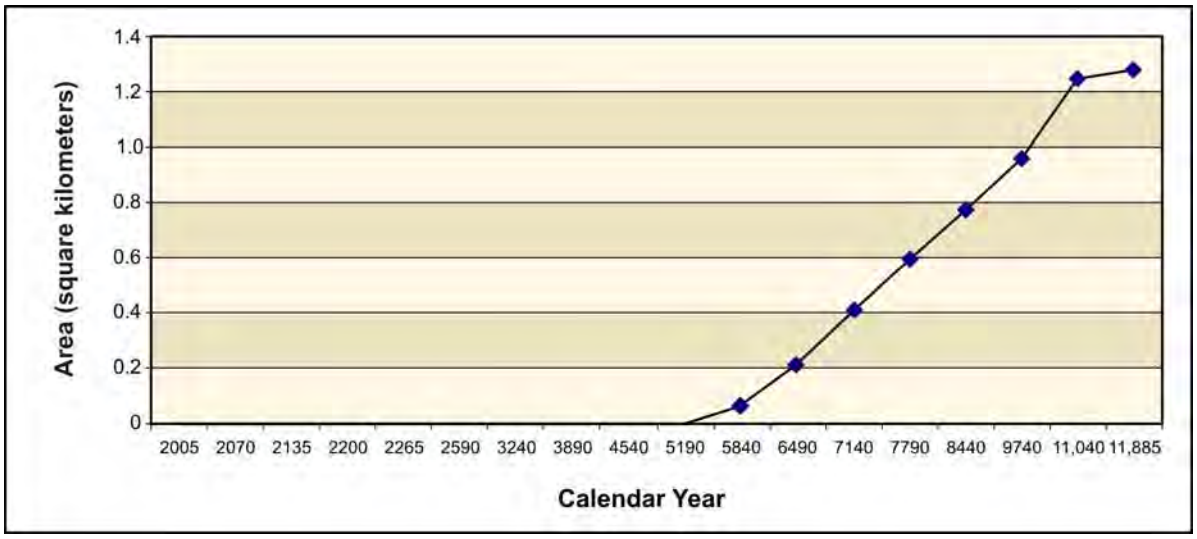
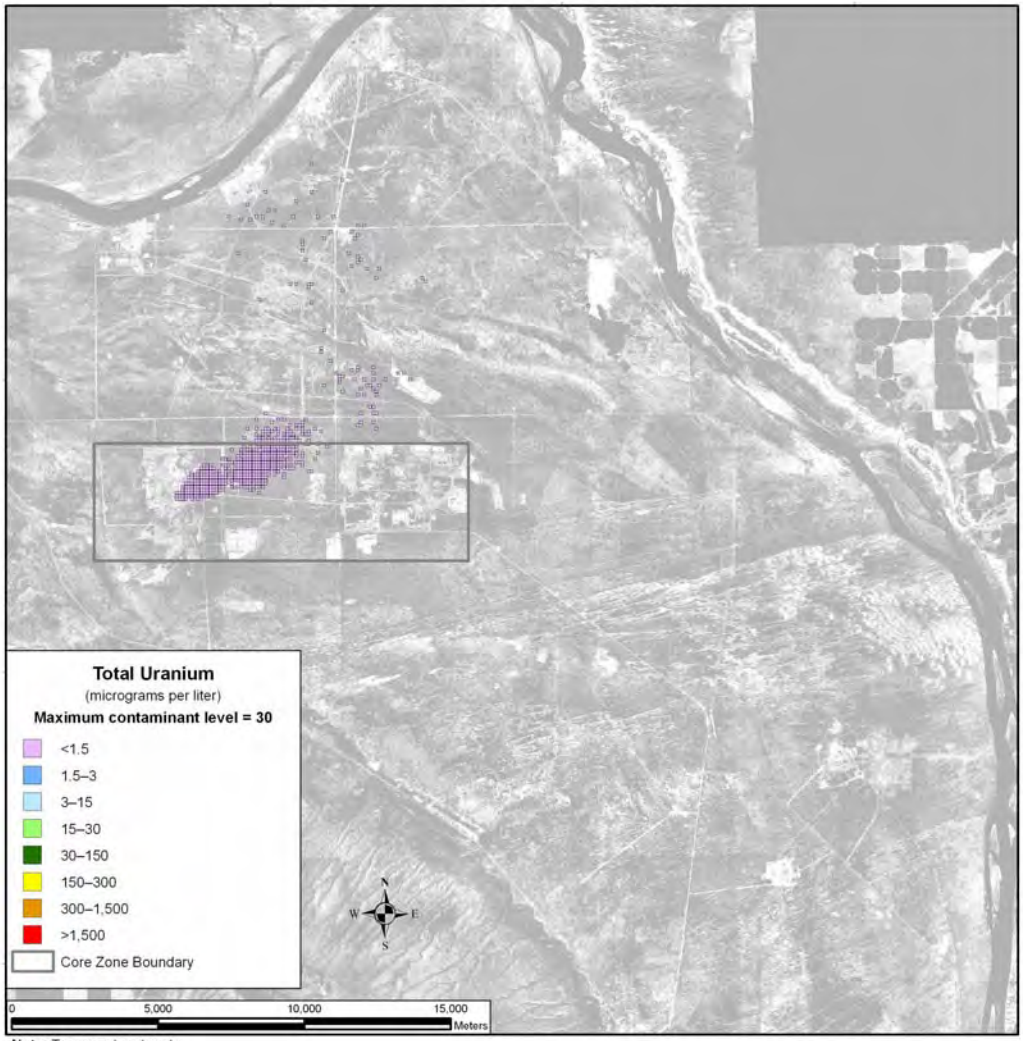
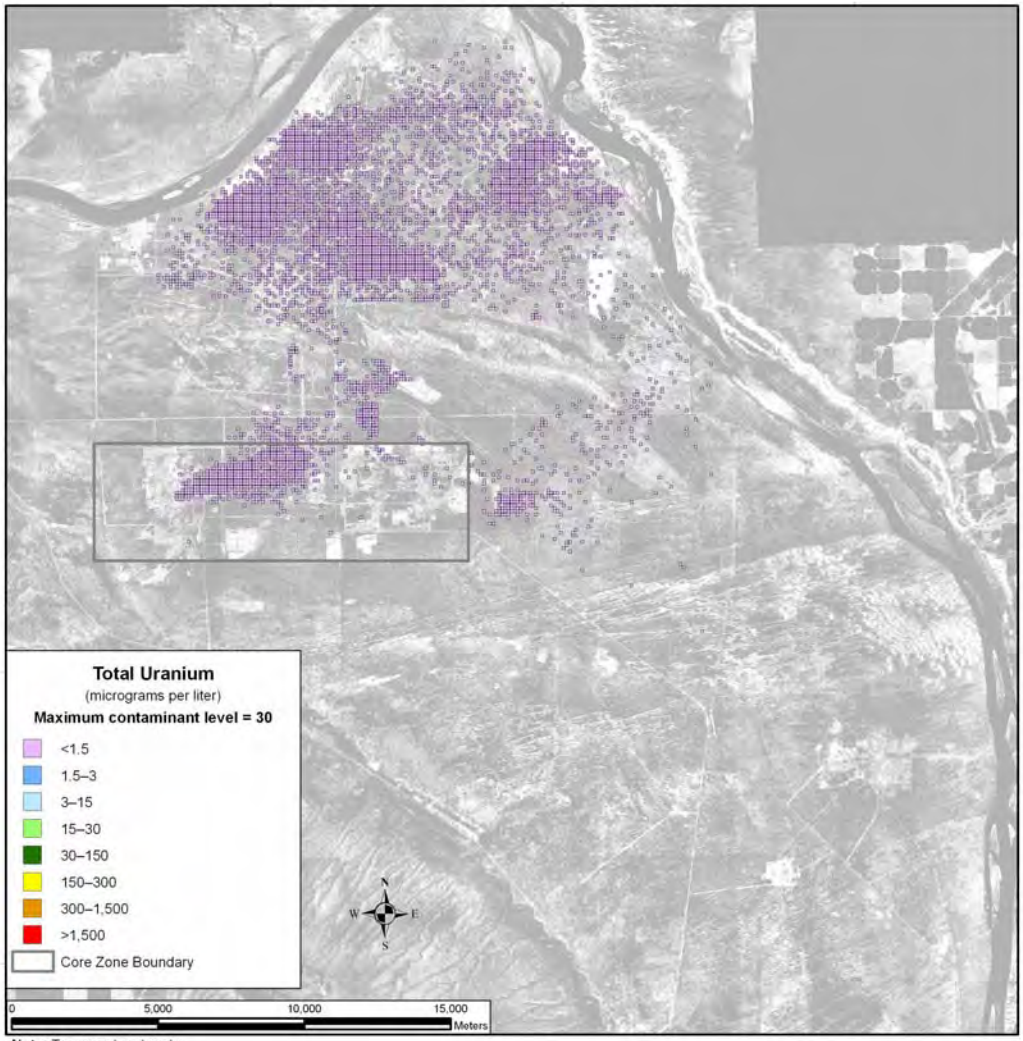


Figure 5–1248. Alternative Combination 2 Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time



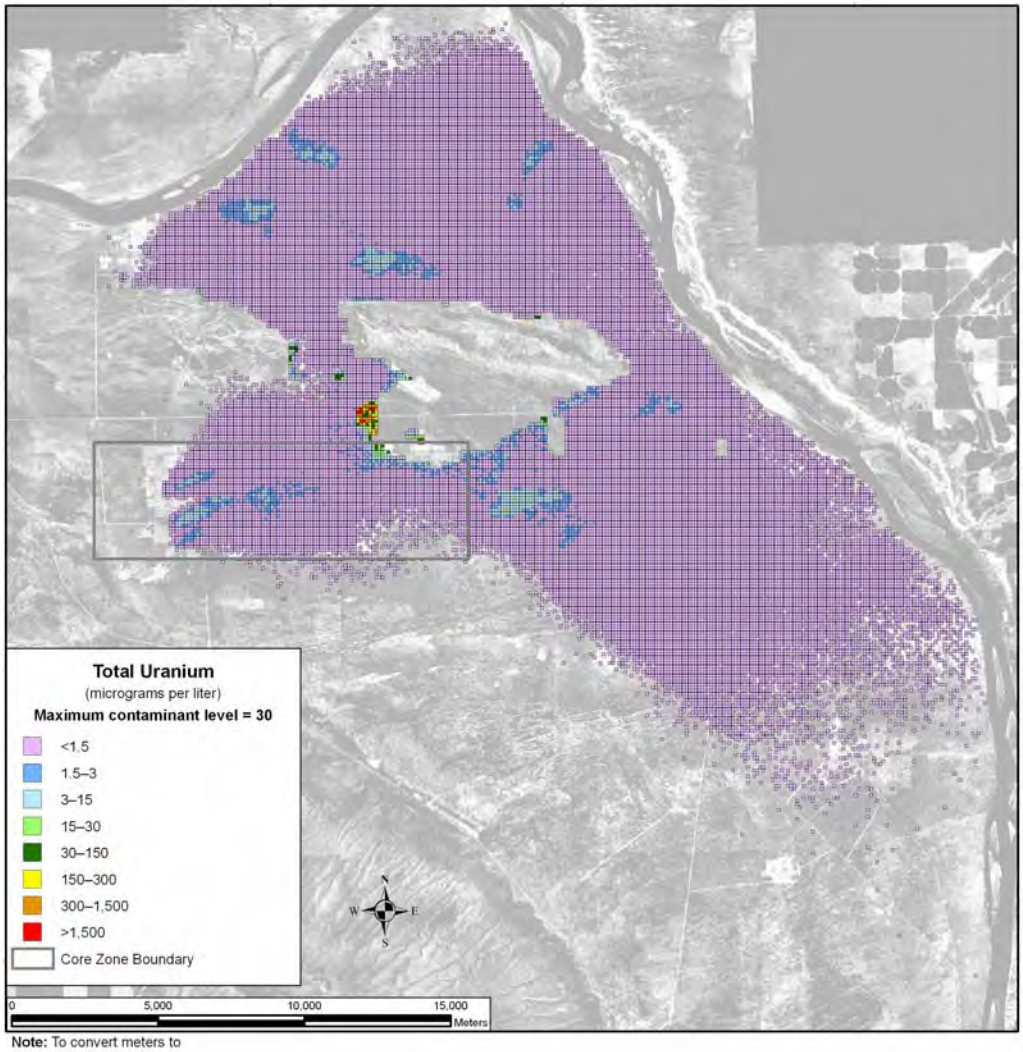
Note: To convert meters to feet, multiply by 3.281

Figure 5–1249. Alternative Combination 2 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281

Figure 5–1250. Alternative Combination 2 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1251. Alternative Combination 2 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

The long-term impacts of Alternative Combination 2 are dominated by tank farm sources for tritium, uranium-238, chromium, nitrate, and total uranium. The dominant contributors for iodine-129 and technetium-99 are waste management sources, particularly offsite waste disposed of at IDF-East. Contributions from FFTF Decommissioning Alternative 2 sources account for well below 1 percent of the total amount released to the environment.

For the conservative tracers, concentrations at the Core Zone Boundary exceed benchmark standards by an order of magnitude during the first several thousand years of the period of analysis, and concentrations at the Columbia River nearshore are about an order of magnitude lower. For chromium and nitrate, the concentration trend decreases with time past CY 6000. For iodine-129 and technetium-99, the concentration trend is level with respect to time, and concentrations are within an order of magnitude of the benchmark concentration at both the Core Zone Boundary and the Columbia River nearshore. The intensities and areas of these groundwater plumes are highest during the early and later parts of the period of analysis.

For tritium, concentrations at the Core Zone Boundary exceed the benchmark by about three orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River approach the benchmark during this time. Attenuation by radioactive decay is the predominant mechanism that limits the intensity and duration of groundwater impacts of tritium. After CY 2100, tritium impacts are essentially negligible.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species exceed the benchmark at the Core Zone Boundary beyond CY 9000, but remain about an order of magnitude lower than the benchmark at the Columbia River after CY 10,000. The intensity is highest and the area of the contamination plume largest near the end of the period of analysis.

5.4.1.3 Alternative Combination 3

This section describes the results of the long-term groundwater impacts analysis for Alternative Combination 3, which comprises Tank Closure Alternative 6B, Base Case; FFTF Decommissioning Alternative 2; and Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case. The focus is the combined long-term groundwater impacts of these alternatives. More-detailed discussion of the individual impacts is provided in Sections 5.1.1, 5.2.1, and 5.3.1.

This discussion of long-term impacts is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers were obtained from the combination of the COPC drivers for the three individual alternatives that compose the alternative combination. They fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. The other COPCs that were analyzed do not significantly contribute to risk or hazard during the period of analysis because of limited inventory, limited rates of release (i.e., retention in waste form), high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

ANALYSIS OF RELEASE AND MASS BALANCE

This section presents the impacts of Alternative Combination 3 in terms of total amount of COPCs released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies, chemicals in kilograms. Both are totaled over the 10,000-year period of analysis.

Table 5–161 lists the release to the vadose zone for the COPC drivers. For Alternative Combination 3, the release to the vadose zone is controlled by a combination of inventory and waste form. For tank closure and FFTF decommissioning sources, the entire inventory is released to the vadose zone during the period of analysis. For some waste management sources (e.g., PPF glass), some of the inventory is not released to the vadose zone during the 10,000-year period of analysis because of retention in the waste form. The release to the vadose zone for Alternative Combination 3 is dominated by sources associated with Tank Closure Alternative 6B, Base Case, for tritium, uranium-238, chromium, nitrate, and total uranium. For these COPC drivers, releases from FFTF decommissioning and waste management sources account for less than 25 percent of the total. For iodine-129 and technetium-99, releases to the vadose

zone are dominated by waste management sources, in particular offsite waste disposed of in IDF-East. Offsite waste accounts for over 93 percent of the total release to the vadose zone for iodine-129 and over 83 percent of the total release to the vadose zone for technetium-99.

Table 5–161. Alternative Combination 3 Release to Vadose Zone for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 6B Base	4.59×10^{4}	8.35×10^{-1}	4.53×10^{2}	2.59×10^{1}	9.07×10^{4}	2.56×10^{7}	2.93×10^{4}
FFTF Decommissioning Alternative 3	1.73×10^{-5}	0.00	2.72×10^{1}	0.00	0.00	0.00	0.00
Waste Management Alternative 2 Disposal Group 2, Subgroup 2-B, Base	6.29×10^{4}	1.84×10^{1}	2.53×10^{3}	3.30×10^{2}	6.48×10^{3}	9.38×10^{6}	1.27×10^{4}
Total	1.09×10^{5}	1.92×10^{1}	3.01×10^{3}	3.56×10^{2}	9.71×10^{4}	3.49×10^{7}	4.20×10^{4}

Key: Base=Base Case; COPC=constituent of potential concern.

Table 5–162 lists the release to groundwater for the COPC drivers. In addition to the inventory and waste form considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. Note that delayed release to the vadose zone (i.e., retention in the waste form) can enhance retention in the vadose zone because contaminant mass released into the vadose zone near the end of the 10,000-year period of analysis may not reach the water table. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater ranges from 100 percent down to 80 percent of the amount released to the vadose zone. For tritium, the amount released to groundwater is attenuated by radioactive decay during transit through the vadose zone. About 70 percent of the tritium released to the vadose zone reaches the unconfined aquifer. For uranium-238 and total uranium, the amount released to groundwater is lower than that of the release to the vadose zone because of retardation. Less than 3 percent of the uranium-238 and total uranium released to the vadose zone reaches the unconfined aquifer during the period of analysis.

Table 5–162. Alternative Combination 3 Release to Groundwater for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	Iodine-129	Technetium-99	Uranium-238	Chromium	Nitrate	Total Uranium
Tank Closure Alternative 6B Base	3.23×10^{4}	7.49×10^{-1}	4.08×10^{2}	7.31×10^{-1}	9.27×10^{4}	2.64×10^{7}	2.42×10^{2}
FFTF Decommissioning Alternative 3	2.58×10^{-8}	0.00	2.62×10^{1}	0.00	0.00	0.00	0.00
Waste Management Alternative 2 Disposal Group 2, Subgroup 2-B, Base	0.00	1.68×10^{1}	2.27×10^{3}	2.68×10^{-7}	6.46×10^{3}	9.36×10^{6}	4.64×10^{-4}
Total	3.23×10^{4}	1.75×10^{1}	2.71×10^{3}	7.31×10^{-1}	9.92×10^{4}	3.58×10^{7}	2.42×10^{2}

Key: Base=Base Case; COPC=constituent of potential concern.

Table 5–163 lists the release to the Columbia River for the COPC drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 3 percent of the tritium released to groundwater reaches the Columbia River. For uranium-238 and total uranium, the amount released to the Columbia River is lower than that released to groundwater because of retardation in the aquifer. Overall, about 30 percent of the amount released to groundwater during the period of analysis reaches the Columbia River.

Table 5–163. Alternative Combination 3 Release to Columbia River for the COPC Drivers

Alternative	Radiological COPCs (curies)				Chemical COPCs (kilograms)		
	Hydrogen-3 (Tritium)	**Iodine-129**	**Technetium-99**	**Uranium-238**	**Chromium**	**Nitrate**	**Total Uranium**
Tank Closure Alternative 6B Base	8.70×10^{2}	7.23×10^{-1}	3.94×10^{2}	2.44×10^{-1}	9.23×10^{4}	2.63×10^{7}	7.87×10^{1}
FFTF Decommissioning Alternative 3	0.00	0.00	2.72×10^{1}	0.00	0.00	0.00	0.00
Waste Management Alternative 2 Disposal Group 2, Subgroup 2-B, Base	0.00	1.63×10^{1}	2.20×10^{3}	0.00	6.22×10^{3}	9.21×10^{6}	3.05×10^{-5}
Total	8.70×10^{2}	1.70×10^{1}	2.62×10^{3}	2.44×10^{-1}	9.85×10^{4}	3.55×10^{7}	7.87×10^{1}

Key: Base=Base Case; COPC=constituent of potential concern.

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Alternative Combination 3 in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. Concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile upper confidence limit of the concentration is included on several of these graphs. This confidence interval was calculated to aid to interpreting data with a significant amount random fluctuation (noise). The confidence interval was calculated when the concentration had a reasonable degree of noise, the concentration trend was level, and the concentrations were near the benchmark. The benchmark concentration for each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–164 lists the maximum concentrations of the COPCs at the peak year for the Core Zone Boundary and the Columbia River nearshore.

Table 5–164. Alternative Combination 3 Maximum COPC Concentrations in the Peak Year at the Core Zone Boundary and Columbia River Nearshore

Contaminant	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide picocuries per liter			
Hydrogen-3 (Tritium)	**2,820,000**	1,280	20,000
	(1956)	(1994)	
Technetium-99	**144,000**	716	900
	(1956)	(8477)	
Iodine-129	**187**	**6**	1
	(1956)	(9652)	
Uranium isotopes (includes uranium-233, -234, -235, -238)	10	0	15
	(11,758)	(11,844)	
Chemical in micrograms per liter			
Chromium	**28,000**	33	100
	(1956)	(2695)	
Nitrate	**12,900,000**	8,420	45,000
	(1956)	(2450)	
Total uranium	7	0	30
	(11,678)	(11,508)	

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern.

Figure 5–1252 shows concentration versus time for tritium. Note that for visual clarity, the time period shown on this figure is from CY 1940 through CY 2640 rather than for the full 10,000-year period of analysis. Concentrations at the Core Zone Boundary exceed the benchmark concentration by about two orders of magnitude for a short period of time during the early part of the period of analysis. During this time, groundwater concentrations at the Columbia River nearshore peak at about an order of magnitude lower than the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor at times later than CY 2100.

