SECTION

8 OF 11

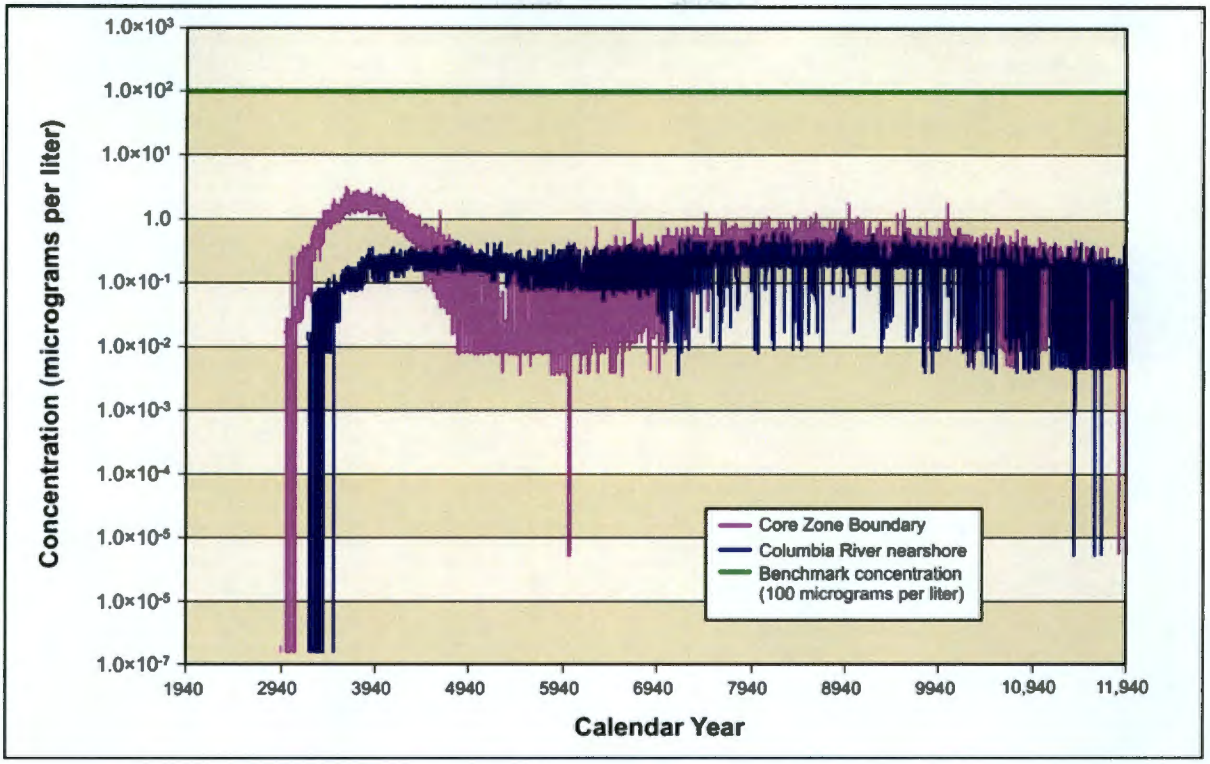


Figure 5–723. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Chromium Concentration Versus Time

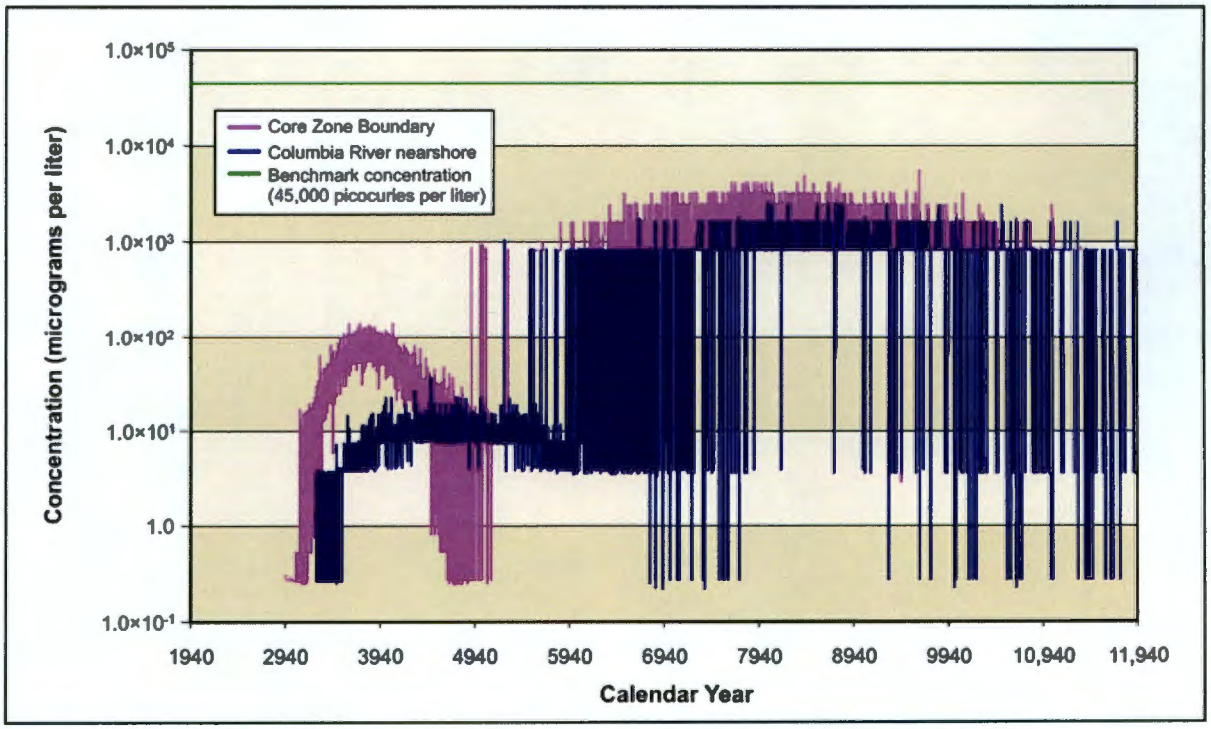


Figure 5–724. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Nitrate Concentration Versus Time

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.

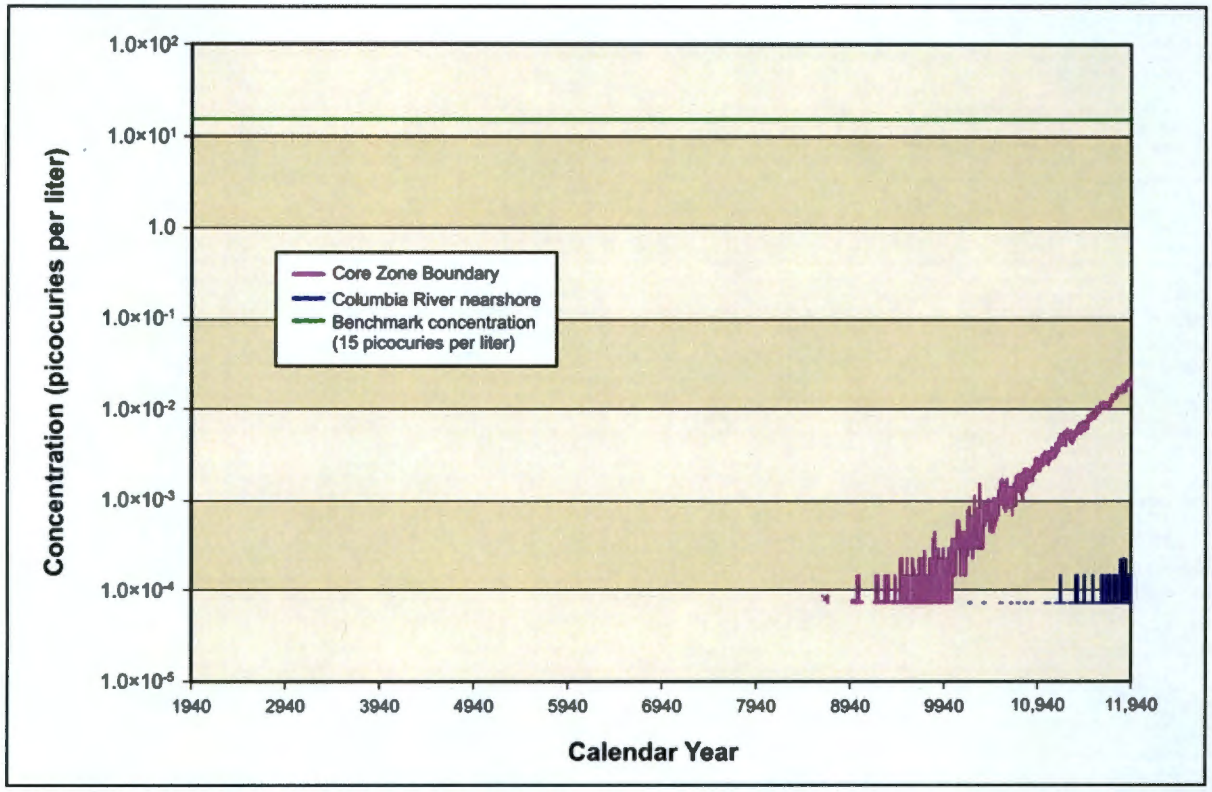


Figure 5–725. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Uranium-238 Concentration Versus Time

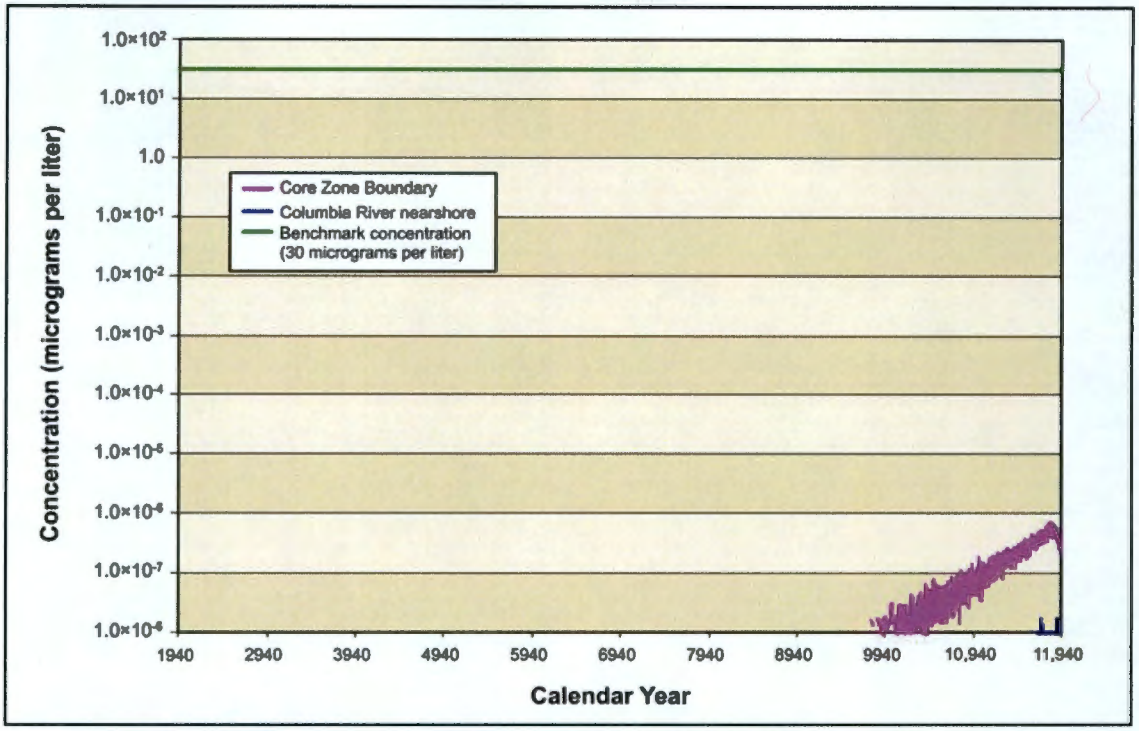
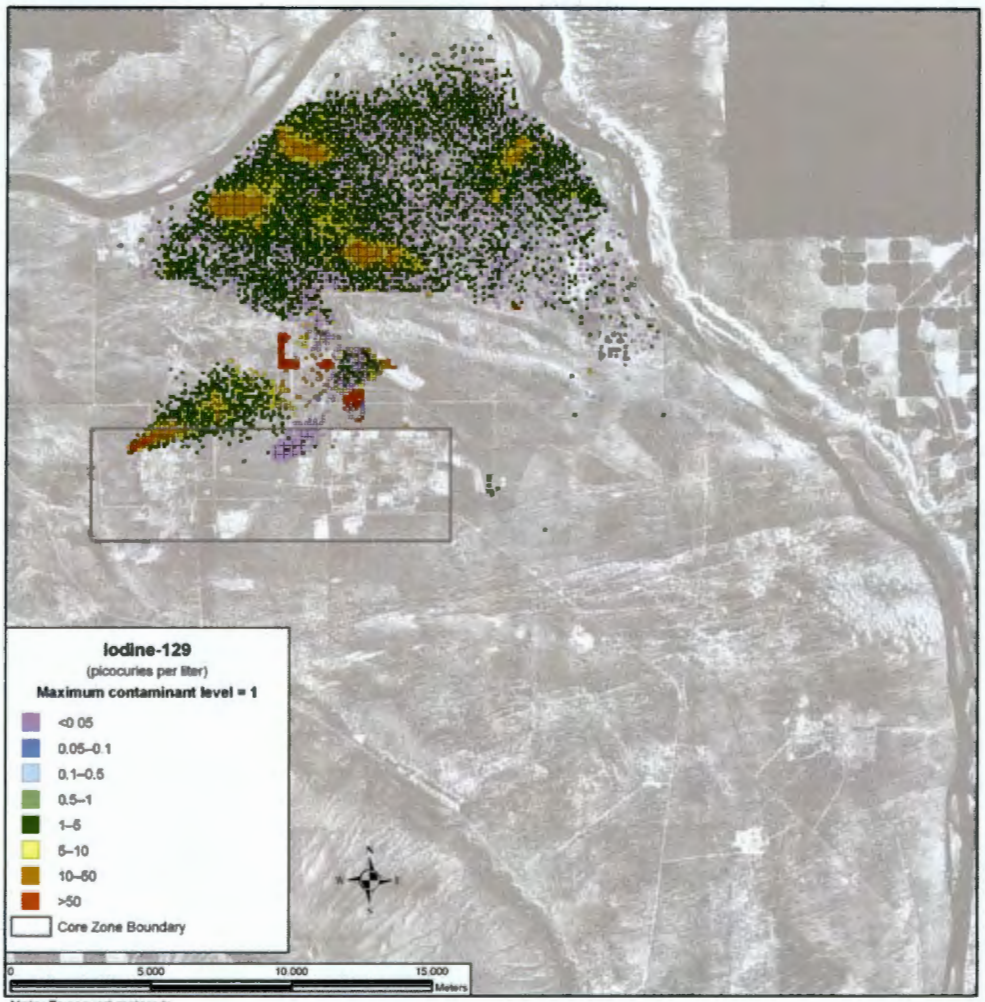


Figure 5–726. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

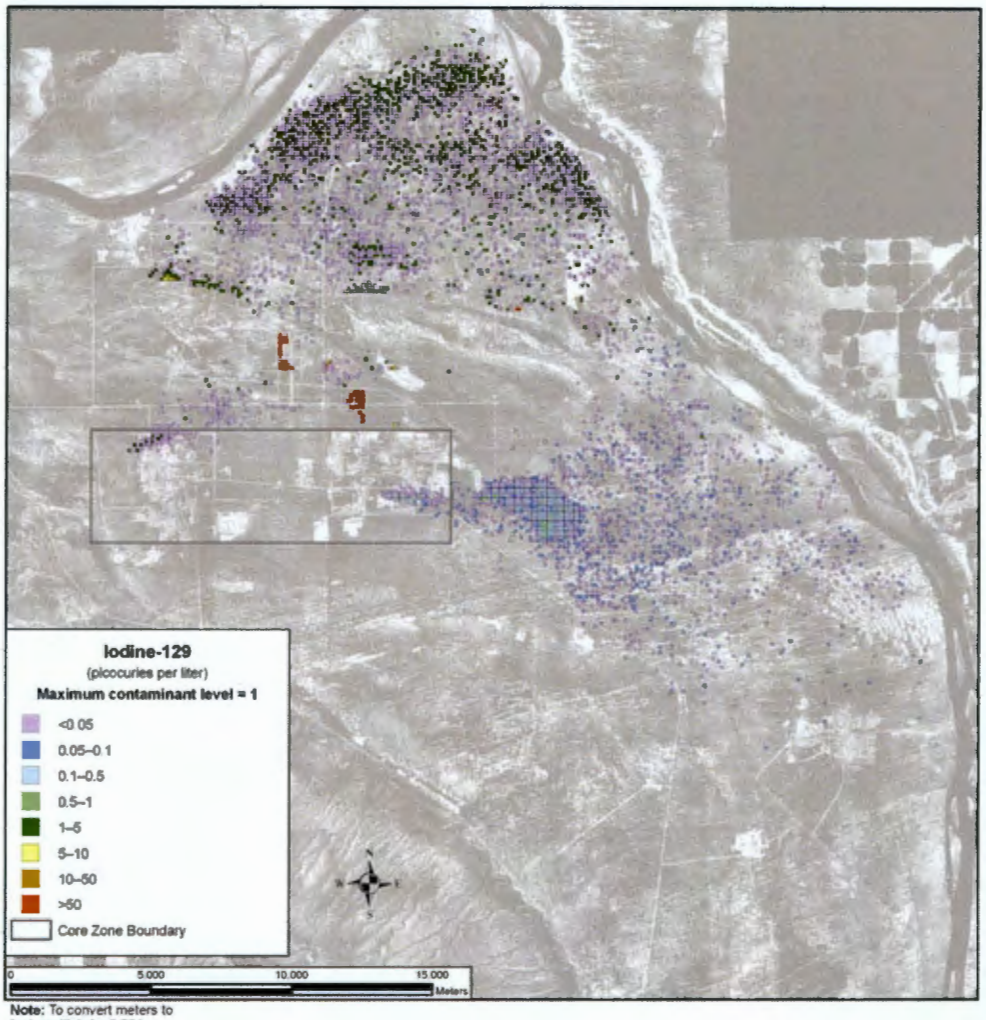
This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, in terms of the spatial distribution of groundwater concentrations at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations of 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).



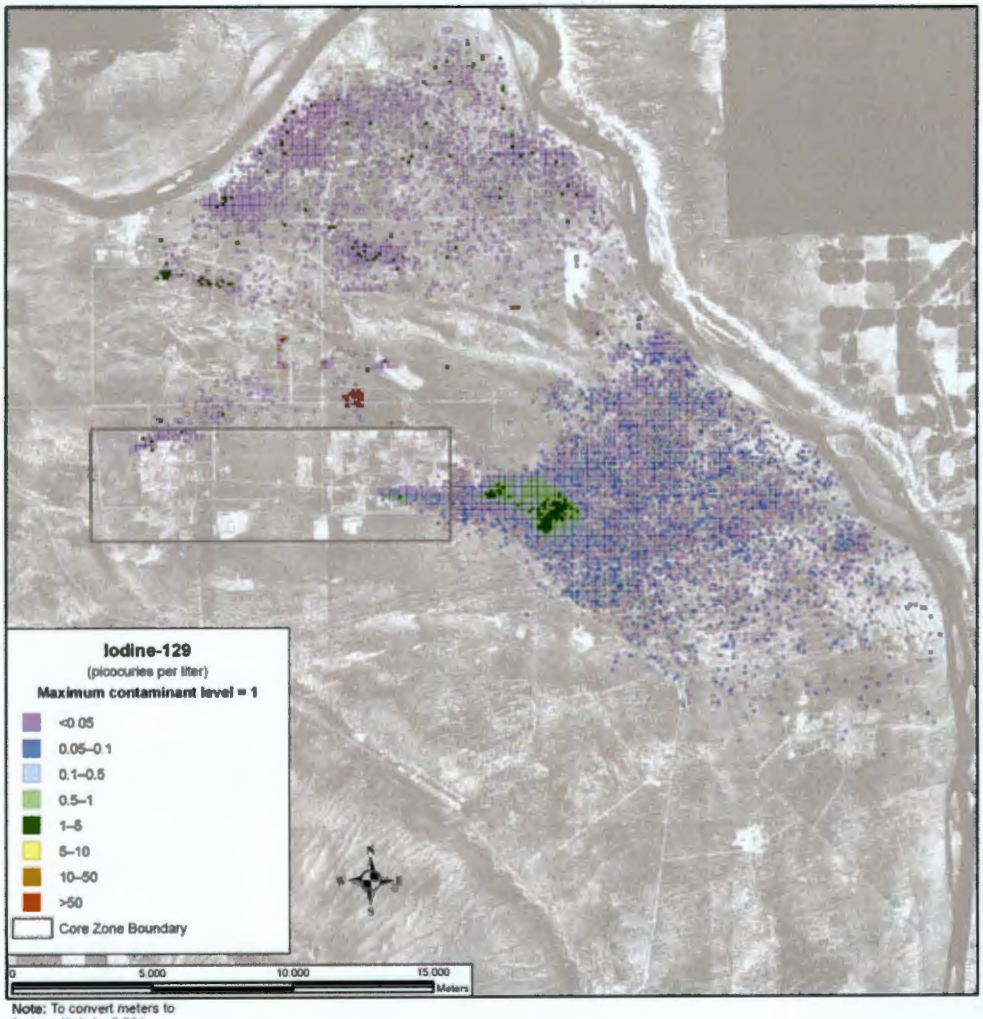
Note: To convert meters to feet, multiply by 3.281

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



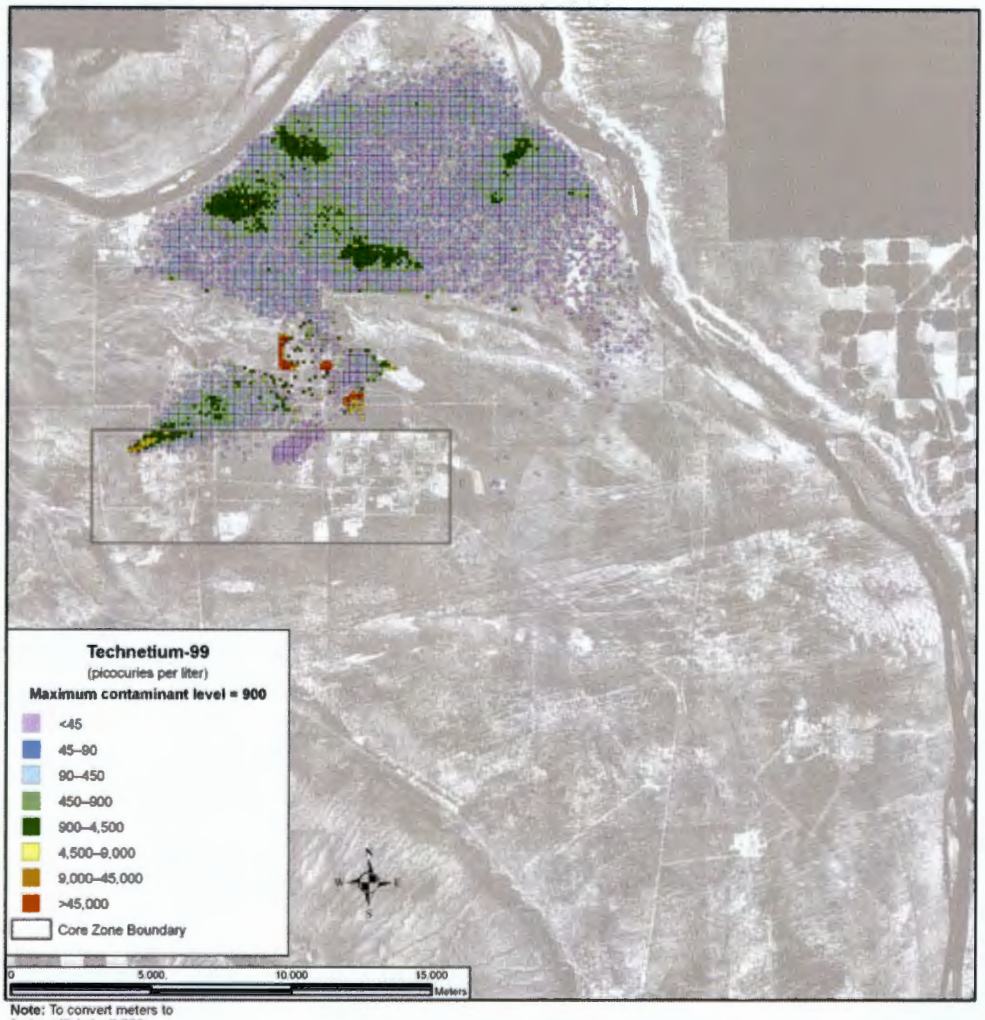
Note: To convert meters to feet, multiply by 3.281

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



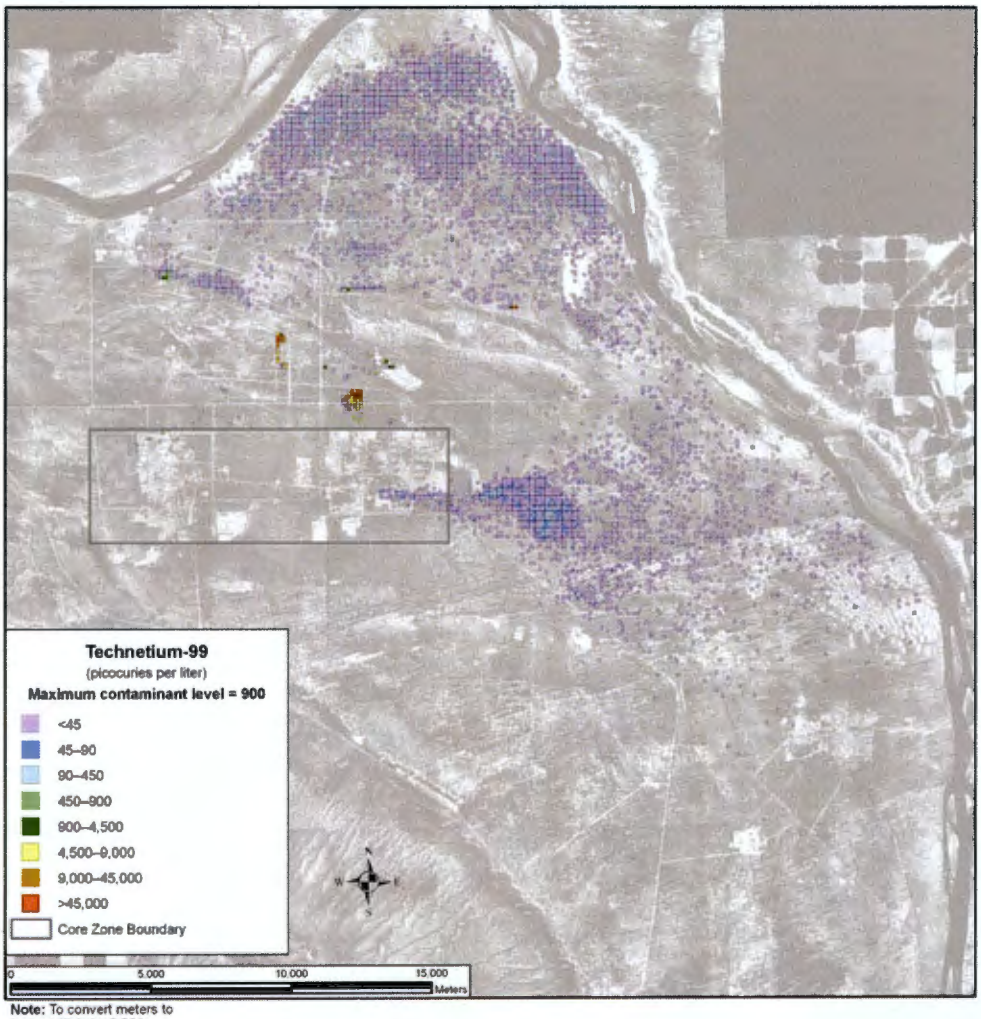
Note: To convert meters to feet, multiply by 3.281

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



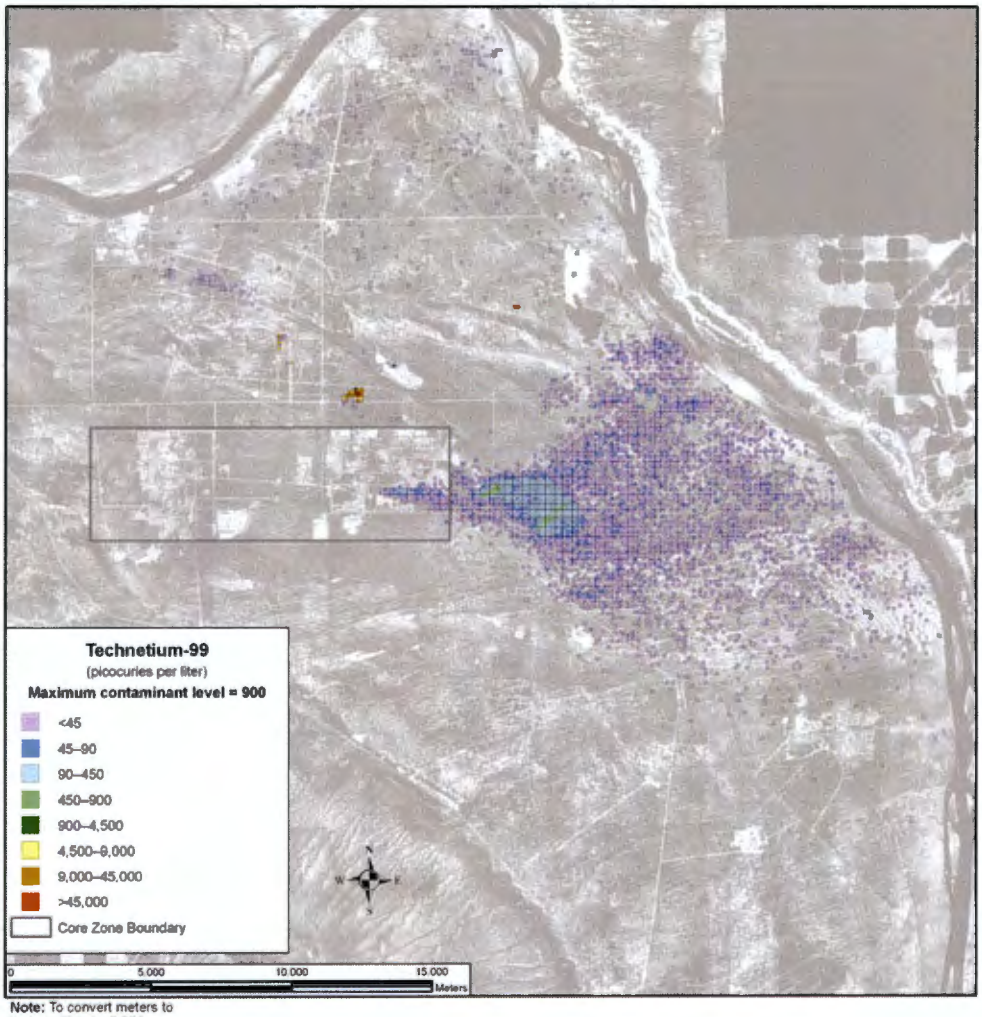
Note: To convert meters to feet, multiply by 3.281

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



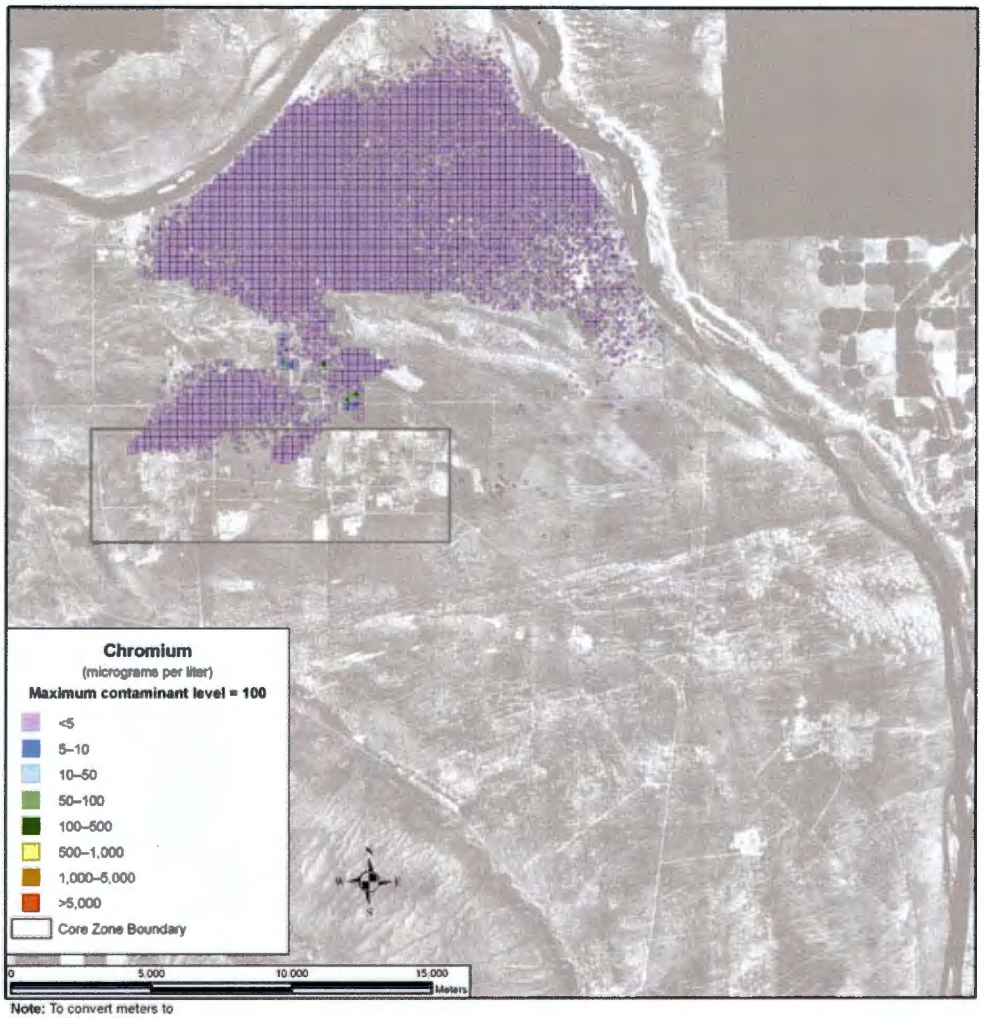
Note: To convert meters to feet, multiply by 3.281