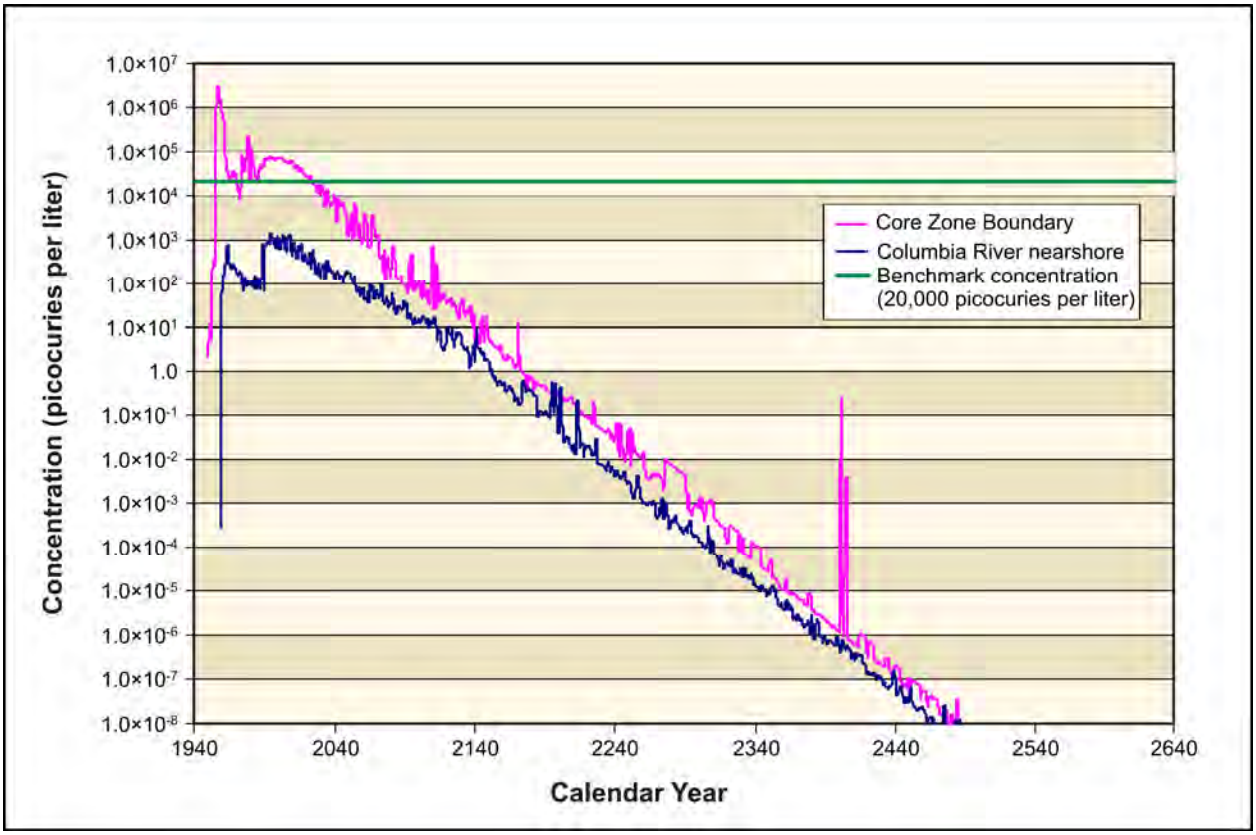


Figure 5–1252. Alternative Combination 3 Hydrogen-3 (Tritium) Concentration Versus Time

Figures 5–1253 and 5–1254 show concentration versus time for chromium and nitrate (the conservative tracers that are not affected by retention in the waste forms). Groundwater concentrations of chromium exceed benchmark concentrations by an order of magnitude during the first several thousand years of the analysis. During this time, groundwater concentrations at the Columbia River nearshore are below, but within an order of magnitude of, the benchmark concentration. During later times in the analysis, the concentrations at the Core Zone Boundary and the Columbia River nearshore are below the benchmark by about one and two orders of magnitude, respectively. Nitrate shows a similar concentration pattern with respect to time. For iodine-129 and technetium-99, the behavior during the first four thousand years is similar to that of chromium and nitrate (see Figures 5–1255 and 5–1256). After CY 6000, the effects of delayed release from waste management sources are seen. For iodine-129, the post–CY 6000 concentrations at the Core Zone Boundary and the Columbia River nearshore are above, but within an order of magnitude of, the benchmark concentration. For technetium-99, the corresponding concentrations are below, but within an order of magnitude of, the benchmark concentration.

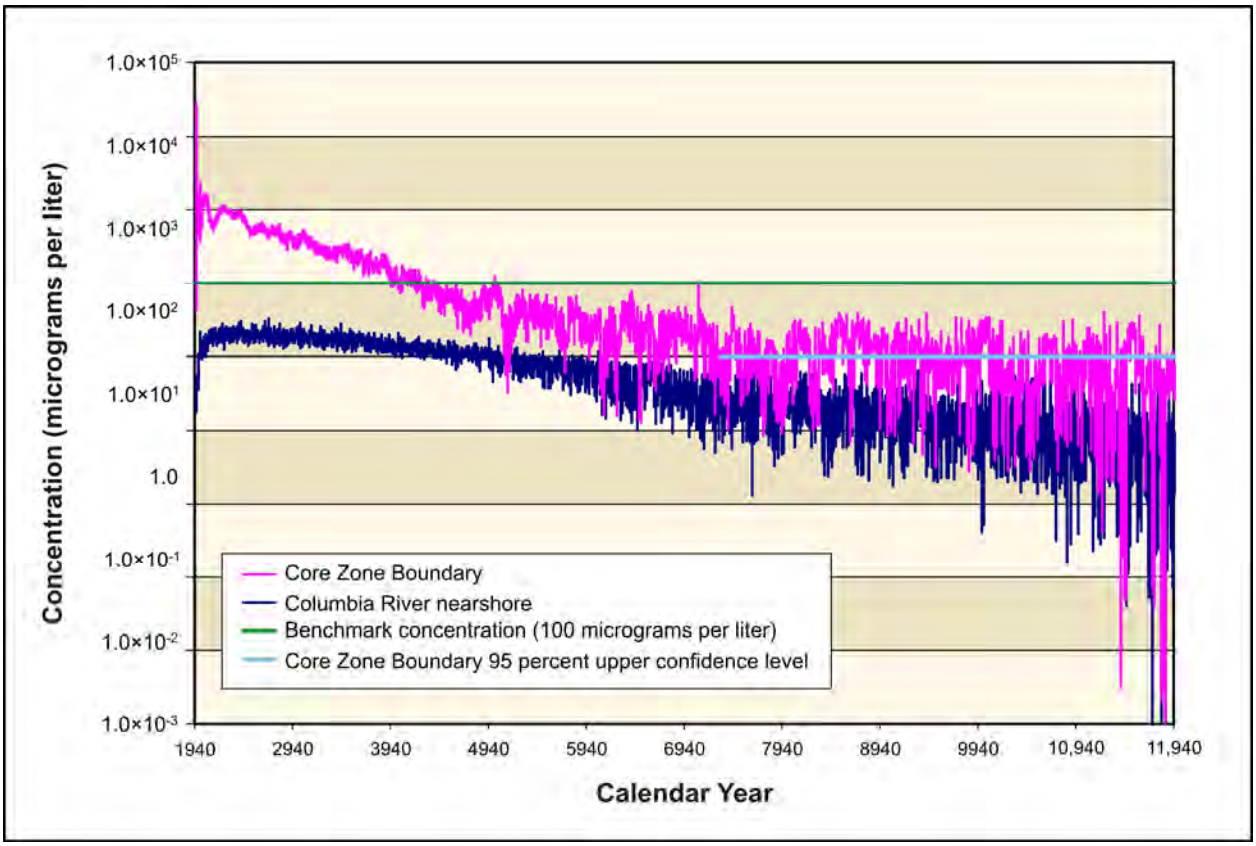


Figure 5–1253. Alternative Combination 3 Chromium Concentration Versus Time

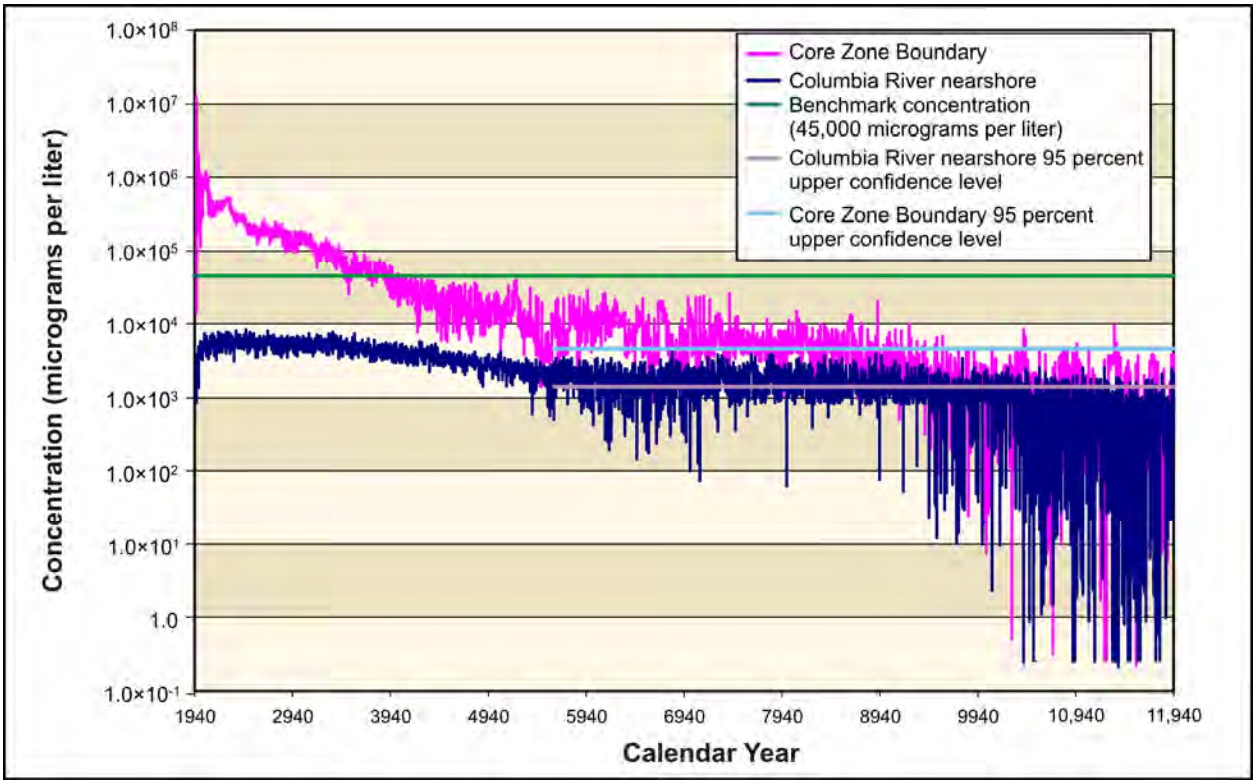


Figure 5–1254. Alternative Combination 3 Nitrate Concentration Versus Time

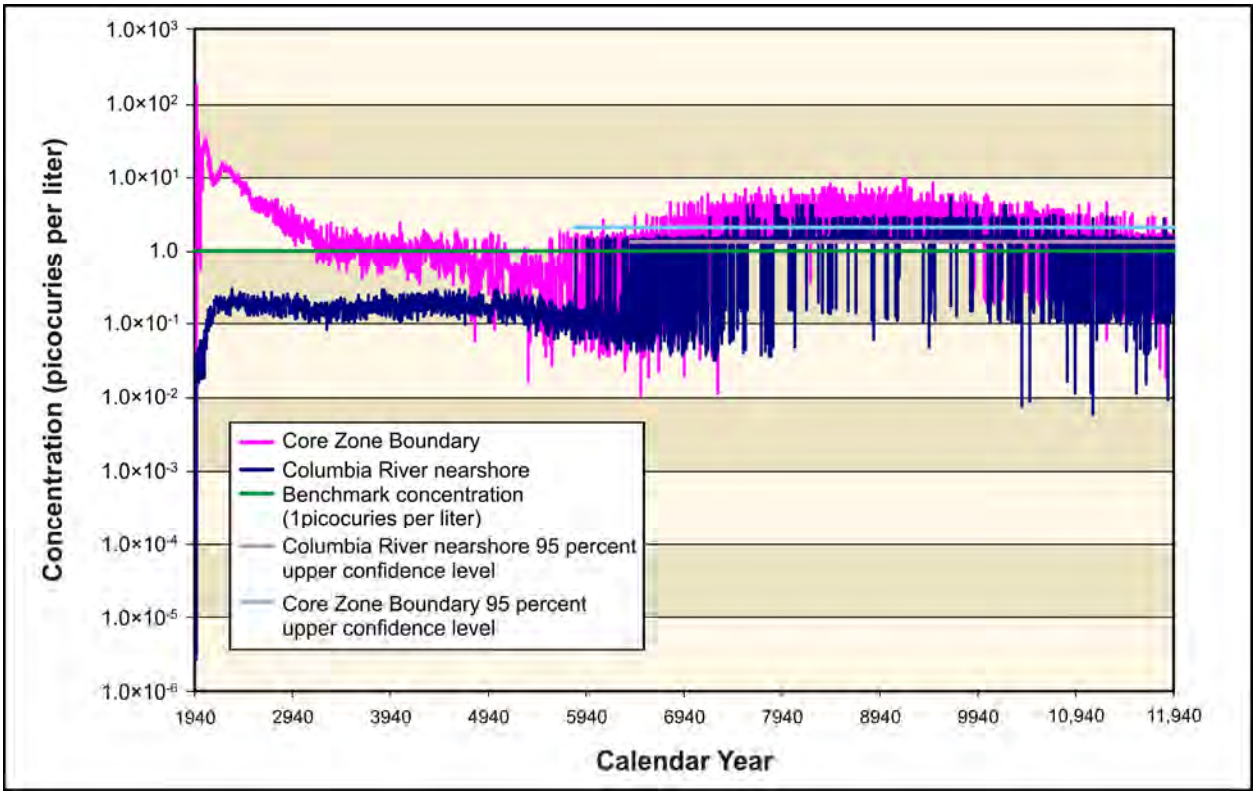


Figure 5–1255. Alternative Combination 3 Iodine-129 Concentration Versus Time

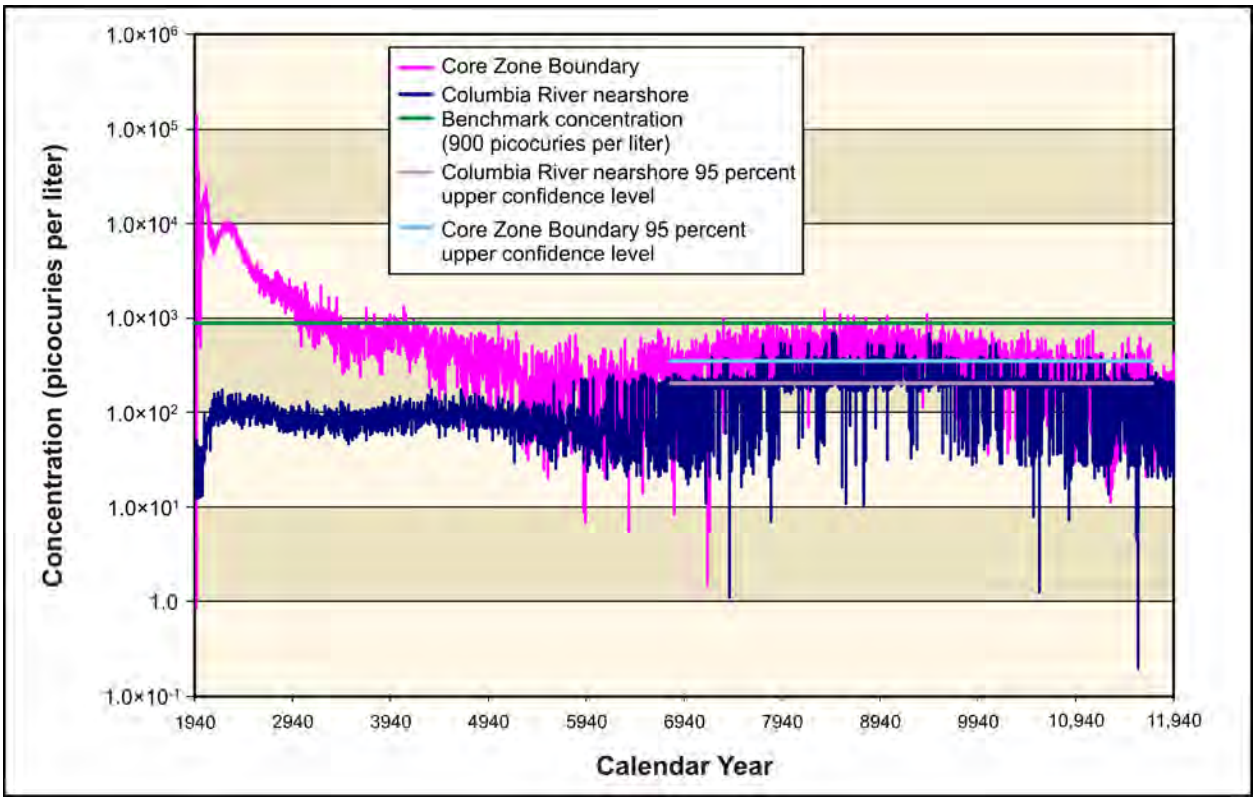


Figure 5–1256. Alternative Combination 3 Technetium-99 Concentration Versus Time

Figures 5–1257 and 5–1258 show concentration versus time for uranium-238 and total uranium. Concentrations of uranium-238 and total uranium rise throughout the period of analysis. The travel times of these COPCs from the source locations to the Core Zone Boundary and Columbia River nearshore are retarded relative to the conservative tracers by a factor of about seven. Concentrations of uranium-238 and total uranium approach, but do not exceed, the benchmark concentration at the Core Zone Boundary at the end of the period of analysis. Groundwater concentrations at the Columbia River nearshore rise throughout the period of analysis, but remain more than an order of magnitude below the benchmark concentration by CY 11,940.

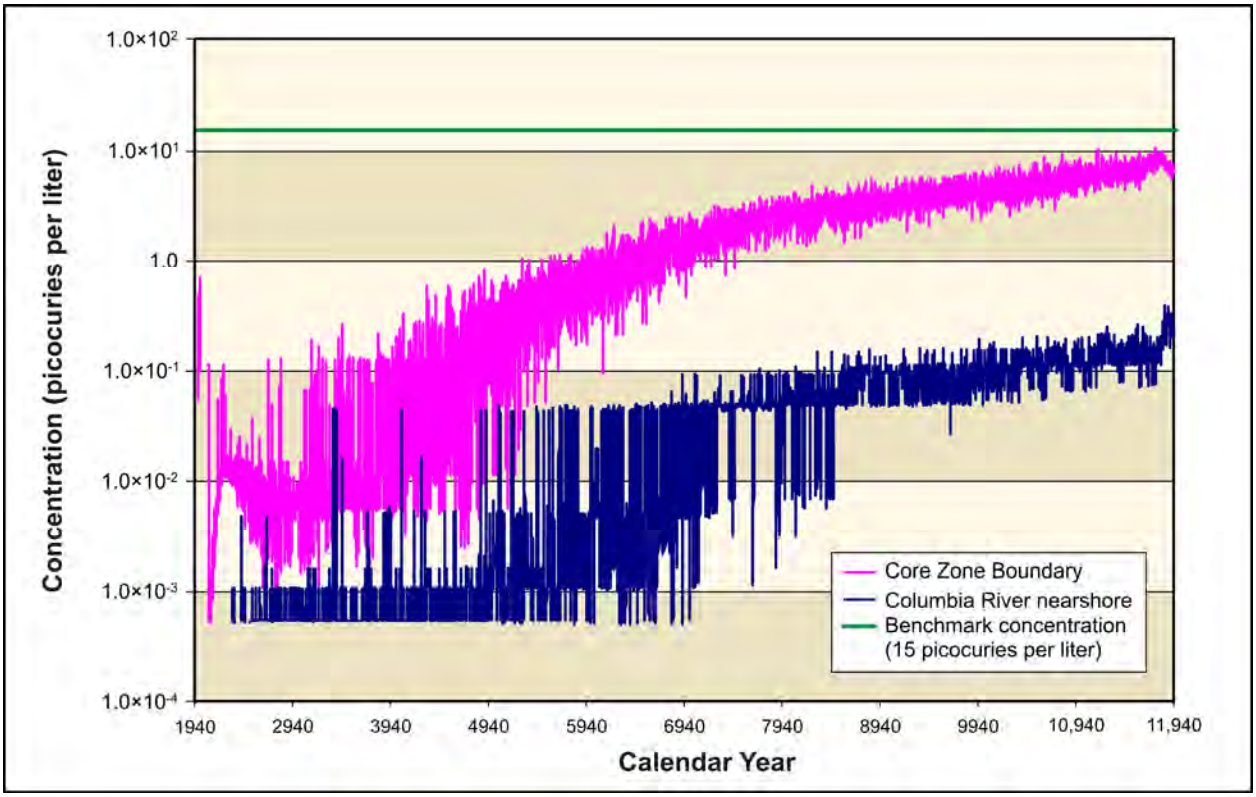


Figure 5–1257. Alternative Combination 3 Uranium-238 Concentration Versus Time

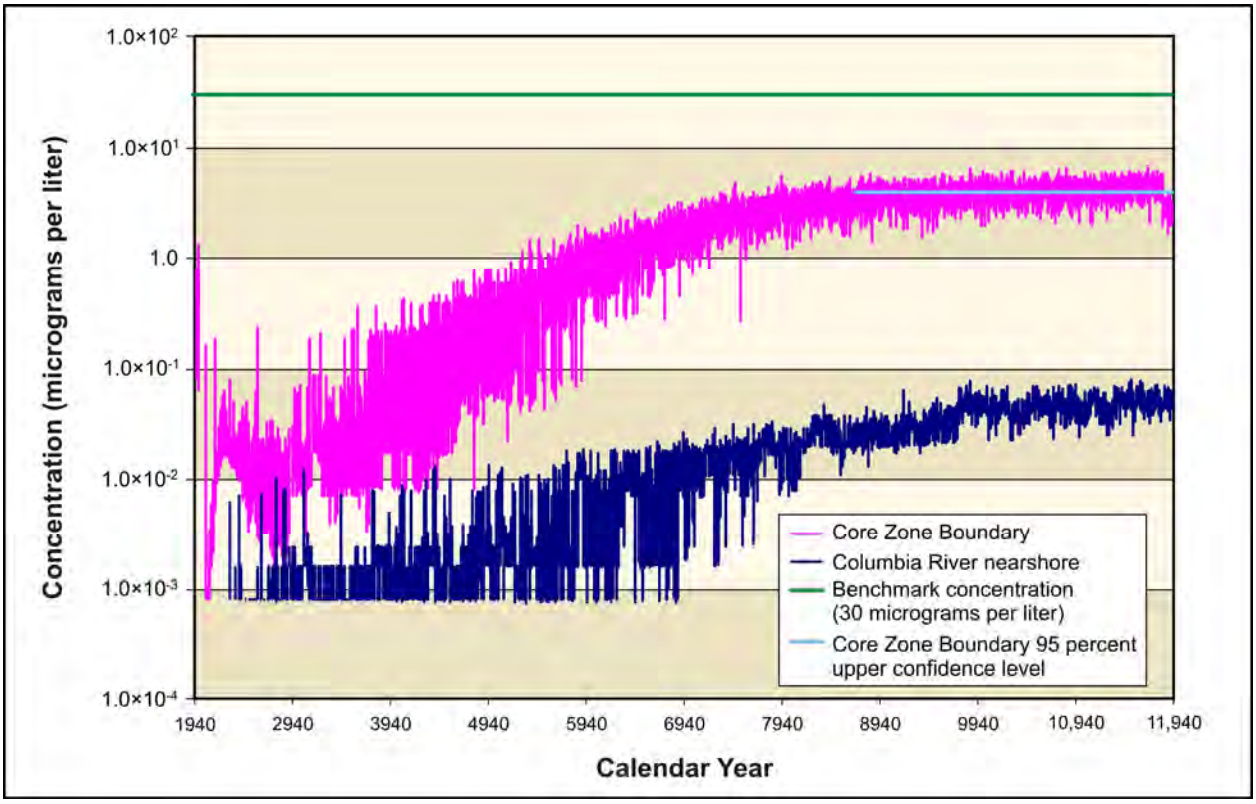


Figure 5–1258. Alternative Combination 3 Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Alternative Combination 3 in terms of the spatial distribution of groundwater concentrations at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations of each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations lower than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–1259 shows the spatial distribution of groundwater concentration for tritium during CY 2005. Releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crossing the Core Zone Boundary, and extending toward Gable Gap. Peak concentrations in this plume are about 10 to 20 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135.