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



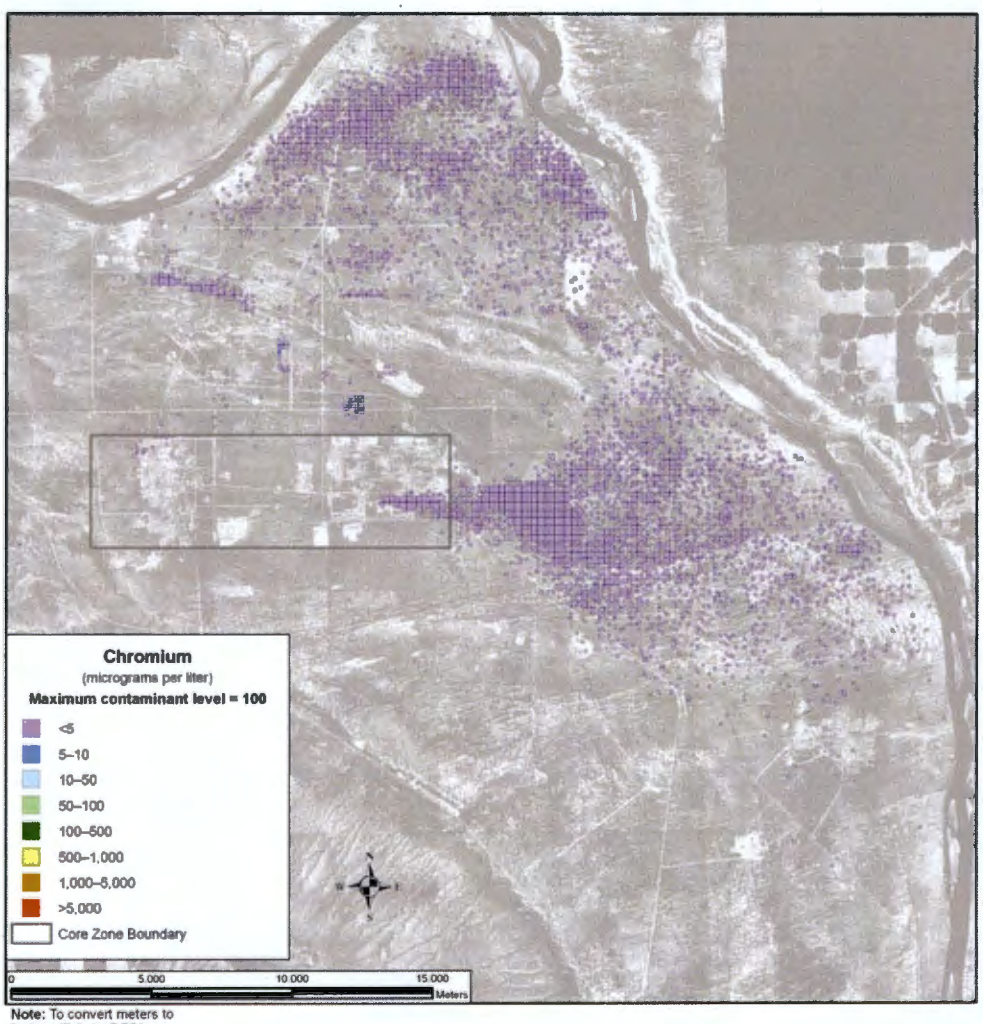
Note: To convert meters to feet, multiply by 3.281

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



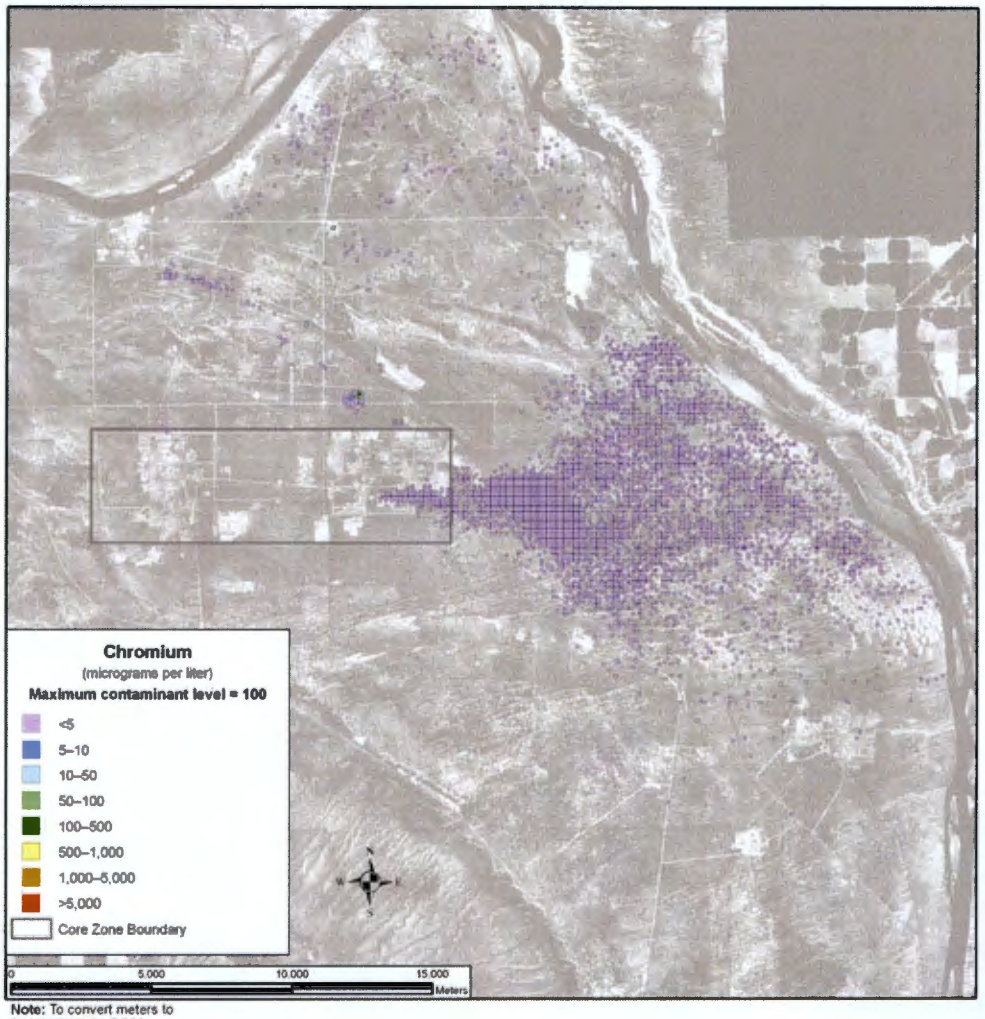
Note: To convert meters to feet, multiply by 3.281

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



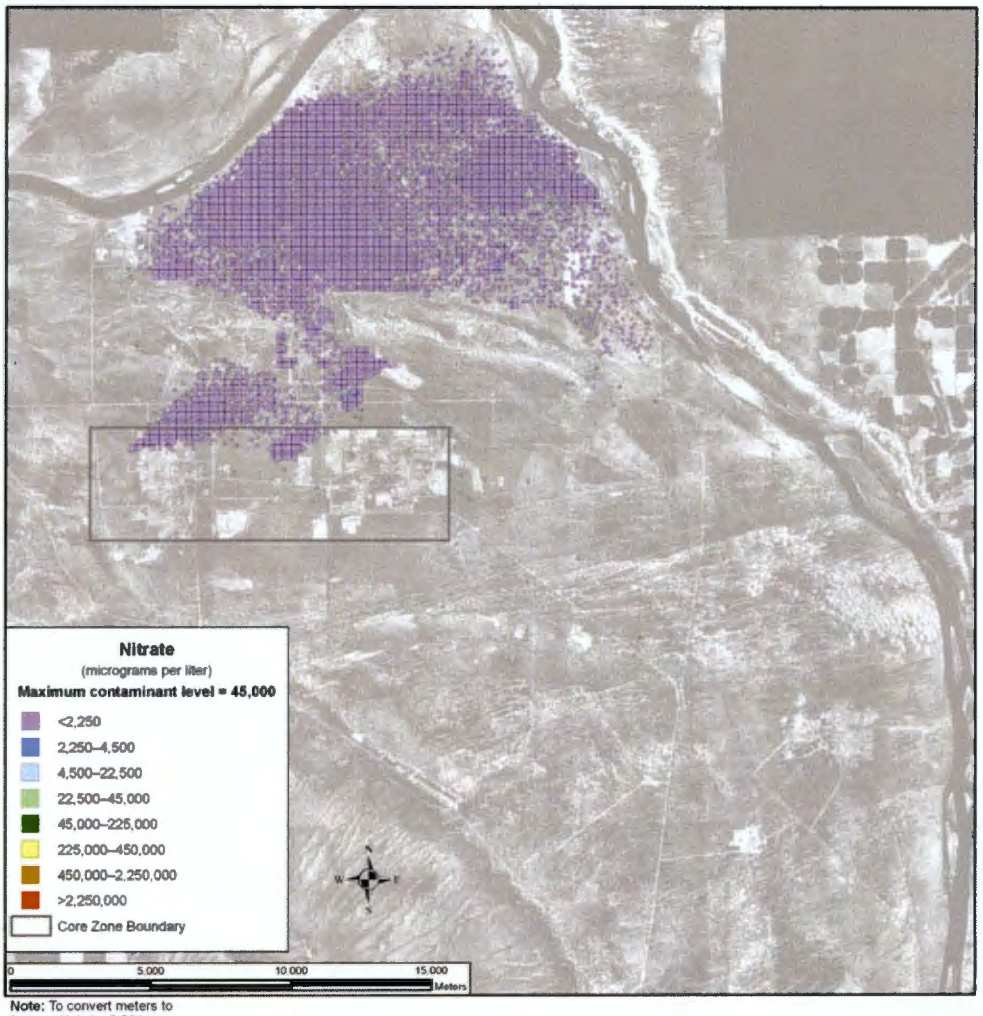
Note: To convert meters to feet, multiply by 3.281

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



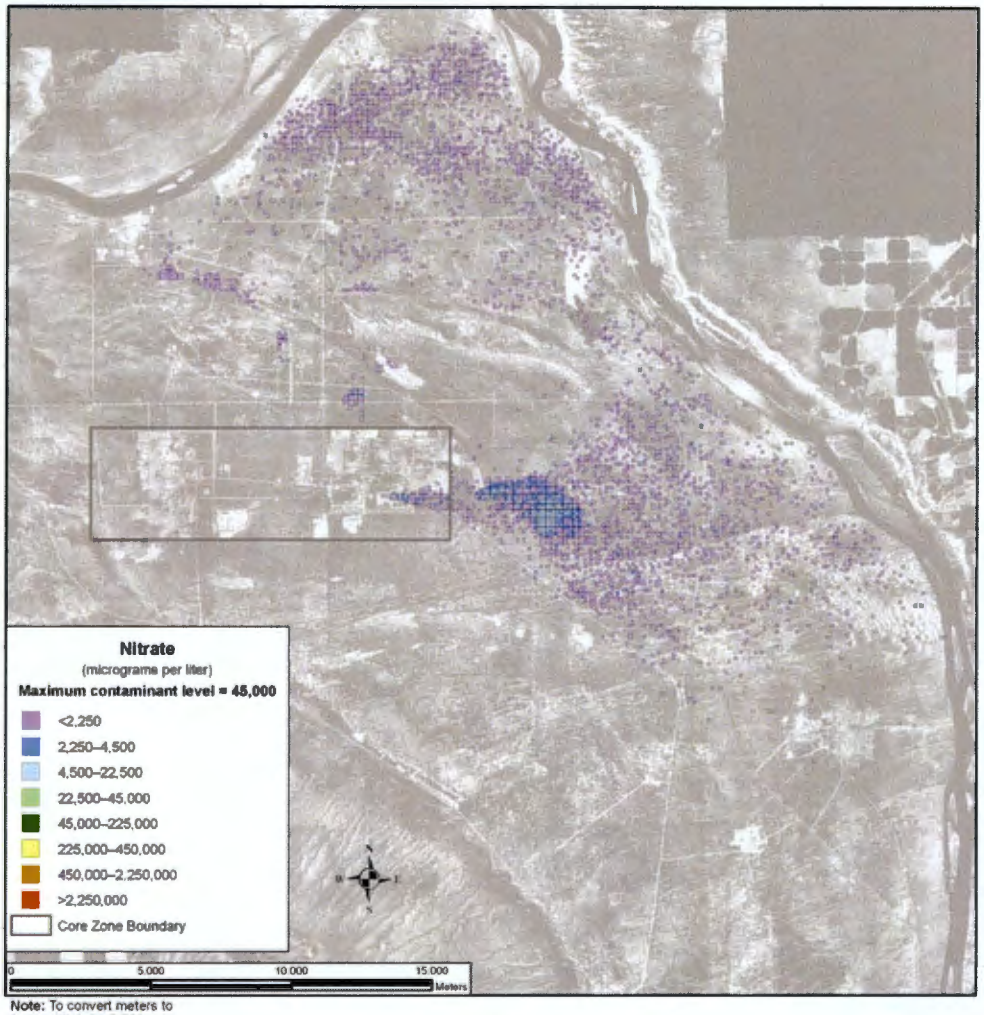
Note: To convert meters to feet, multiply by 3.281

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



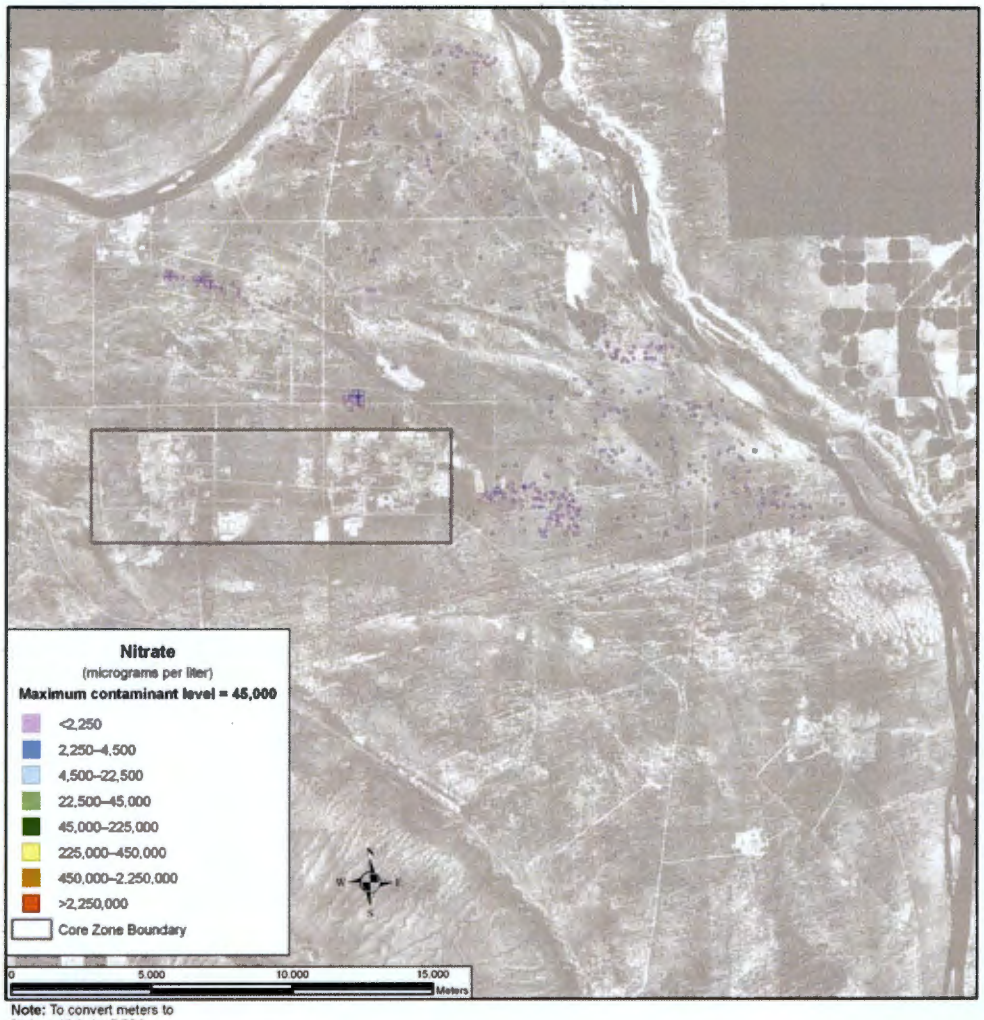
Note: To convert meters to feet, multiply by 3.281

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

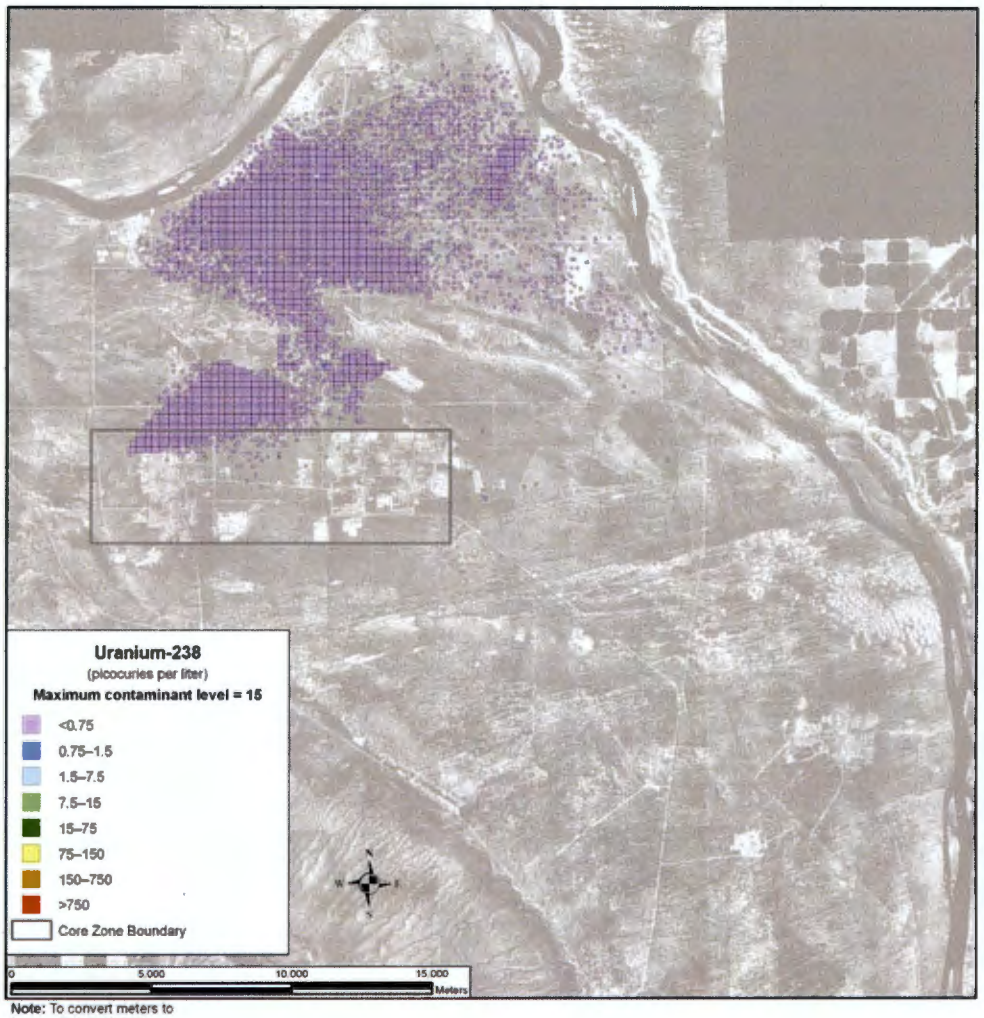
Figure 5–737. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

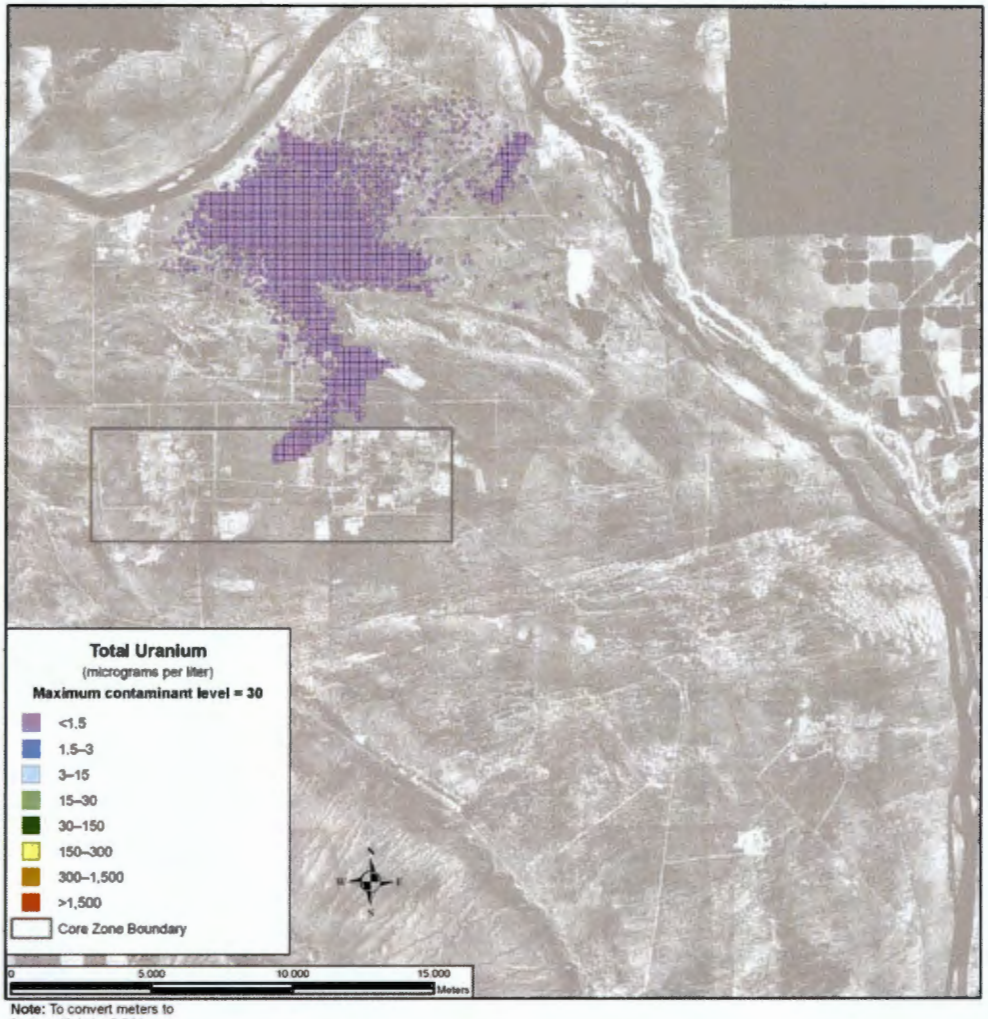
Figure 5–738. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

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.

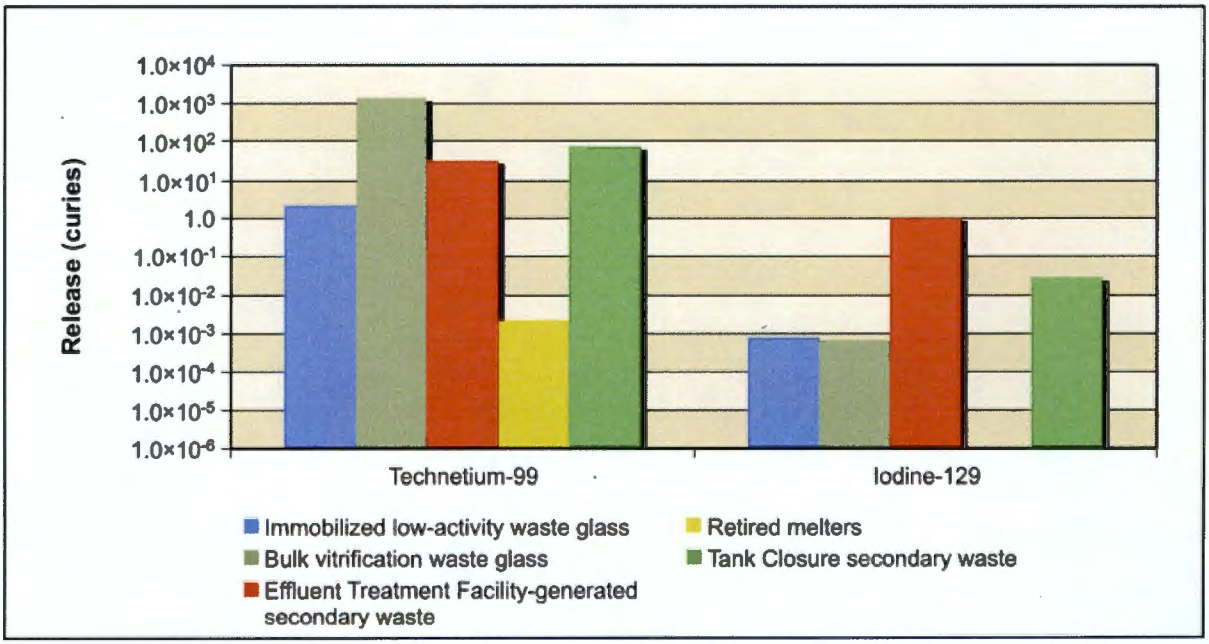


Figure 5–741. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

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.

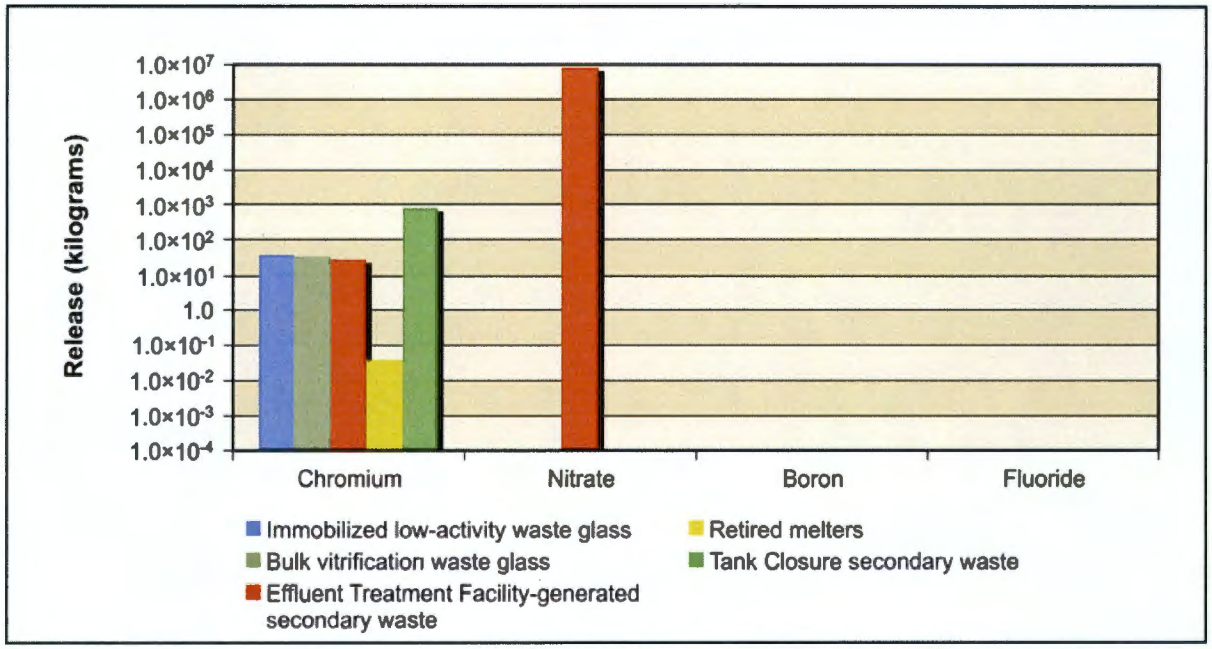


Figure 5–742. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

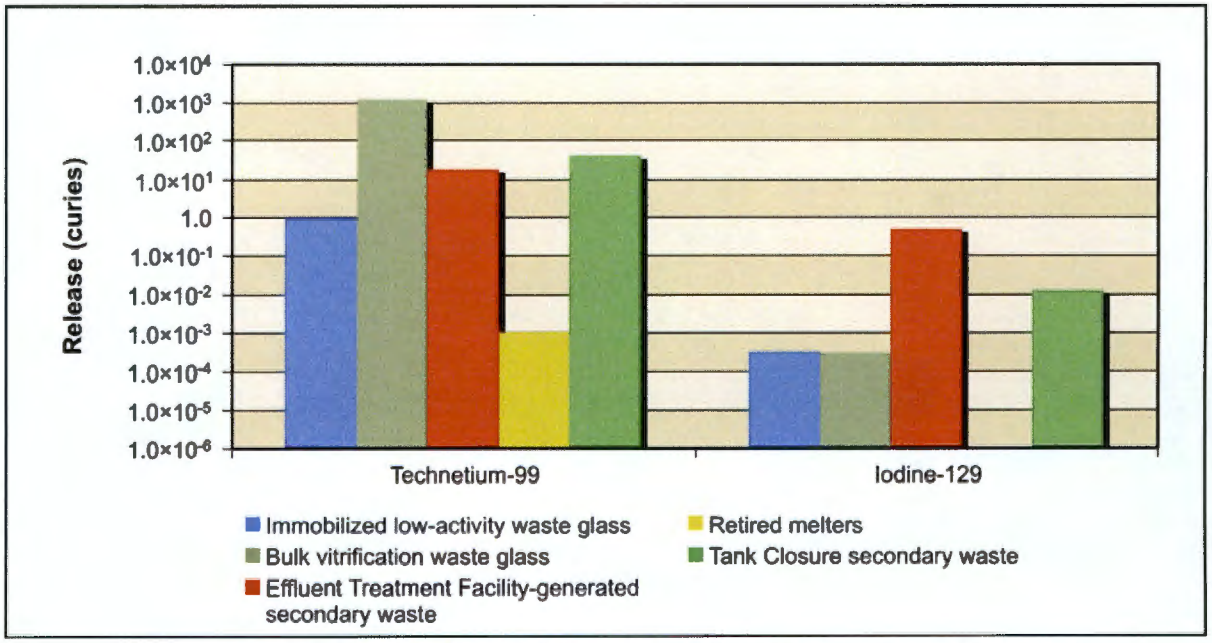


Figure 5–743. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

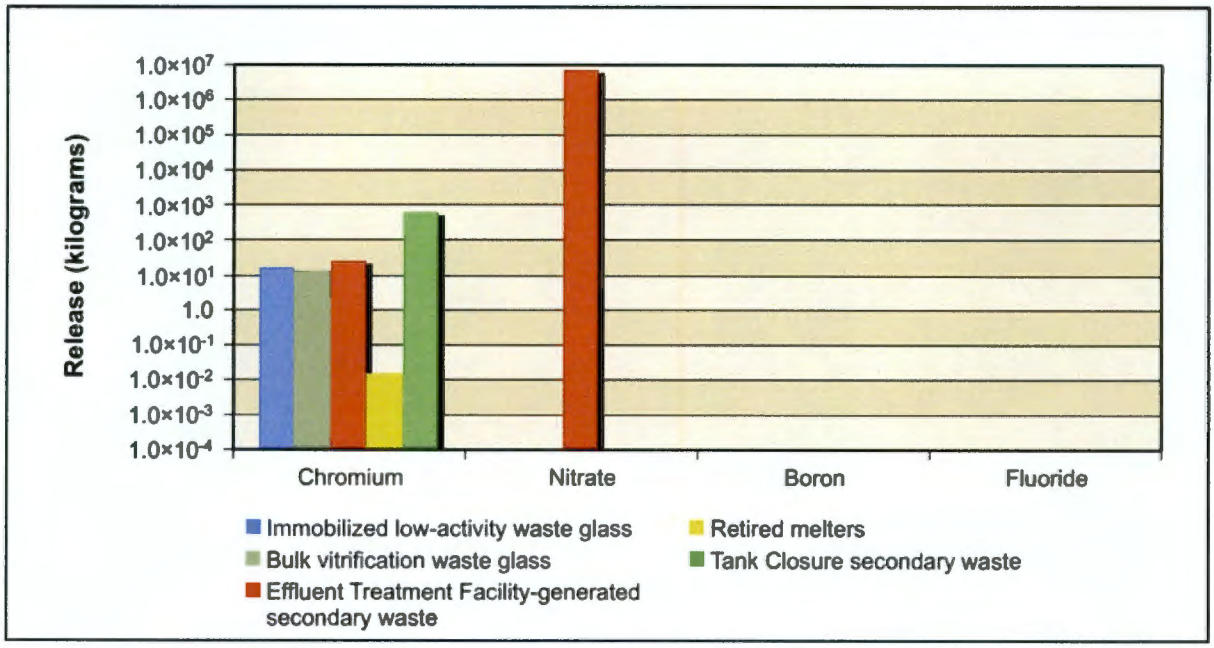


Figure 5–744. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

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.