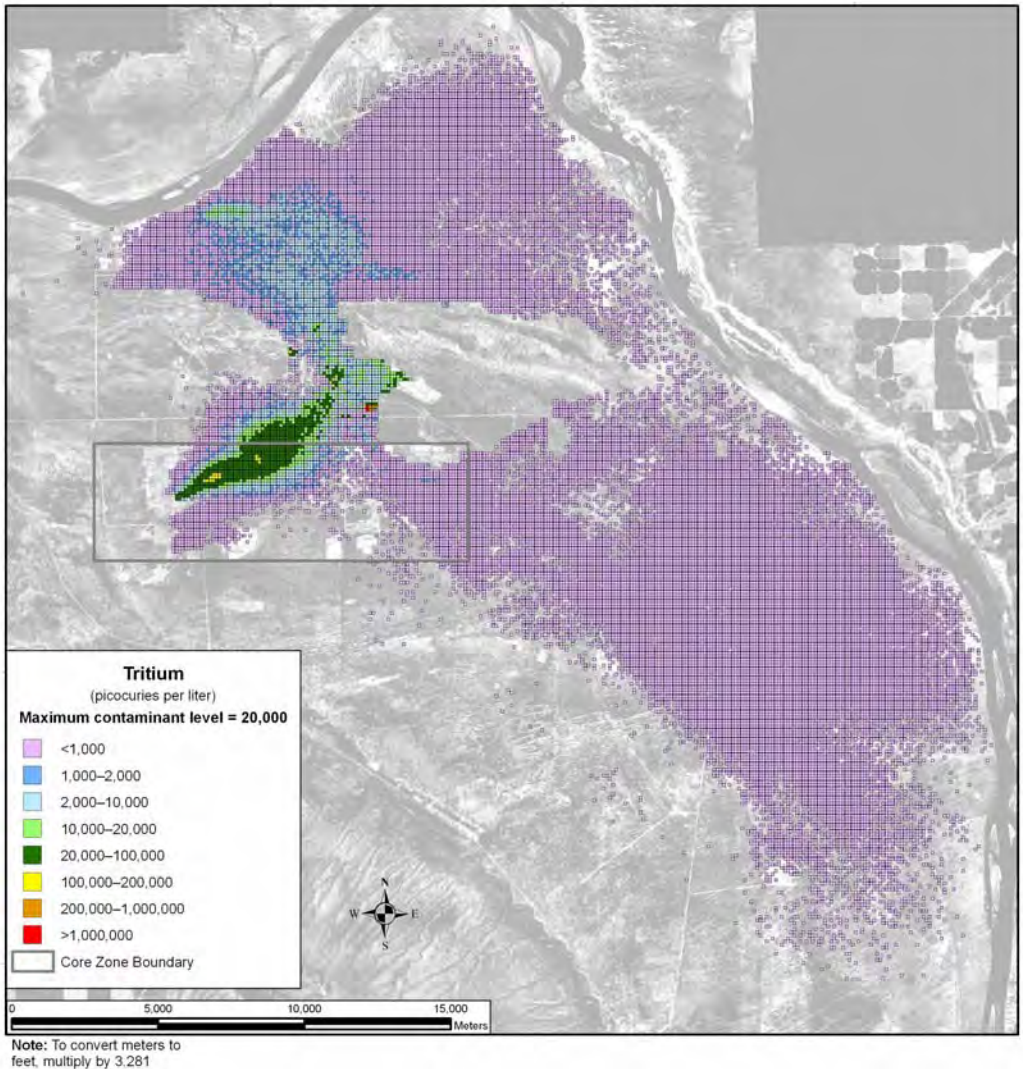
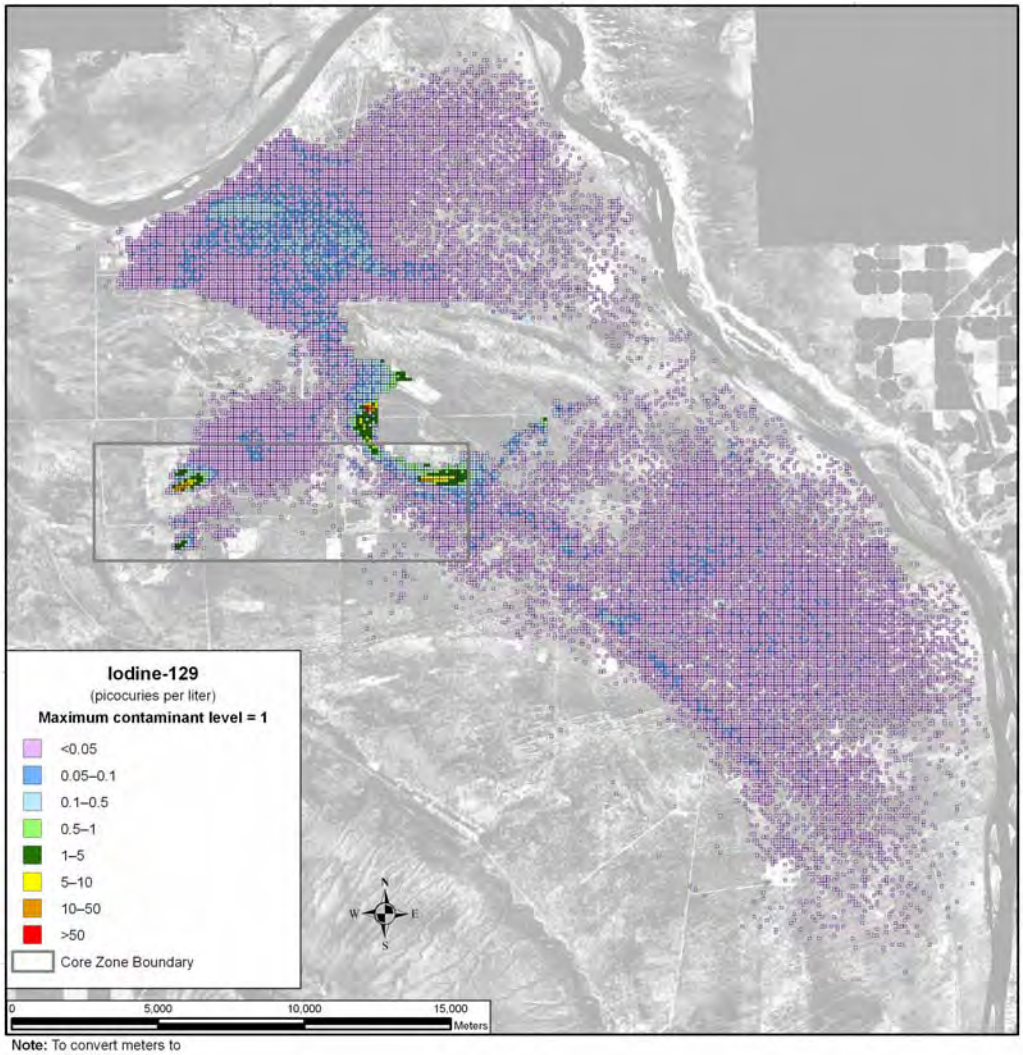


Figure 5–1259. Alternative Combination 3 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration During Calendar Year 2005

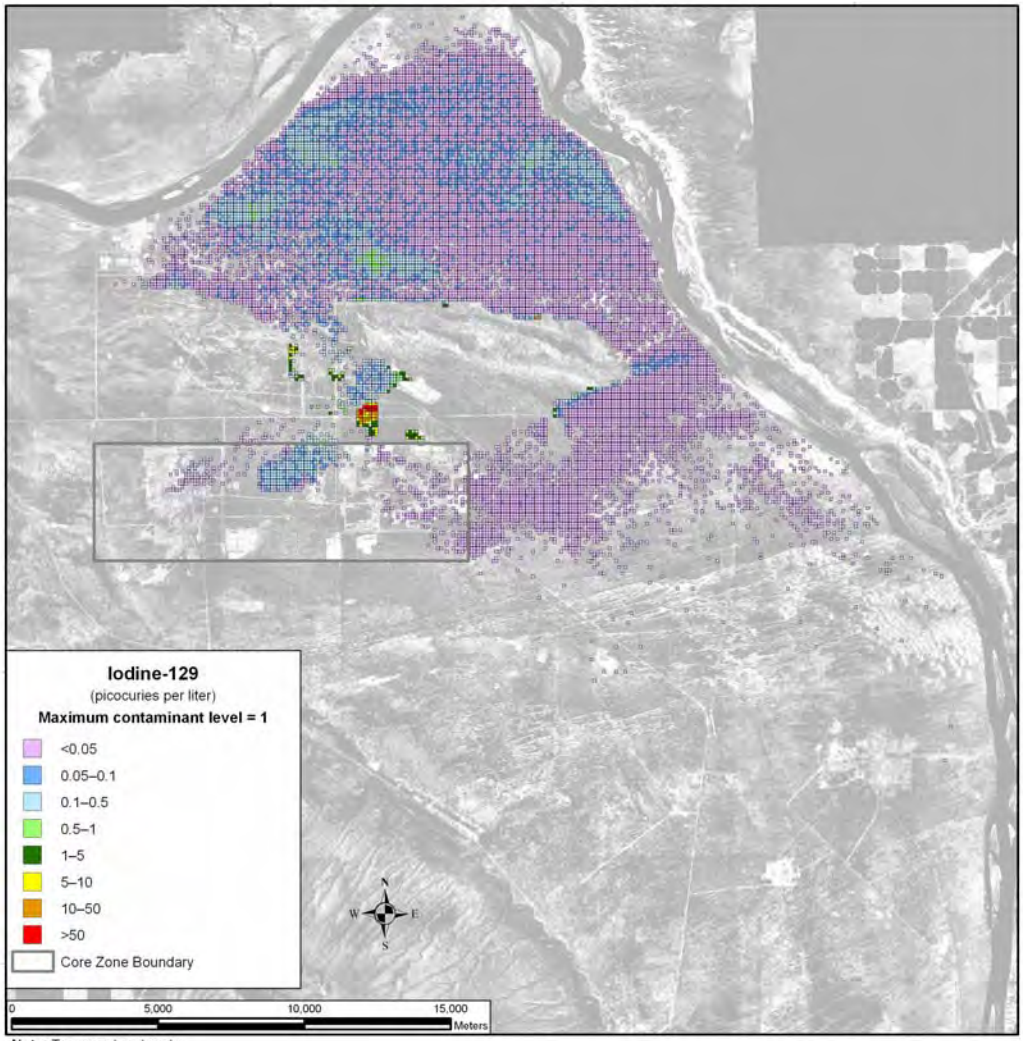
Figure 5–1260 shows the spatial distribution of groundwater concentration for iodine-129 during CY 2005. Releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceed the benchmark concentration associated with the T Barrier, B Barrier, and A Barrier. Peak concentrations in this plume are about 10 to 50 times greater than the benchmark, and mostly contained within the Core Zone Boundary. Around CY 3890, releases from the RPPDF create a rather small plume near the center of the Core Zone, with concentrations less than an order of magnitude below the benchmark (see Figure 5–1261). A comparison of this result against the corresponding distribution for Alternative Combination 1 (see Figure 5–1200) illustrates the reduction in impacts resulting from retrieval of other tank farm sources and from clean closure. By CY 7140, the spatial distribution of the groundwater concentration is driven primarily by waste management sources IDF-East (see Figure 5–1262). The impact is characterized by a plume east of the Core Zone Boundary that exceeds the benchmark concentration by more than an order of magnitude. Because of retention in the waste forms, this impact lasts until the end of the 10,000-year period of analysis (see Figure 5–1263). Figure 5–1264 shows the total area for which groundwater concentrations of iodine-129 exceed the benchmark concentration as a function of time. Again, a comparison of this result with the corresponding distribution for Alternative Combination 1 (see Figure 5–1202) illustrates the reduction of impacts resulting from retrieval of other tank farm sources (around CY 4000), but also the increase in impacts

associated with waste management sources, primarily offsite waste (around CY 9000). Figures 5–1265 through 5–1269 show the spatial distribution at the same four times and the total area of exceedance versus time for technetium-99. The spatial distribution of technetium-99 is similar to that of iodine-129. The other conservative tracers, chromium (see Figures 5–1270 through 5–1273) and nitrate (see Figures 5–1274 through 5–1277) show similar spatial distributions.



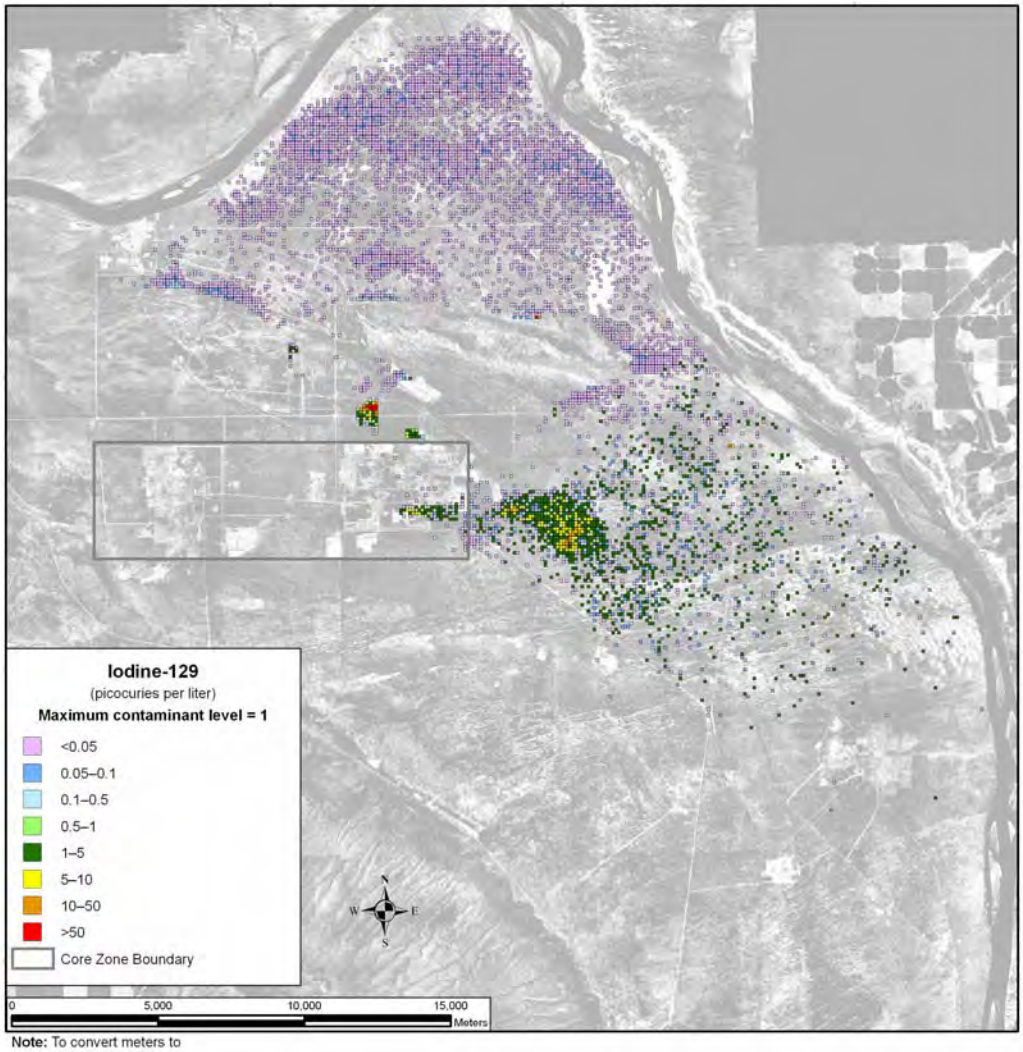
Note: To convert meters to feet, multiply by 3.281

Figure 5–1260. Alternative Combination 3 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 2005



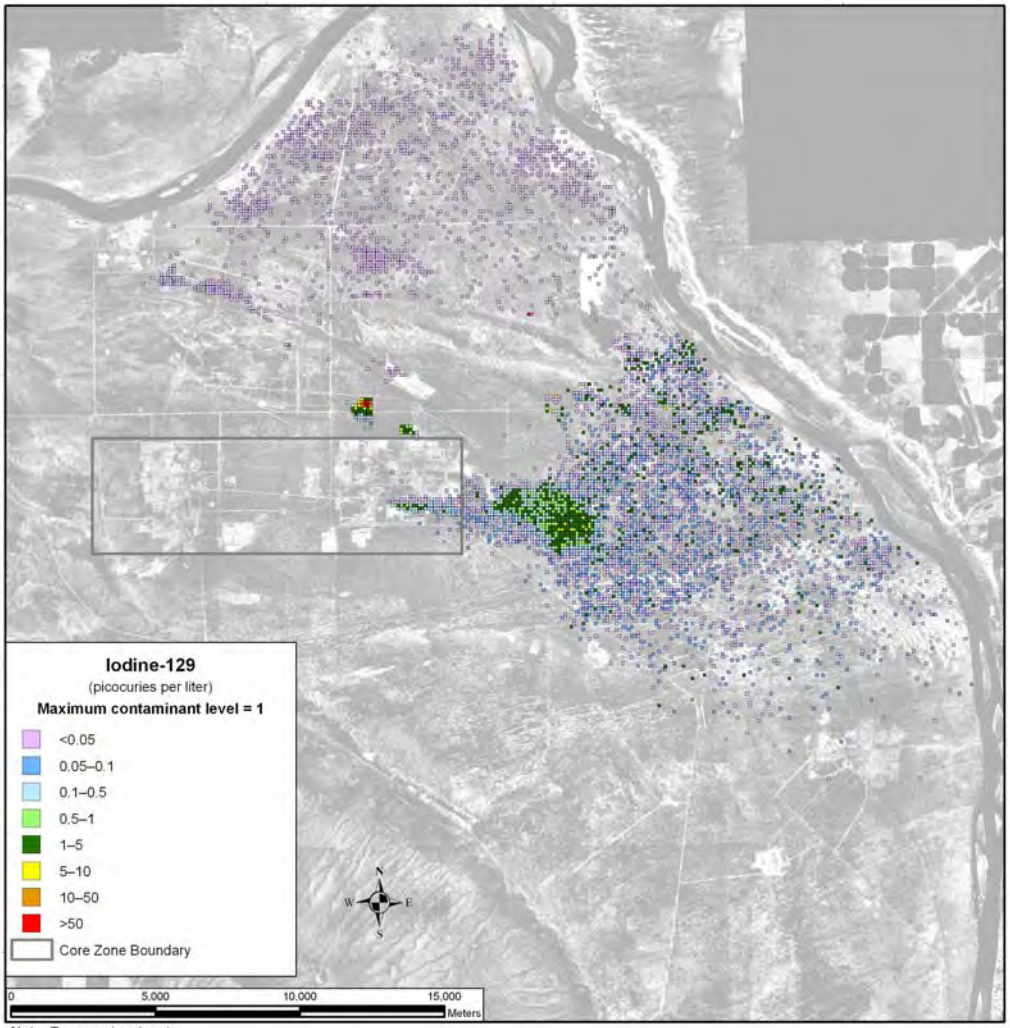
Note: To convert meters to feet, multiply by 3.281

Figure 5–1261. Alternative Combination 3 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1262. Alternative Combination 3 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–1263. Alternative Combination 3 Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

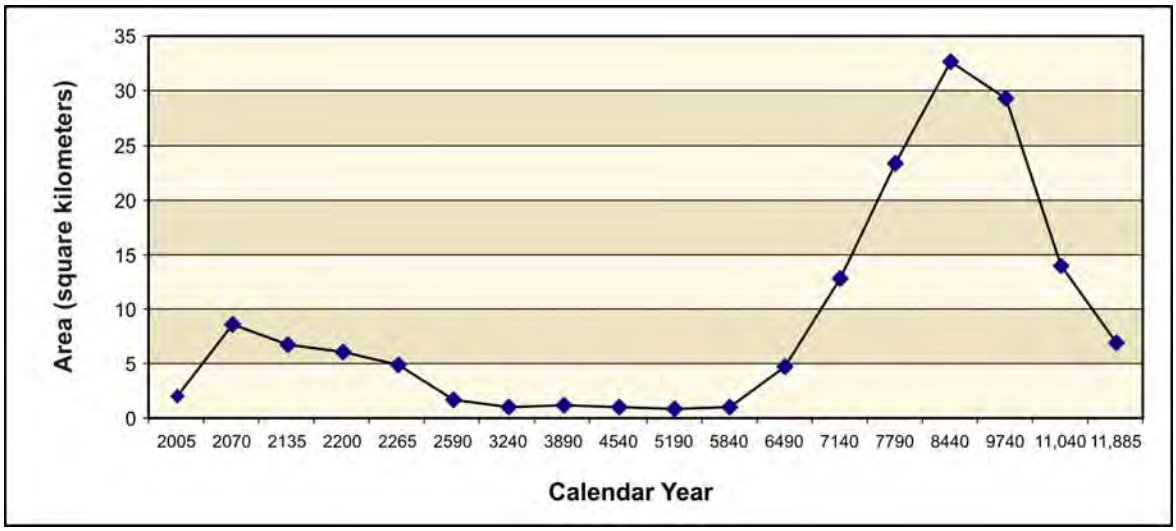
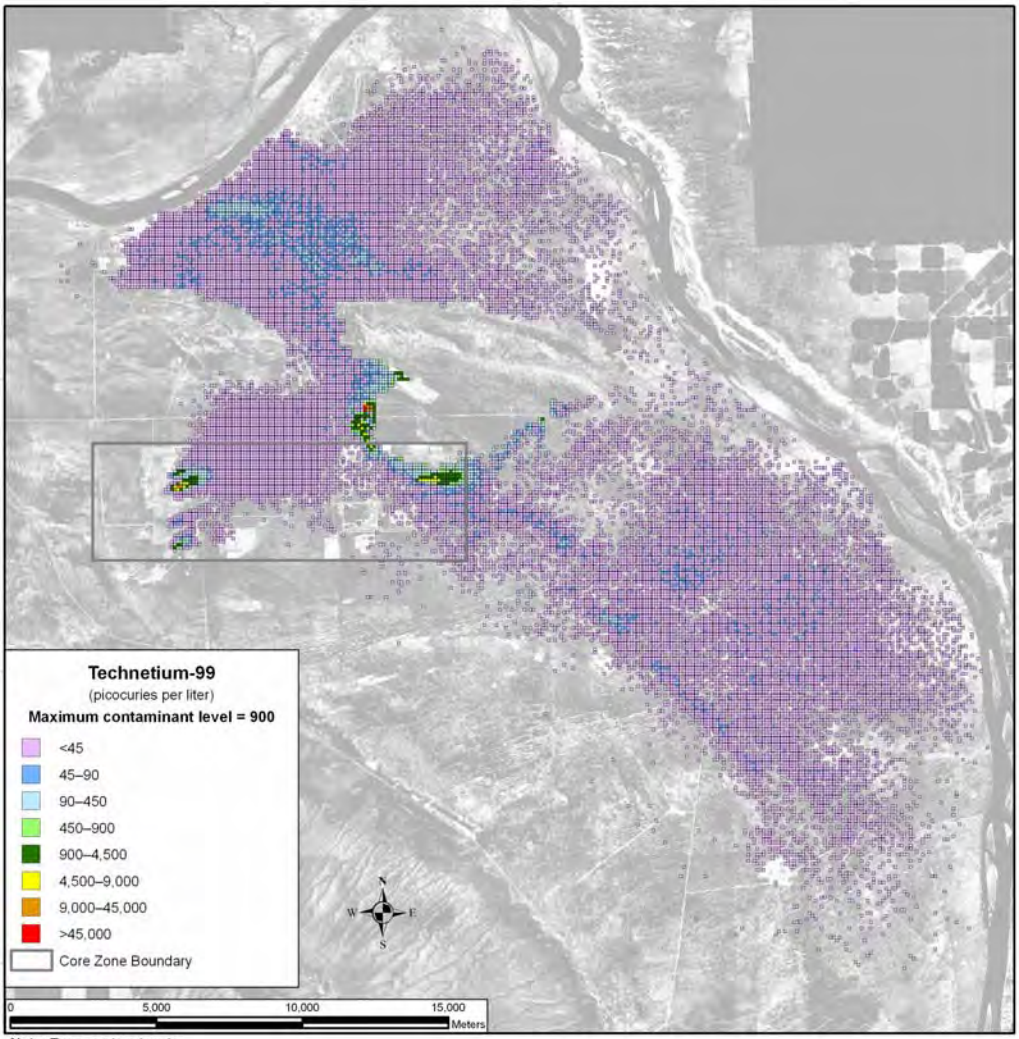
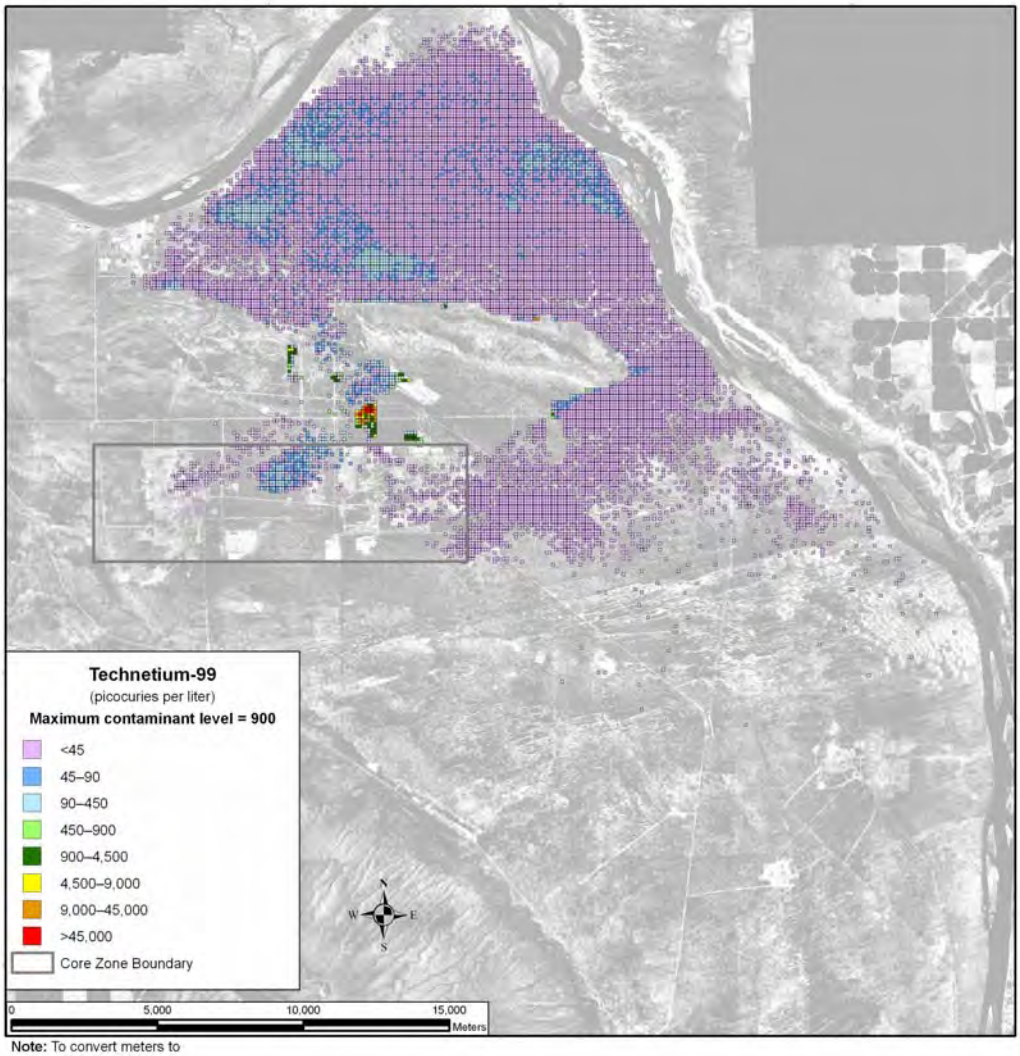


Figure 5–1264. Alternative Combination 3 Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time



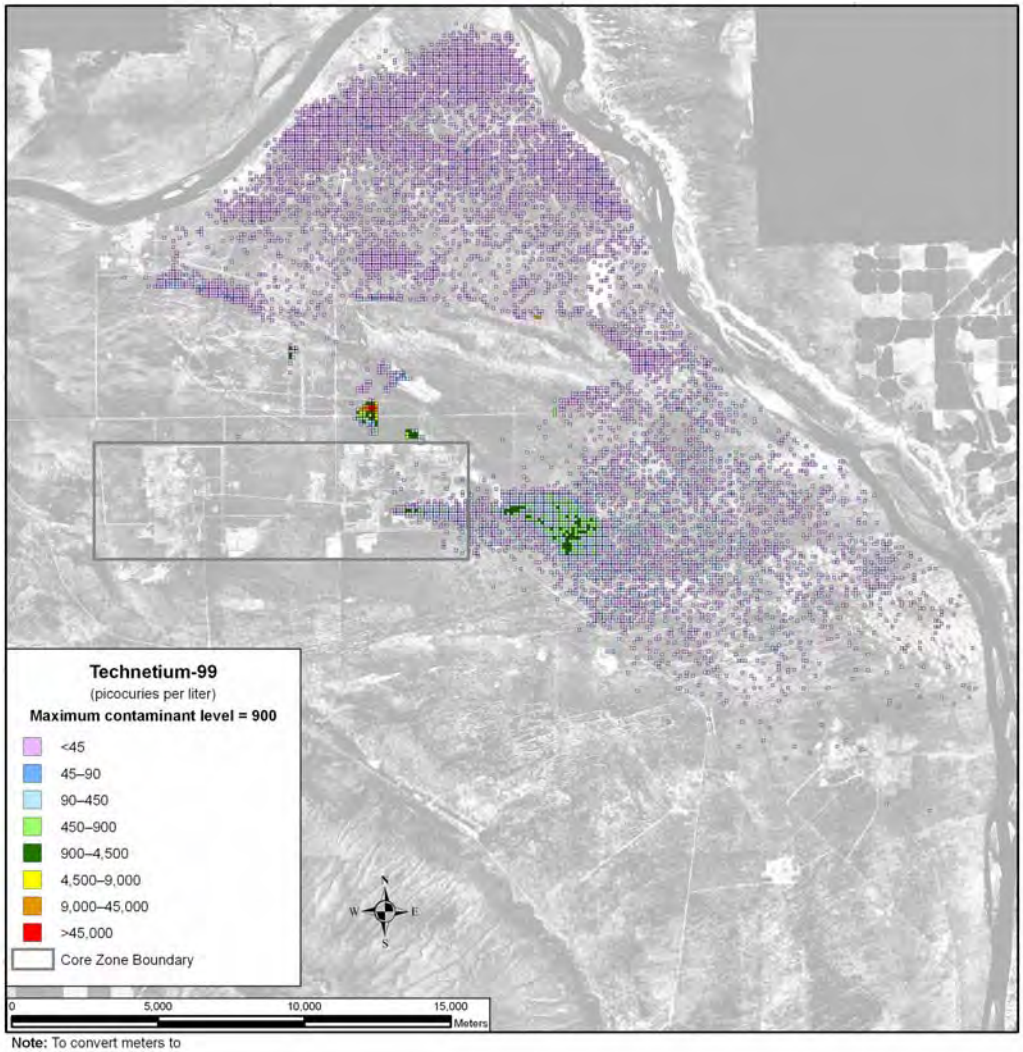
Note: To convert meters to feet, multiply by 3.281

Figure 5–1265. Alternative Combination 3 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 2005



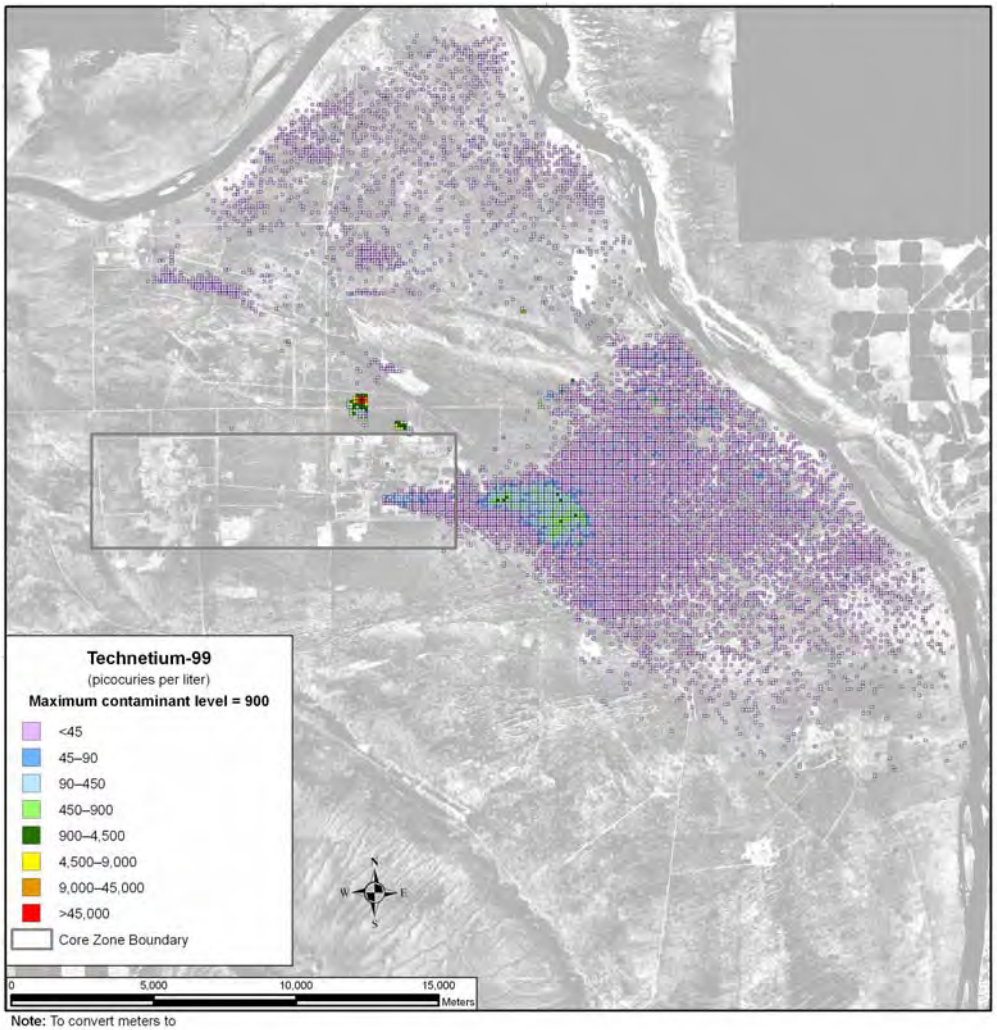
Note: To convert meters to feet, multiply by 3.281

Figure 5–1266. Alternative Combination 3 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1267. Alternative Combination 3 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–1268. Alternative Combination 3 Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

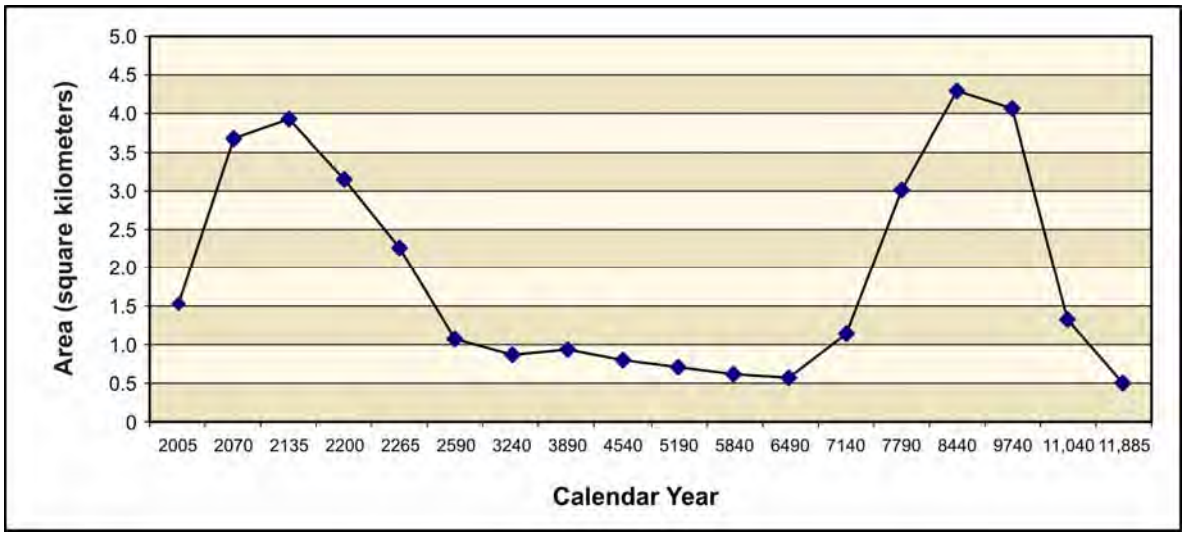
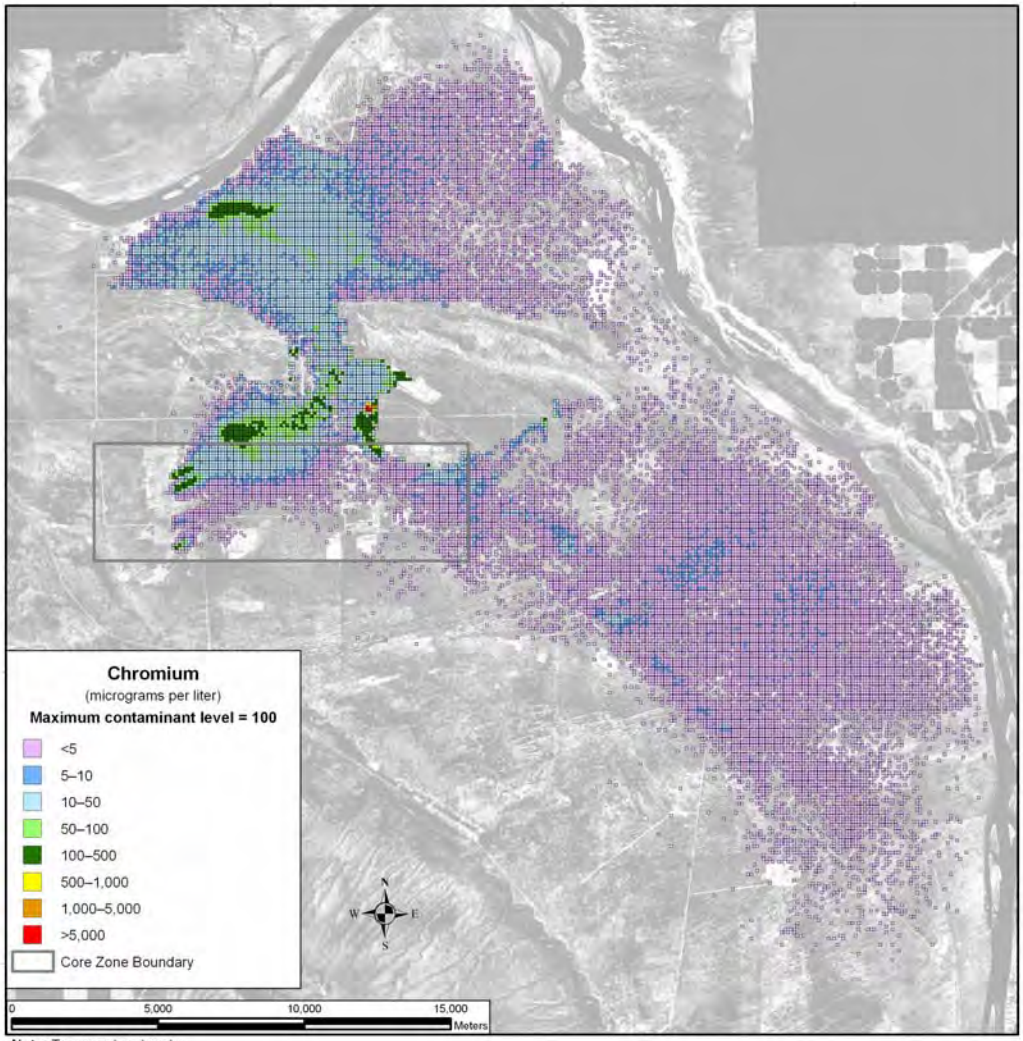
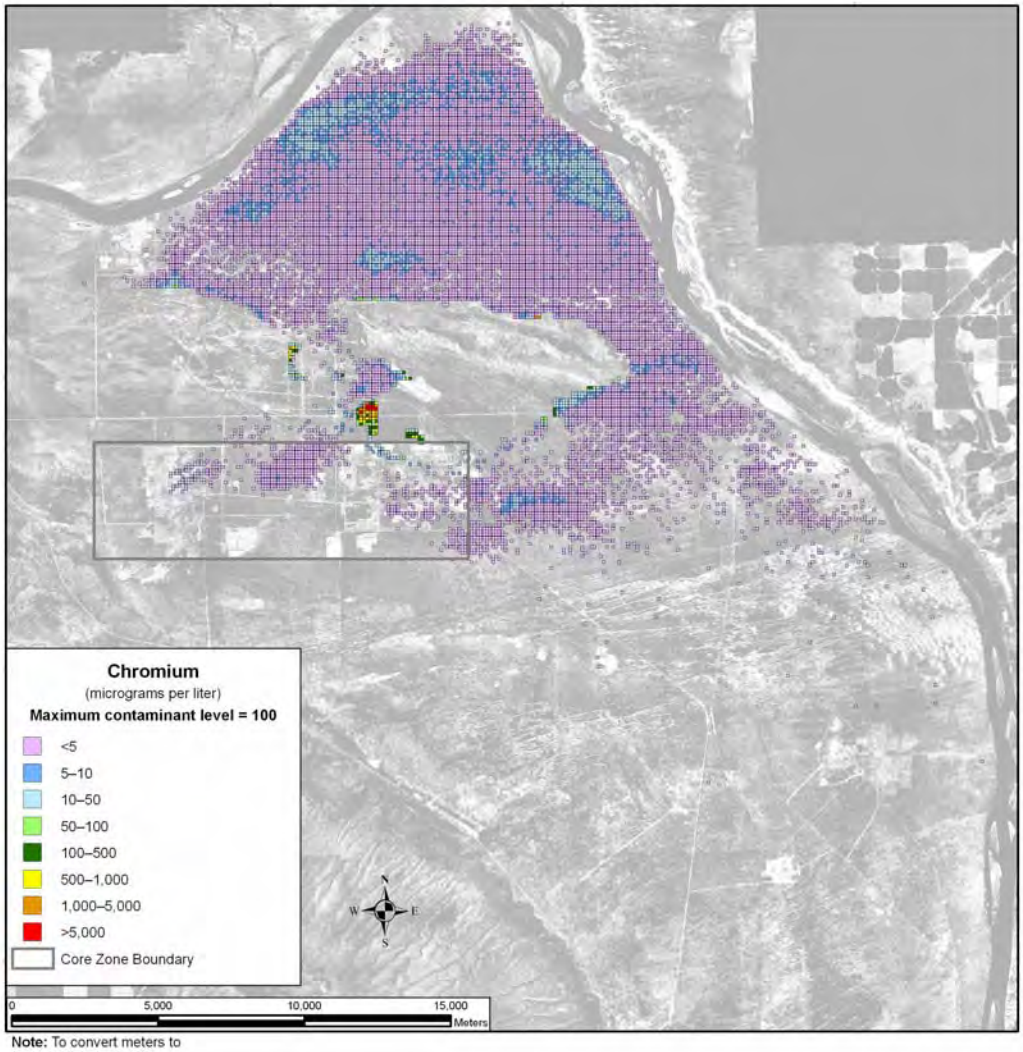


Figure 5–1269. Alternative Combination 3 Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time