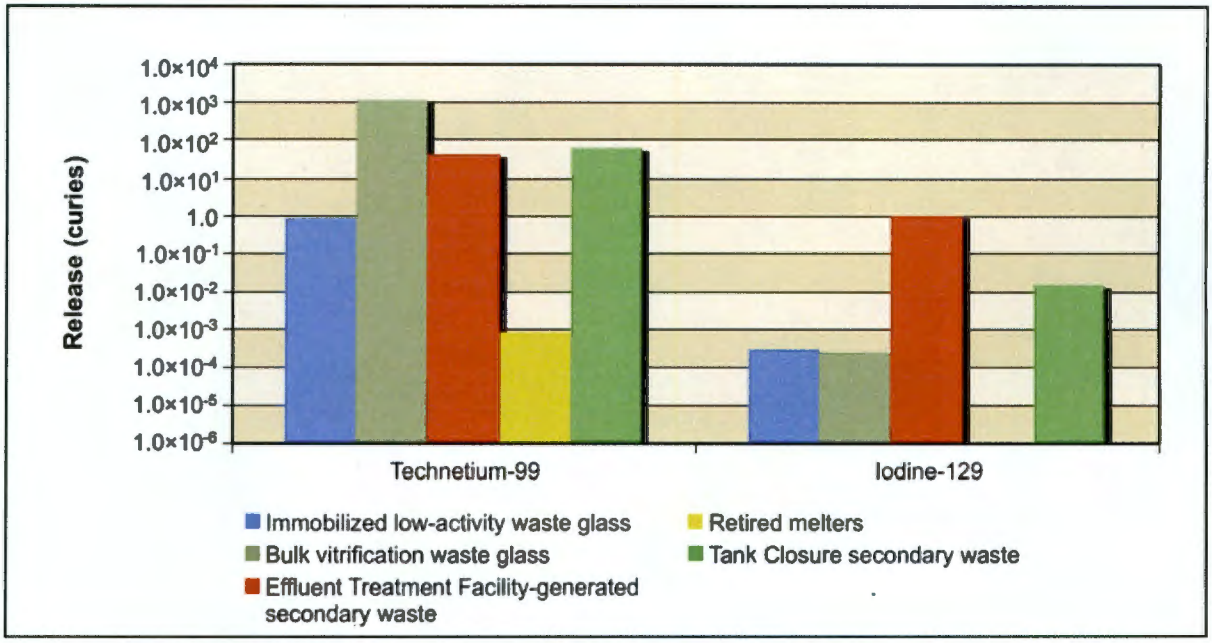


Figure 5–745. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

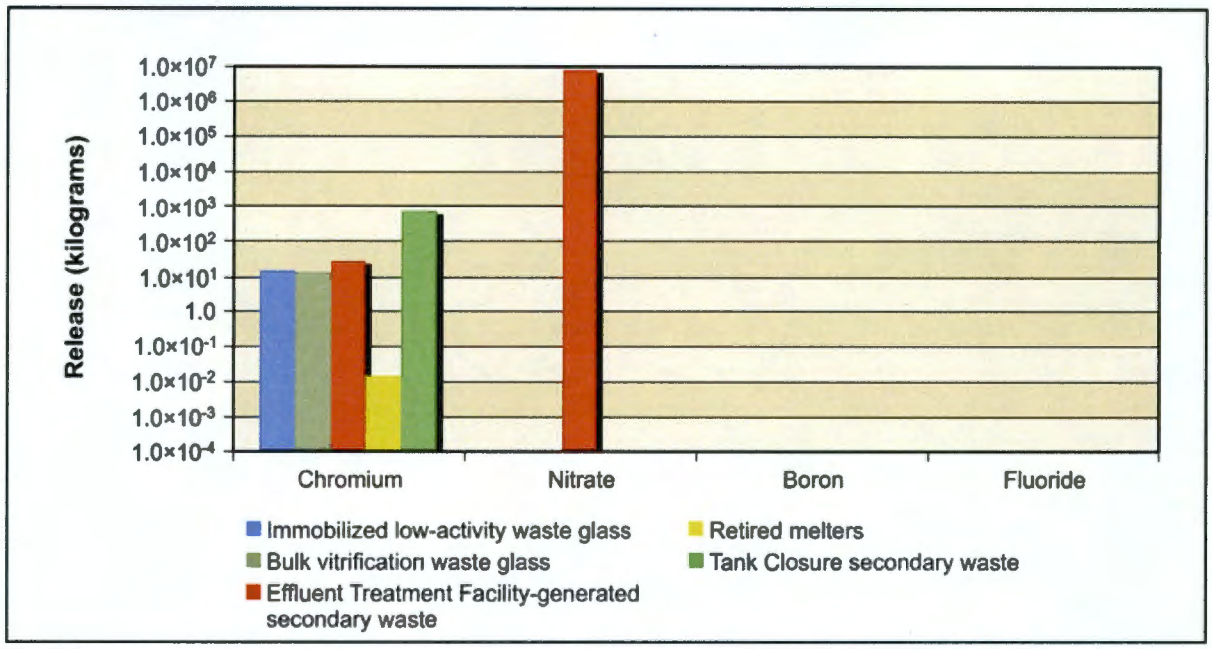


Figure 5–746. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

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.

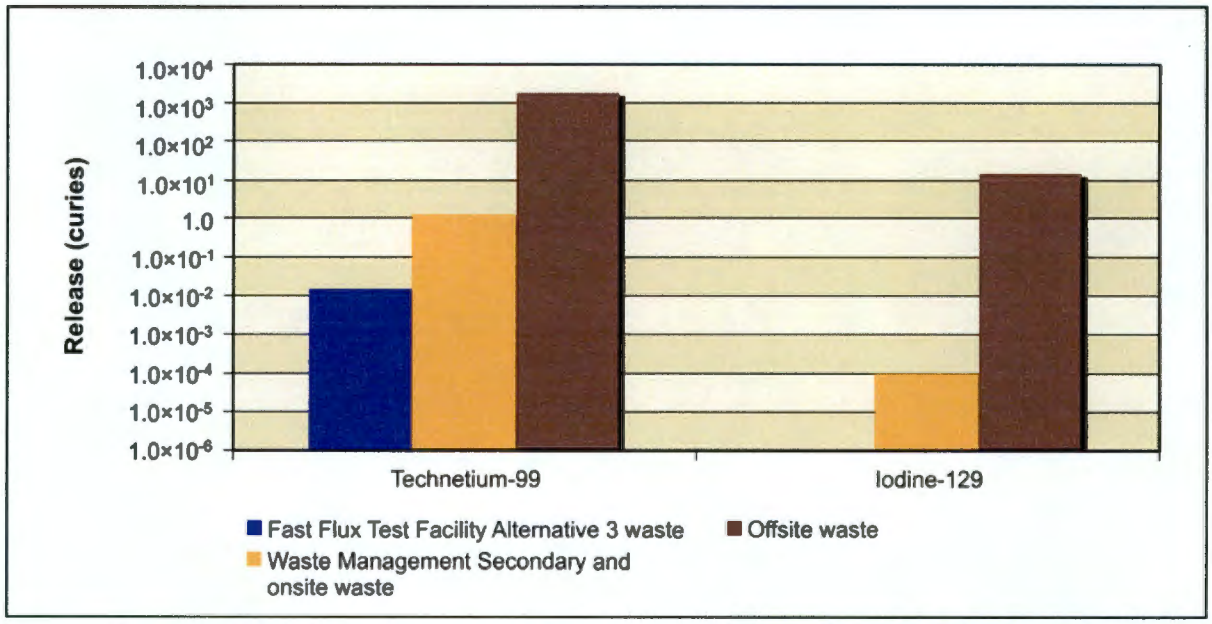


Figure 5–747. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

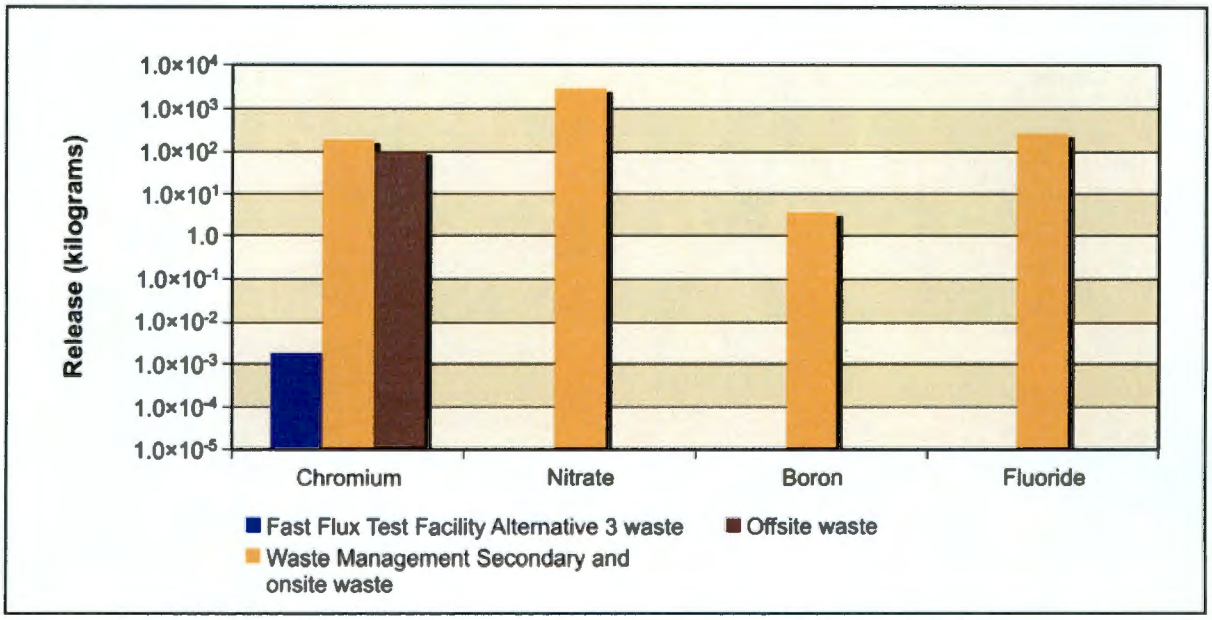


Figure 5–748. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

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.

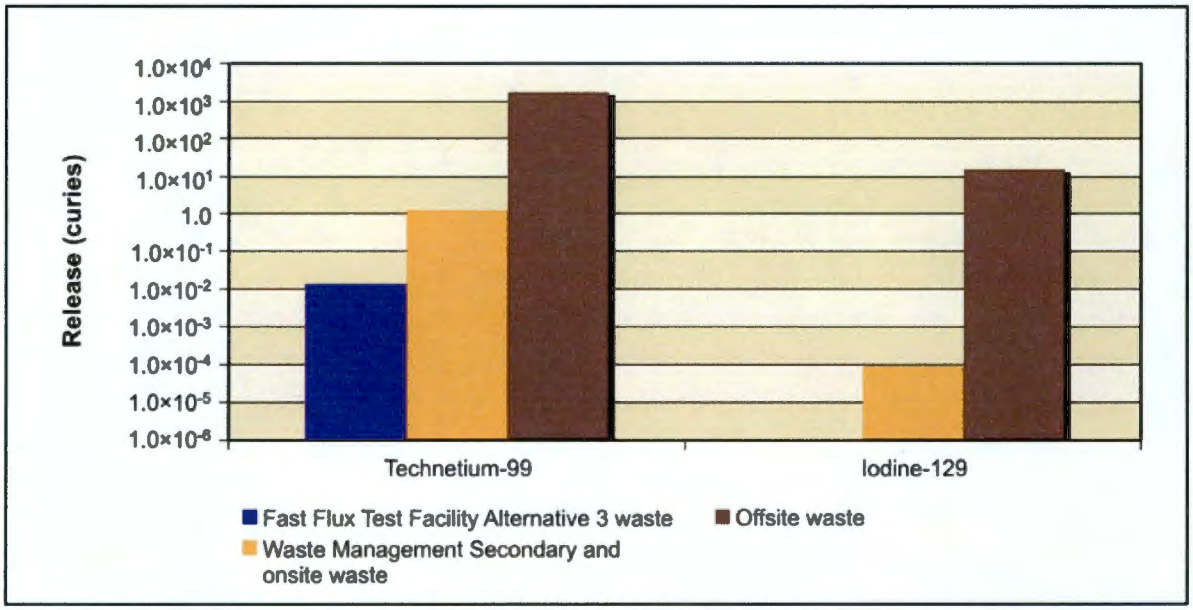


Figure 5–749. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

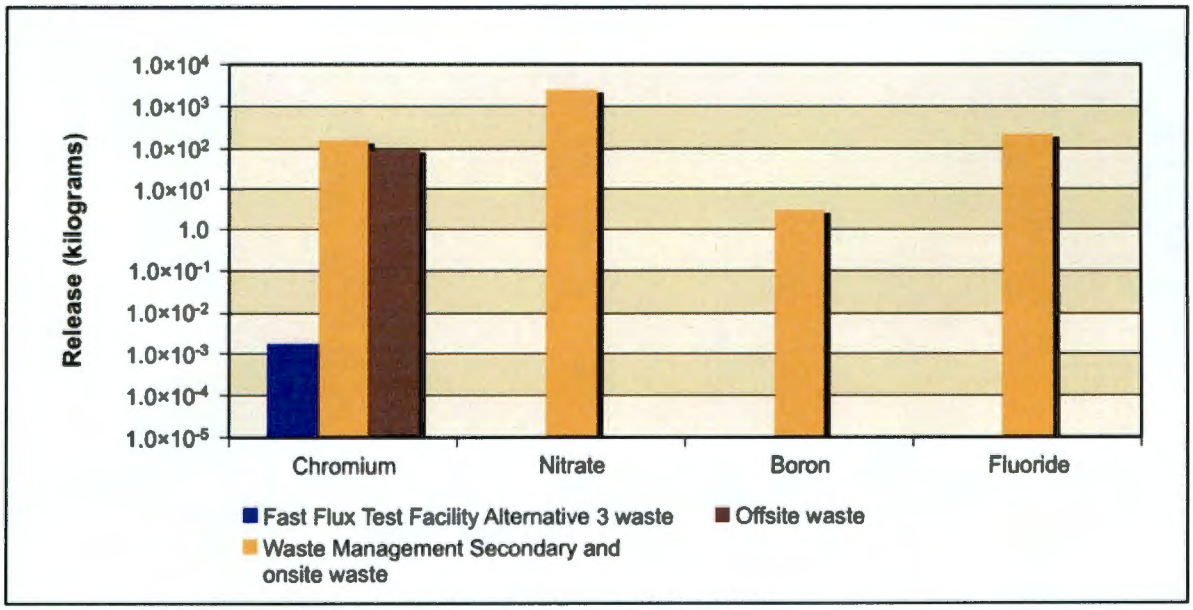


Figure 5–750. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

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.

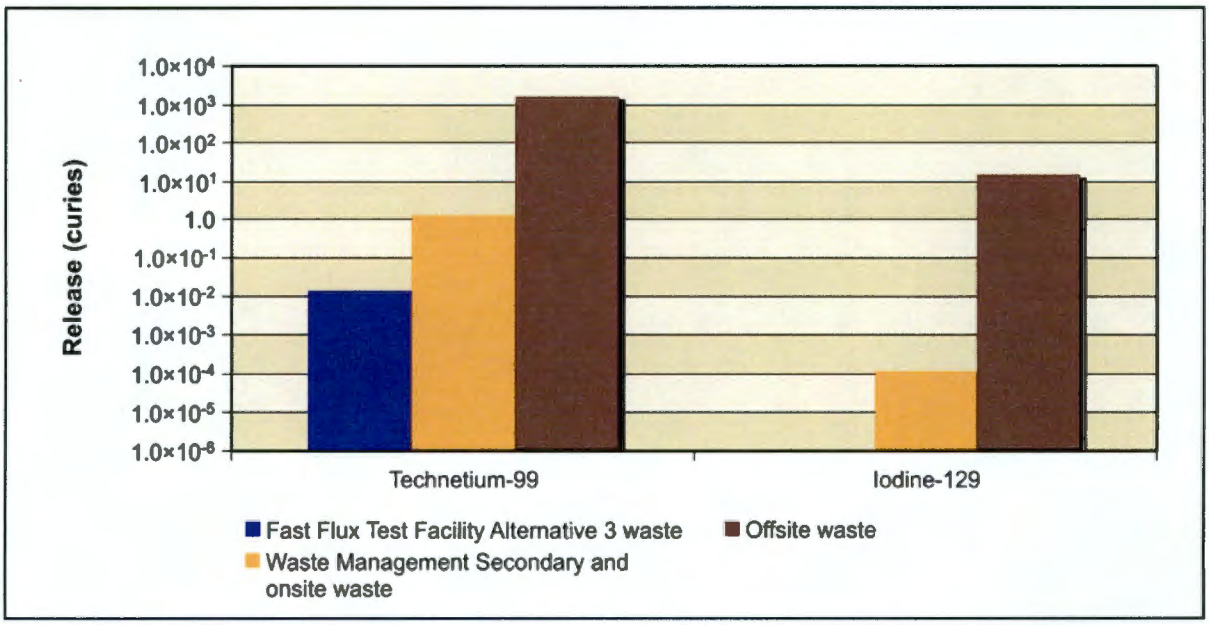


Figure 5–751. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

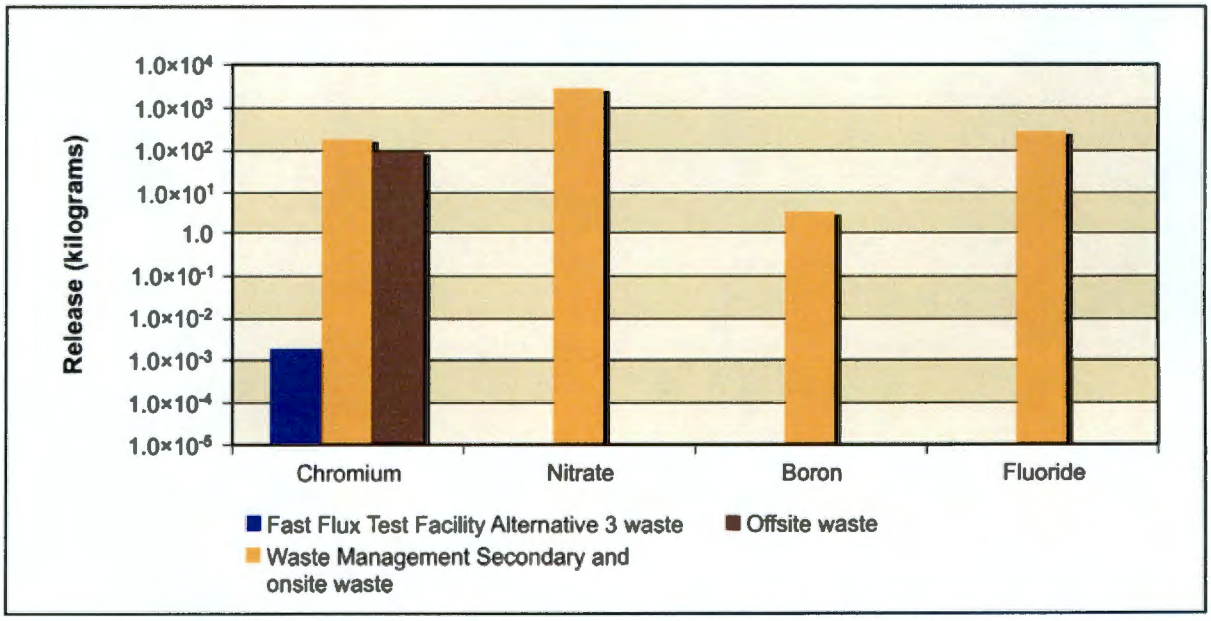


Figure 5–752. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

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.

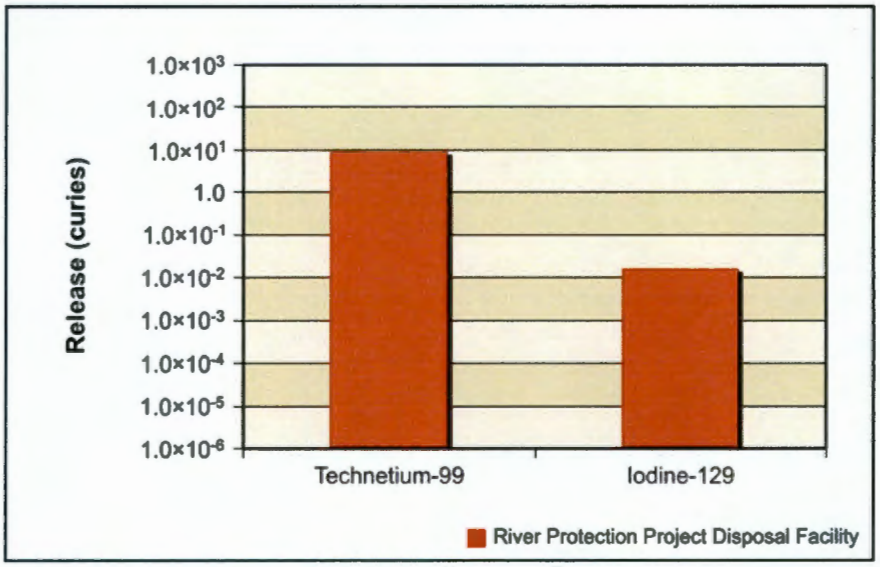


Figure 5–753. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

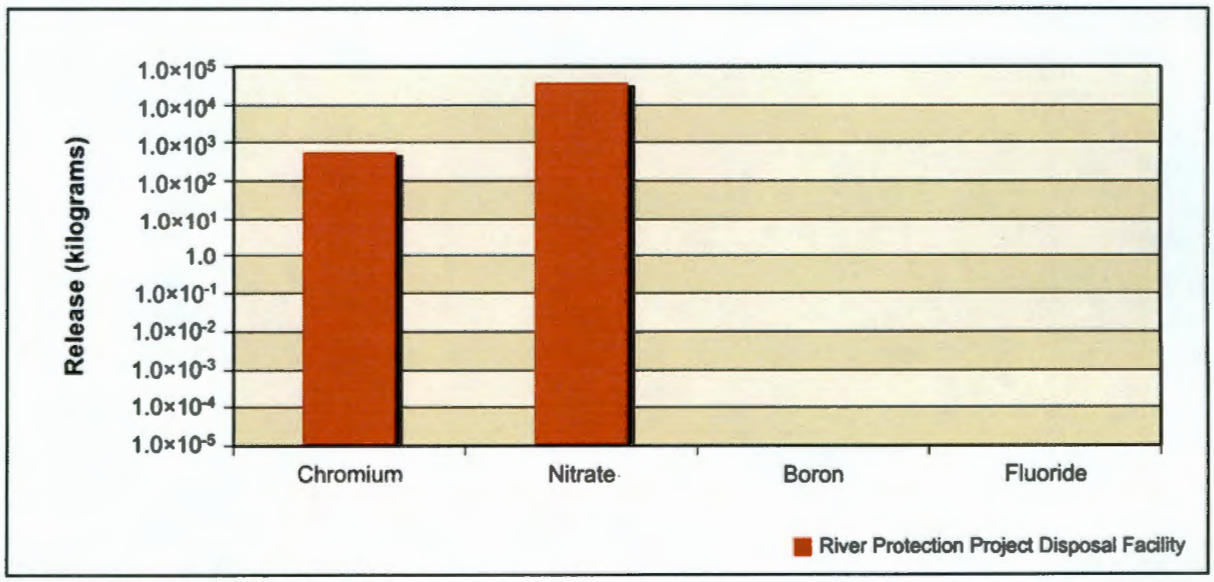


Figure 5–754. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

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.

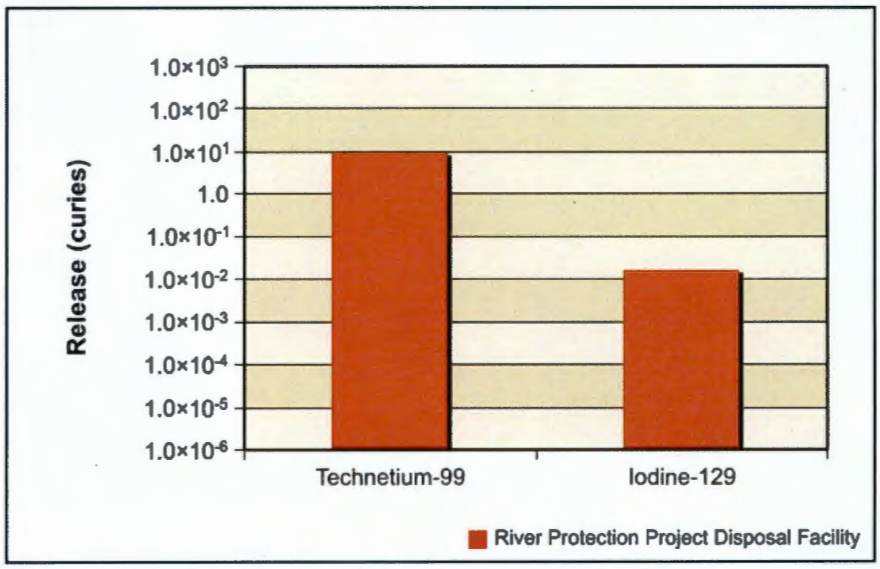


Figure 5–755. Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Groundwater

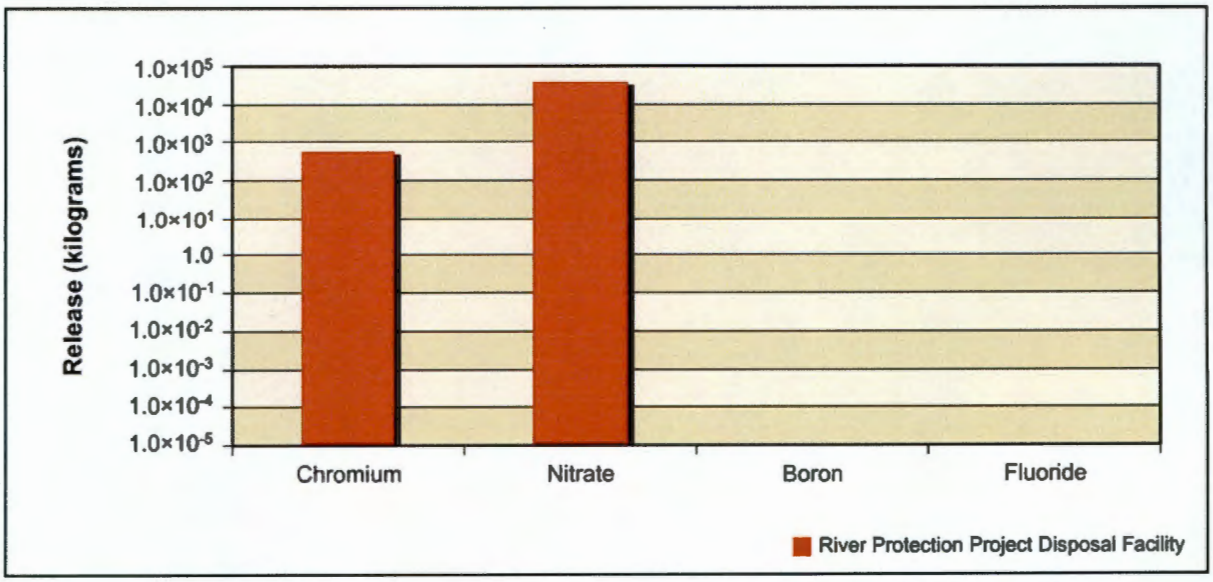


Figure 5–756. Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Groundwater

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.

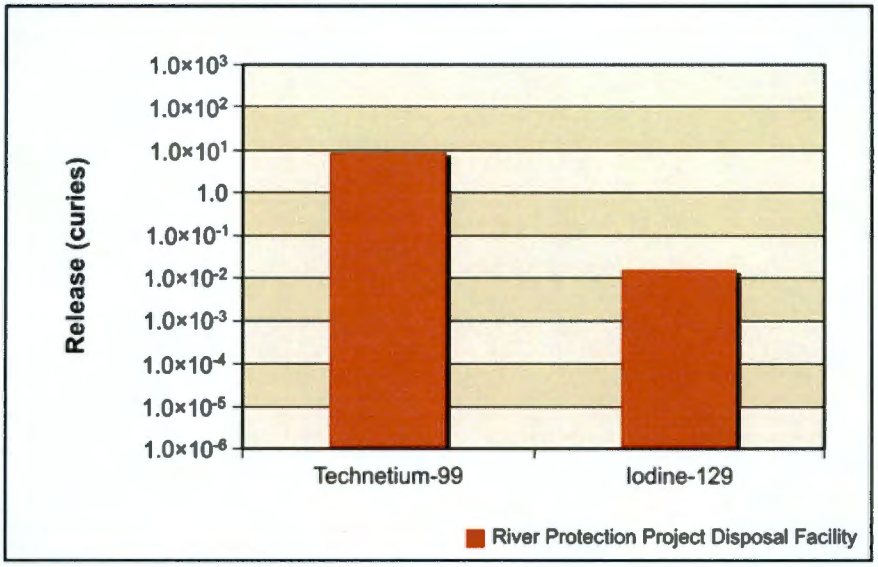


Figure 5–757. Management Alternative 3, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Columbia River

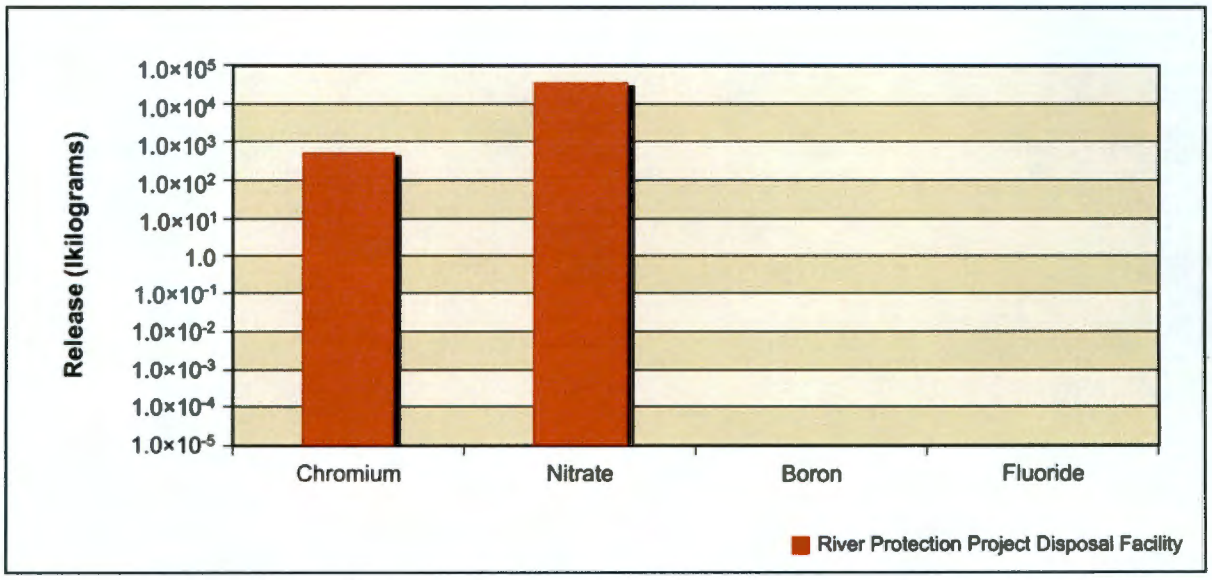


Figure 5–758. Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Columbia River

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.