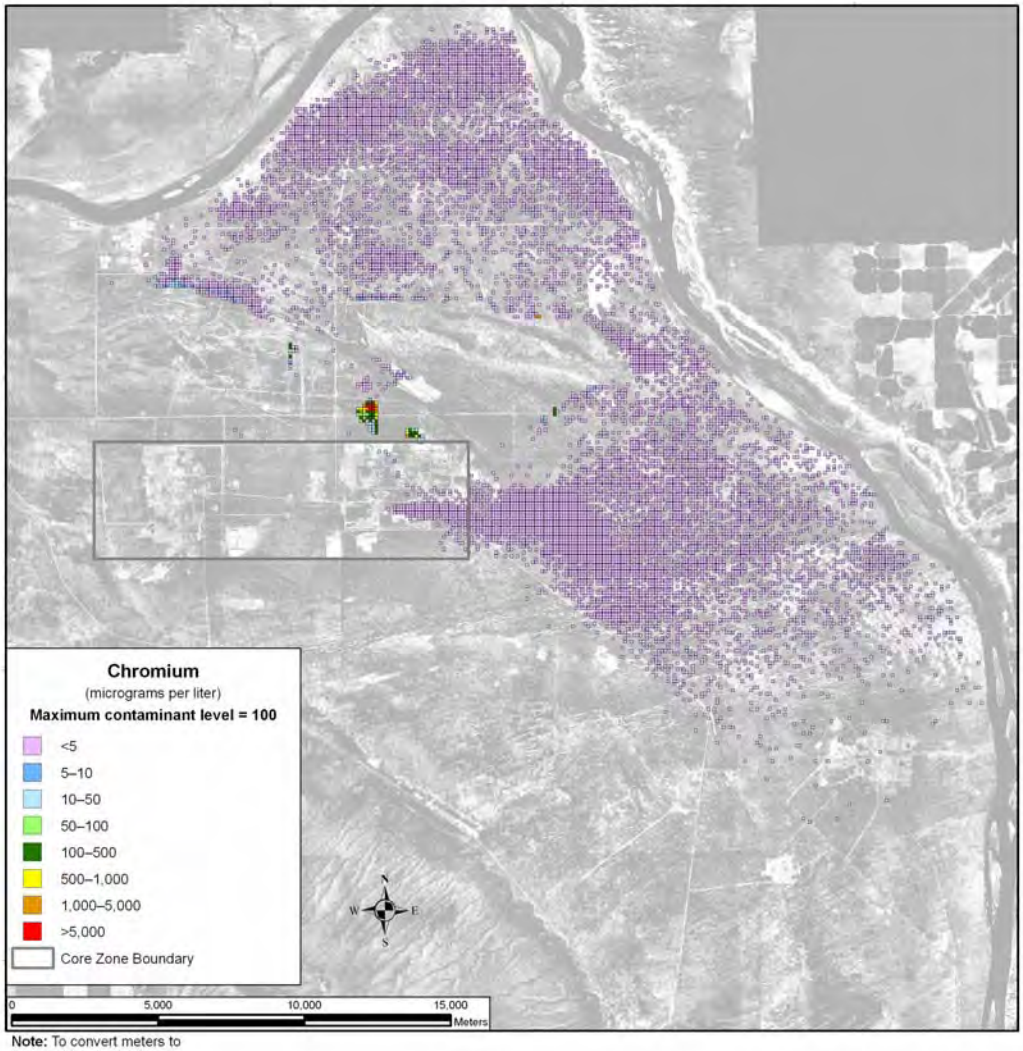
Note: To convert meters to feet, multiply by 3.281

Figure 5–1270. Alternative Combination 3 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 2005



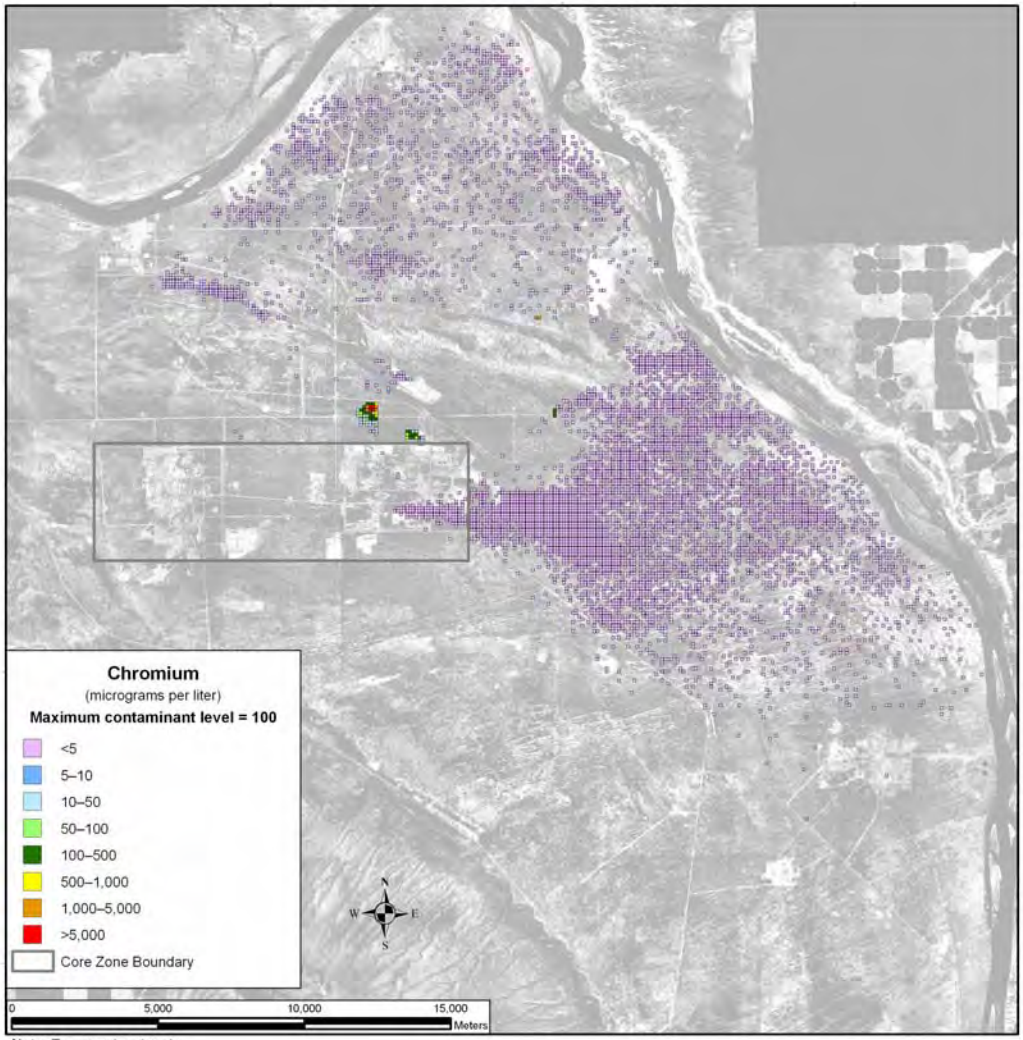
Note: To convert meters to feet, multiply by 3.281

Figure 5–1271. Alternative Combination 3 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



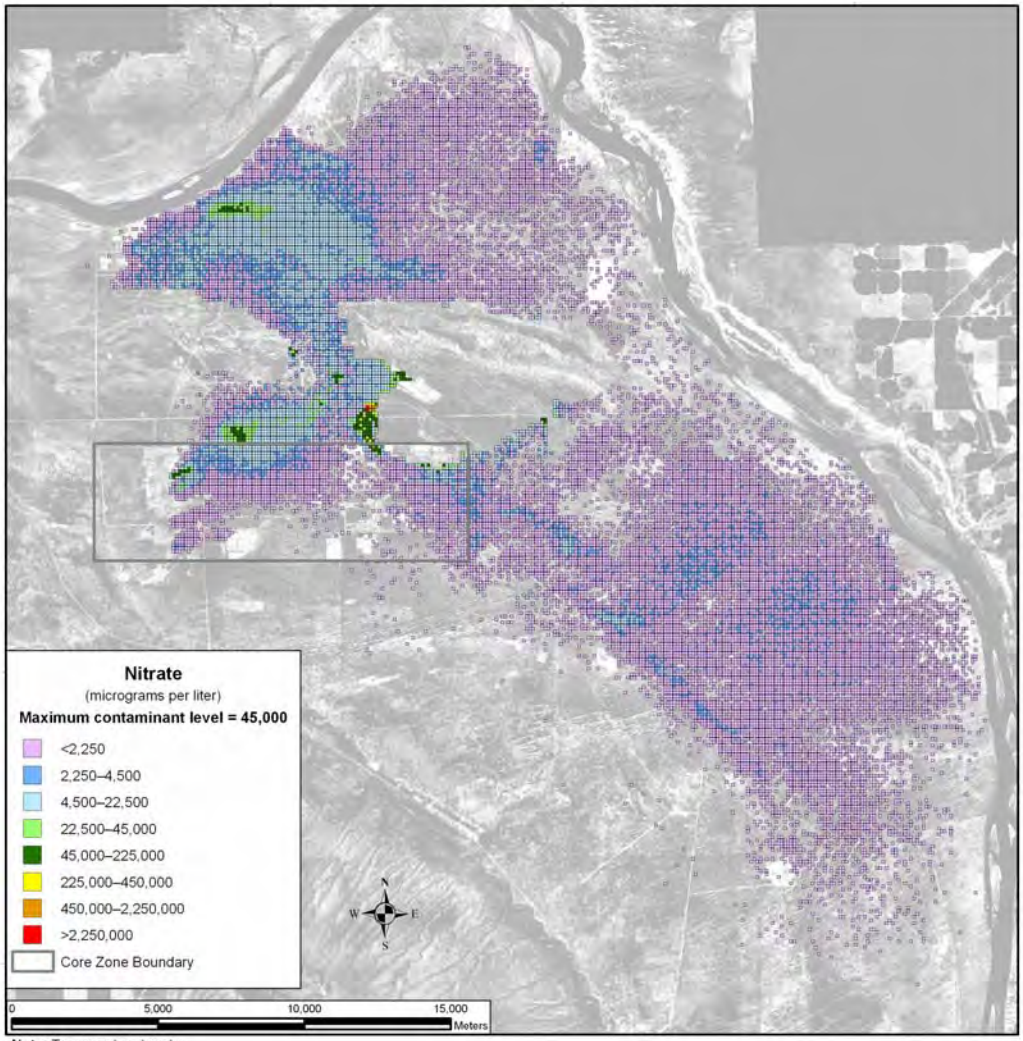
Note: To convert meters to feet, multiply by 3.281

Figure 5–1272. Alternative Combination 3 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



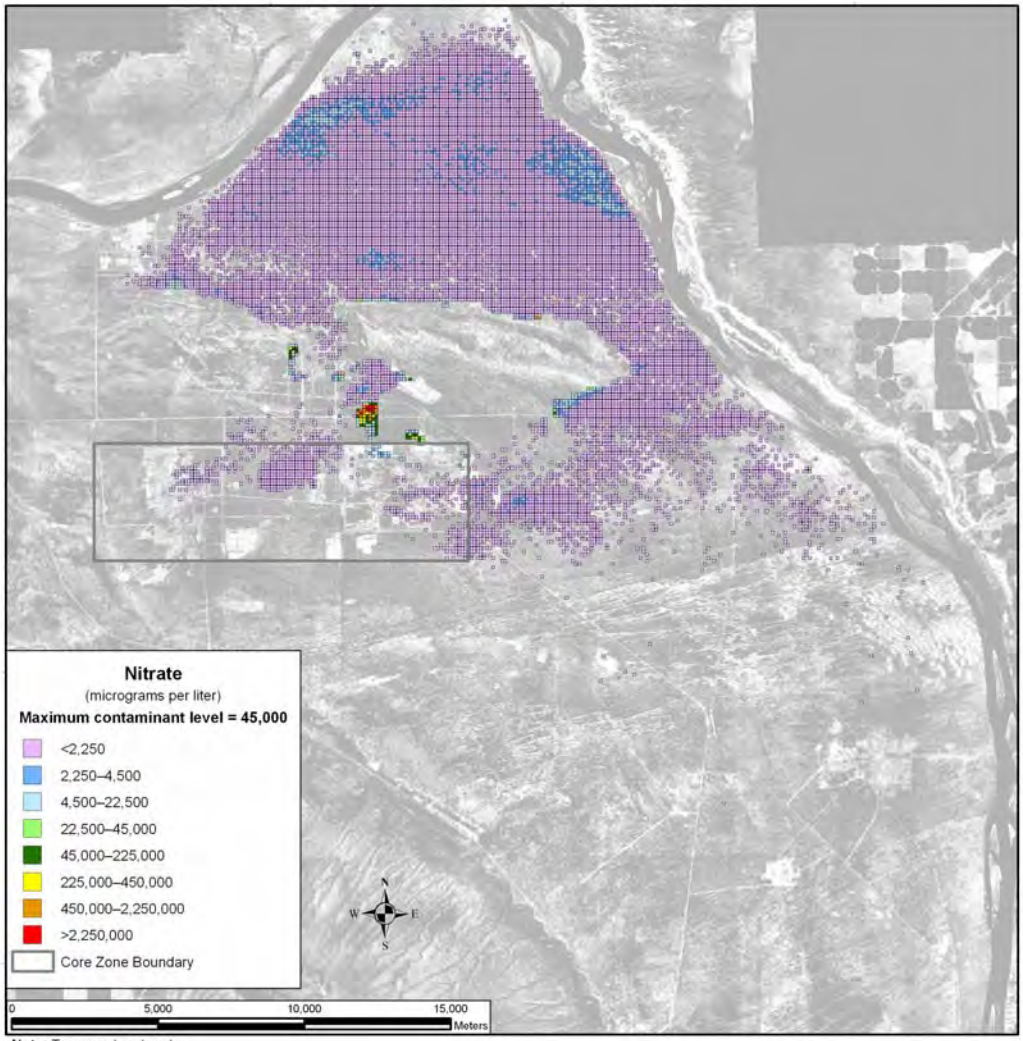
Note: To convert meters to feet, multiply by 3.281

Figure 5–1273. Alternative Combination 3 Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



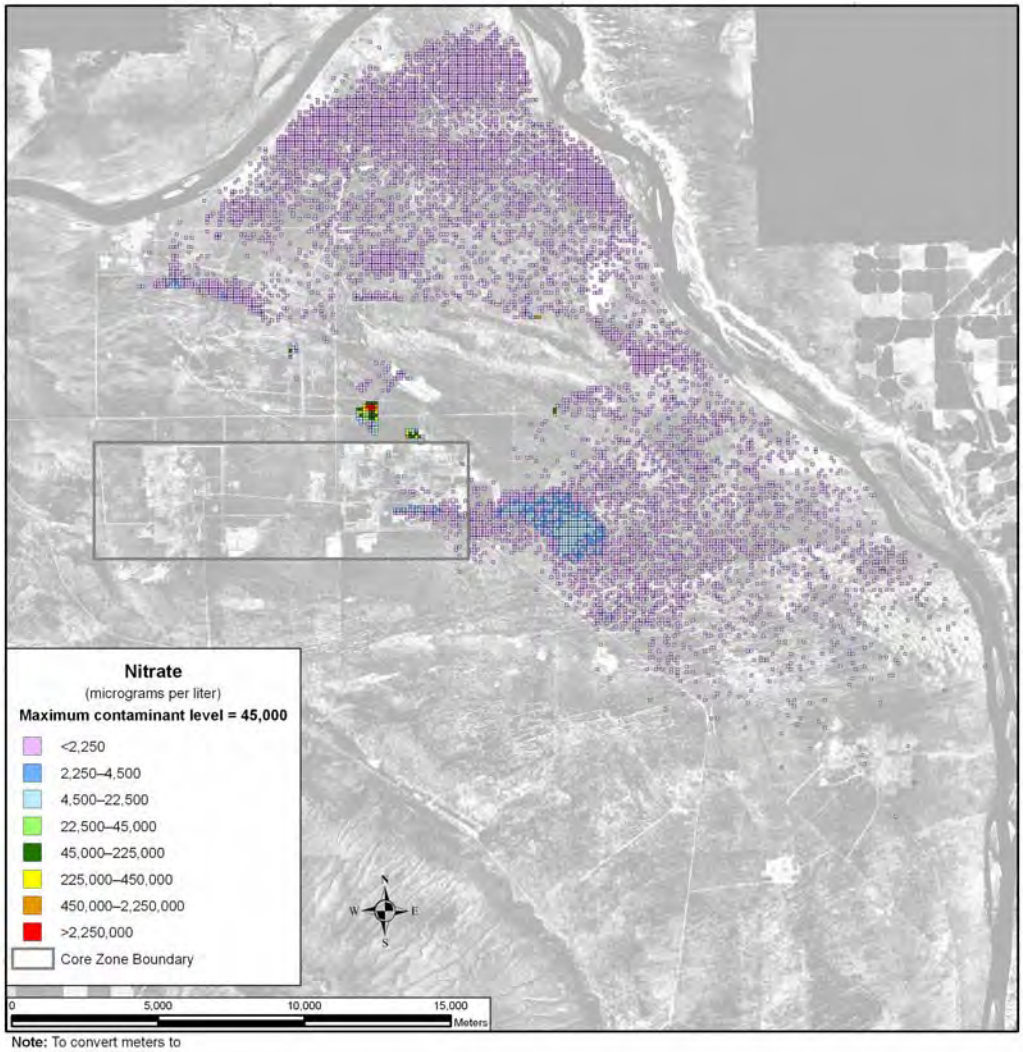
Note: To convert meters to feet, multiply by 3.281

Figure 5–1274. Alternative Combination 3 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 2005



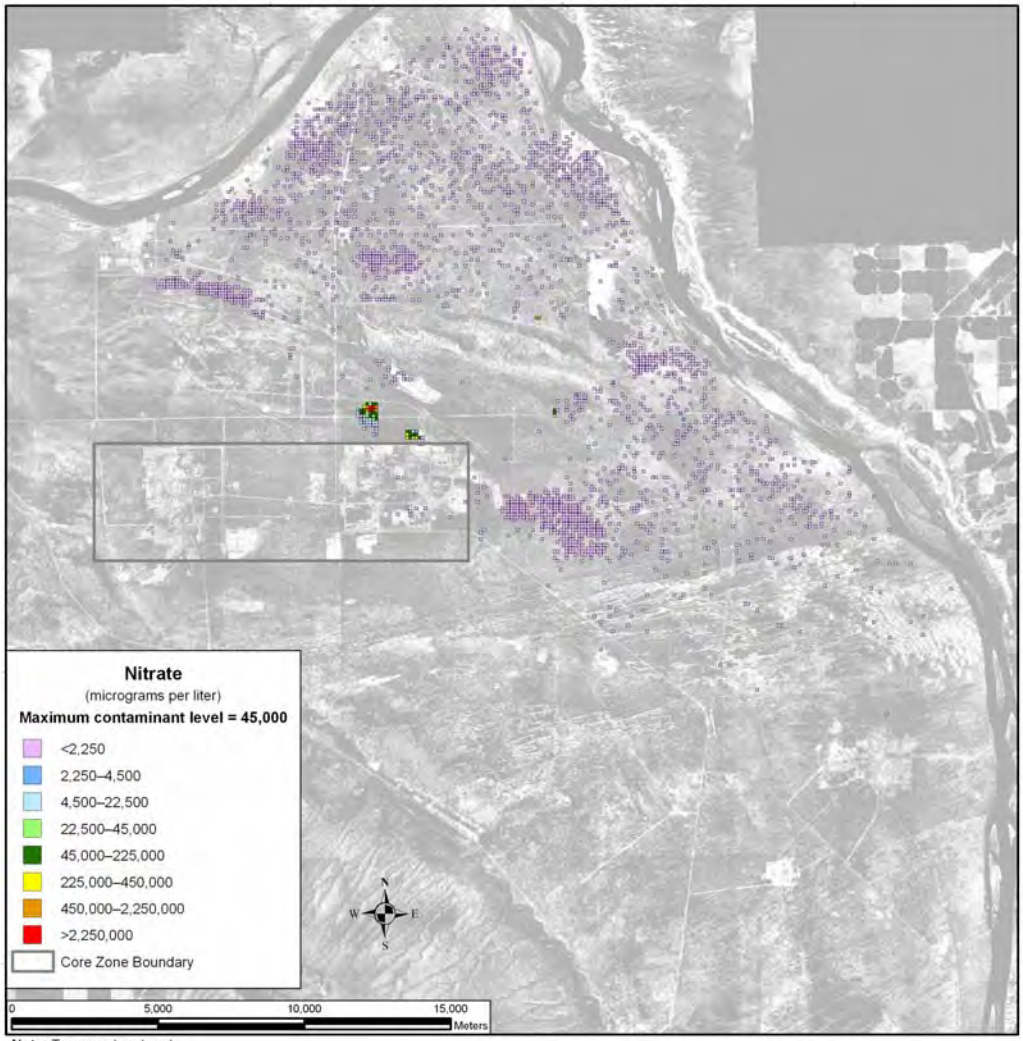
Note: To convert meters to feet, multiply by 3.281

Figure 5–1275. Alternative Combination 3 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

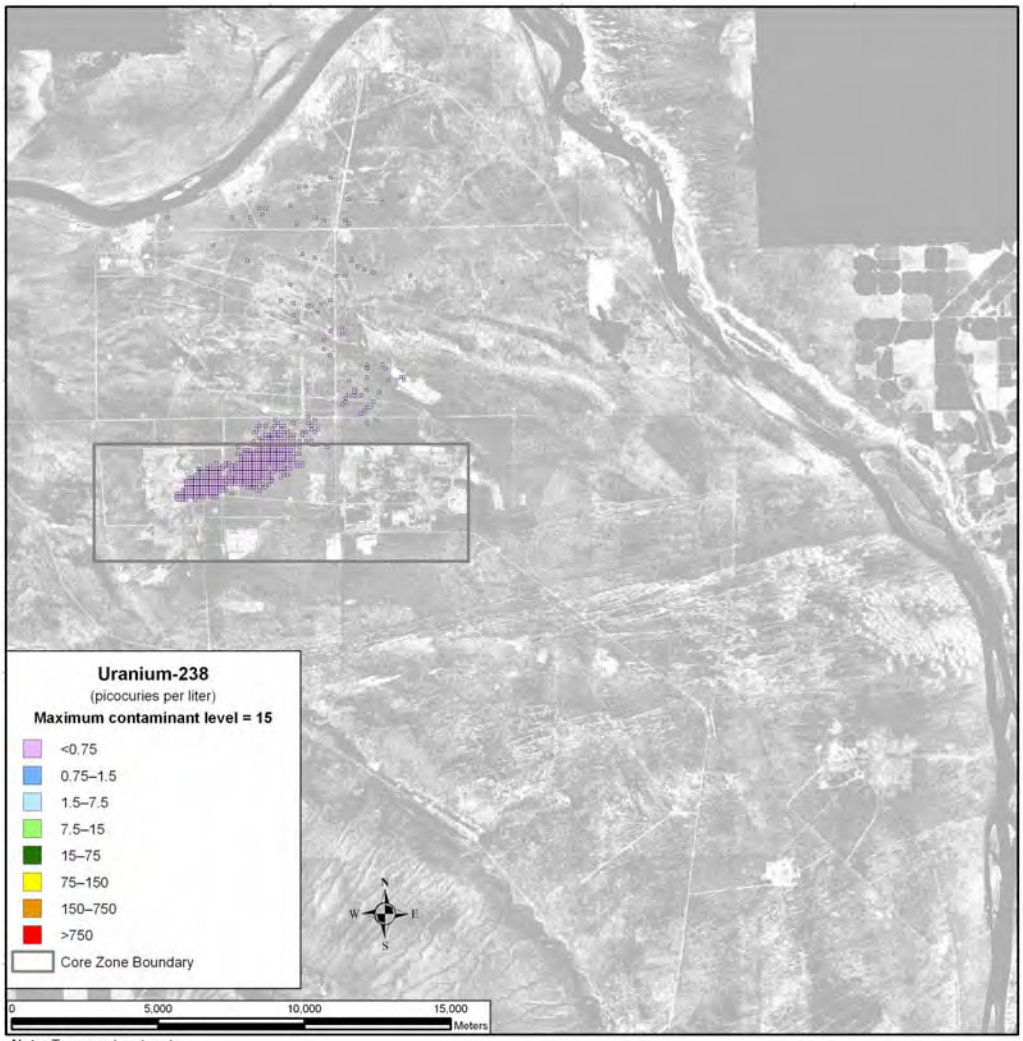
Figure 5–1276. Alternative Combination 3 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

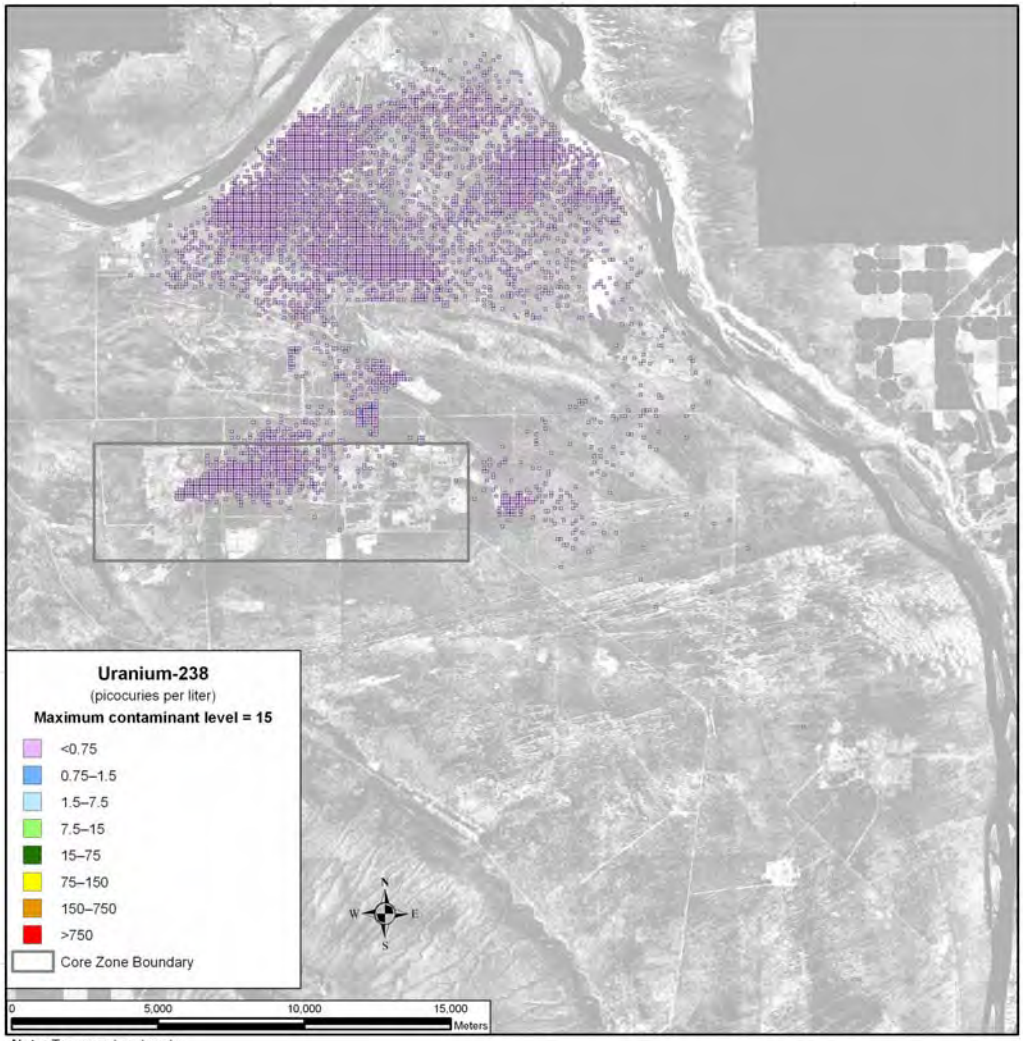
Figure 5–1277. Alternative Combination 3 Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Uranium-238 and total uranium show different spatial distributions over time. These COPCs are not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–1278 shows the distribution of uranium-238 during CY 2135. There is a small plume associated with cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark and contained within the Core Zone Boundary. By CY 3890 (see Figure 5–1279), the area of the plume has grown, but there are no significant increases in peak concentration. At CY 11,885 (see Figure 5–1280), the greatest development of the plume during the analysis period is seen. Figure 5–1281 shows the total area for which groundwater concentrations of uranium-238 exceed the benchmark concentration as a function of time. The area of exceedance is largest near the end of the period of analysis. Figures 5–1282 through 5–1284 show the corresponding spatial distribution for total uranium.



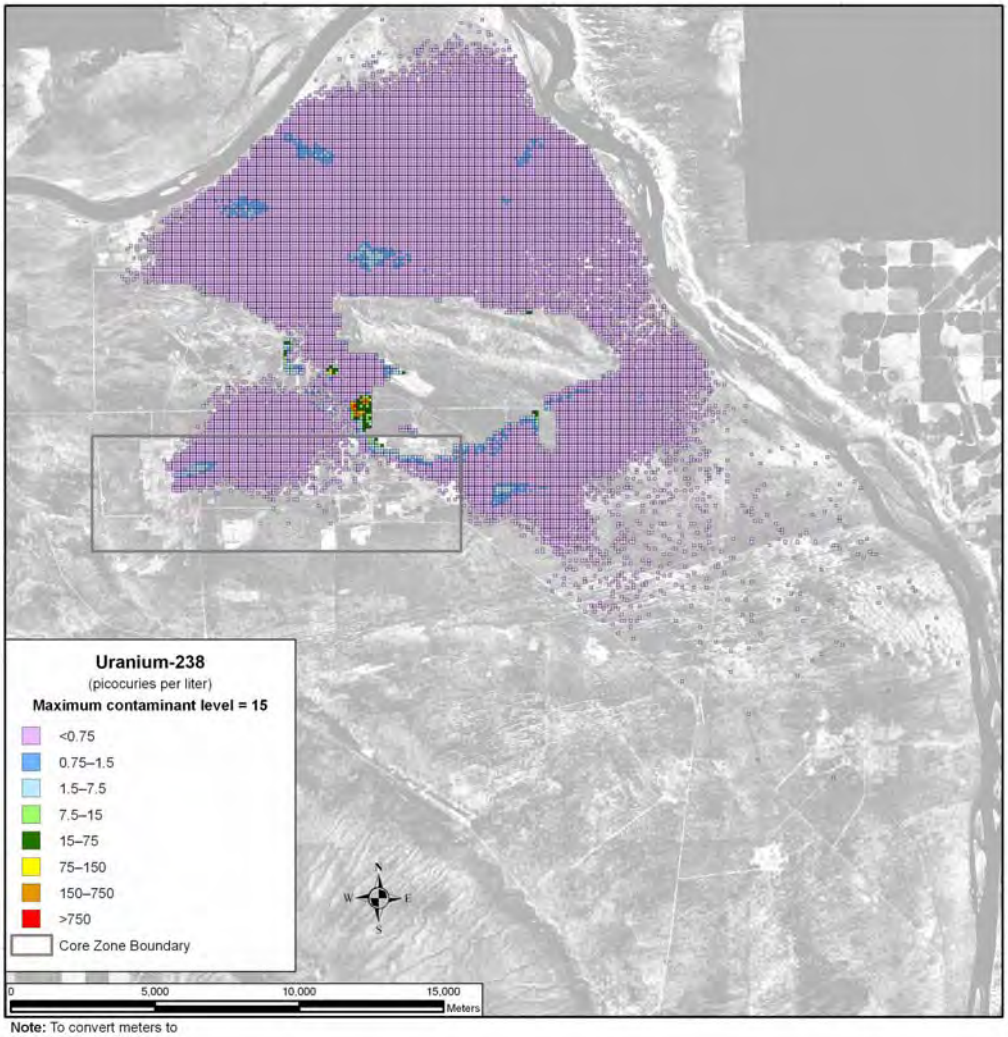
Note: To convert meters to feet, multiply by 3.281

Figure 5–1278. Alternative Combination 3 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281

Figure 5–1279. Alternative Combination 3 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1280. Alternative Combination 3 Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

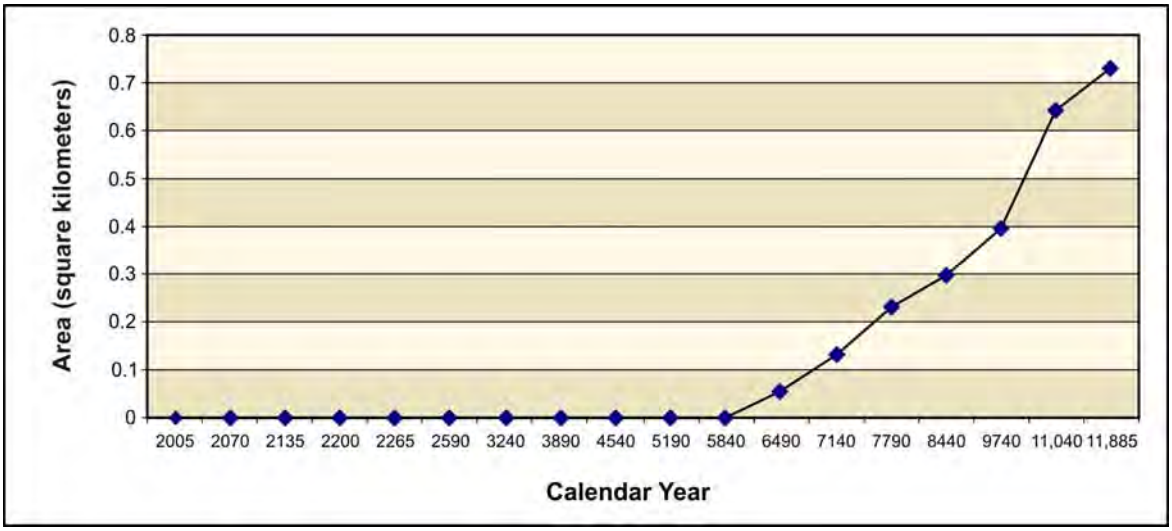
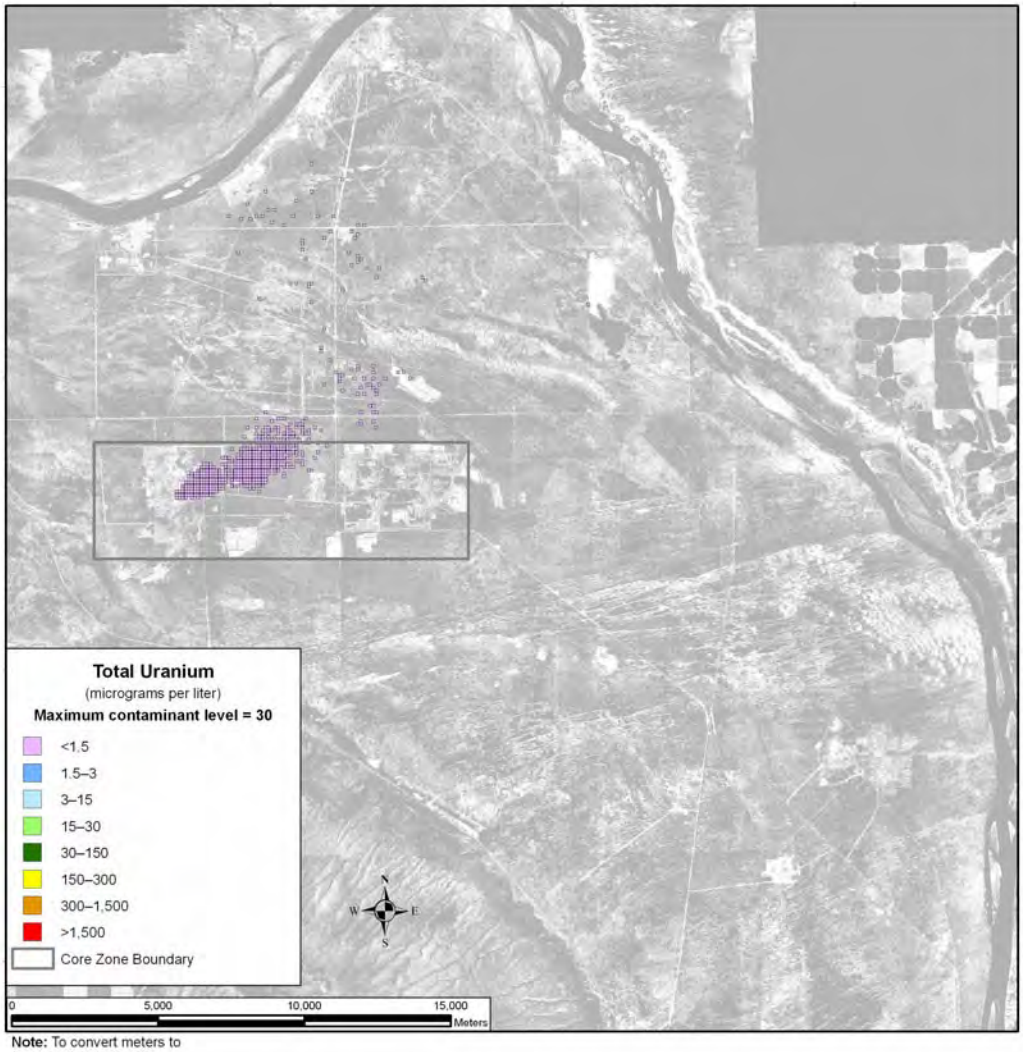
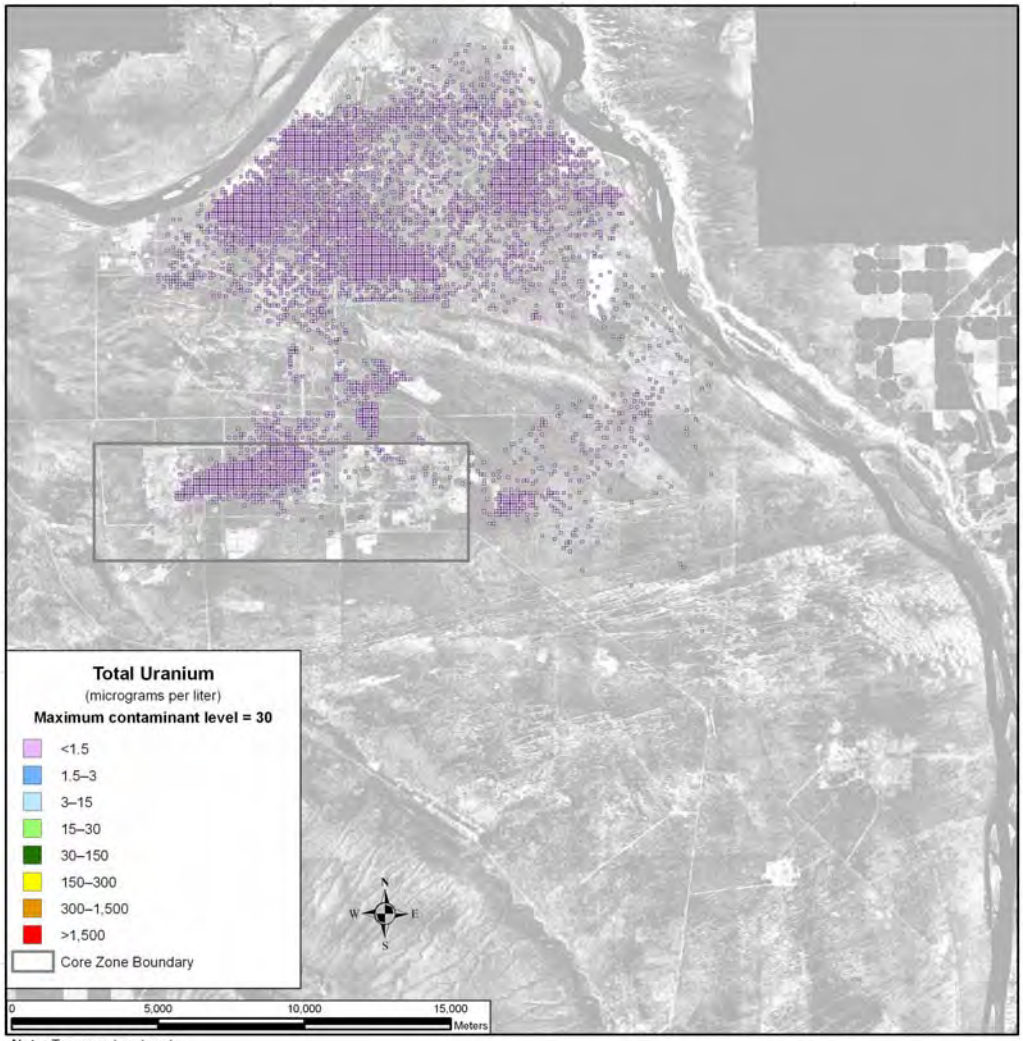


Figure 5–1281. Alternative Combination 3 Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time



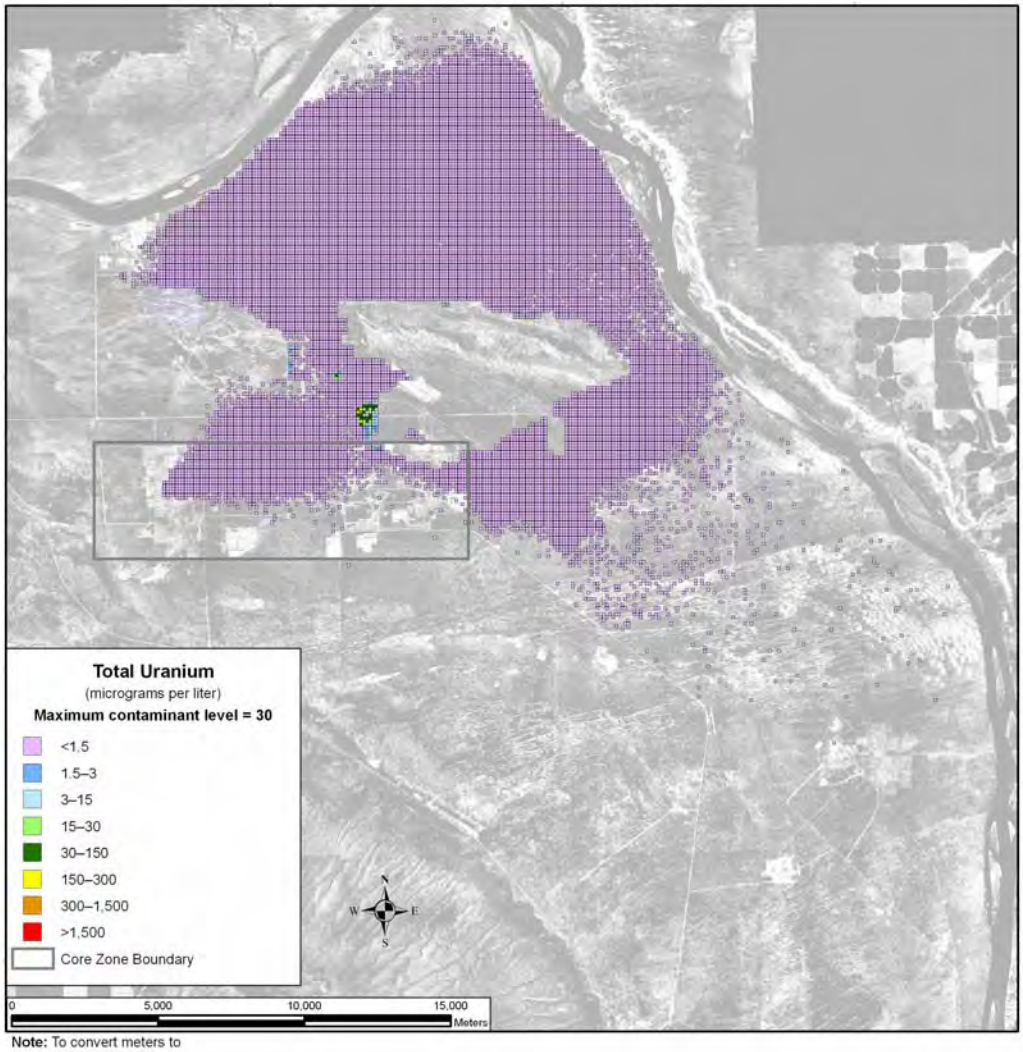
Note: To convert meters to feet, multiply by 3.281

Figure 5–1282. Alternative Combination 3 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281

Figure 5–1283. Alternative Combination 3 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–1284. Alternative Combination 3 Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

The long-term impacts for Alternative Combination 3 are dominated by tank farm sources (cribs and trenches [ditches] and past leaks) for tritium, uranium-238, chromium, nitrate, and total uranium. The dominant contributors for iodine-129 and technetium-99 are waste management sources, particularly offsite waste disposed of at IDF-East. Contributions from FFTF Decommissioning Alternative 3 sources are essentially negligible.

For the conservative tracers, concentrations at the Core Zone Boundary exceed benchmark standards by an order of magnitude during the first several thousand years of the period of analysis, and concentrations at the Columbia River nearshore are about an order of magnitude lower. For chromium and nitrate, the concentration trend decreases with time past CY 6000. For iodine-129 and technetium-99, the concentration trend is level with respect to time, and concentrations are within an order of magnitude of the benchmark concentration at both the Core Zone Boundary and the Columbia River nearshore. The intensities and areas of these groundwater plumes are highest during the early and later parts of the period of analysis.

For tritium, concentrations at the Core Zone Boundary exceed the benchmark by about three orders of magnitude during the first 100 years of the period of analysis. Concentrations at the Columbia River nearshore approach the benchmark during this time. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts by tritium. After CY 2100, tritium impacts are essentially negligible.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species approach, but do not exceed, the benchmark at the Core Zone Boundary beyond CY 9000, and remain at least an order of magnitude lower than the benchmark at the Columbia River nearshore after CY 10,000. The intensity is highest and the area of the contamination plume largest near the end of the period of analysis.