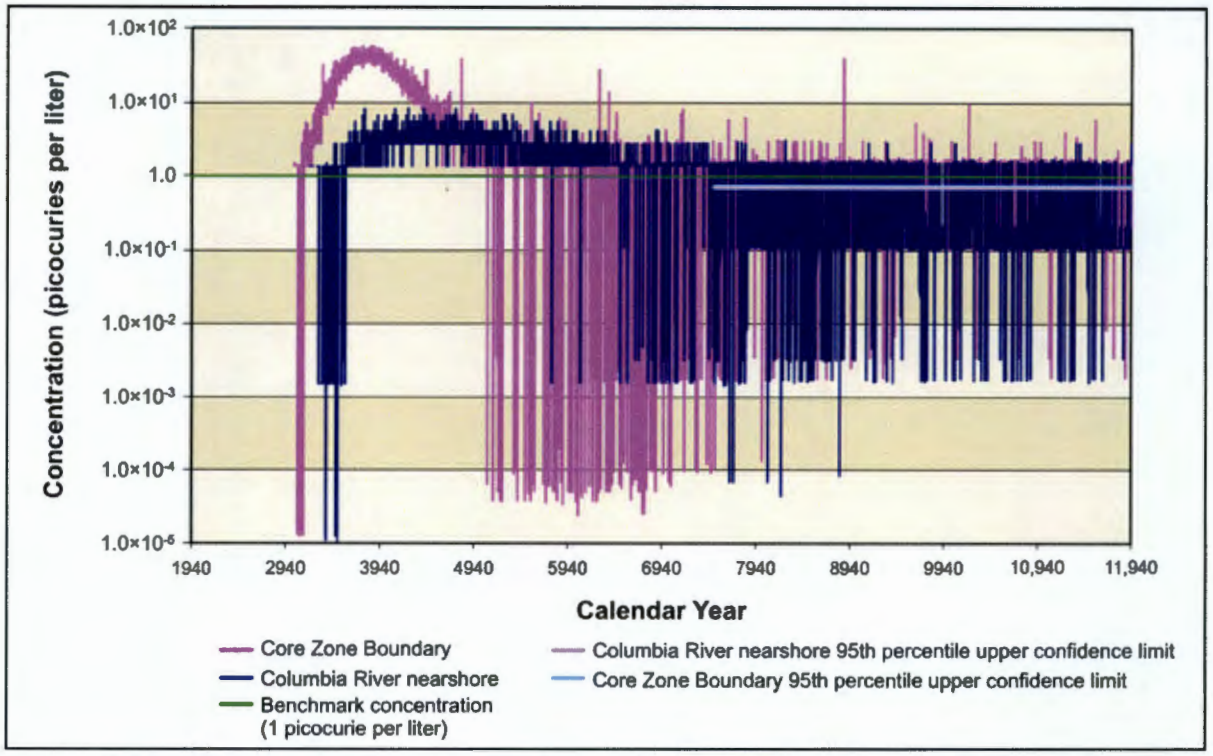


Figure 5–759. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Iodine-129 Concentration Versus Time

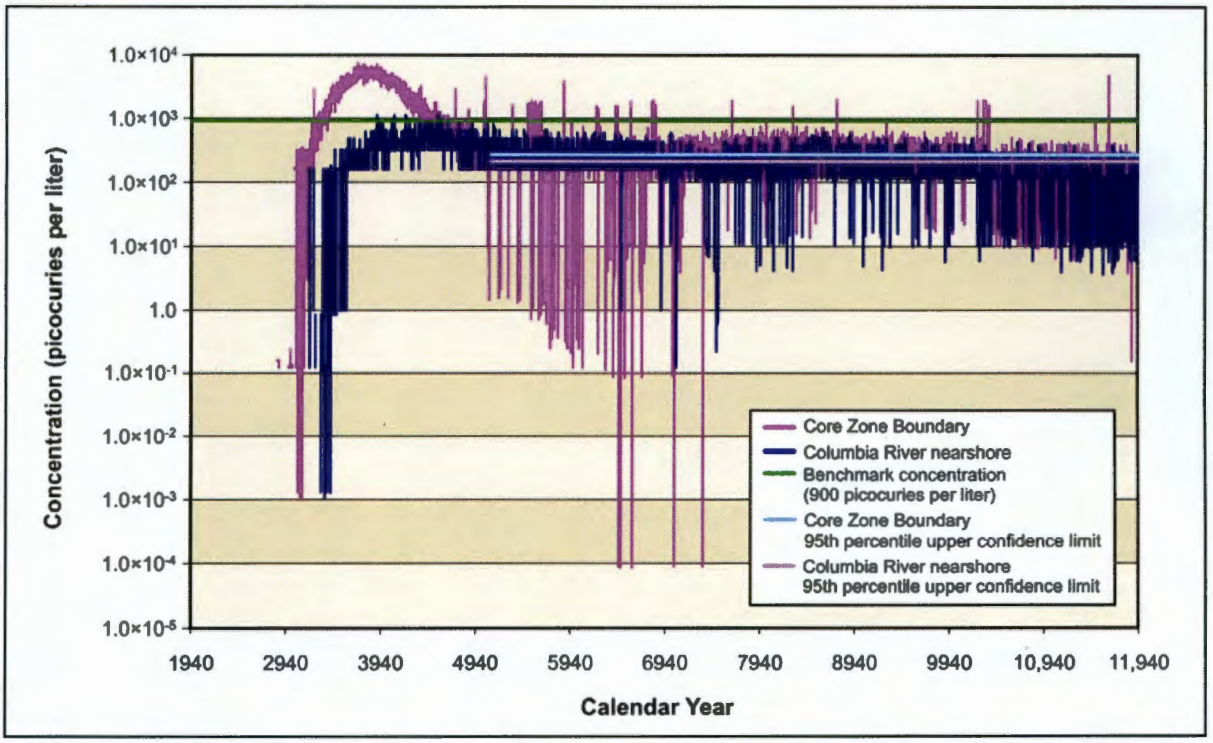


Figure 5–760. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Technetium-99 Concentration Versus Time

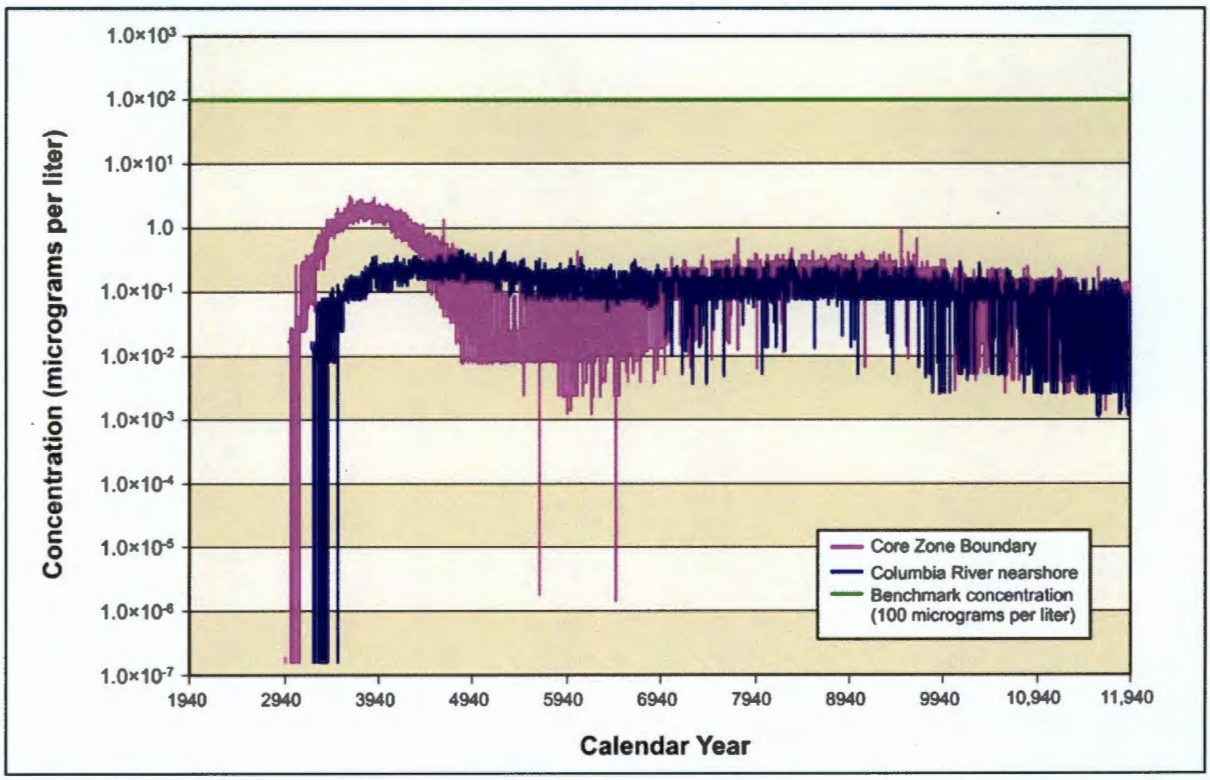


Figure 5–761. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Chromium Concentration Versus Time

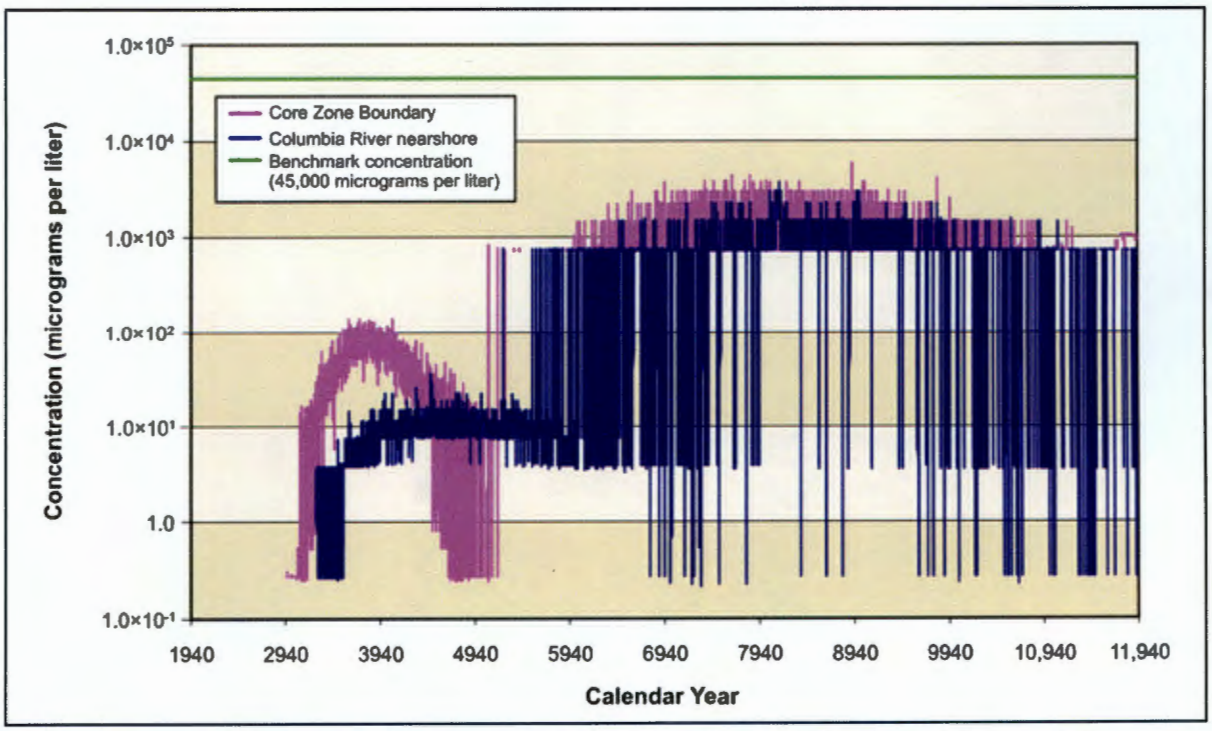


Figure 5–762. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Nitrate Concentration Versus Time

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.

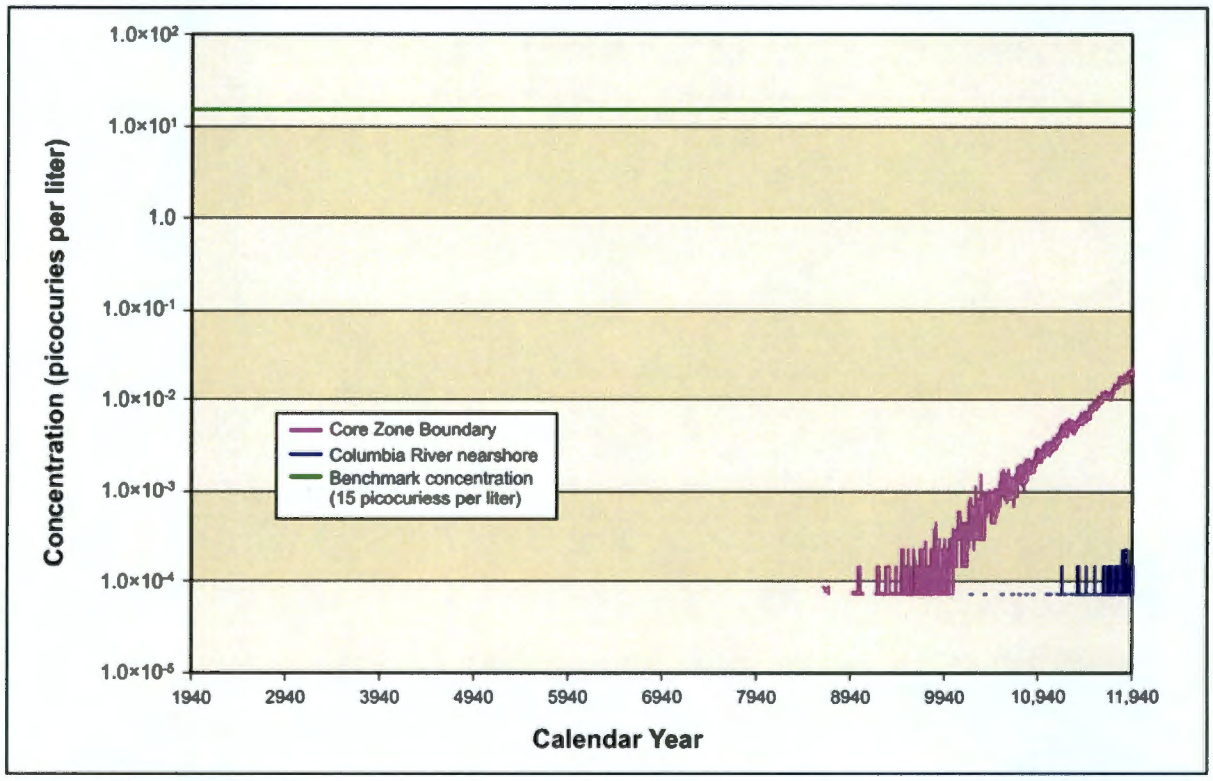


Figure 5–763. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Uranium-238 Concentration Versus Time

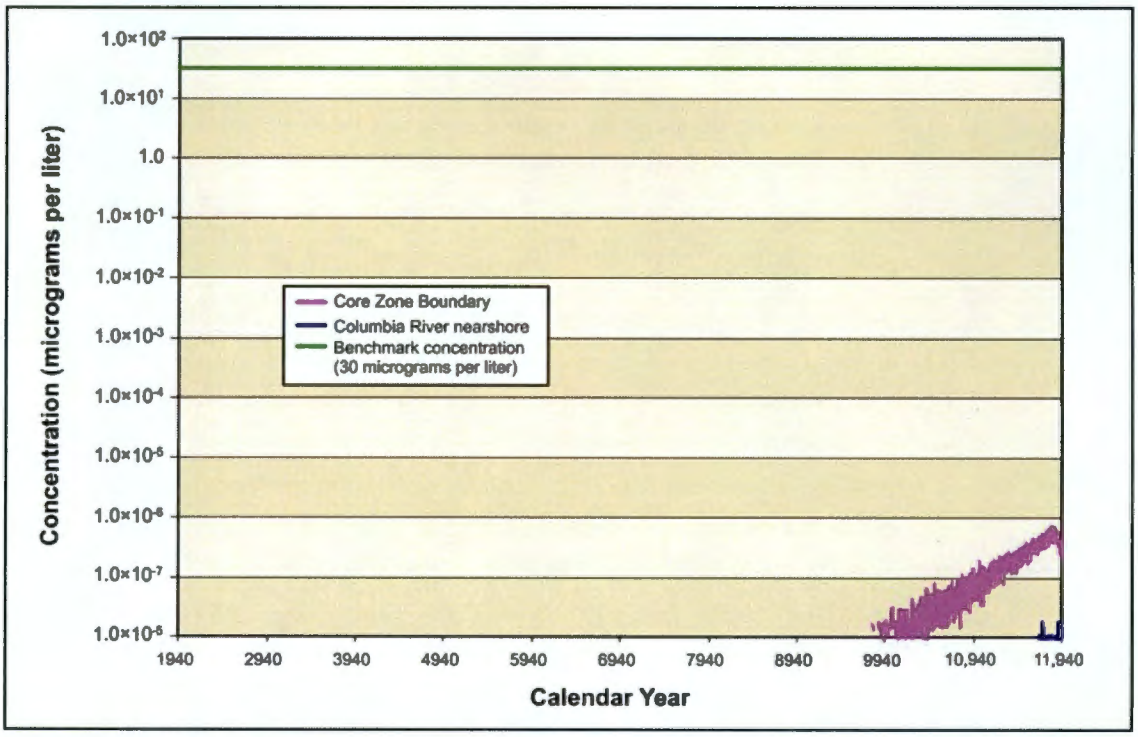
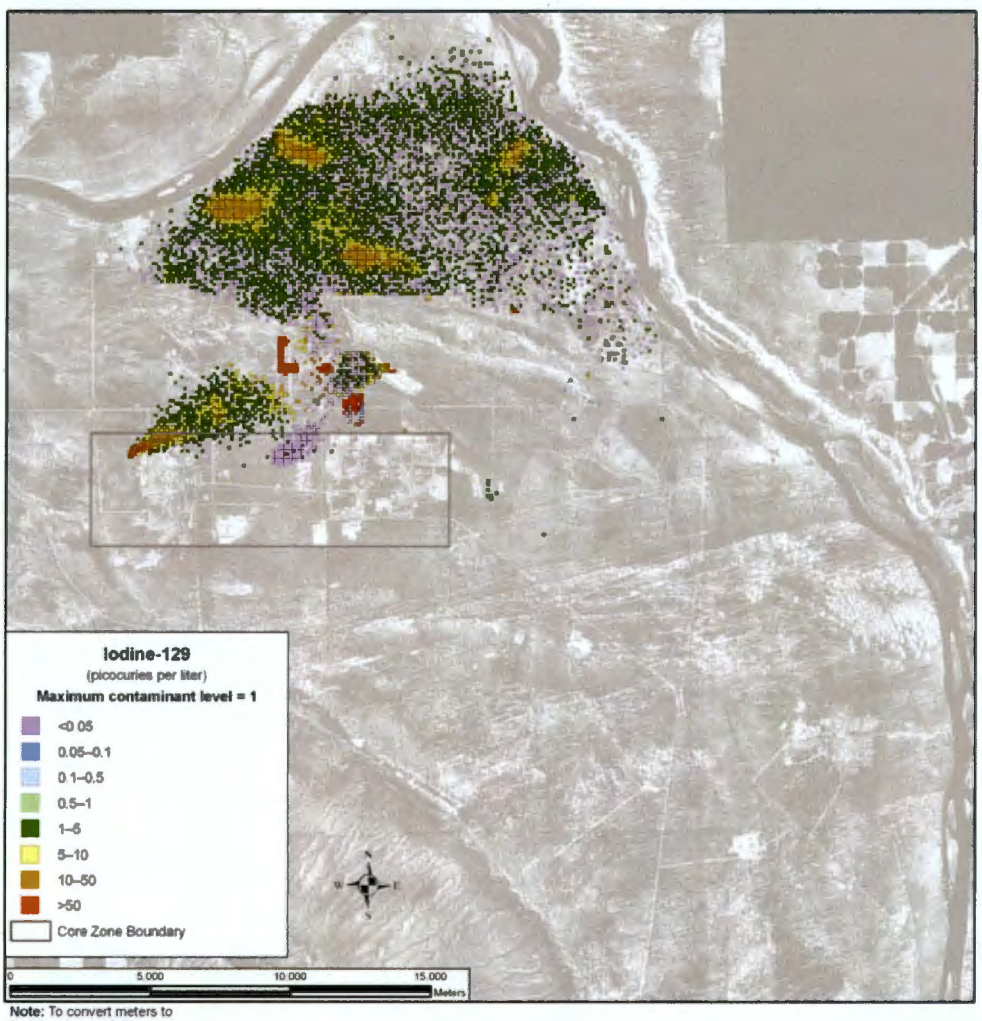


Figure 5–764. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Total Uranium Concentration Versus Time

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

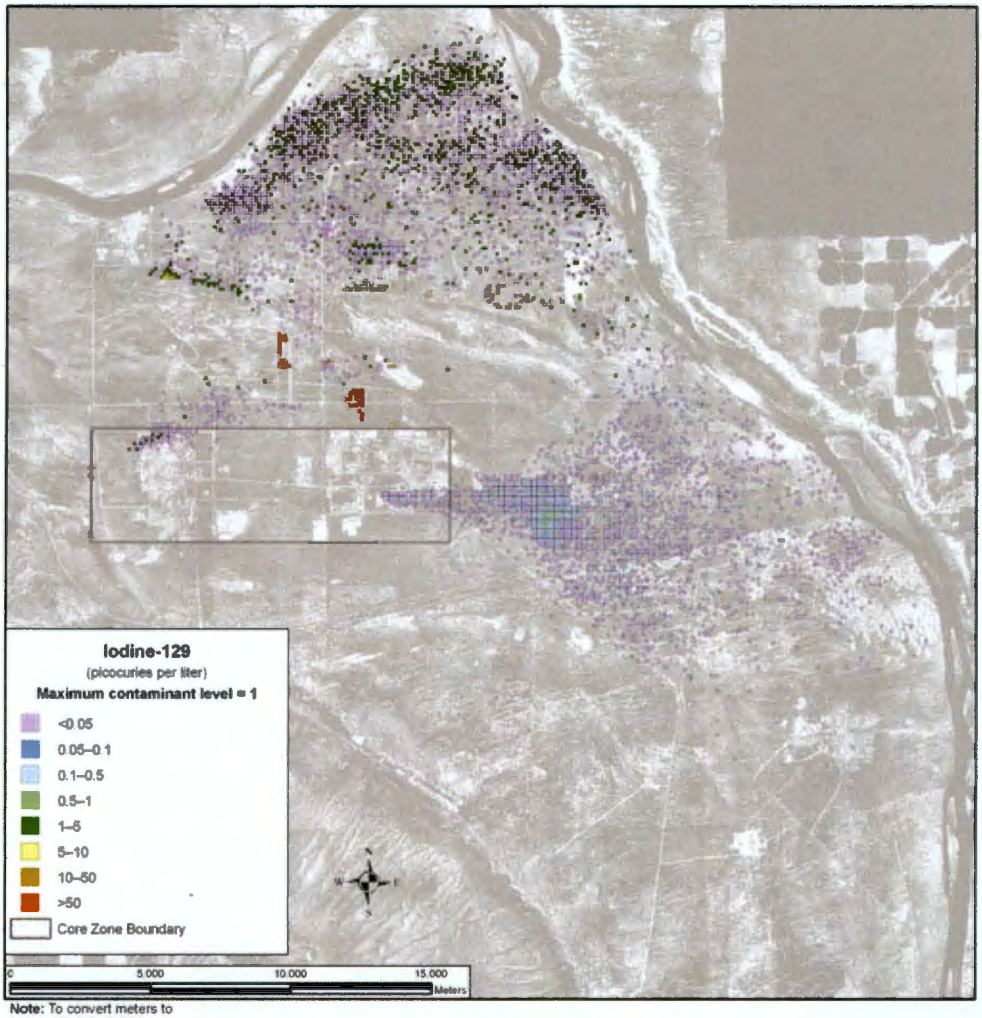
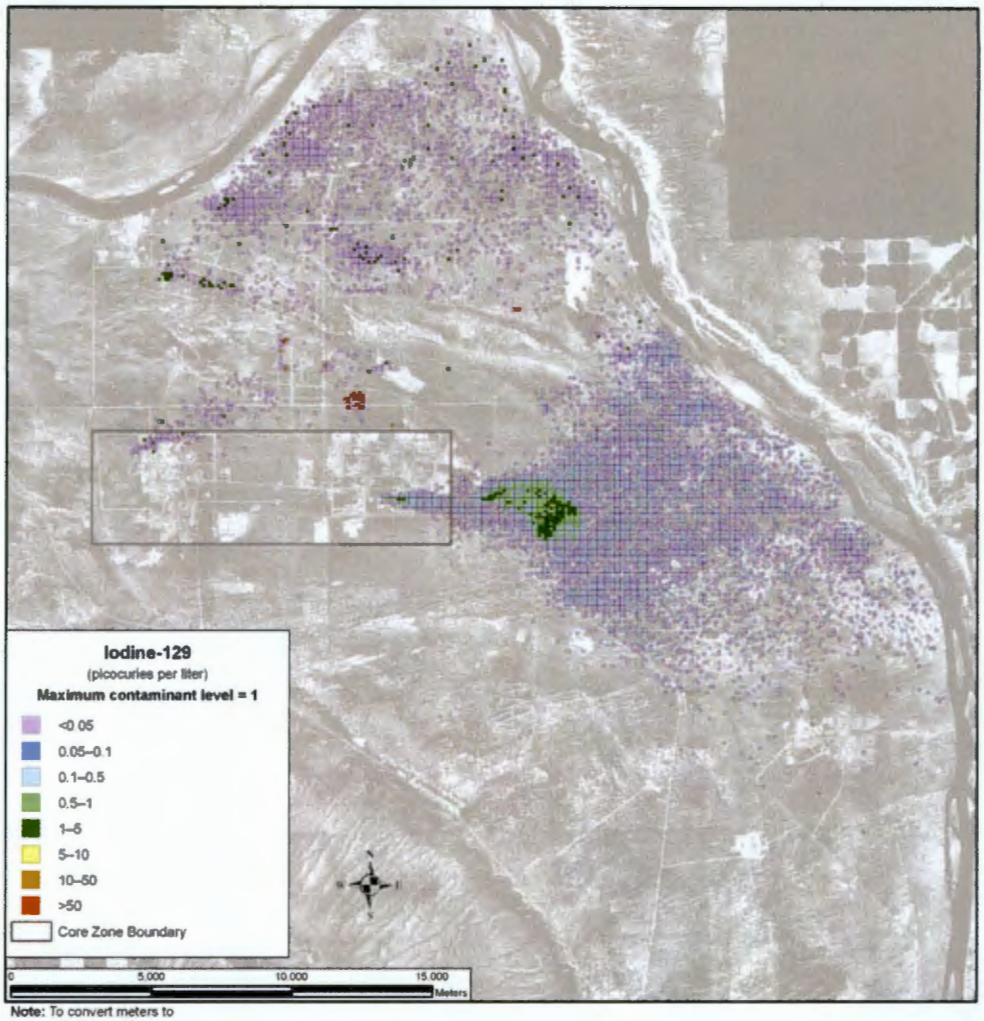
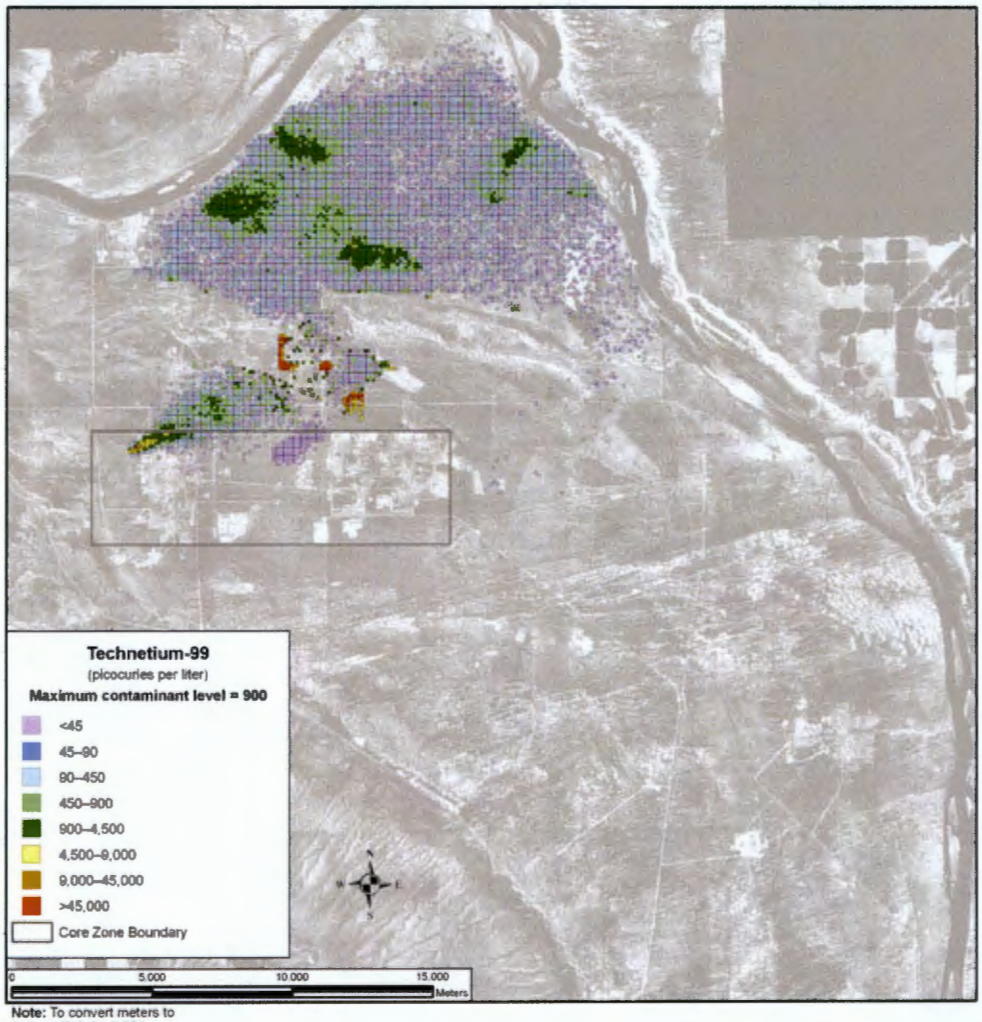


Figure 5–766. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



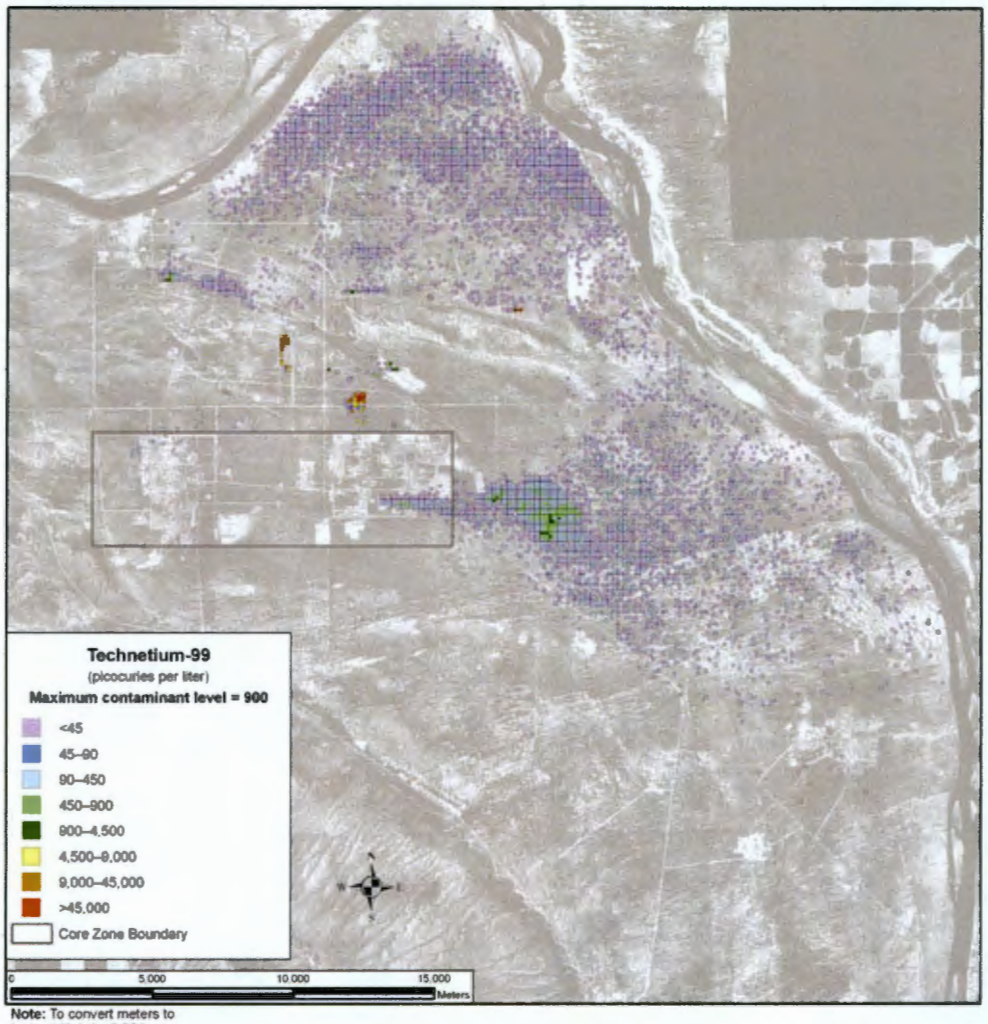
Note: To convert meters to feet, multiply by 3.281

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



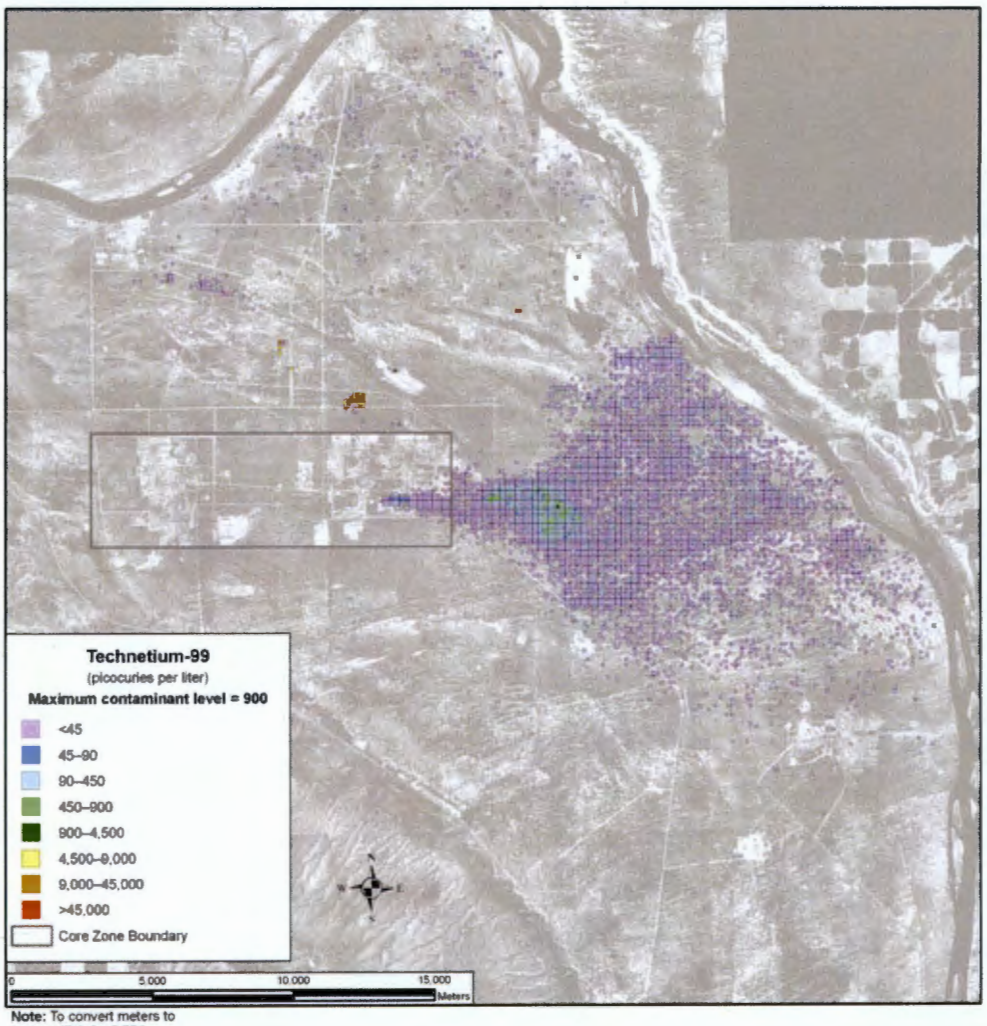
Note: To convert meters to feet, multiply by 3.281

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



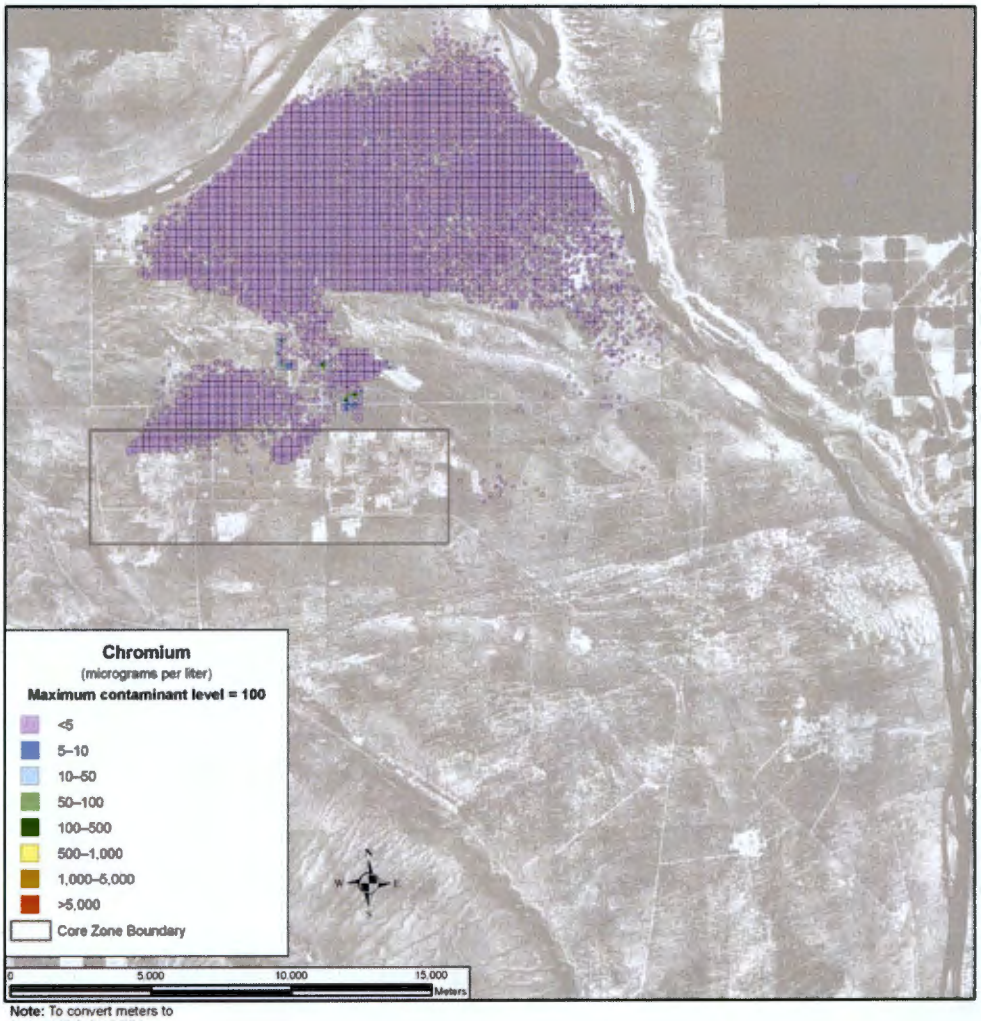
Note: To convert meters to feet, multiply by 3.281

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



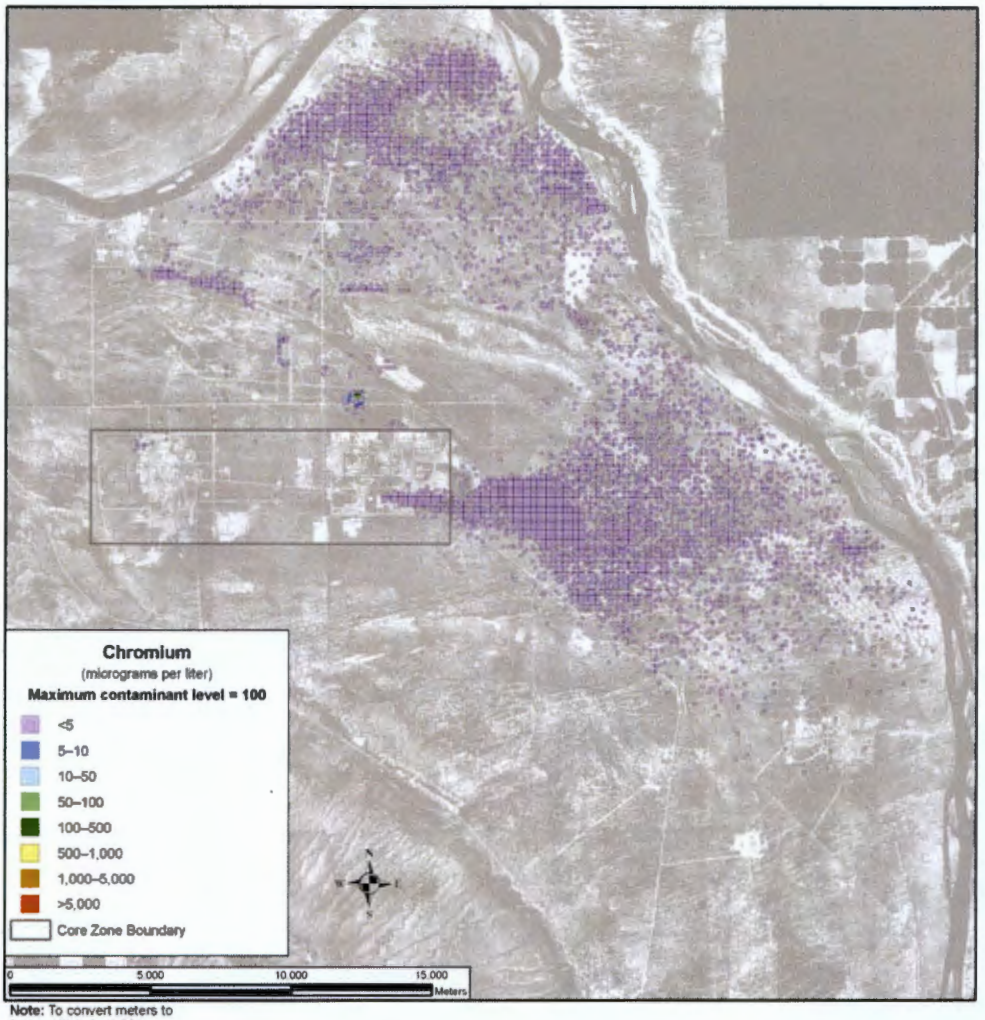
Note: To convert meters to feet, multiply by 3.281

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



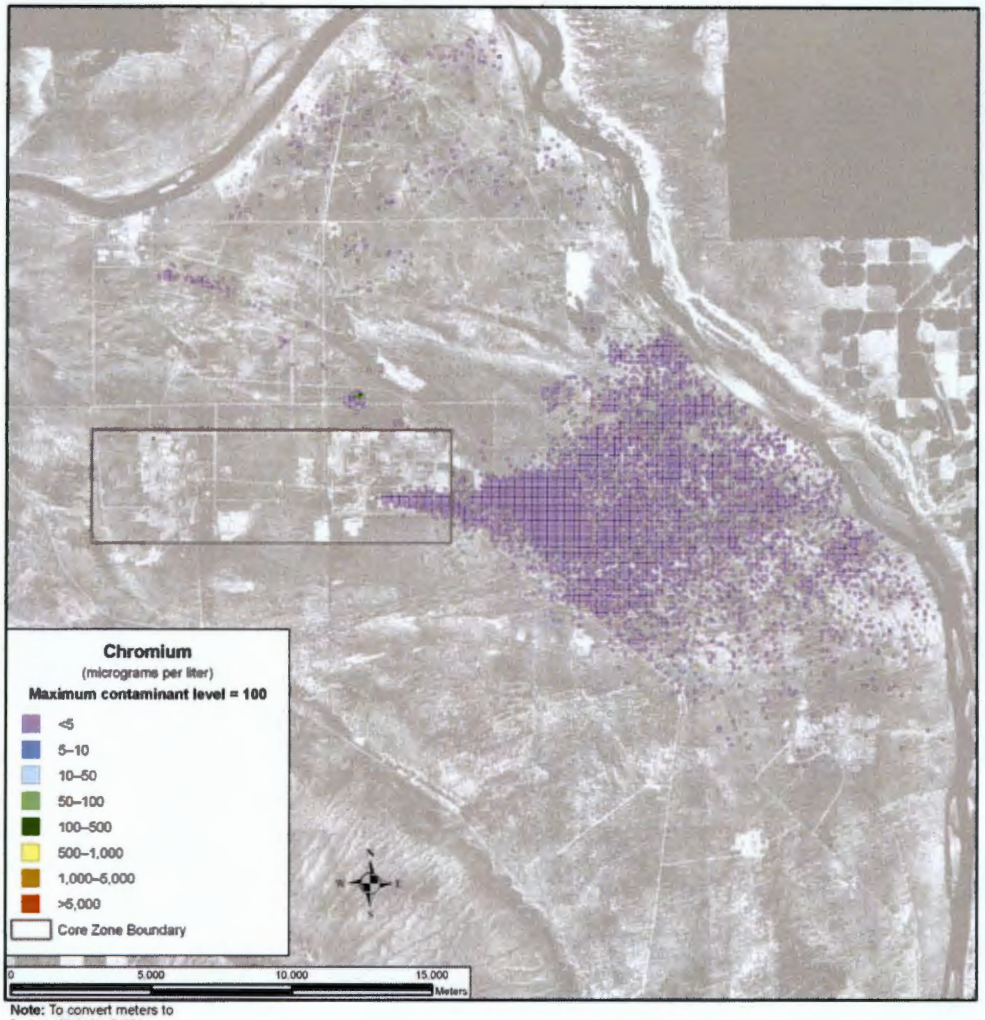
Note: To convert meters to feet, multiply by 3.281

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



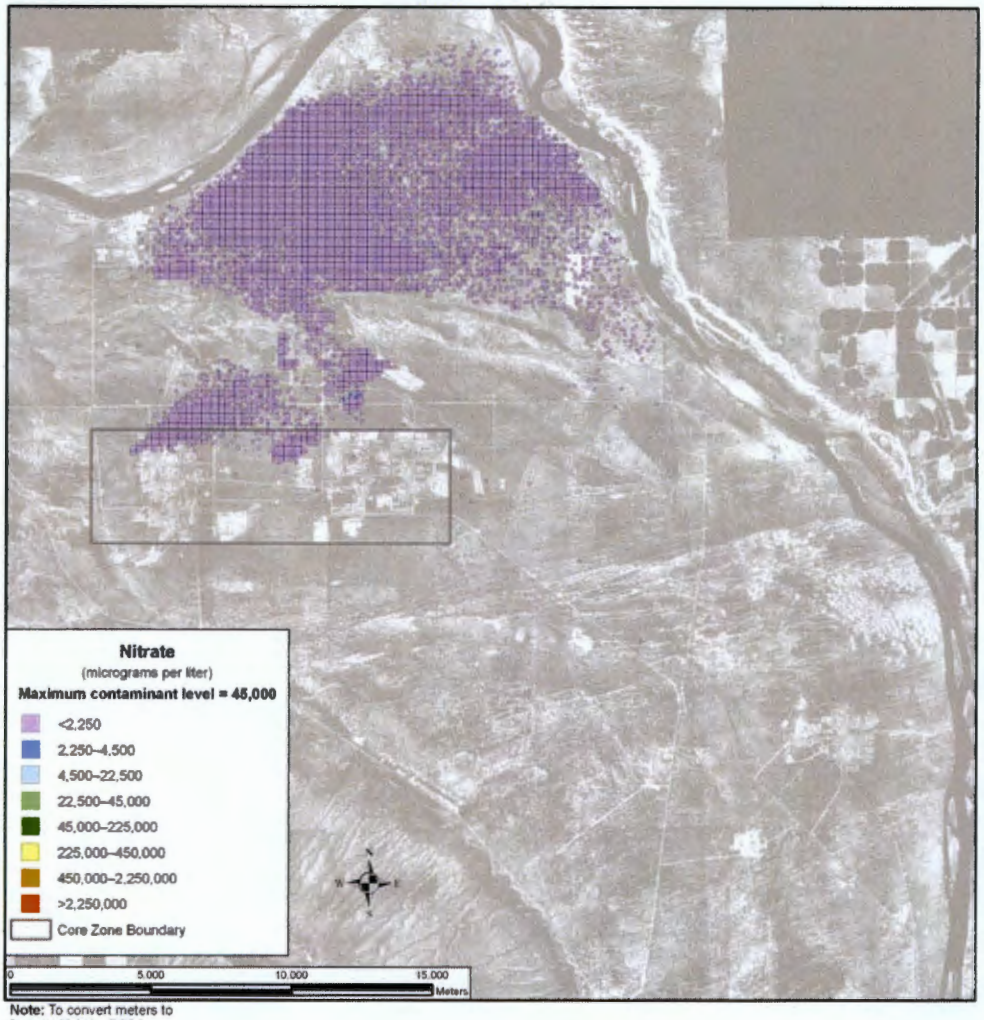
Note: To convert meters to feet, multiply by 3.281

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



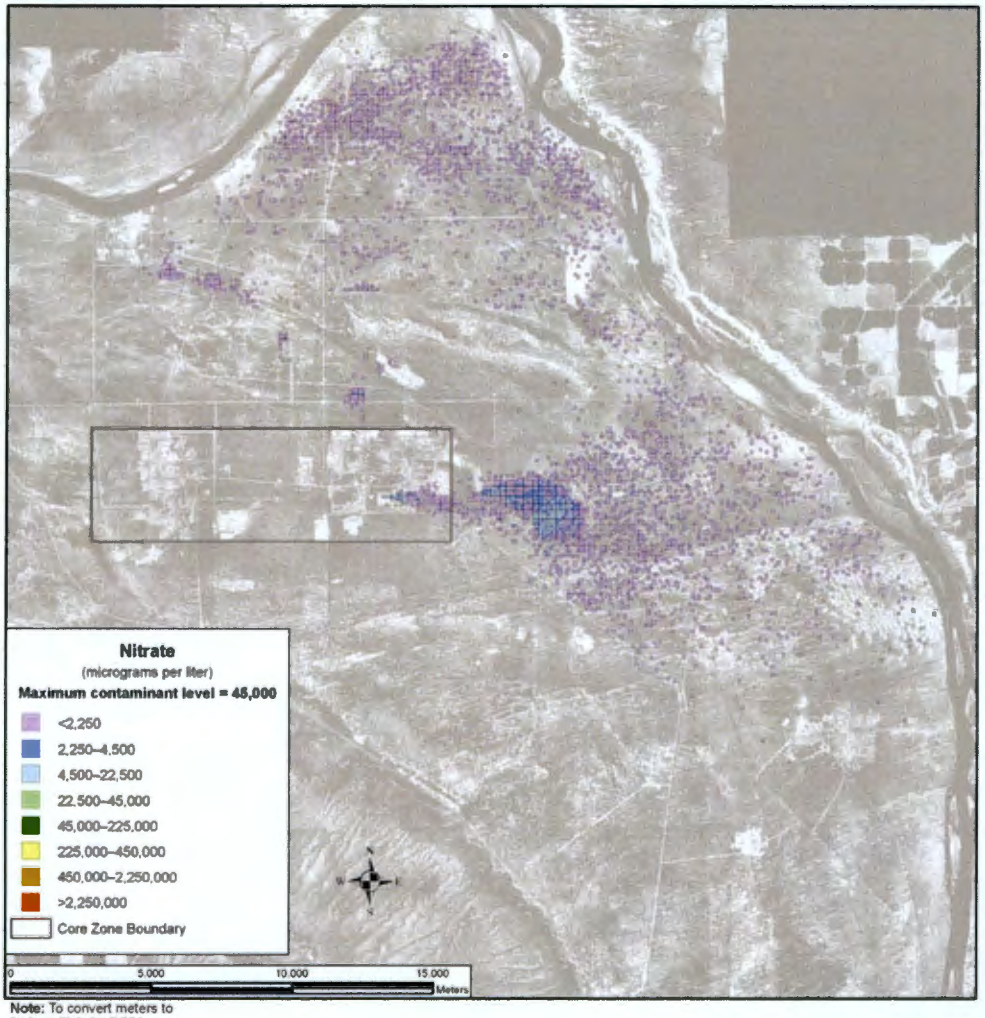
Note: To convert meters to feet, multiply by 3.281

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



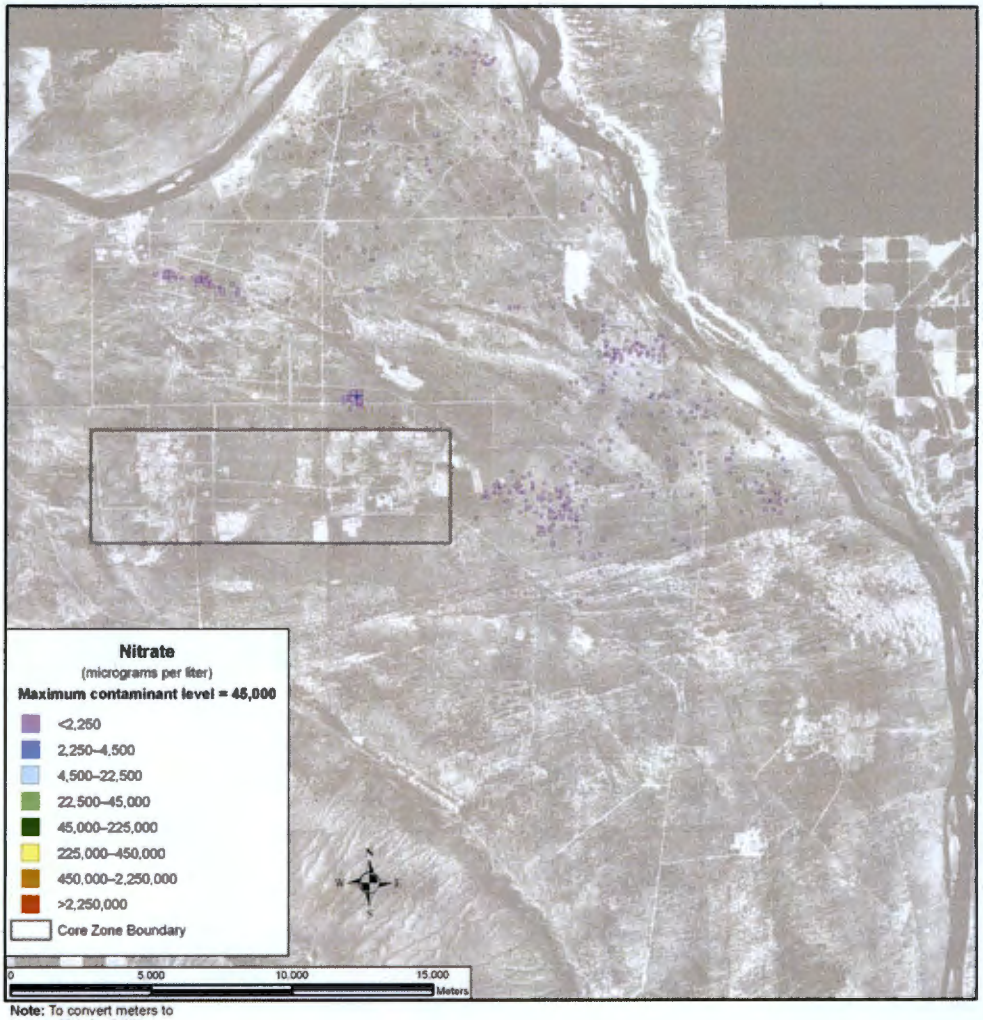
Note: To convert meters to feet, multiply by 3.281

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

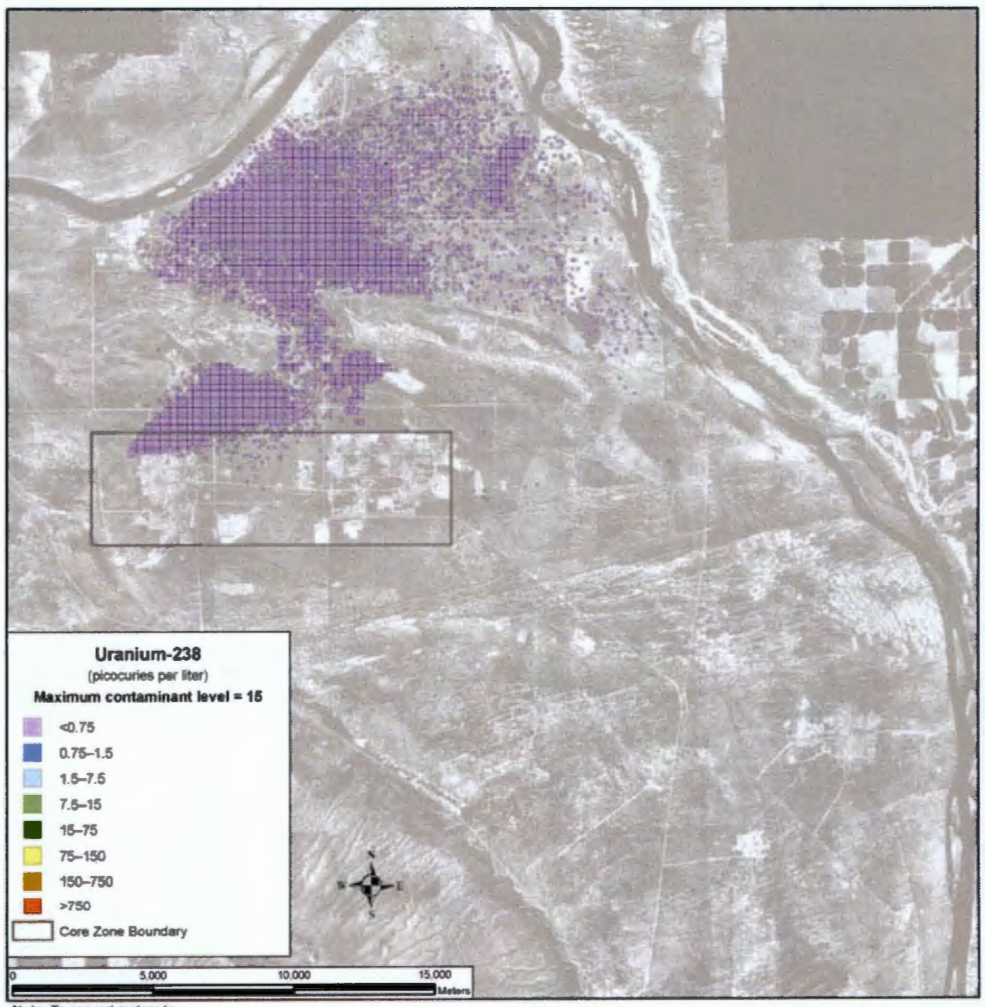
Figure 5–775. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

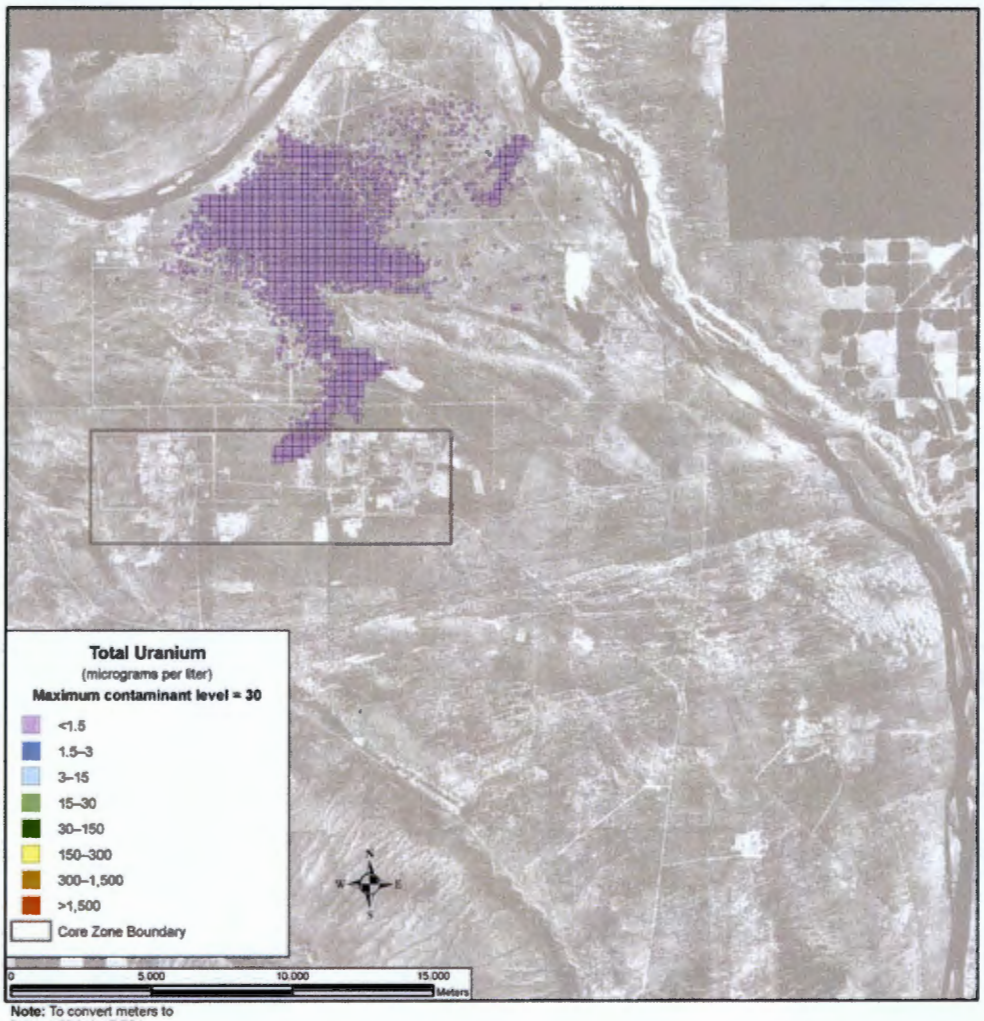
Figure 5–776. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

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



Note: To convert meters to feet, multiply by 3.281

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.

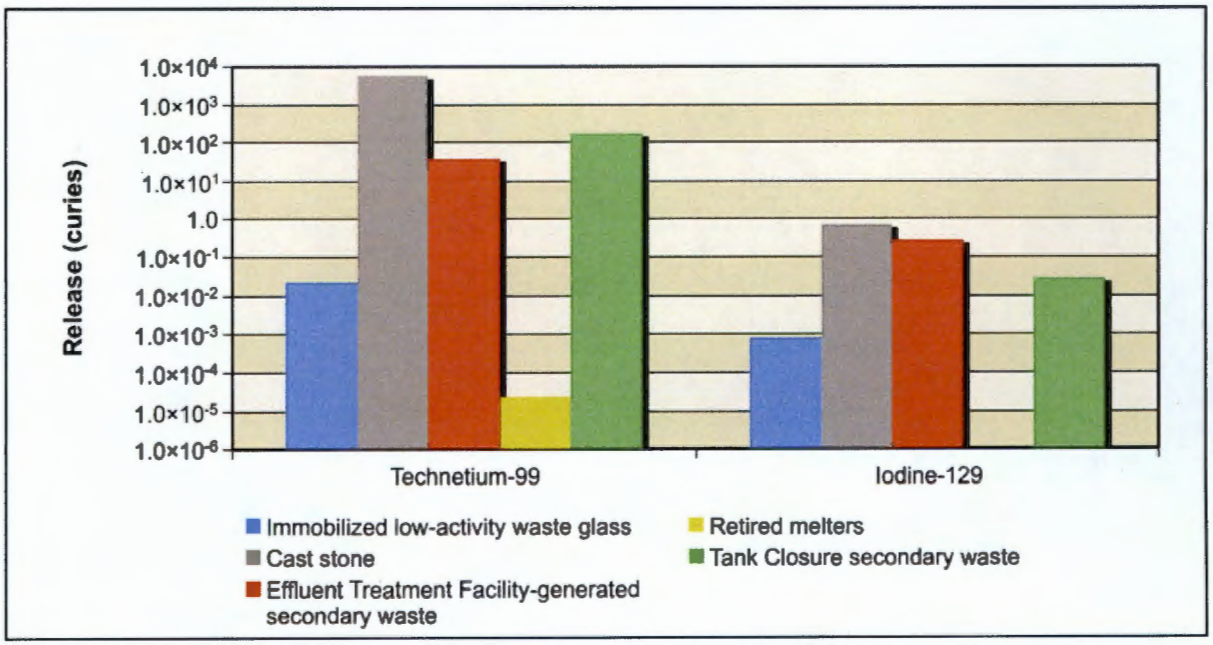


Figure 5–779. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Area to Vadose Zone

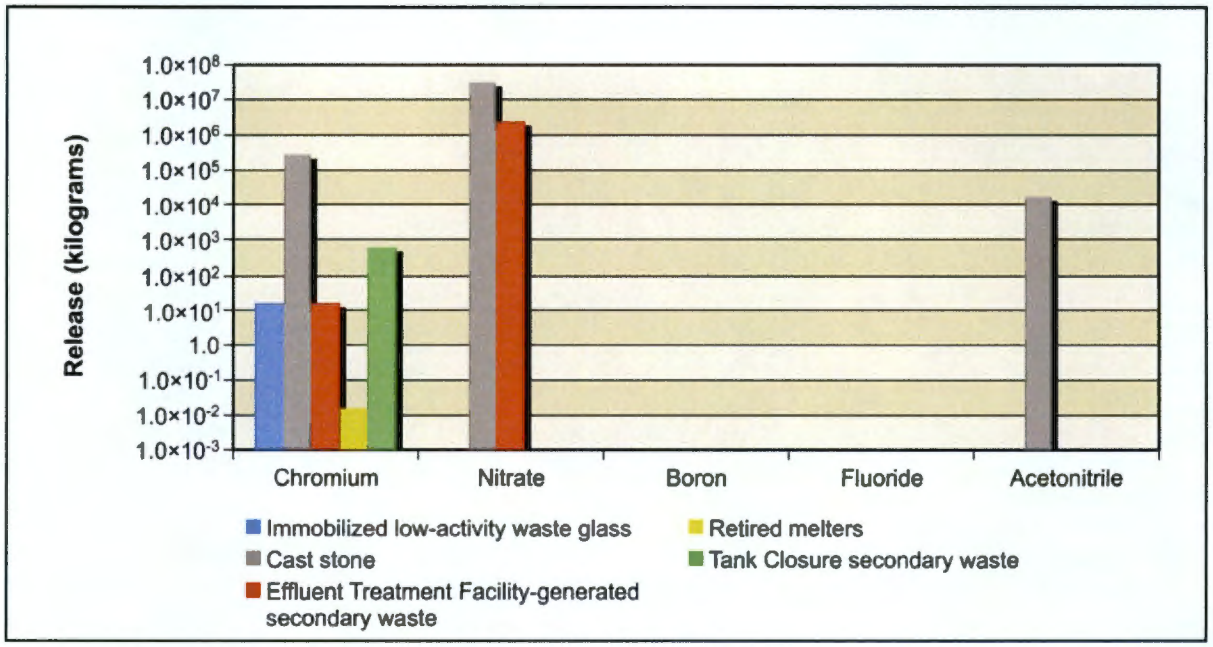


Figure 5–780. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Area to Vadose Zone

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.