5.4.2 Human Health Impacts

This section evaluates long-term impacts on human health as a result of the three combinations of Tank Closure, FFTF Decommissioning, and Waste Management alternatives. Alternative Combination 1 comprises the No Action Alternatives for tank closure (Tank Closure Alternative 1), FFTF decommissioning (FFTF Decommissioning Alternative 1), and waste management (Waste Management Alternative 1). Alternative Combination 2 comprises Tank Closure Alternative 2B; FFTF Decommissioning Alternative 2 (Entombment); and Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A. Alternative Combination 3 comprises Tank Closure Alternative 6B, Base Case; FFTF Decommissioning Alternative 3 (Removal); and Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

The long-term human health impacts due to release of radionuclides are estimated as dose and lifetime risk of incidence of cancer. Potential human health impacts due to release of chemical constituents include both carcinogenic effects and other forms of toxicity. Impacts of carcinogenic chemicals are estimated as lifetime risk of incidence of cancer. Noncarcinogenic effects are estimated as Hazard Quotient, the ratio of the long-term intake of a single chemical to intake that produces no observable effect, and as Hazard Index, the sum of the Hazard Quotients of a group of chemicals.

As with the individual alternatives, four measures of human health impacts are considered in this analysis—lifetime risks of developing cancer from radiological and chemical constituents, dose from radiological constituents, and Hazard Index from chemical constituents. These measures are calculated for each year for 10,000 years for each receptor at four locations (i.e., facility barriers, Core Zone Boundary, Columbia River nearshore, and Columbia River surface water). This is a large amount of information that must be summarized to allow interpretation of results. The method chosen is to present dose for the year of maximum dose, risk for the year of maximum risk, and Hazard Index for the year of maximum Hazard Index. This choice is based on regulation of radiological impacts as dose and the analysis results that peak risk and peak noncarcinogenic impacts expressed as Hazard Index may occur at times other than that of peak dose.

Onsite locations are the facility barriers, Core Zone Boundary, and Columbia River nearshore. Offsite locations are access points to Columbia River surface water near the site and at population centers downstream of the site. Estimates of concentration of constituents in the Columbia River surface water are used to calculate impacts for both offsite location points of analysis. Total offsite population is 5 million people. Four types of receptor are considered. The first type, a drinking-water well user, uses groundwater as a source of drinking water. The second type, a resident farmer, uses groundwater for drinking water consumption and irrigation of crops. Garden size and crop yield are assumed adequate to produce approximately 25 percent of average requirements of crops and animal products. The third type, an American Indian resident farmer, also uses groundwater for drinking water consumption and irrigation of crops. Garden size and crop yield are assumed adequate to produce the entirety of average

requirements of crops and animal products. The fourth type, an American Indian hunter-gatherer, is impacted by both groundwater and surface water because he uses surface water for drinking water consumption and consumes both wild plant materials, which use groundwater, and game animals, which use surface water.

The significance of dose impacts is evaluated by comparison with the 100-millirem-per-year all-exposure modes standard specified for protection of the public and the environment in DOE Order 5400.5, *Radiation Protection of the Public and the Environment*. The level of protection provided for the drinking water pathway is evaluated by comparison with applicable drinking water standards presented in Section 5.1.1. Population doses are compared with the total effective dose equivalent from background sources of 365 millirem per year for a member of the population of the United States (NCRP 1987). The significance of noncarcinogenic chemical impacts is evaluated by comparison with a Hazard Index guideline value of unity.

5.4.2.1 Alternative Combination 1

Potential human health impacts of Alternative Combination 1 for the years of peak impact for the time period beginning in CY 1940 are summarized in Tables 5–165 and 5–166. The key radiological constituent contributors to human health risk are tritium, technetium-99, iodine-129, and uranium isotopes. The chemical risk and hazard drivers are acetonitrile, boron and boron compounds, chromium, fluoride, nitrate, and total uranium. For radionuclides, the dose standard would be exceeded at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the Core Zone Boundary and the Columbia River nearshore location for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 3.39 person-rem per year for the year of maximum impact.

The time series of lifetime radiological risk for the drinking-water well user at the Core Zone Boundary are presented in Figures 5–1285 and 5–1286 for Tank Closure Alternative 1 and Waste Management Alternative 1, respectively. The time series of lifetime radiological risk for the drinking-water well user at the FFTF Barrier is presented in Figure 5–1287 for FFTF Decommissioning Alternative 1. Impacts estimated for FFTF Decommissioning Alternative 1 and Waste Management Alternative 1 are lower than those estimated for Tank Closure Alternative 1 because FFTF has a lower inventory of radiological constituents and Waste Management Alternative 1 considers disposal only of onsite-generated LLW that is not related to tank closure activities. Tank Closure Alternative 1 assumes catastrophic failure of HLW tanks after loss of institutional control, leading to lifetime risk on the order of 0.02 at CY 3800 and long-term risk on the order of 0.002. In addition, planned discharges to cribs and trenches (ditches) and past leaks from tanks produce estimates of a high level of risk for the near-term period and elevated risk extending through the entire long-term period.

Table 5–165. Alternative Combination 1 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Core Zone Boundary	7.44×10^{2}	5.12×10^{2}	2.26×10^{-2}	2.99×10^{-11}	2.26×10^{-2}	1.73×10^{3}	5.88×10^{2}	7.12×10^{-2}	1.13×10^{-7}	7.12×10^{-2}
Columbia River near shore	1.19×10^{1}	1.88	3.40×10^{-4}	6.19×10^{-13}	3.40×10^{-4}	2.62×10^{1}	1.98	1.07×10^{-3}	6.47×10^{-10}	1.07×10^{-3}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.77×10^{-4}	1.60×10^{-4}	2.76×10^{-8}	3.39×10^{-14}	2.76×10^{-8}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–166. Alternative Combination 1 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On site										
Core Zone Boundary	3.40×10^{3}	1.02×10^{3}	1.54×10^{-1}	5.17×10^{-3}	1.55×10^{-1}	N/A	N/A	N/A	N/A	N/A
Columbia River near shore	5.11×10^{1}	3.10	2.30×10^{-3}	2.97×10^{-5}	2.32×10^{-3}	5.44×10^{-1}	1.14	6.69×10^{-6}	1.48×10^{-5}	1.77×10^{-5}
Off site										
Columbia River	2.61×10^{-3}	2.10×10^{-1}	9.42×10^{-8}	1.56×10^{-9}	9.47×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

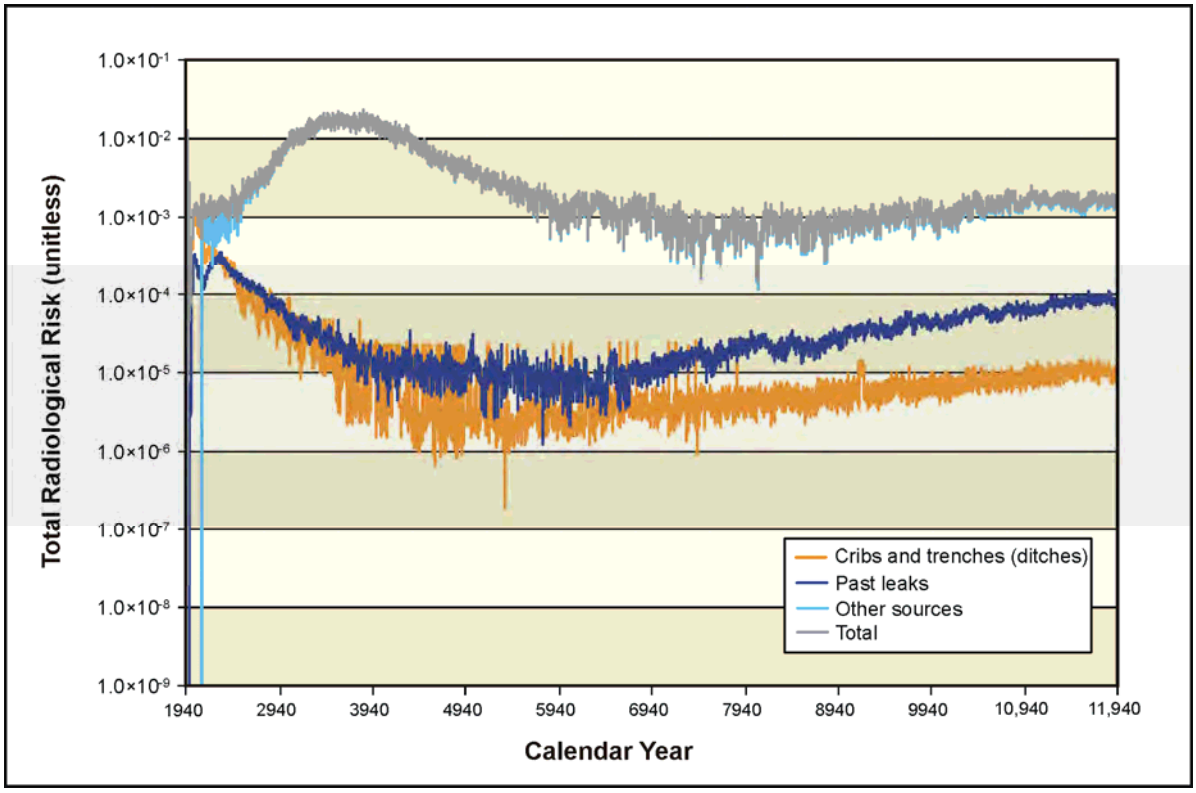


Figure 5–1285. Tank Closure Alternative 1 Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

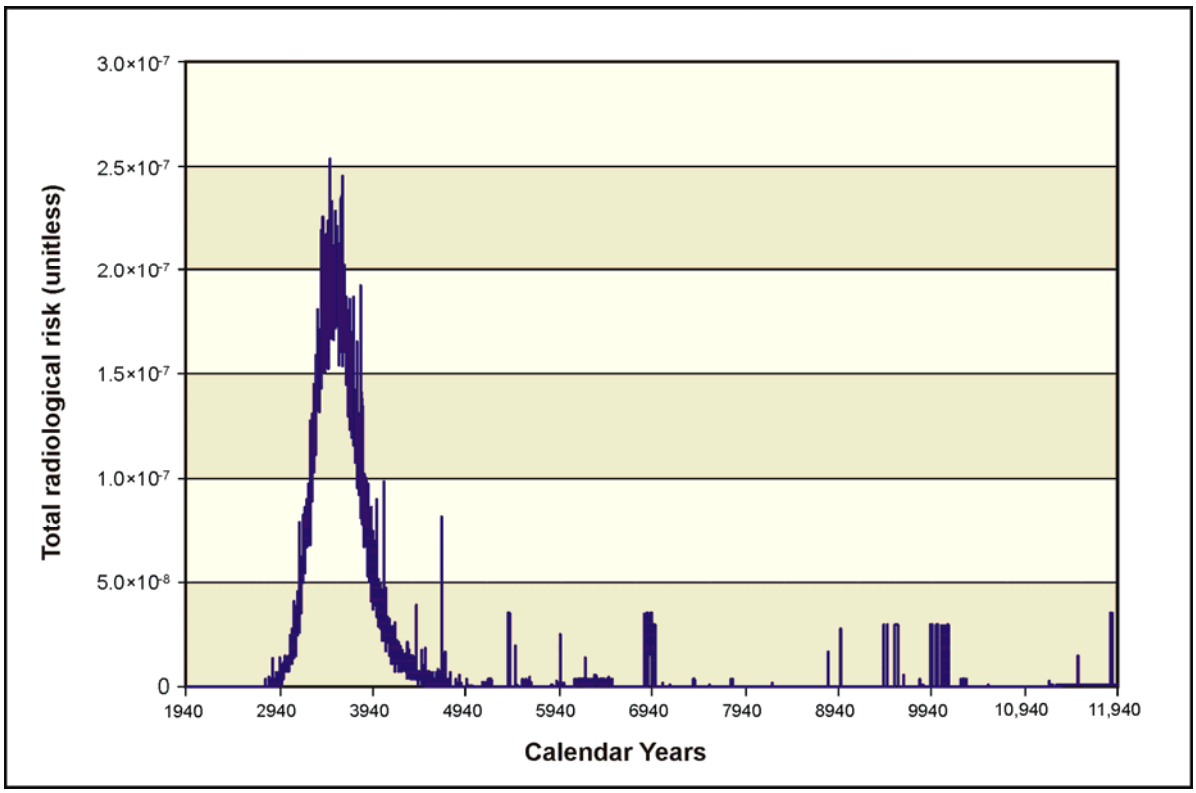


Figure 5–1286. Waste Management Alternative 1 Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

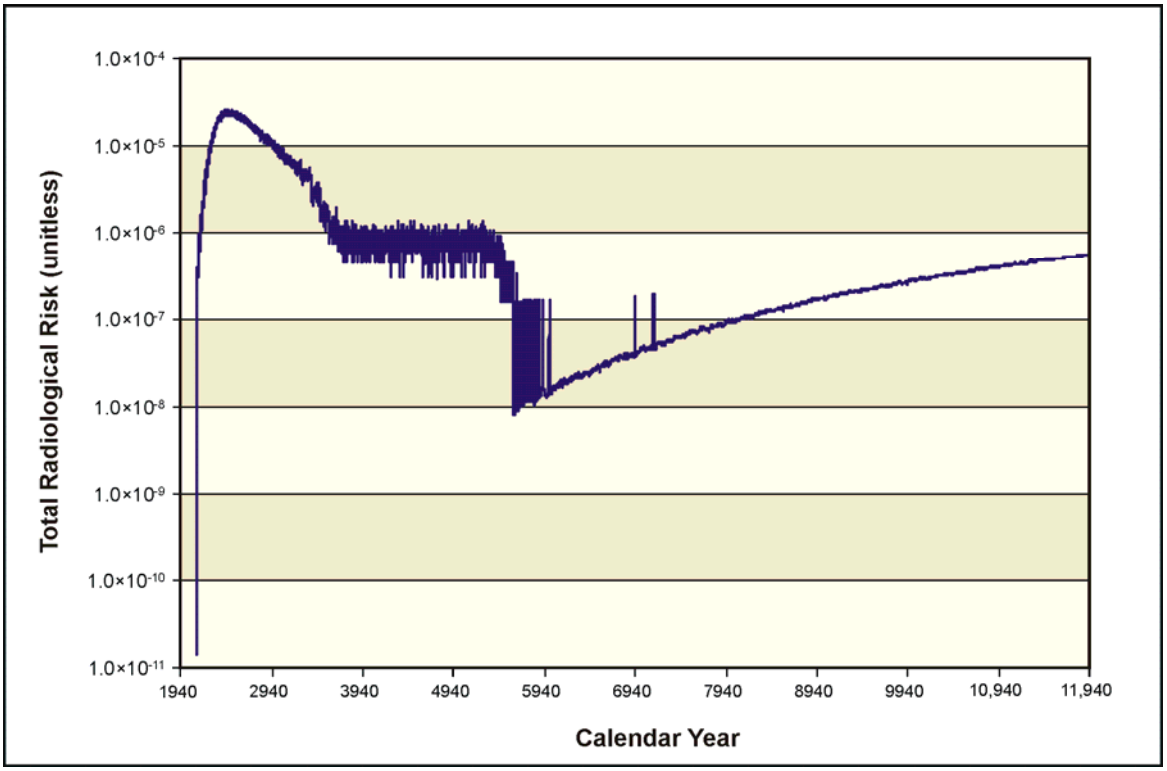


Figure 5–1287. FFTF Decommissioning Alternative 1 Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the FFTF Barrier

5.4.2.2 Alternative Combination 2

Potential human health impacts of Alternative Combination 2 for the year of peak impact for the time period beginning in CY 1940 are summarized in Tables 5–167 and 5–168. The key radiological constituent contributors to human health risk are tritium, carbon-14, technetium-99, iodine-129, and uranium isotopes. The chemical risk and hazard drivers are chromium and nitrate. For radionuclides, the dose standard would be exceeded at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 9.53×10^{-1} person-rem per year for the year of maximum impact.

The time series of lifetime radiological risk for the drinking-water well user at the Core Zone Boundary are presented in Figures 5–1288 and 5–1289 for Tank Closure Alternative 2B and Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, respectively. The time series of lifetime radiological risk for the drinking-water well user at the FFTF Barrier is presented in Figure 5–1290 for FFTF Decommissioning Alternative 2. Tank Closure Alternative 2B assumes retrieval of 99 percent of tank waste, producing significant reduction in impacts relative to Tank Closure Alternative 1. Peak lifetime risk due to future releases from the tank farms is reduced by a factor of approximately 100 to 3×10^{-4}. Estimates of impacts for planned discharges to cribs and trenches (ditches) and past leaks from tanks are similar to those for Tank Closure Alternative 1, with estimates of high level of risk, approximately 0.02, for the near-term period and elevated risk extending through the entire long-term period. The estimate of peak lifetime risk at the Core Zone Boundary under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, is approximately 3×10^{-5}. Disposal of offsite waste at IDF-East is the major contributor to this risk, while disposal of ETF-generated, tank closure, and secondary waste account for the remainder of the total risk. The estimate of peak lifetime risk for release from the entombed FFTF is approximately 2×10^{-5}.

Table 5–167. Alternative Combination 2 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On site										
Core Zone Boundary	6.36×10^{2}	4.97×10^{2}	1.24×10^{-2}	3.26×10^{-14}	1.24×10^{-2}	1.24×10^{3}	5.70×10^{2}	3.48×10^{-2}	1.10×10^{-7}	3.48×10^{-2}
Columbia River nearshore	2.64	4.35×10^{-1}	5.12×10^{-5}	1.07×10^{-15}	5.12×10^{-5}	4.09	4.70×10^{-1}	1.49×10^{-4}	1.35×10^{-10}	1.49×10^{-4}
Off site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.91×10^{-4}	1.63×10^{-4}	5.83×10^{-9}	3.52×10^{-14}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–168. Alternative Combination 2 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad. Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On site										
Core Zone Boundary	2.36×10^{3}	9.85×10^{2}	7.43×10^{-2}	5.05×10^{-3}	7.93×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	7.52	7.58×10^{-1}	3.15×10^{-4}	6.17×10^{-6}	3.15×10^{-4}	4.04×10^{-1}	7.14×10^{-1}	4.98×10^{-6}	3.09×10^{-6}	6.40×10^{-6}
Off site										
Columbia River	5.59×10^{-4}	2.11×10^{-1}	1.80×10^{-8}	1.61×10^{-9}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

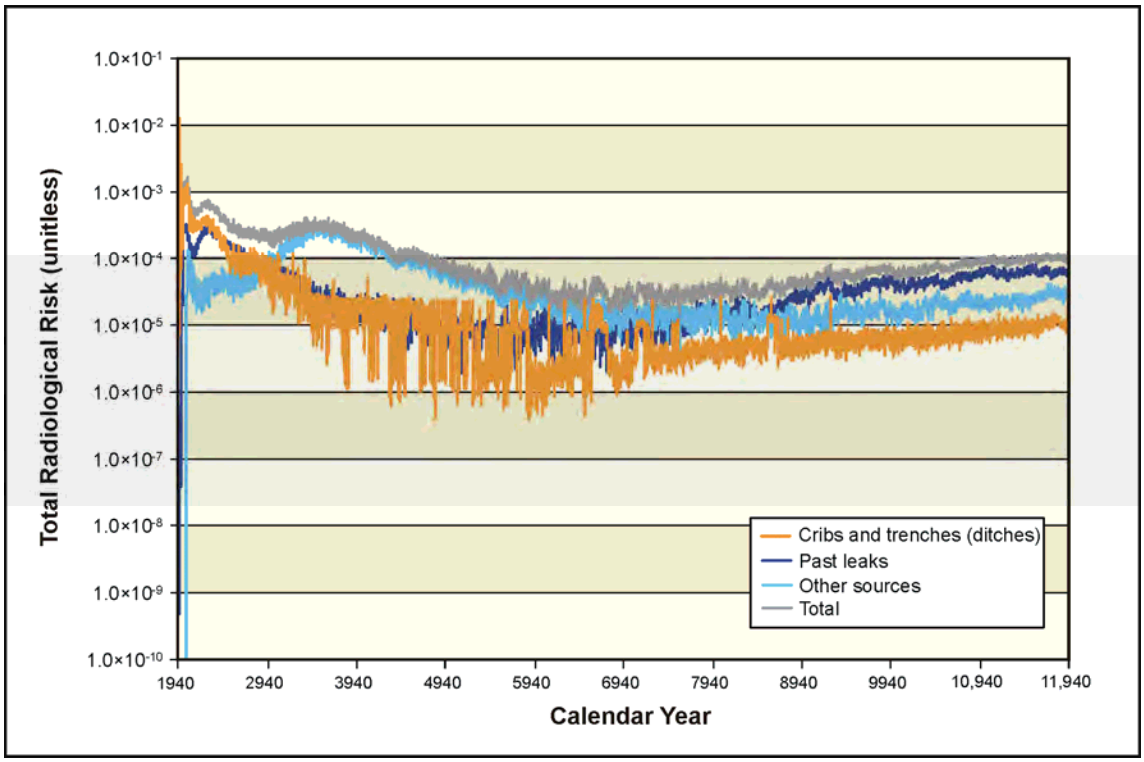


Figure 5–1288. Tank Closure Alternative 2B Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