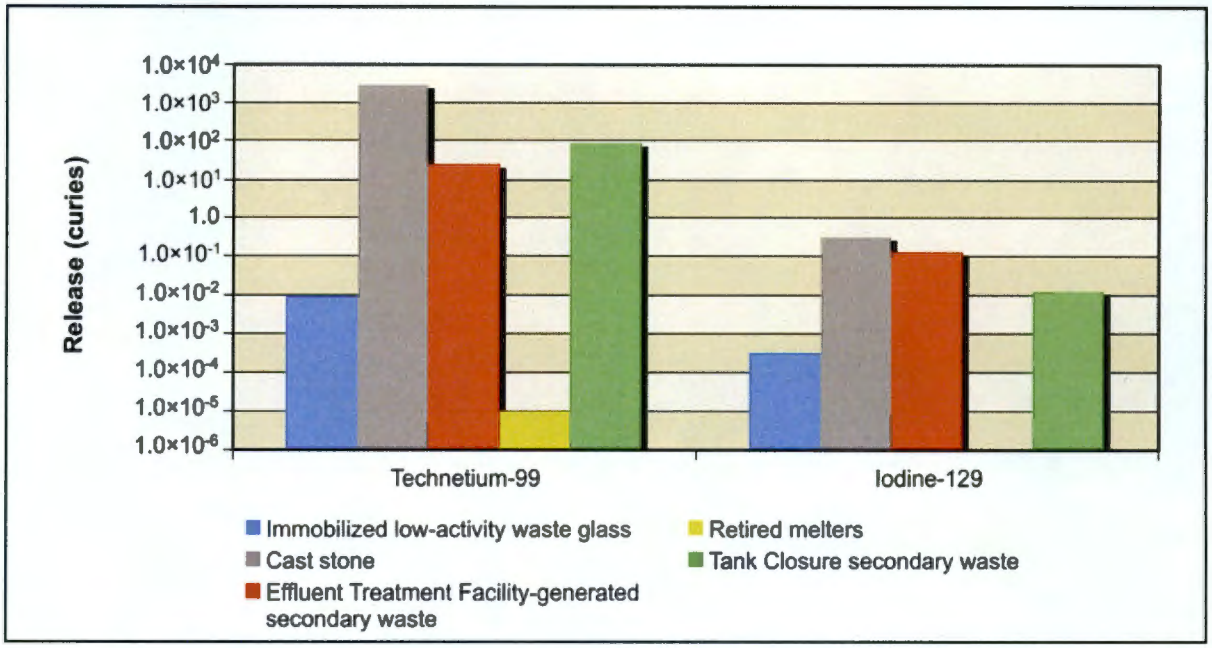


Figure 5–781. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Area to Groundwater

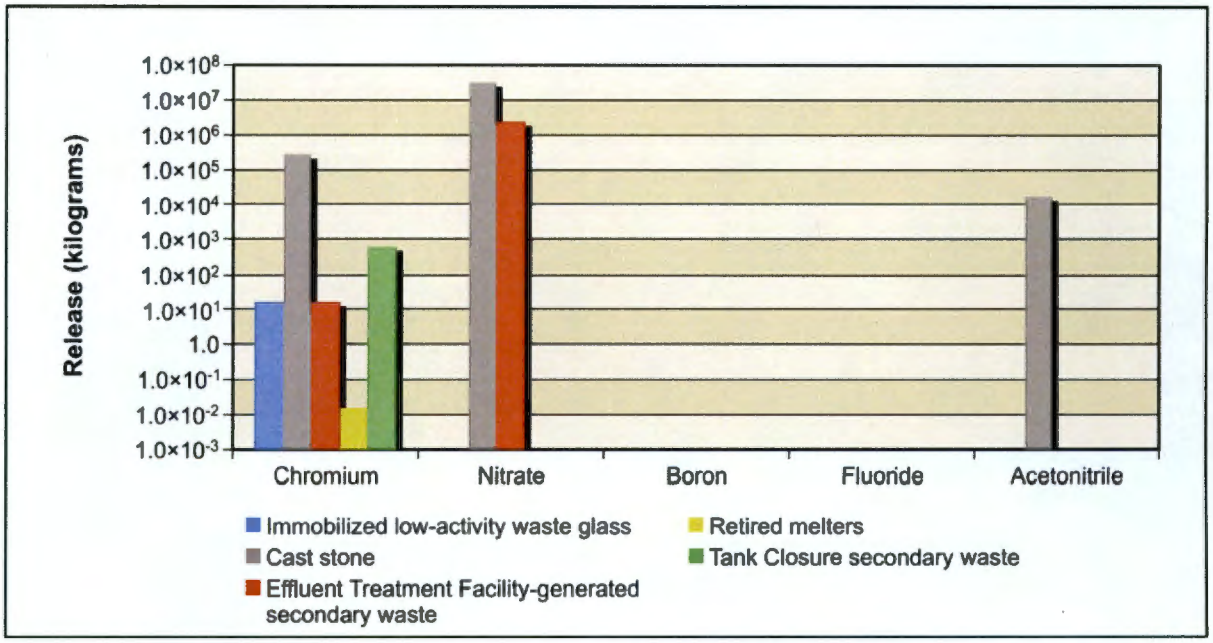


Figure 5–782. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Area to Groundwater

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.

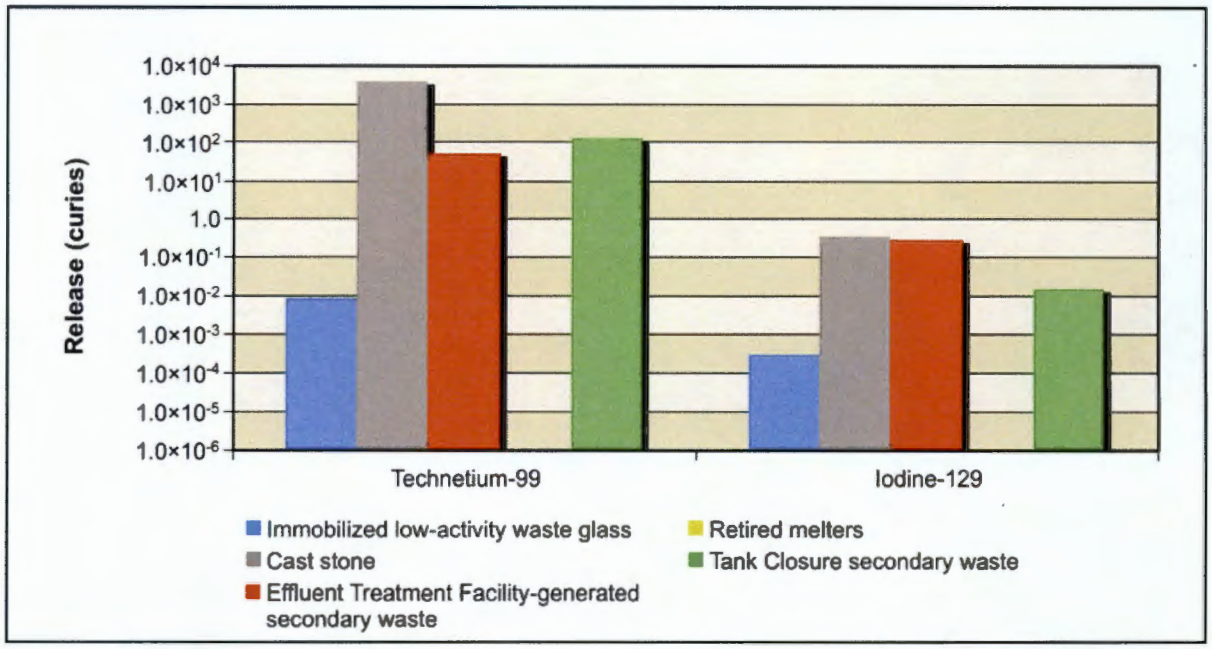


Figure 5–783. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Area to Columbia River

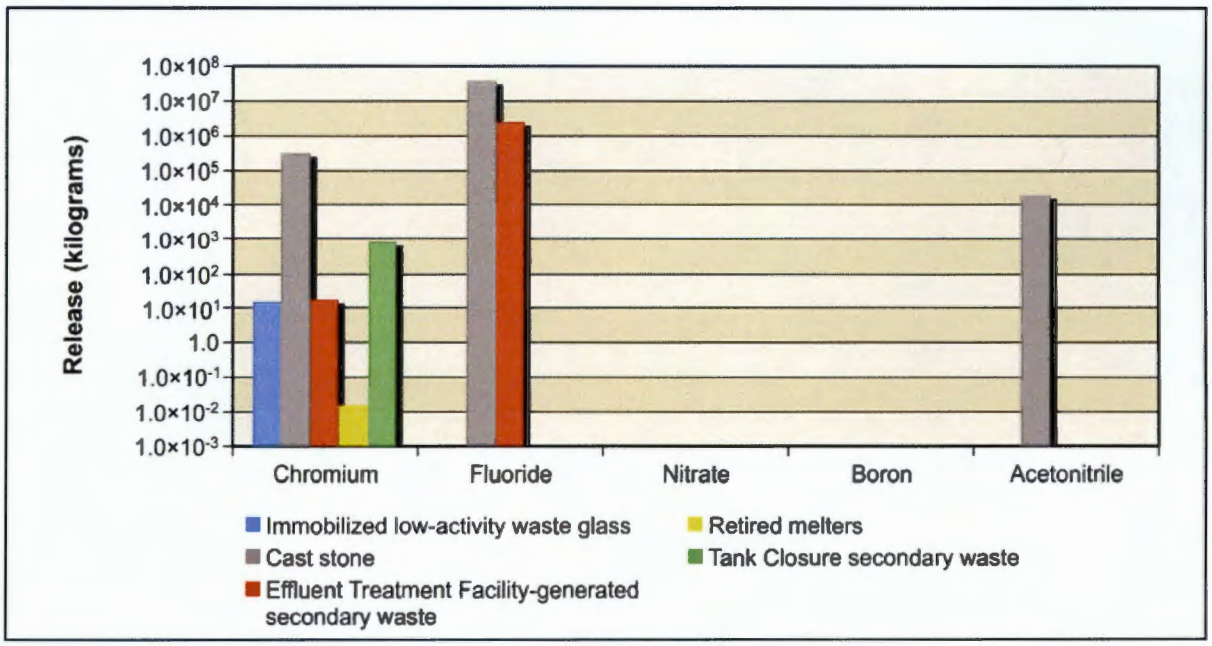


Figure 5–784. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Area to Columbia River

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.

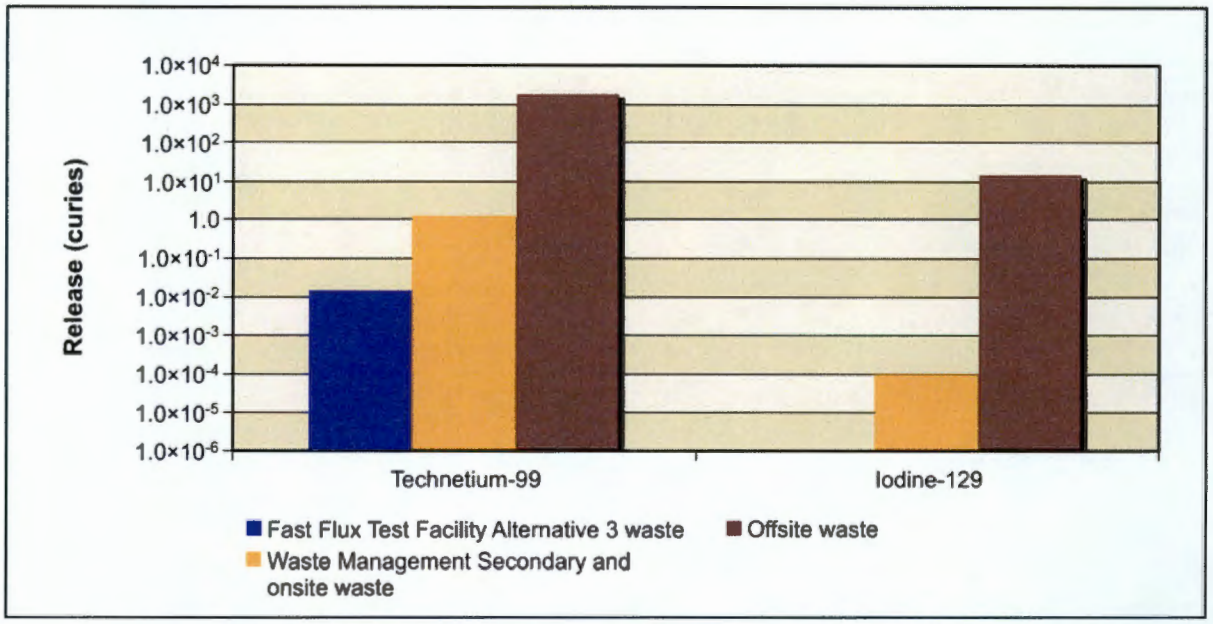


Figure 5–785. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-West Area Integrated Disposal Area to Vadose Zone

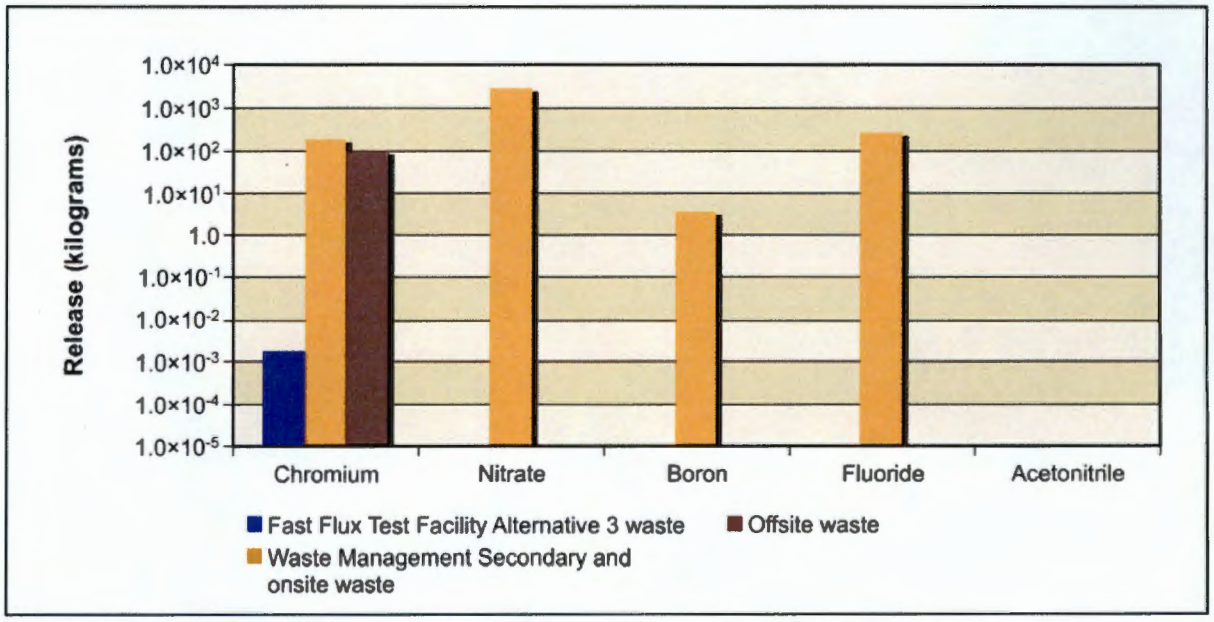


Figure 5–786. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-West Area Integrated Disposal Area to Vadose Zone

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.

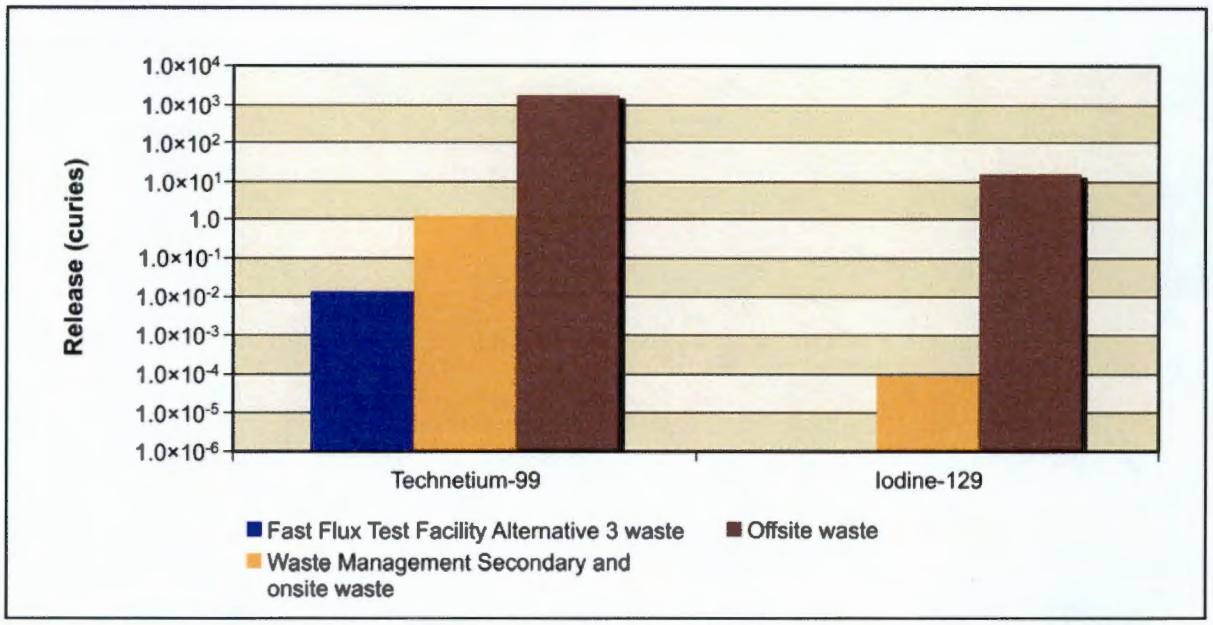


Figure 5–787. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-West Area Integrated Disposal Area to Groundwater

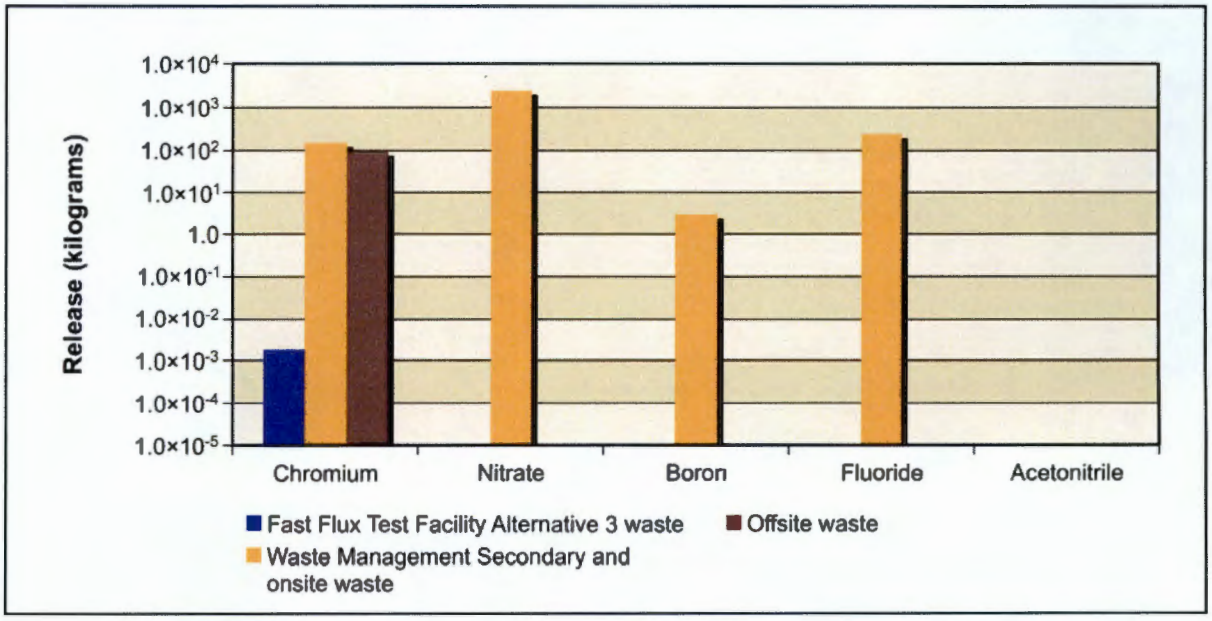


Figure 5–788. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-West Area Integrated Disposal Area to Groundwater

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.

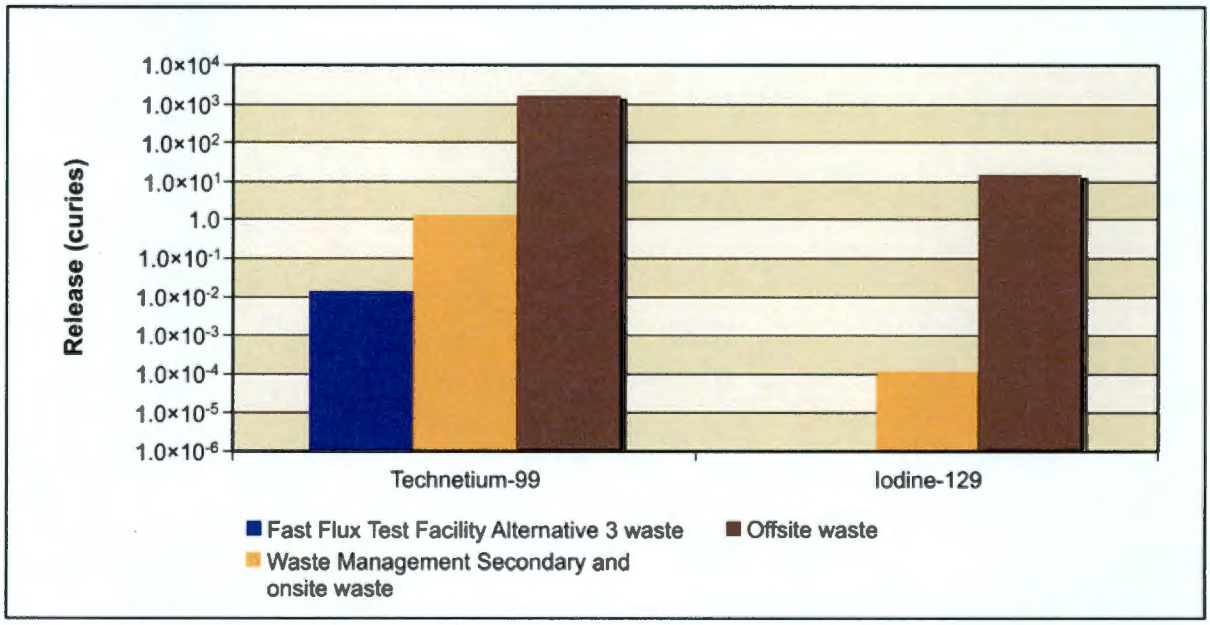


Figure 5–789. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-West Area Integrated Disposal Area to Columbia River

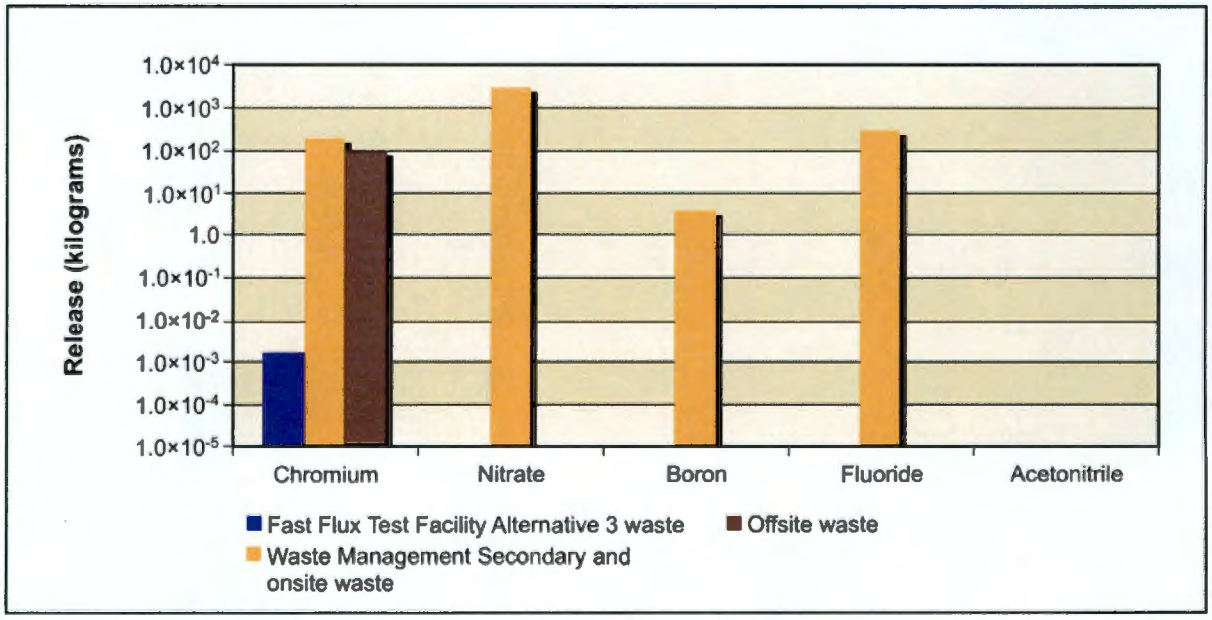


Figure 5–790. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-West Area Integrated Disposal Area to Columbia River

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.

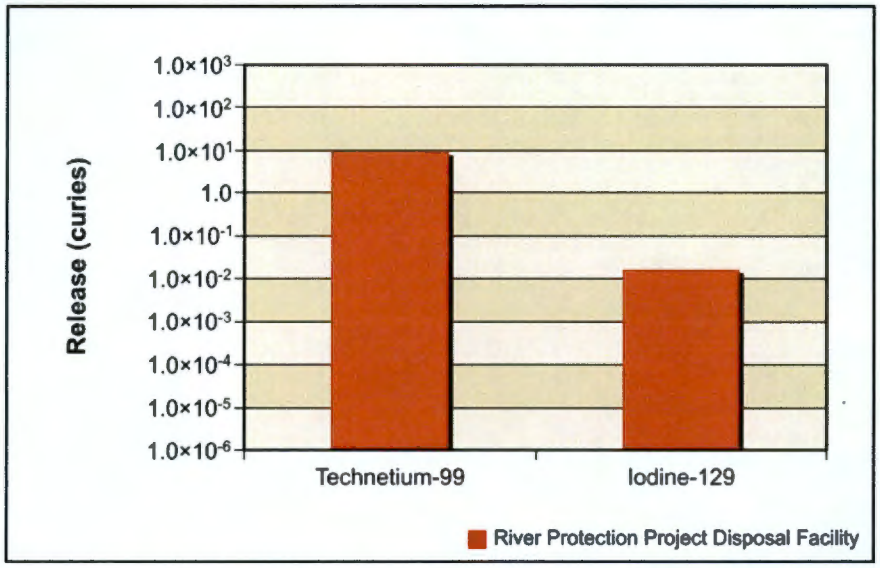


Figure 5–791. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Area to Vadose Zone

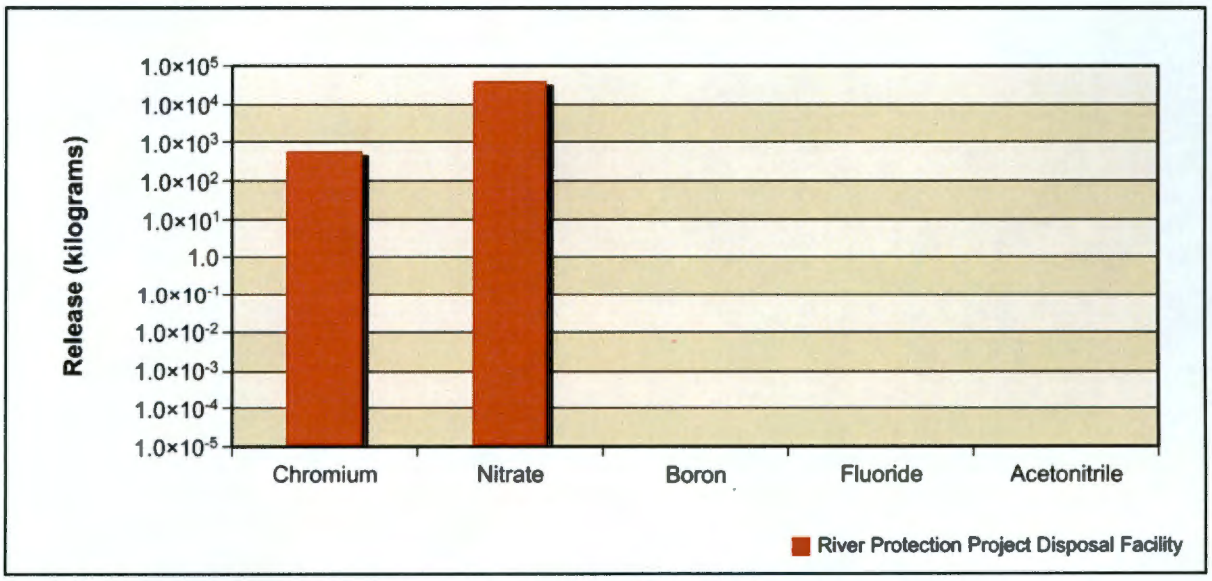


Figure 5–792. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Area to Vadose Zone

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.

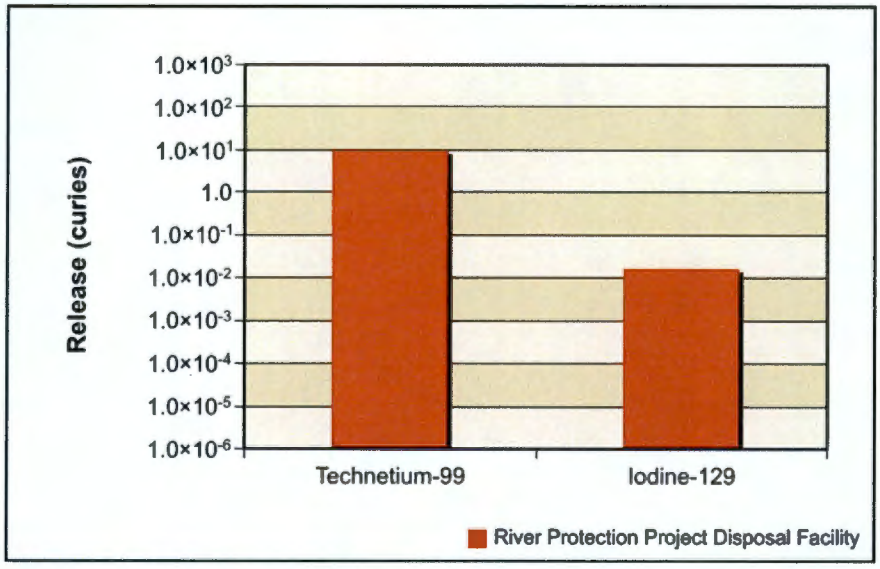


Figure 5–793. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Area to Groundwater

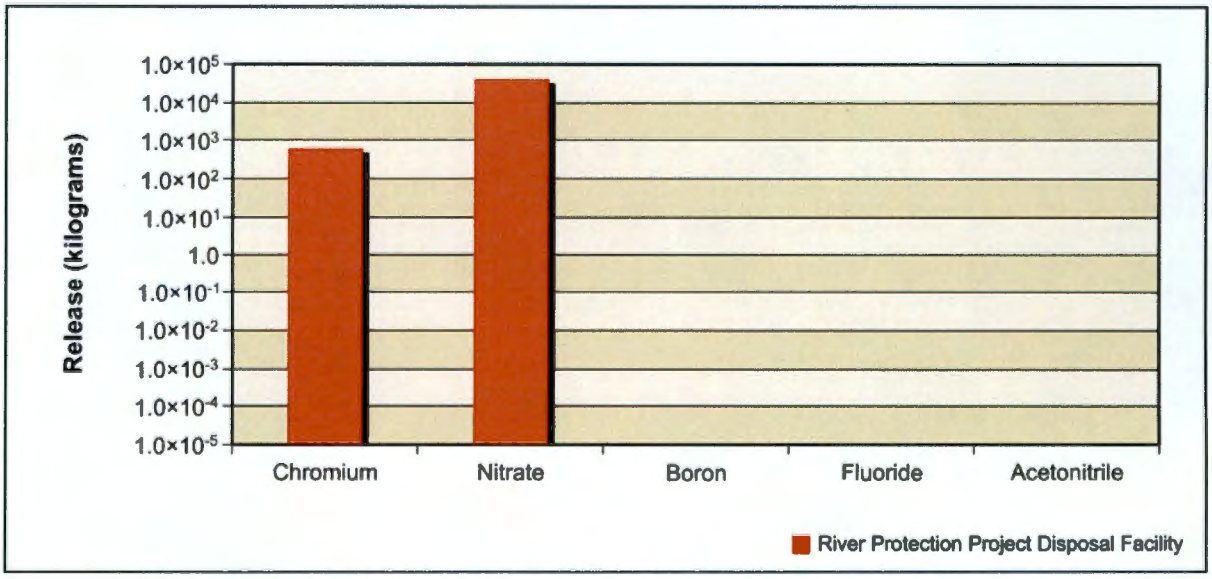


Figure 5–794. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Area to Groundwater

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.

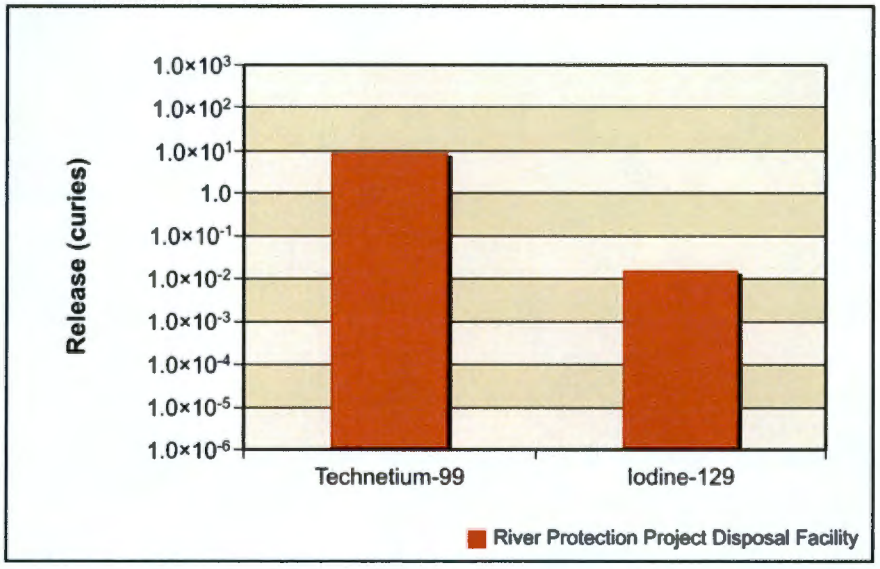


Figure 5–795. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Area to Columbia River

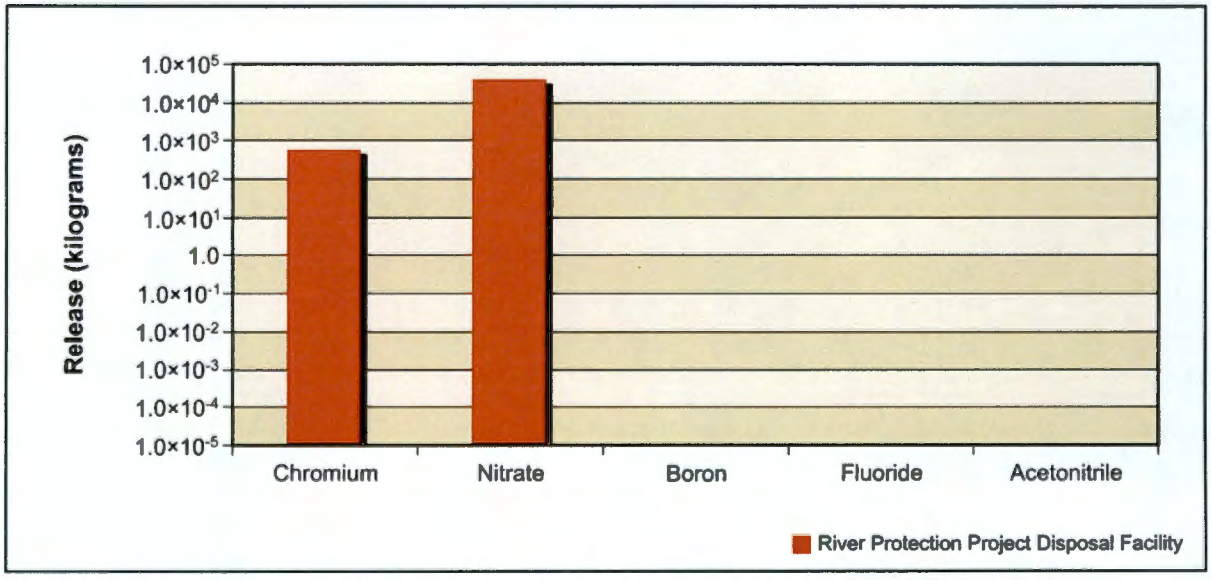


Figure 5–796. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Area to Columbia River

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.

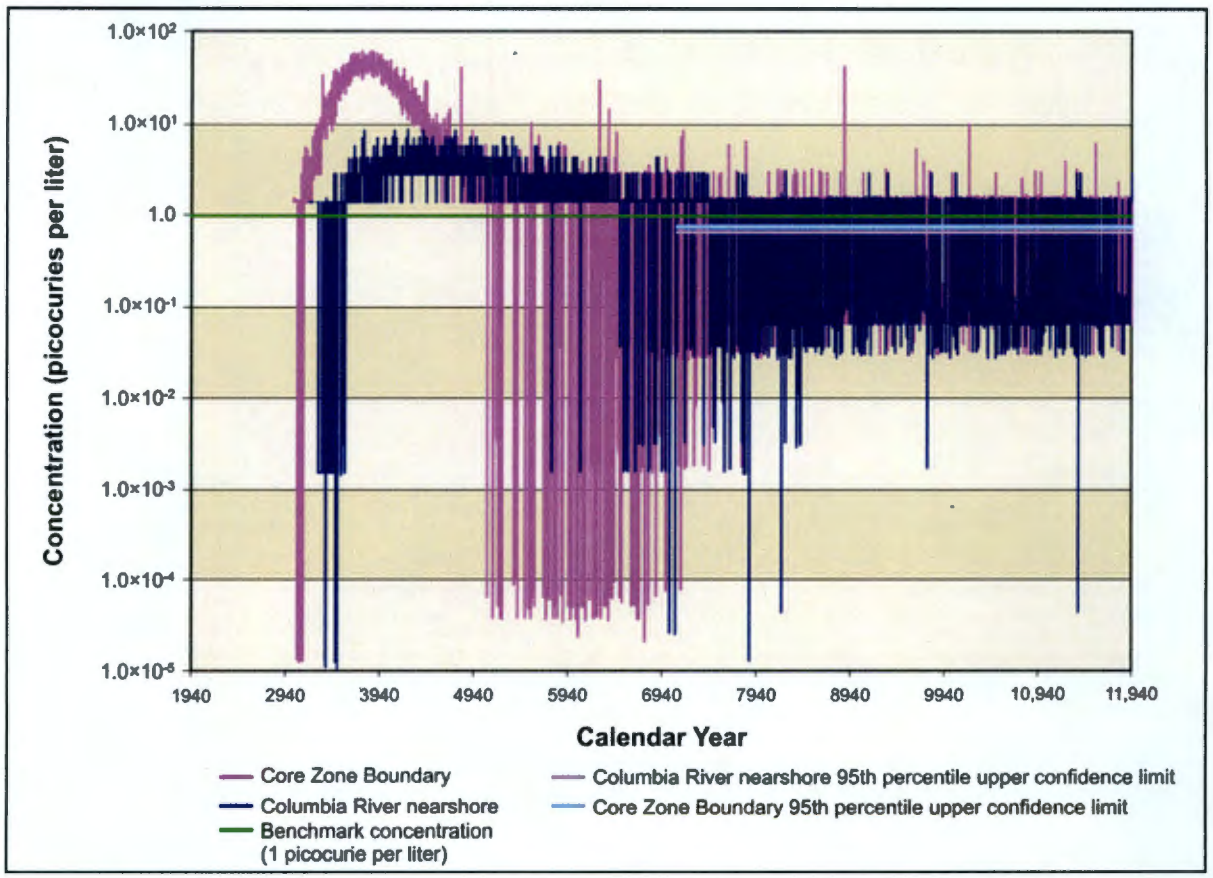


Figure 5–797. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Iodine-129 Concentration Versus Time

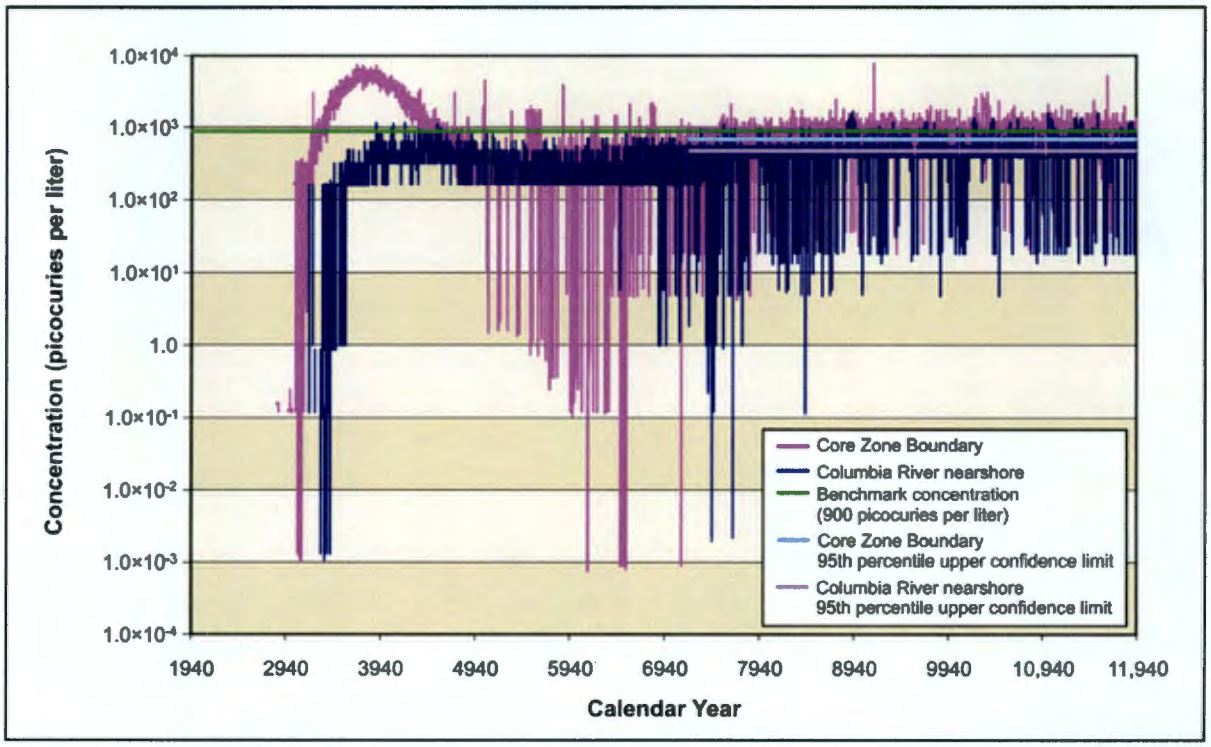


Figure 5–798. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Technetium-99 Concentration Versus Time

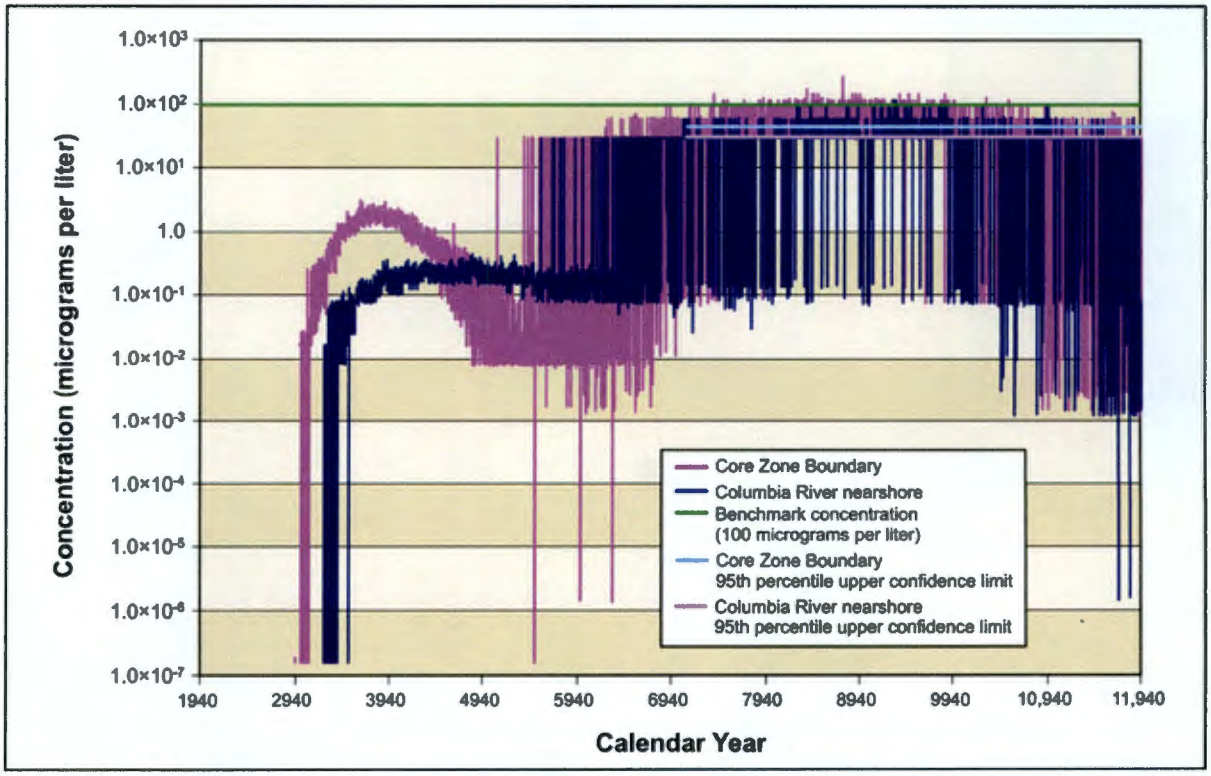


Figure 5–799. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Chromium Concentration Versus Time

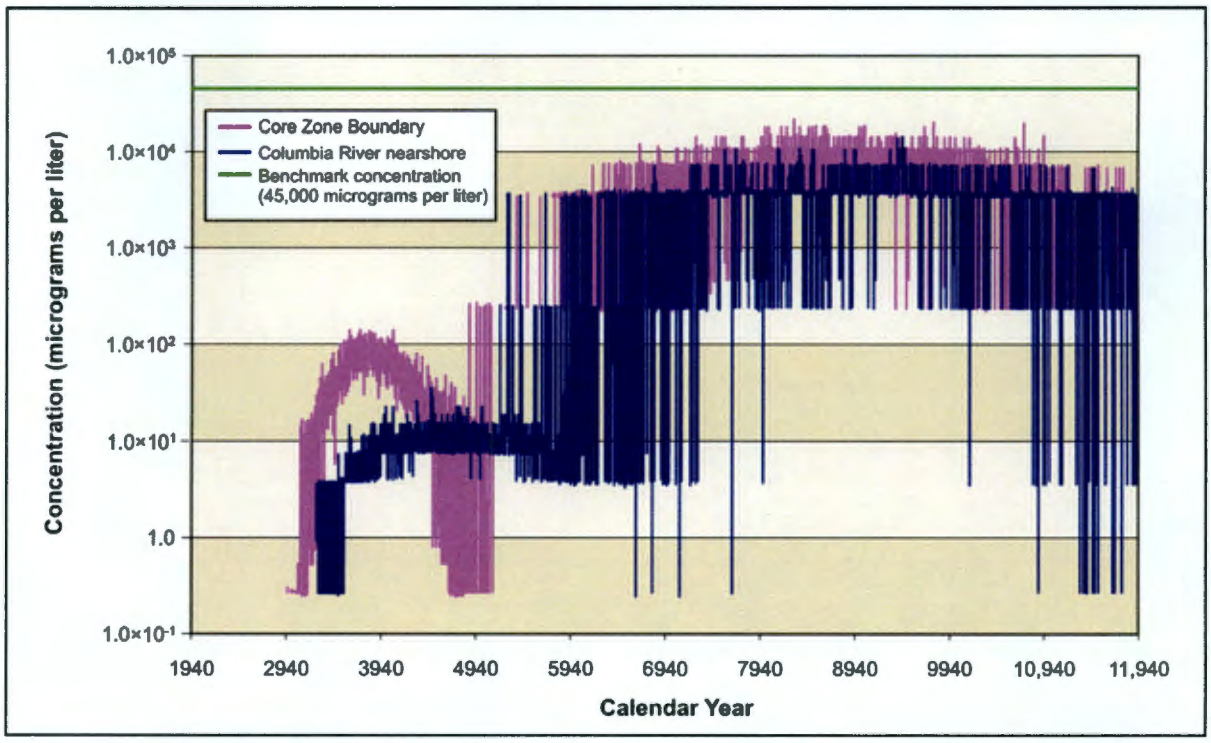


Figure 5–800. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Nitrate Concentration Versus Time

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.

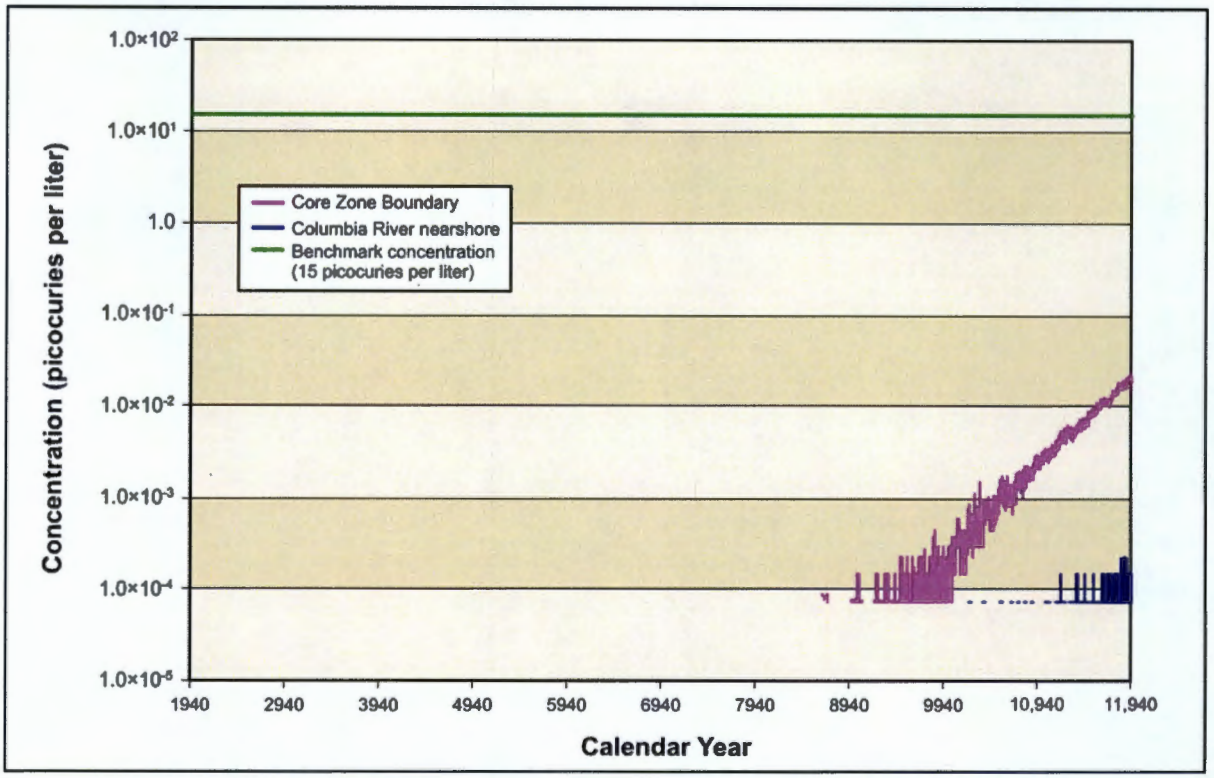


Figure 5–801. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Uranium-238 Concentration Versus Time

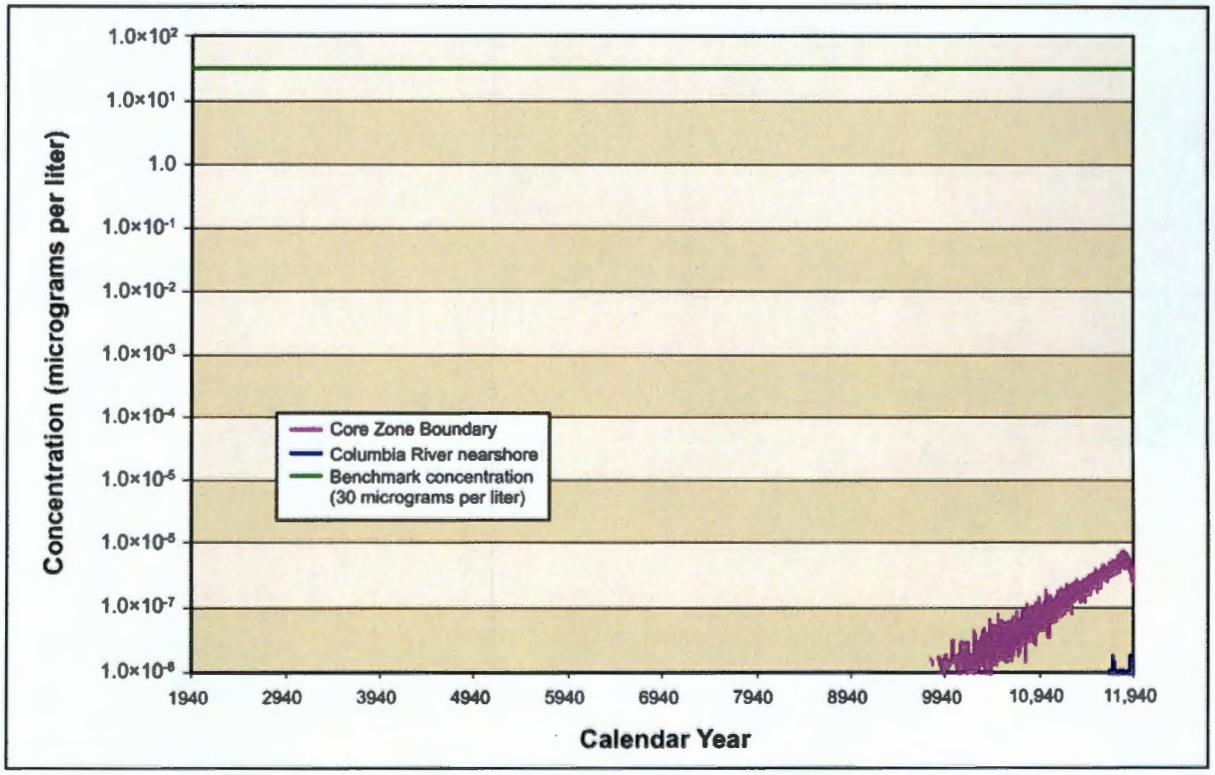
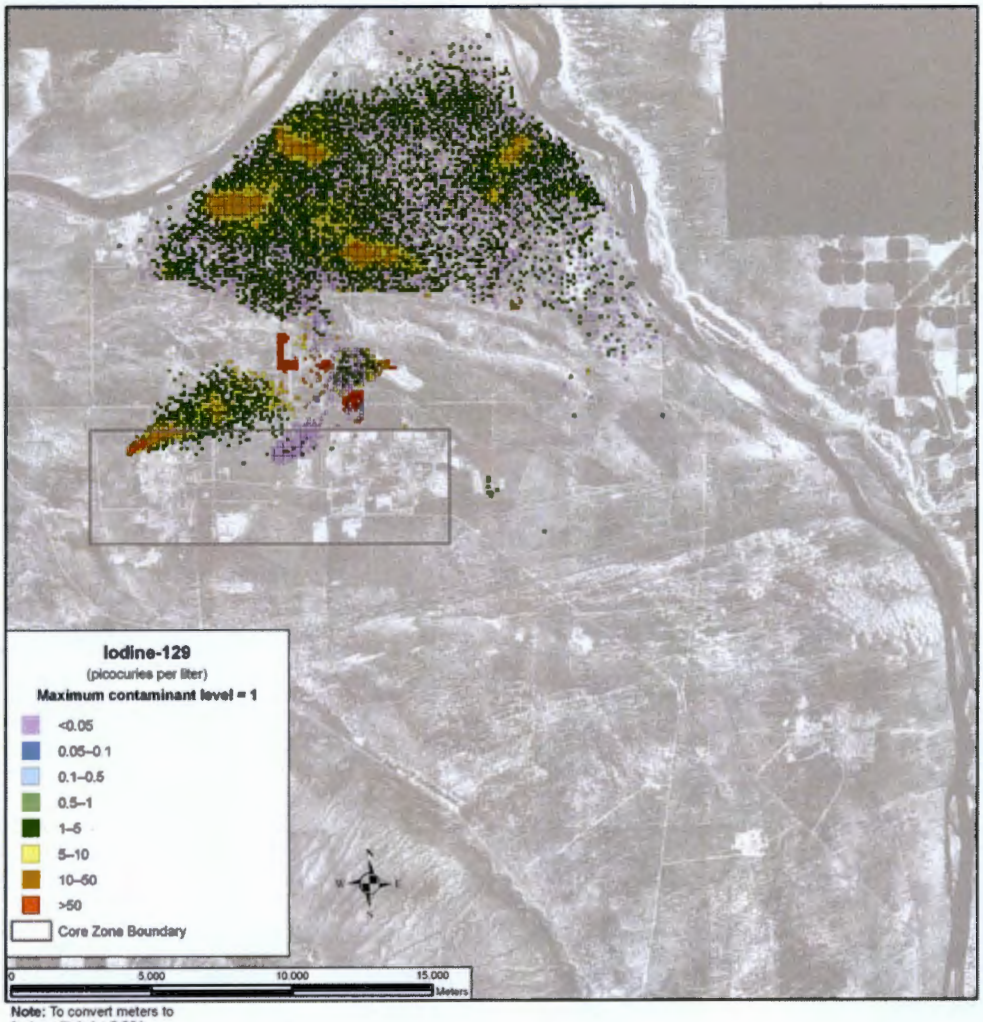


Figure 5–802. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

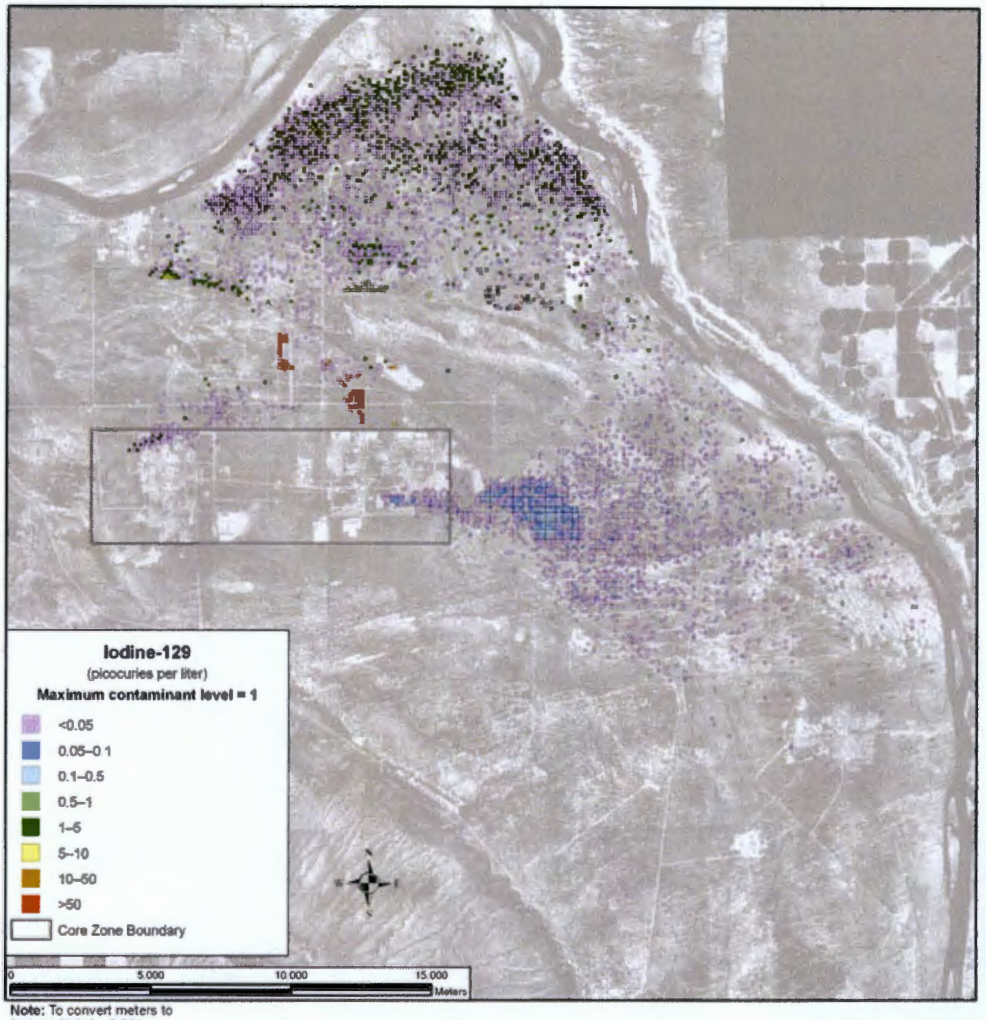
This section presents the impacts of Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter. Concentrations for 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).



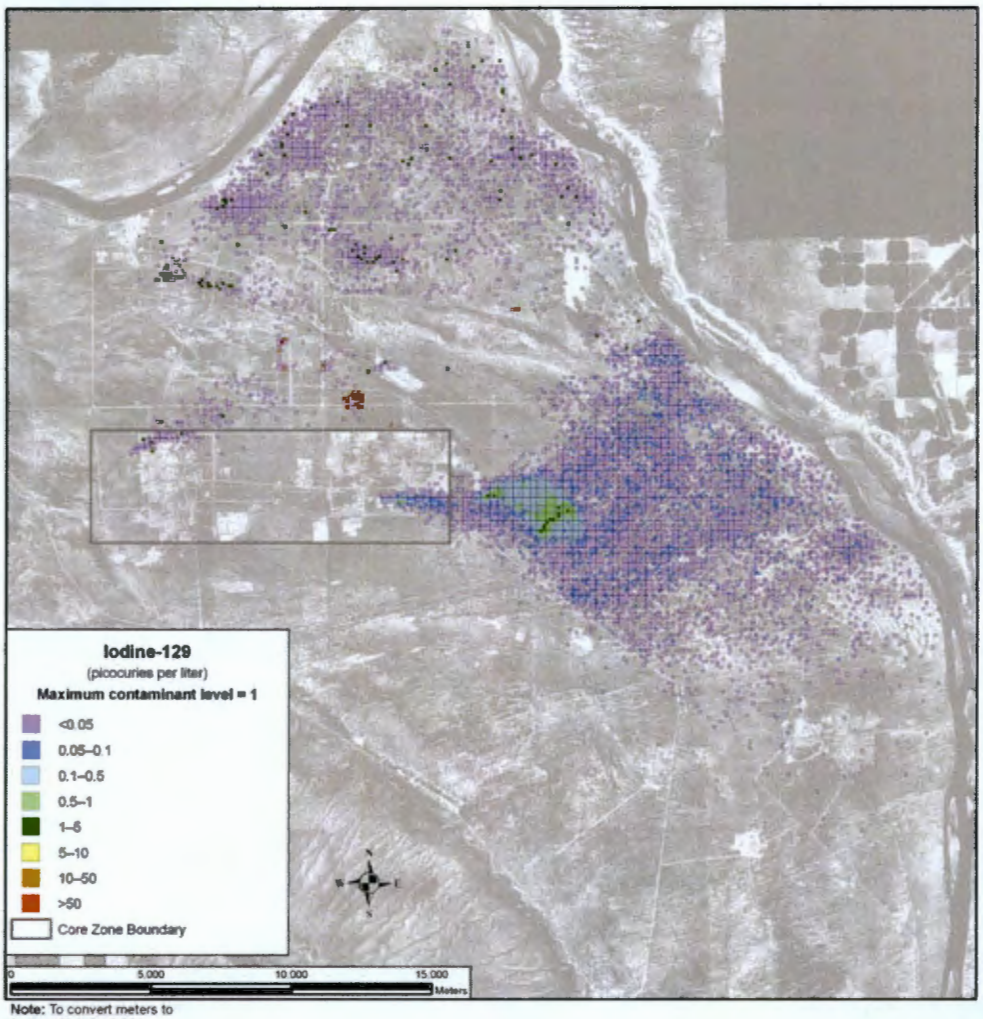
Note: To convert meters to feet, multiply by 3.281

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



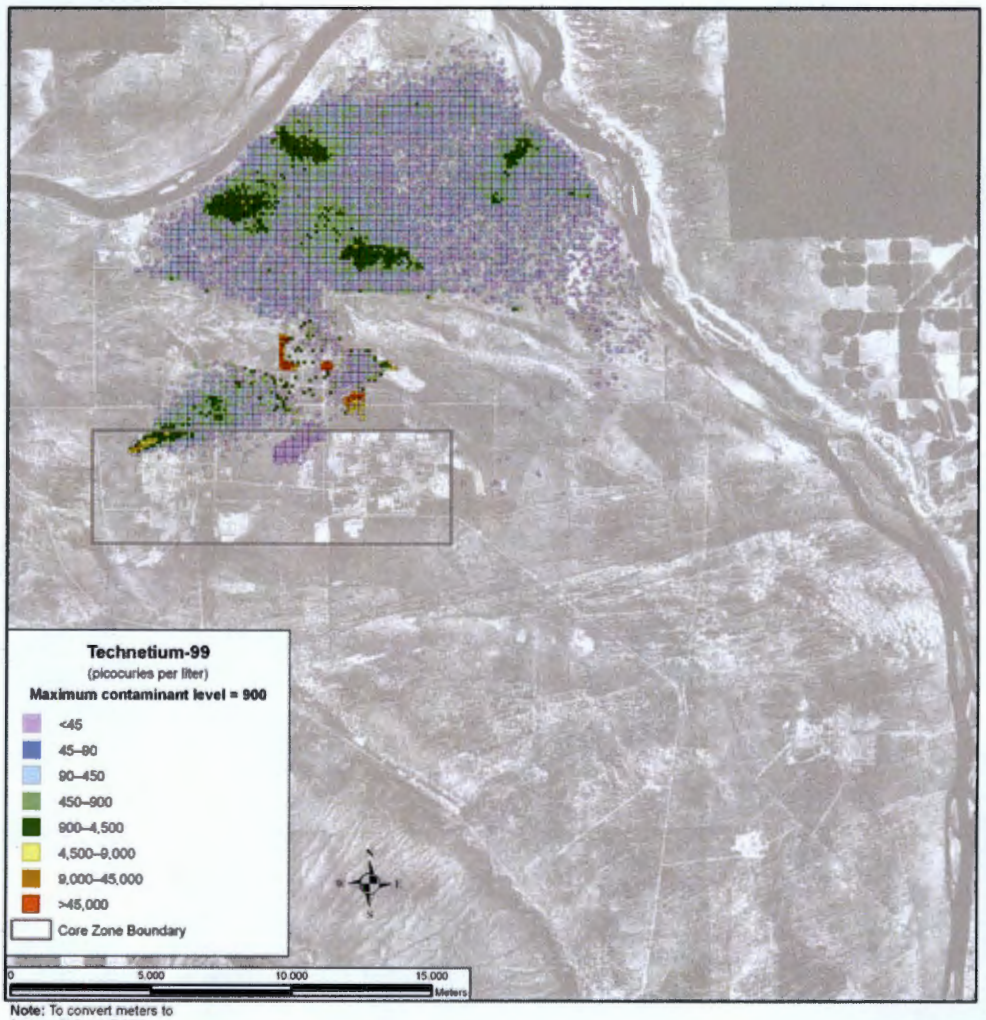
Note: To convert meters to feet, multiply by 3.281