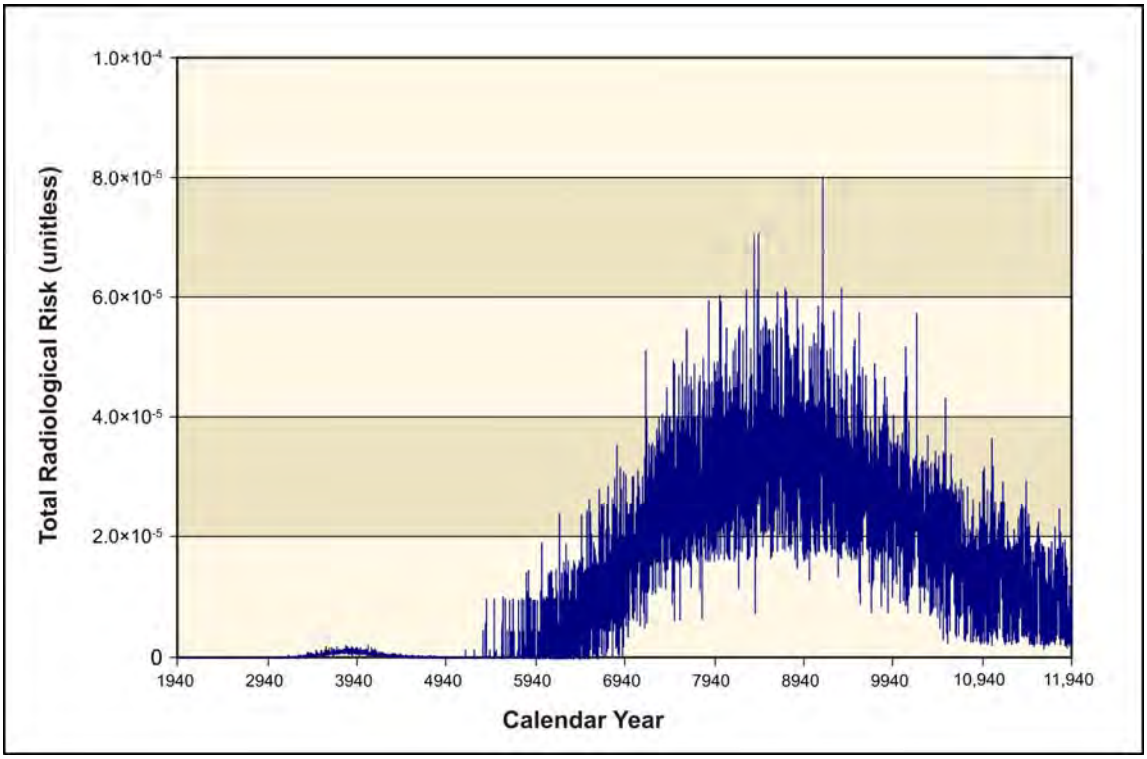


Figure 5–1289. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

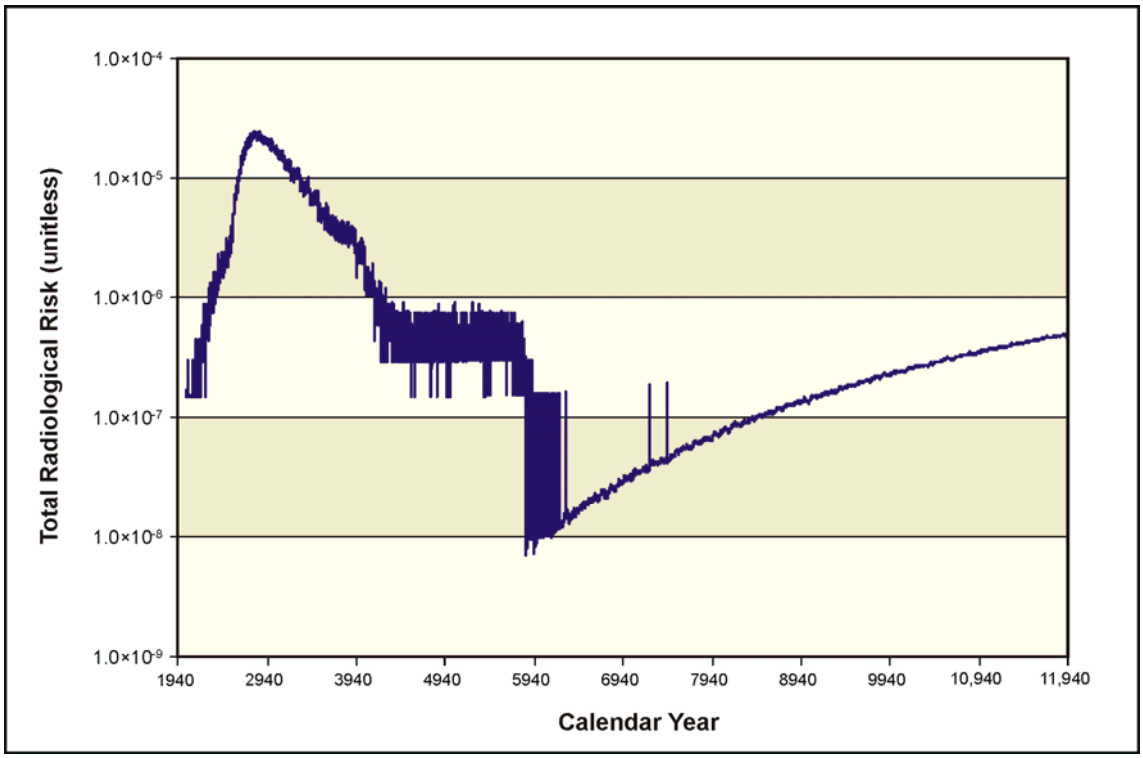


Figure 5–1290. FFTF Decommissioning Alternative 2 Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the FFTF Barrier

5.4.2.3 Alternative Combination 3

Potential human health impacts of Alternative Combination 3 are summarized in Tables 5–169 and 5–170. The key radiological constituent contributors to human health risk are tritium, technetium-99, iodine-129, and uranium isotopes. The chemical risk and hazard drivers are chromium and nitrate. For radionuclides, the dose standard would be exceeded at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer. The Hazard Index guideline would be exceeded primarily due to chromium and nitrate at the Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer. Population dose was estimated as 9.53×10^{-1} person-rem per year for the year of maximum impact.

The time series of lifetime radiological risk for the drinking-water well user at the Core Zone Boundary are presented in Figures 5–1291 and 5–1292 for Tank Closure Alternative 6B, Base Case, and Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, respectively. Tank Closure Alternative 6B, Base Case, assumes removal of the HLW waste tanks and recovery of tank farm contaminated soil, producing significant reduction in impacts relative to both Tank Closure Alternatives 1 and 2B. Risk due to future releases from the tank farms is eliminated. Estimates of impacts for planned discharges to cribs and trenches (ditches) are similar to those for Tank Closure Alternatives 1 and 2B, but long-term risk from past tank leaks are reduced by a factor of approximately 100 to approximately 1×10^{-6}. The estimate of peak lifetime risk at the Core Zone Boundary for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, approximately 4×10^{-5}, is slightly higher than that for Alternative 2, Disposal Group 1, Subgroup 1-A, reflecting disposal of greater quantities of waste. Disposal of offsite waste at IDF-East is the major contributor to the peak lifetime risk, while disposal of ETF-generated and tank closure secondary waste are secondary contributors. Increase of the disposal inventory for the RPPDF accentuates the pulse in the risk curve (see Figure 5–1292) centered at CY 4000. Risk due to releases from FFTF is eliminated by removal under FFTF Decommissioning Alternative 3.

Table 5–169. Alternative Combination 3 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On Site										
Core Zone Boundary	6.36×10^{2}	4.97×10^{2}	1.24×10^{-2}	0.00	1.24×10^{-2}	1.24×10^{3}	5.70×10^{2}	3.48×10^{-2}	1.10×10^{-7}	3.48×10^{-2}
Columbia River nearshore	1.94	4.22×10^{-1}	4.28×10^{-5}	0.00	4.28×10^{-5}	3.74	4.56×10^{-1}	1.48×10^{-4}	1.31×10^{-10}	1.48×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.91×10^{-4}	1.63×10^{-4}	5.83×10^{-9}	3.52×10^{-14}	5.83×10^{-9}

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

Table 5–170. Alternative Combination 3 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index (unitless)	Rad. Risk at Year of Peak Rad. Risk (unitless)	Nonrad Risk at Year of Peak Nonrad Risk (unitless)	Total Risk at Year of Peak Total Risk (unitless)
On site										
Core Zone Boundary	2.36×10^{3}	9.85×10^{2}	7.43×10^{-2}	5.05×10^{-3}	7.93×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	7.20	7.35×10^{-1}	3.18×10^{-4}	6.00×10^{-6}	3.19×10^{-4}	4.04×10^{-1}	7.14×10^{-1}	4.98×10^{-6}	3.00×10^{-6}	6.40×10^{-6}
Off site										
Columbia River	5.59×10^{-4}	2.11×10^{-1}	1.80×10^{-8}	1.61×10^{-9}	1.88×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Rad.=radiological; yr=year.

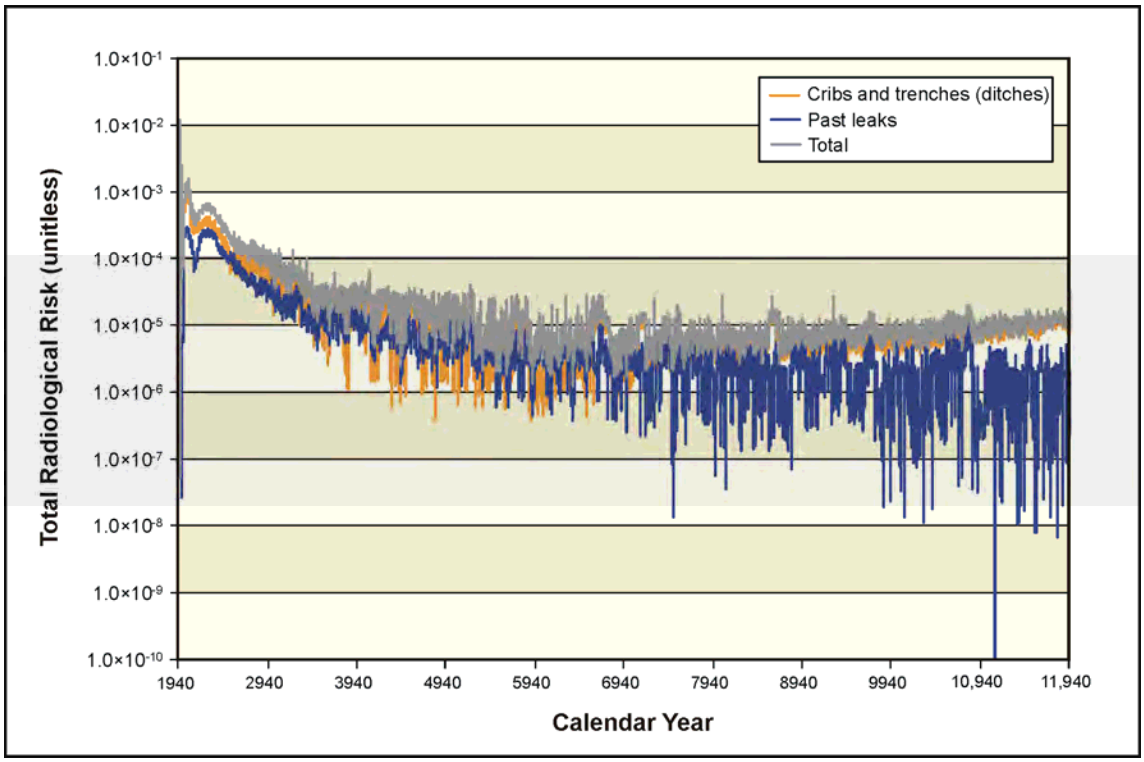


Figure 5–1291. Tank Closure Alternative 6B, Base Case, Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

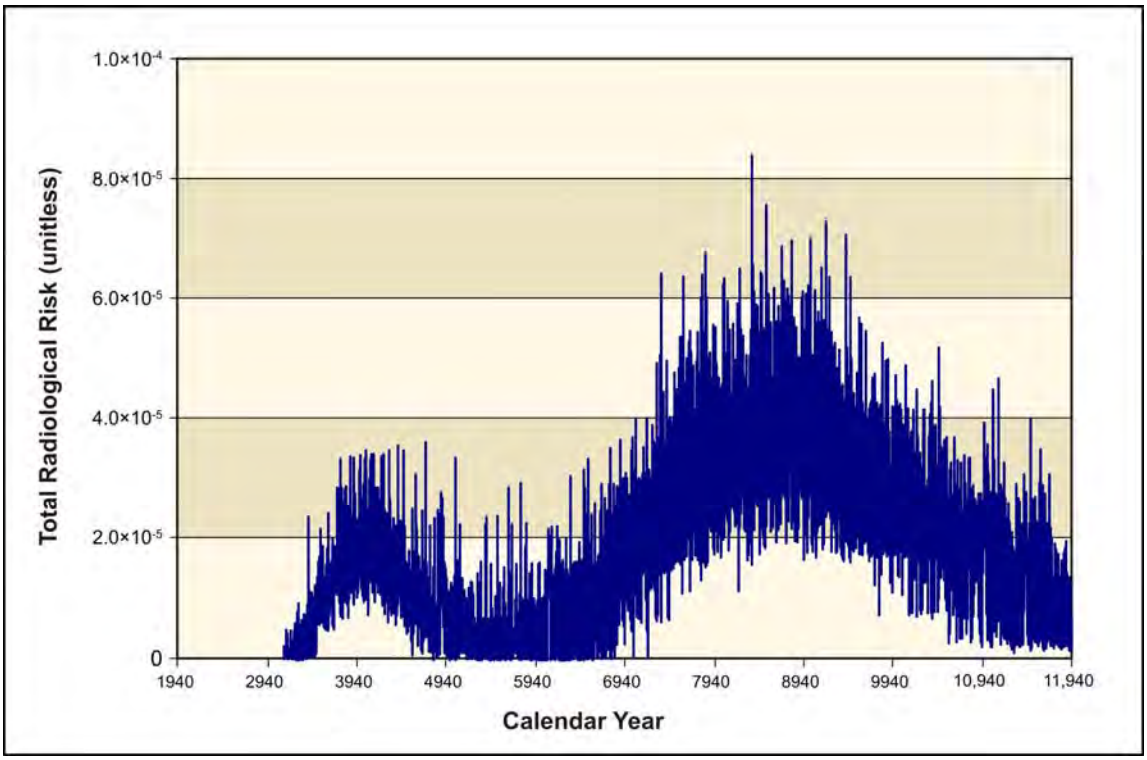


Figure 5–1292. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Time Series of Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.4.3 Ecological Resources

This section evaluates long-term impacts on ecological resources of releases to air and groundwater under three combinations of Tank Closure, FFTF Decommissioning, and Waste Management alternatives.

The long-term impacts on terrestrial ecological resources of releases to air at Hanford were evaluated at the onsite maximum-exposure location (Core Zone Boundary) and on terrestrial, riparian, and aquatic resources at the offsite maximum-exposure location (Columbia River). Impacts on ecological resources of releases to groundwater were evaluated at the Columbia River. Risk indices could not be calculated for soil-dwelling invertebrates, lizards, toads, or birds for chemical COPCs (organic compounds only) because this *TC & WM EIS* does not include toxicity reference values for these receptors for these COPCs. The uncertainty about the risk to ecological resources from releases to air and groundwater under the *TC & WM EIS* alternatives is discussed in Appendix P (see Sections P.2.2 and P.3.2). Calculated risk indices are presented below for the COPCs with the highest Hazard Quotients or Hazard Indices for each receptor.

The highest risk indices for ecological receptors are calculated for Alternative Combinations 1 and 3. For air releases, the risk indices calculated for plants, omnivorous mammals (Great Basin pocket mouse), and mammalian top carnivores (coyote) from air releases are highest under Alternative Combination 1. Risk indices calculated for the soil-dwelling invertebrates, side-blotched lizard, herbivorous mammals (mule deer), herbivorous birds (mourning dove), omnivorous birds (western meadowlark), and avian top carnivores (burrowing owl) are highest under Alternative Combination 3 (see Table 5–171). Predicted emissions of chemical COPCs in air under Alternative Combination 1 pose a small risk to plants (toluene Hazard Quotient is 47) and a moderate risk to mice and the coyote at the onsite maximum-exposure location. The largest calculated Hazard Quotients are xylene (2120), toluene (339), formaldehyde (80), and benzene (17) for the mouse at the onsite maximum-exposure location. Predicted emissions of chemical COPCs in air under Alternative Combination 3 pose a small probability of adverse impacts on the mourning dove and burrowing owl (mercury Hazard Quotient is less than 10) and a moderate probability for the side-blotched lizard (mercury Hazard Quotient is 172), meadowlark (mercury Hazard Quotient is 103), and mule deer (formaldehyde Hazard Quotient is 72) at the onsite maximum-exposure location. There would be no risk to soil-dwelling invertebrates at the onsite maximum-exposure location (calculated mercury Hazard Quotient is 1.02). This value is well within the margin of error of the uncertainties in the estimated exposure and toxicity.

There would be no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air under any of the alternative combinations at the offsite maximum-exposure location (Columbia River). The calculated Hazard Quotient of 2.4 for the mouse exposed to xylene at the Columbia River under Combination Alternative 1 exceeds 1 slightly.

The risk indices for each of the alternative combinations is the sum of the risk indices for the individual Tank Closure, FFTF Decommissioning, and Waste Management alternatives included in the combination. Alternative Combination 3 has the highest calculated risk indices for the side-blotched lizard, mule deer, mourning dove, western meadowlark, and burrowing owl (see Table 5–171). Alternative Combination 3 includes Tank Closure Alternative 6B, and the calculated indices for Tank Closure Alternative 6B are larger than the indices for Tank Closure Alternatives 1 and 2B, which are included, respectively, in Alternative Combinations 1 and 2. The calculated risk indices for these receptors under Tank Closure Alternative 6B are not the largest for such receptors—the largest are for Tank Closure Alternatives 3A and 3C (see Table 5–64). Alternative Combination 1 has the highest calculated risk indices for plants, the Great Basin pocket mouse, and the coyote (see Table 5–171). Alternative Combination 1 includes FFTF Decommissioning Alternative 1, and the calculated indices for FFTF Decommissioning Alternative 1 are much larger than the indices for FFTF Decommissioning Alternatives 2 and 3, which are included, respectively, in Alternative Combinations 2 and 3.

For groundwater releases, the highest risk indices for ecological receptors were calculated under Alternative Combinations 1 and 3 (see Table 5–172). Risk indices exceed 1 for aquatic biota, including salmonids, for chromium under all alternative combinations, corresponding to the Hazard Quotients exceeding 1 under the Tank Closure alternatives included in those alternative combinations. Waste Management Alternatives 2 and 3 (Disposal Group 1, Subgroups 1-C, 1-D, 1-E, and 1-F), which have Hazard Quotients that exceed 1 for aquatic biota and the spotted sandpiper, do not contribute to the risk indices for alternative combinations. There are no other receptors with risk indices exceeding 1 under the alternative combinations, including for all radiological COPCs (see Appendix P, Table P–12).

Table 5–171. Alternative Combinations – Long-Term Impacts of Chemical COPC Releases to Air on Terrestrial Resources at the Onsite Maximum-Exposure Location

Alternative Combination	Maximum Hazard Quotient of Chemical COPC by Receptor								
	Plants	Soil-Dwelling Invertebrate	Side-Blotched Lizard	Great Basin Pocket Mouse	Coyote	Mule Deer	Meadow Lark	Mourning Dove	Burrowing Owl
	Toluene	Mercury	Mercury	Xylene	Xylene	Formaldehyde	Mercury	Mercury	Mercury
1	4.69×10^{1}	0.00	0.00	**2.12×10^{3}**	2.69×10^{2}	4.85×10^{1}	0.00	0.00	0.00
2	2.69	9.85×10^{-1}	**1.66×10^{2}**	1.31×10^{2}	1.67×10^{1}	2.33×10^{1}	9.95×10^{1}	8.22	6.92
3	6.50	1.02	1.72×10^{2}	**3.25×10^{2}**	4.13×10^{1}	7.19×10^{1}	1.03×10^{2}	8.54	7.20

Note: The maximum Hazard Quotient under each alternative combination is indicated by **bold** text.
Key: COPC=constituent of potential concern.

Table 5–172. Alternative Combinations – Long-Term Impacts of Contaminant Releases to Groundwater on Aquatic and Riparian Resources at the Columbia River

Alternative Combination	Maximum Hazard Quotient or Hazard Index of Chemical or Radiological COPC by Receptor						
	Benthic Invertebrate	Muskrat	Spotted Sandpiper	Raccoon	Least Weasel	Bald Eagle	Aquatic Biota/Salmonids
	Chromium	Chromium	Chromium	Uranium	Nitrate	Chromium	Chromium
1	1.20×10^{-1}	4.71×10^{-3}	8.17×10^{-1}	2.95×10^{-1}	6.31×10^{-1}	2.08×10^{-2}	**2.14×10^{1}**
2	2.56×10^{-2}	1.00×10^{-3}	1.74×10^{-1}	2.88×10^{-2}	6.43×10^{-1}	1.51×10^{-2}	**2.22×10^{1}**
3	2.60×10^{-2}	1.02×10^{-3}	1.77×10^{-1}	2.72×10^{-3}	6.44×10^{-1}	1.52×10^{-2}	**2.23×10^{1}**

Note: The maximum Hazard Quotient under each alternative is indicated by **bold** text.
Key: COPC=constituent of potential concern; Rad.=radiological.

5.4.4 Environmental Justice

Sections 5.4.1 and 5.4.2 evaluate groundwater impacts and associated potential long-term human health effects under the combinations of alternatives. Receptors analyzed with a potential for environmental justice concerns include a resident farmer, an American Indian resident farmer, and an American Indian hunter-gatherer. The hypothetical resident farmer, which could represent a low-income population, and American Indian resident farmer were both assumed to use only groundwater for drinking water ingestion and crop irrigation. While only a portion of the food consumed by the resident farmer was assumed to come from crops and animal products exposed to contaminated groundwater, all of the food consumed by the American Indian resident farmer was assumed to be exposed to contaminated groundwater. The American Indian hunter-gatherer was assumed to have a subsistence consumption pattern that differs from the American Indian resident farmer. The American Indian hunter-gatherer does not cultivate crops but gathers food from indigenous plants, harvests fish from the Columbia River, and is exposed to a combination of surface water and groundwater. Given these assumptions, the two American Indian receptors would be most at risk from contaminated groundwater. These receptors were used to develop exposure scenarios at several on- and offsite locations identified in Section 5.4.2. Long-term human health impacts of actions associated with the combinations of alternatives analyzed would be greatest under Alternative Combination 1. Under this combination of alternatives, radiological releases would result in the dose at the Core Zone Boundary exceeding regulatory limits for the resident farmer and the American Indian resident farmer. None of the hypothetical receptors at the Columbia River nearshore would be exposed to a dose in excess of regulatory limits. Nonradiological releases under Alternative Combination 1 would result in exceedance of the Hazard Index guidelines for chromium and nitrate at the Core Zone Boundary and the Columbia River nearshore for the resident farmer and American Indian resident farmer. The analysis determined that the greatest impact of any alternative combination on long-term human health could result in radiological doses in excess of regulatory limits and chemical exposures with a Hazard Index greater than 1 for receptors located on site at the Core Zone Boundary and the Columbia River nearshore. There are no such onsite receptors currently at Hanford. The onsite exposure scenarios do not currently exist and have never existed during Hanford operations. Therefore, the estimated high health risks for past years are hypothetical risks only; no persons were ever exposed at these levels. While it is possible for these receptor scenarios to develop in the future, none are expected for the foreseeable future because the Core Zone is designated as Industrial-Exclusive, the Columbia River nearshore is designated as Preservation (Hanford Reach National Monument), and the area between them is designated as Preservation (DOE 1999). It is unlikely, therefore, that any of the combinations of alternatives would pose a disproportionately high and adverse long-term human health risk to American Indian populations at offsite locations. The greatest risk would be to the American Indian resident farmer at the Core Zone Boundary. During the year of peak dose, this receptor would receive a radiological dose of 3.4 rem. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index greater than 1. The adverse impacts would also be applicable to non–American Indian receptors at the same locations, but to a lesser extent.

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