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



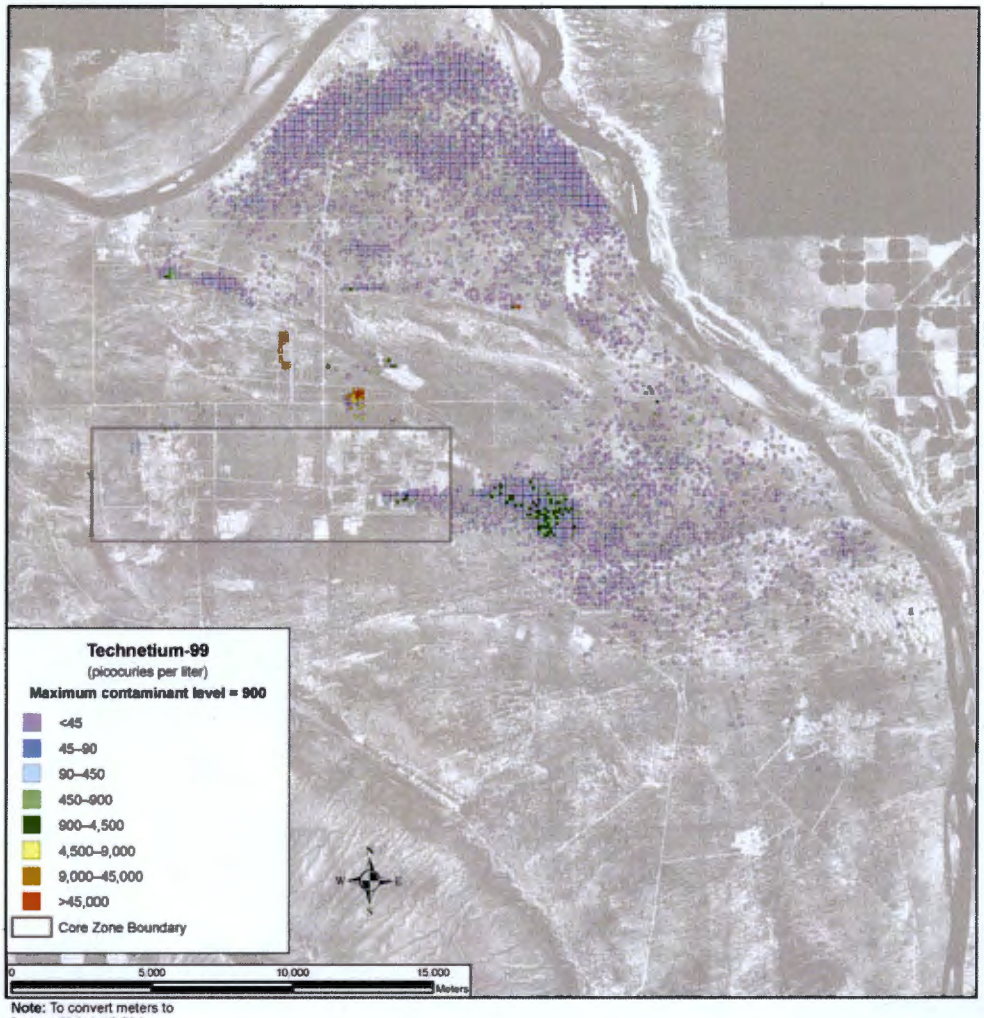
Note: To convert meters to feet, multiply by 3.281

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



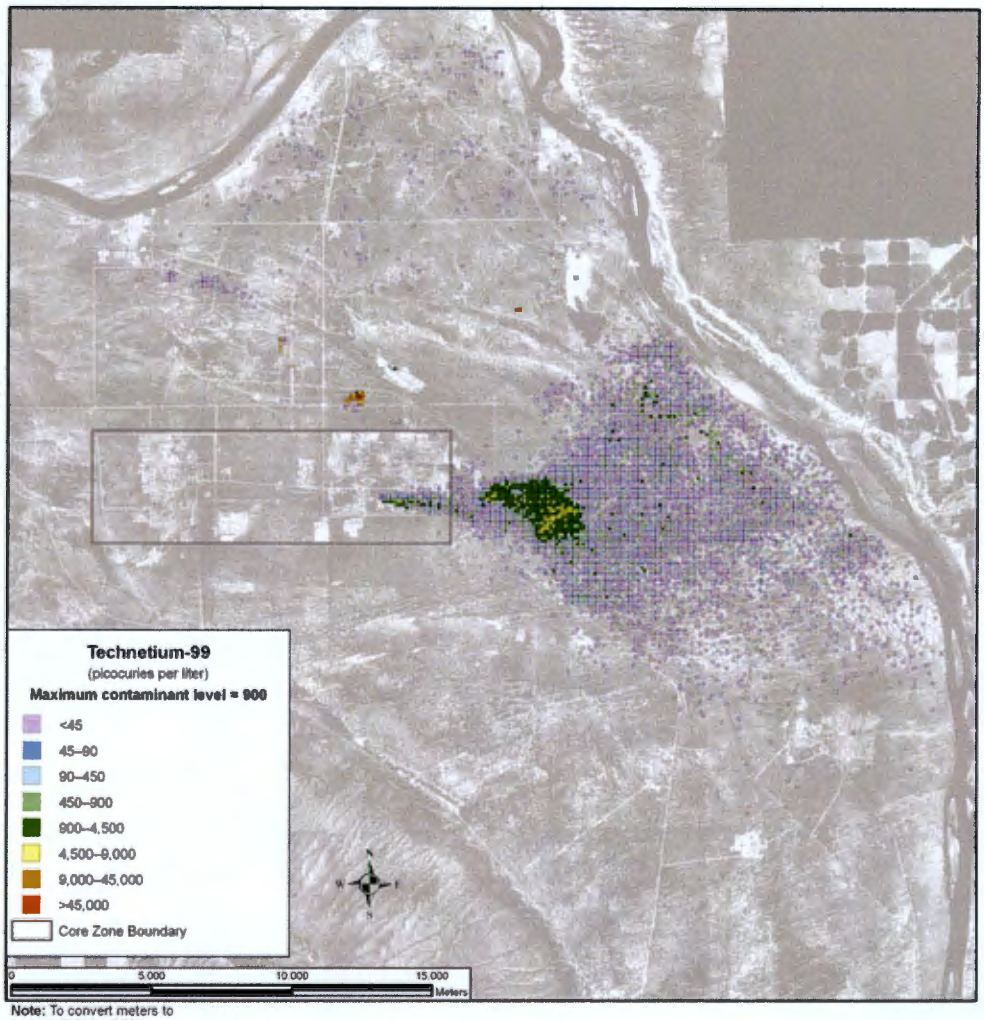
Note: To convert meters to feet, multiply by 3.281

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



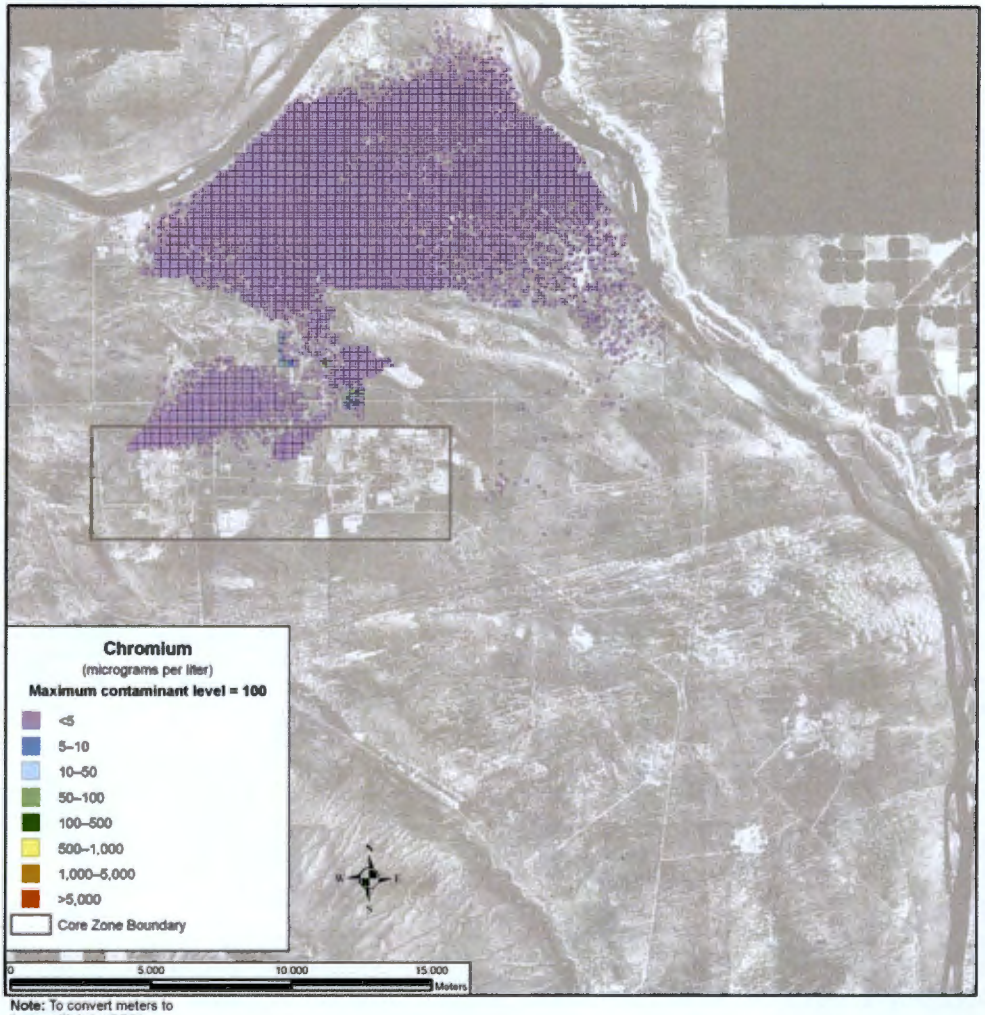
Note: To convert meters to feet, multiply by 3.281

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



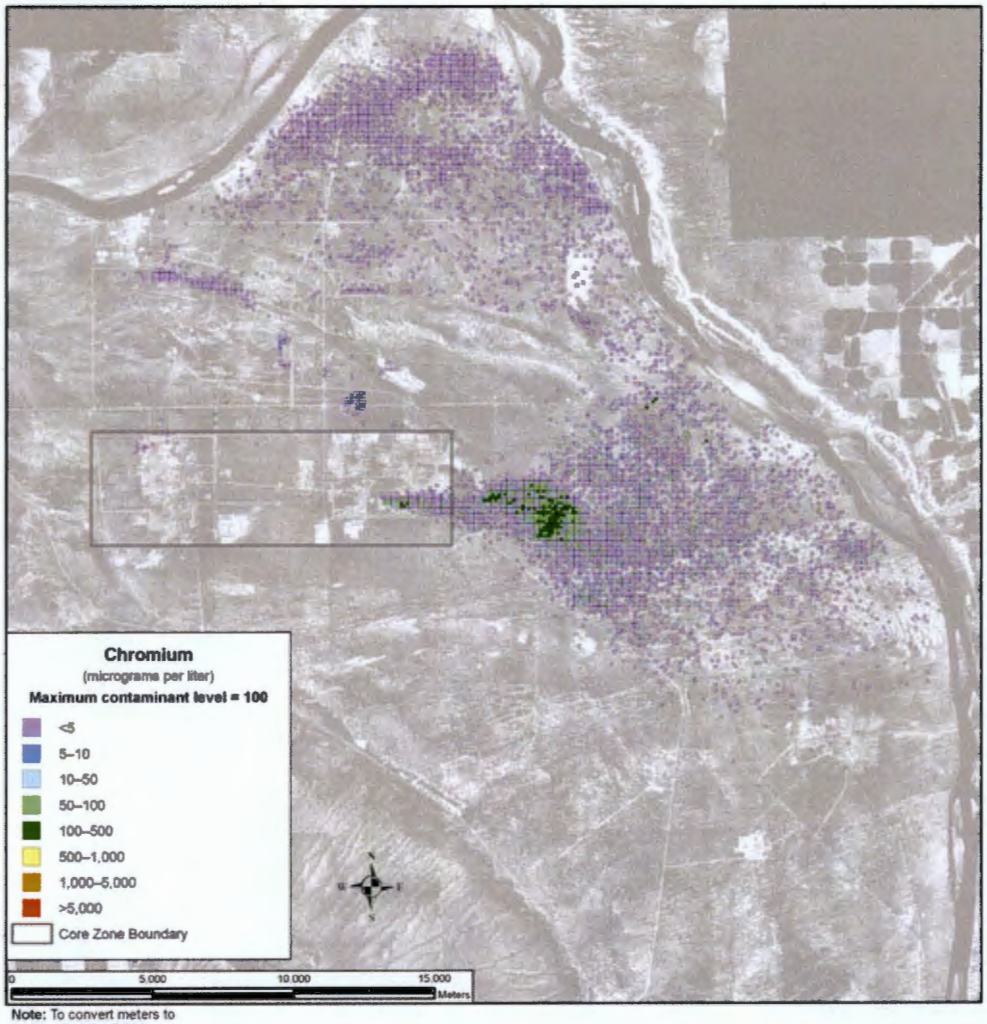
Note: To convert meters to feet, multiply by 3.281

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



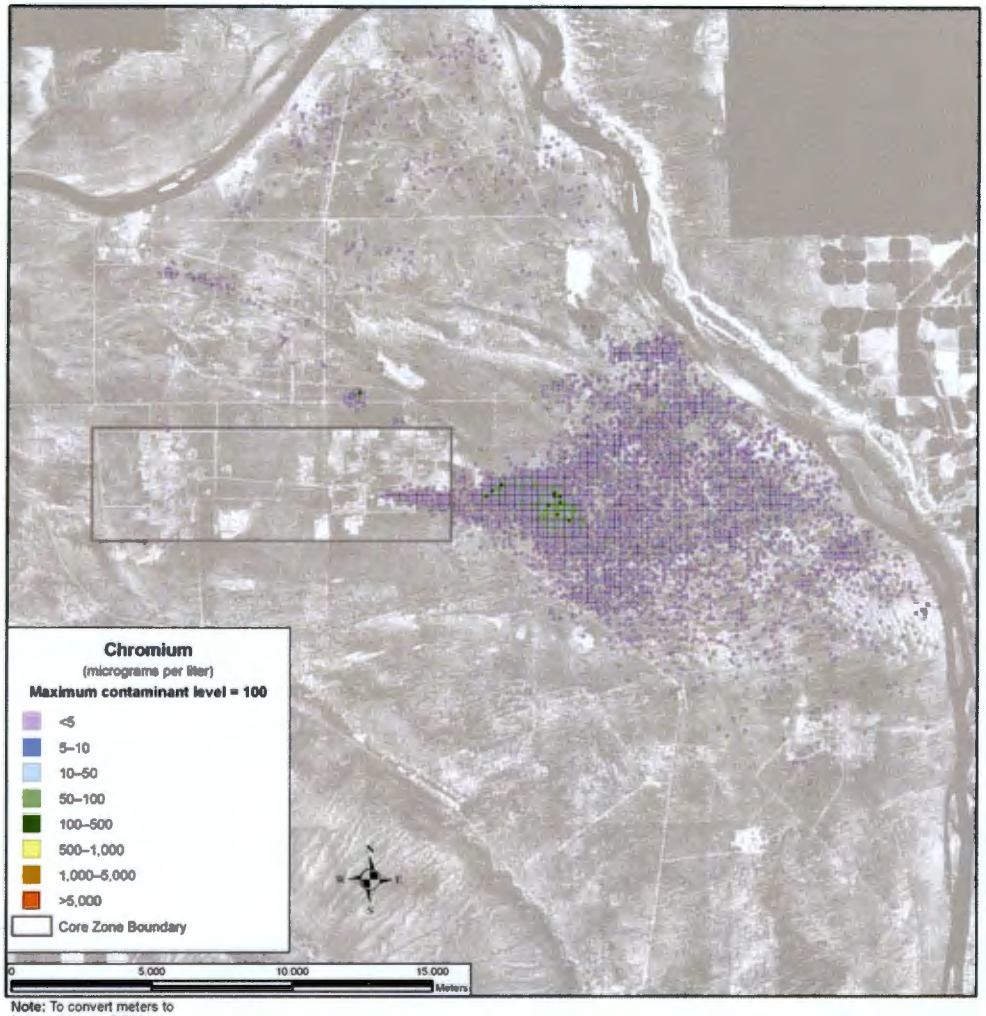
Note: To convert meters to feet, multiply by 3.281

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



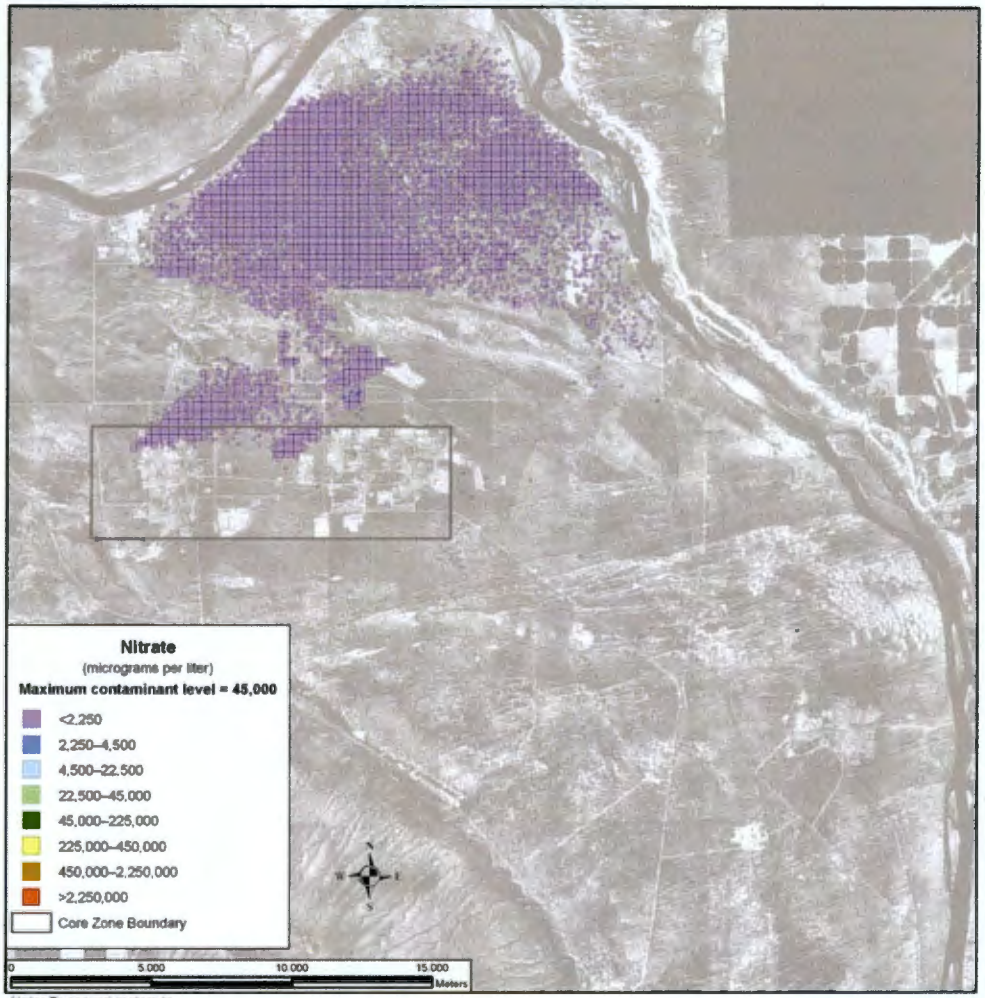
Note: To convert meters to feet, multiply by 3.281

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



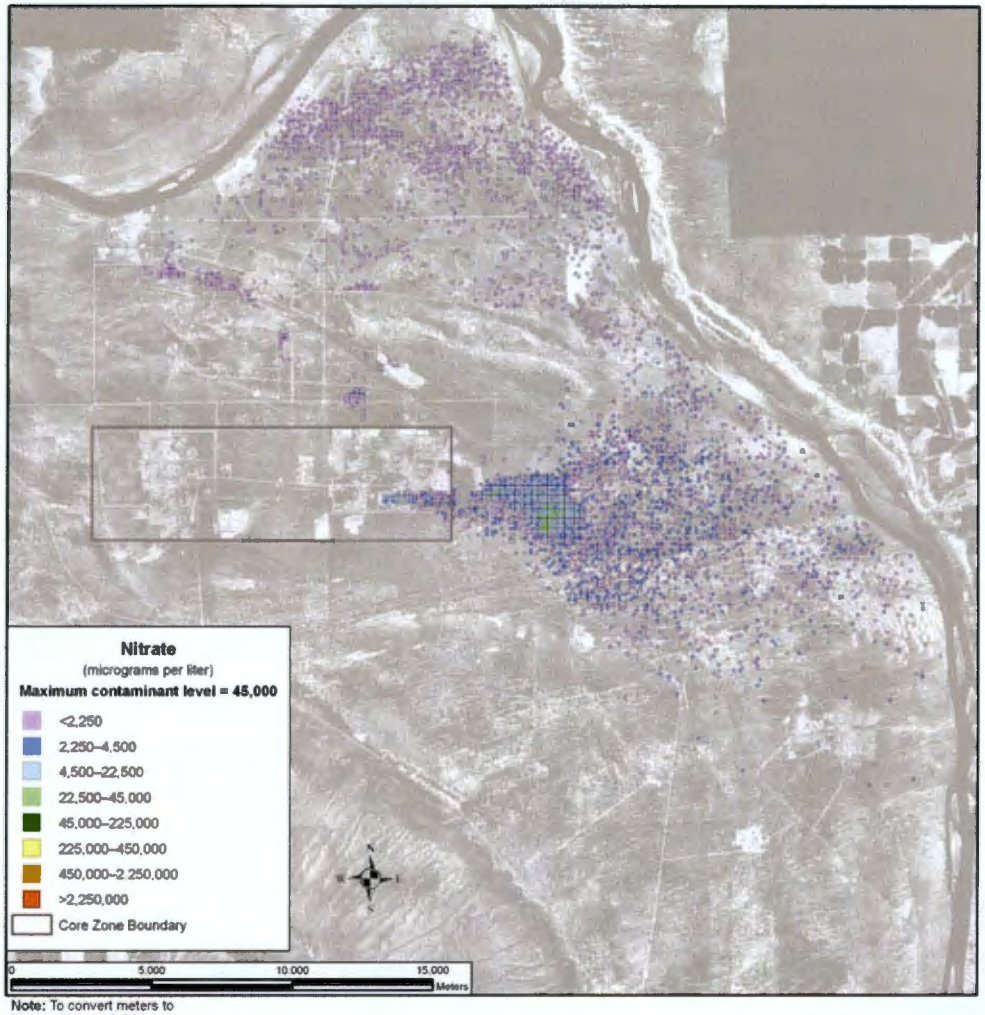
Note: To convert meters to feet, multiply by 3.281

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



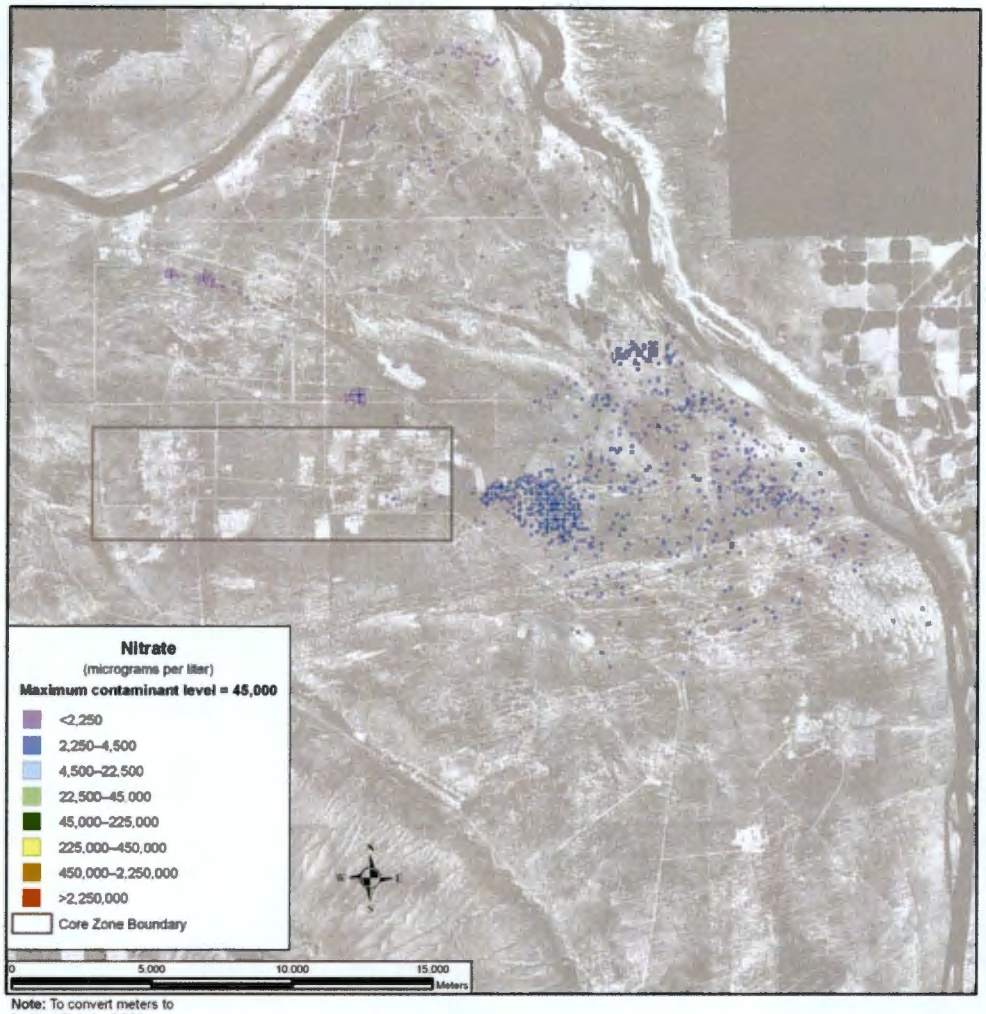
Note: To convert meters to feet, multiply by 3.281

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

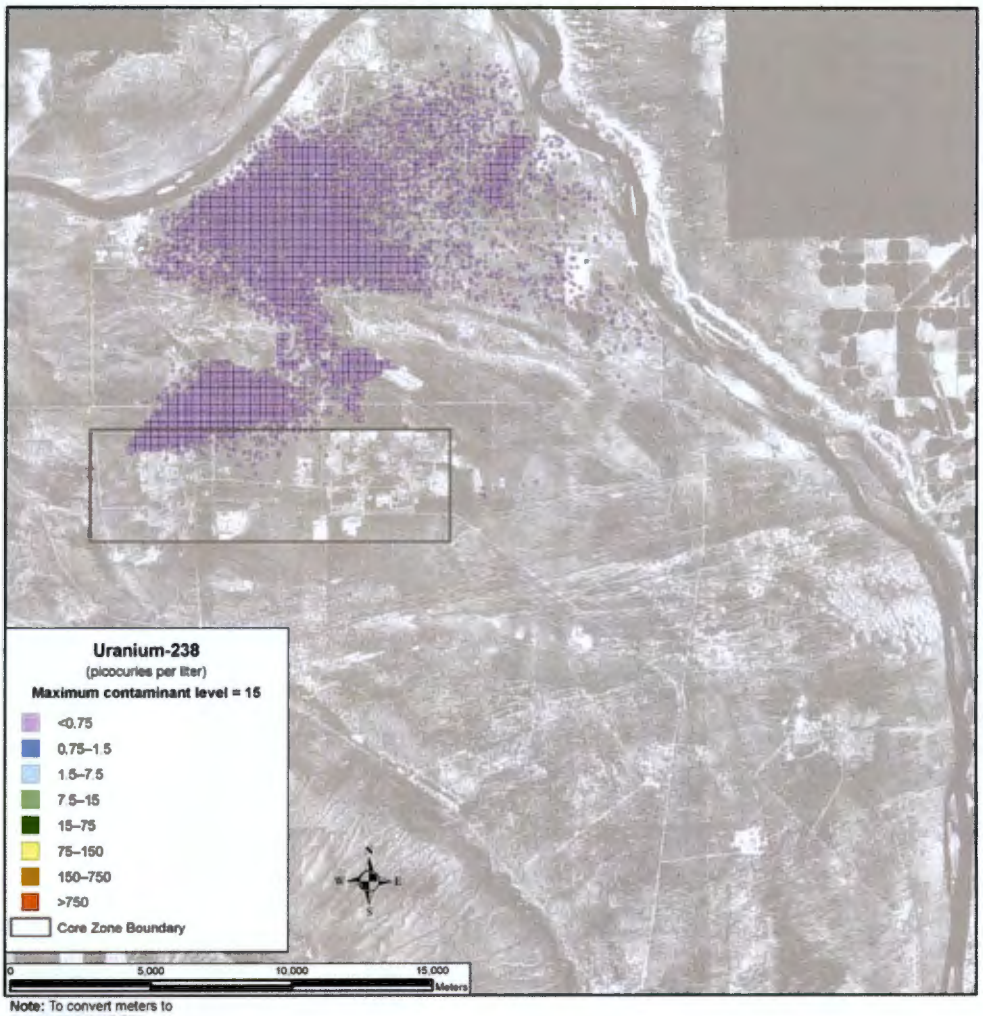
Figure 5–813. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

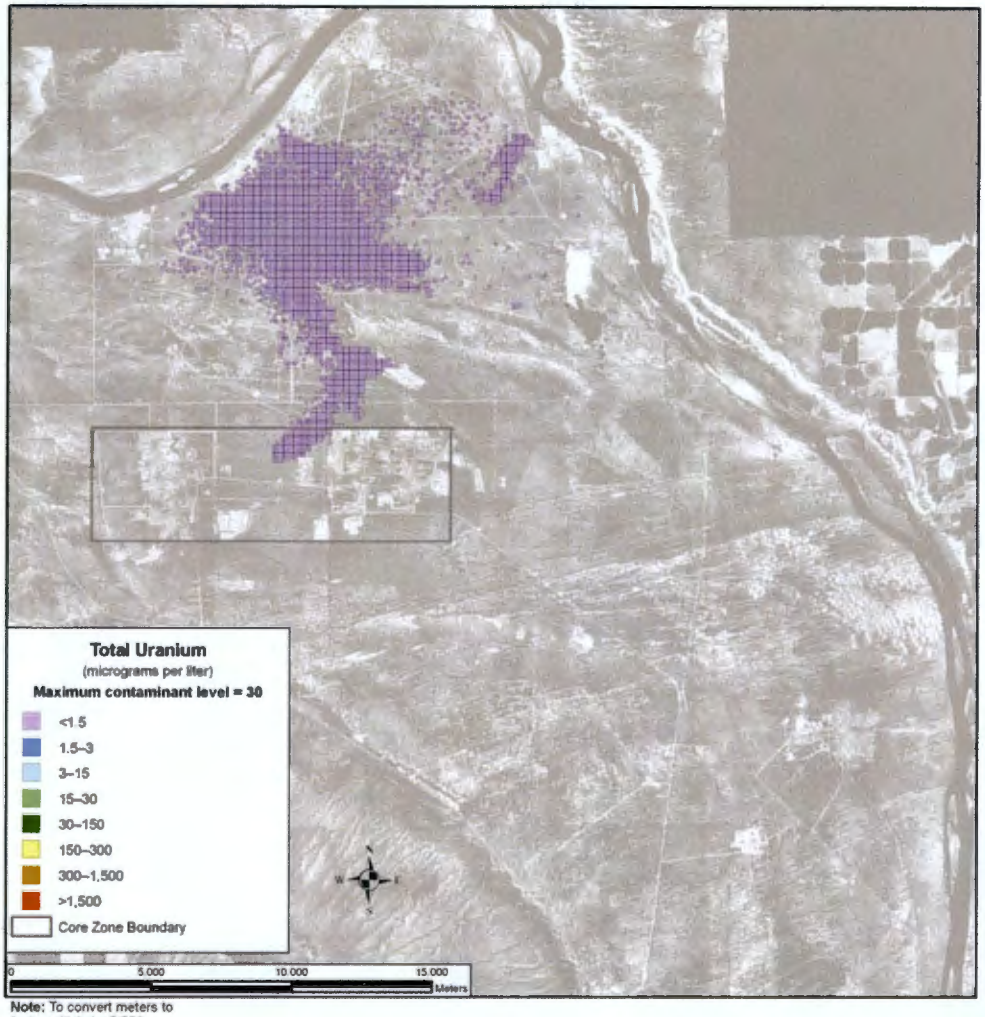
Figure 5–814. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

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.

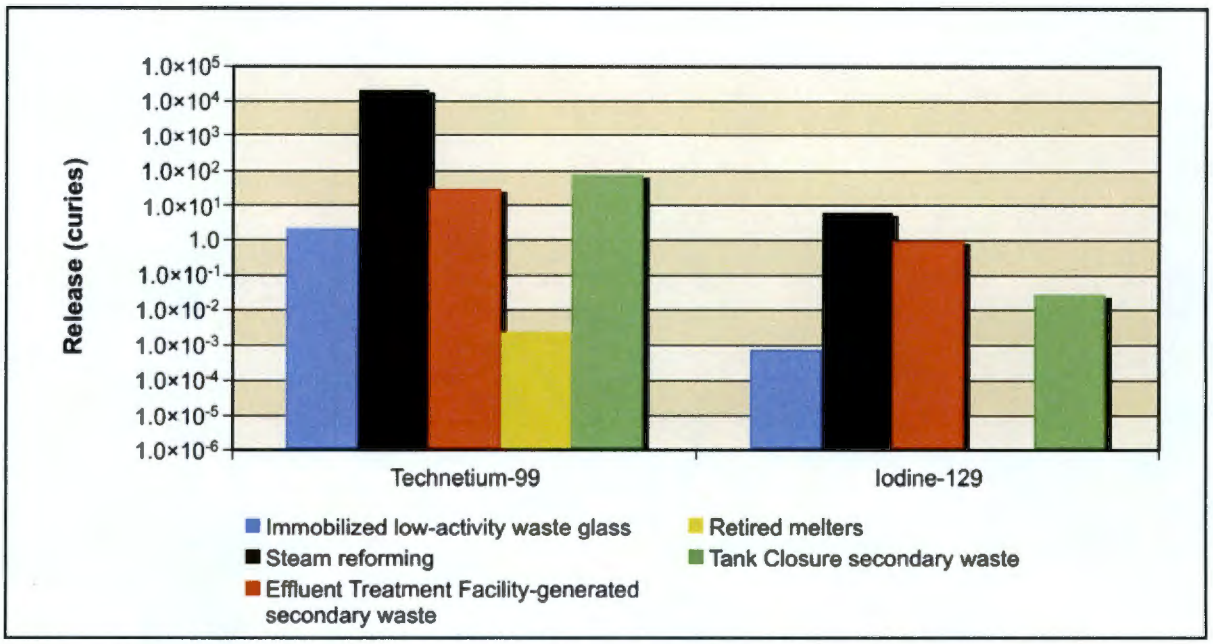


Figure 5–817. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

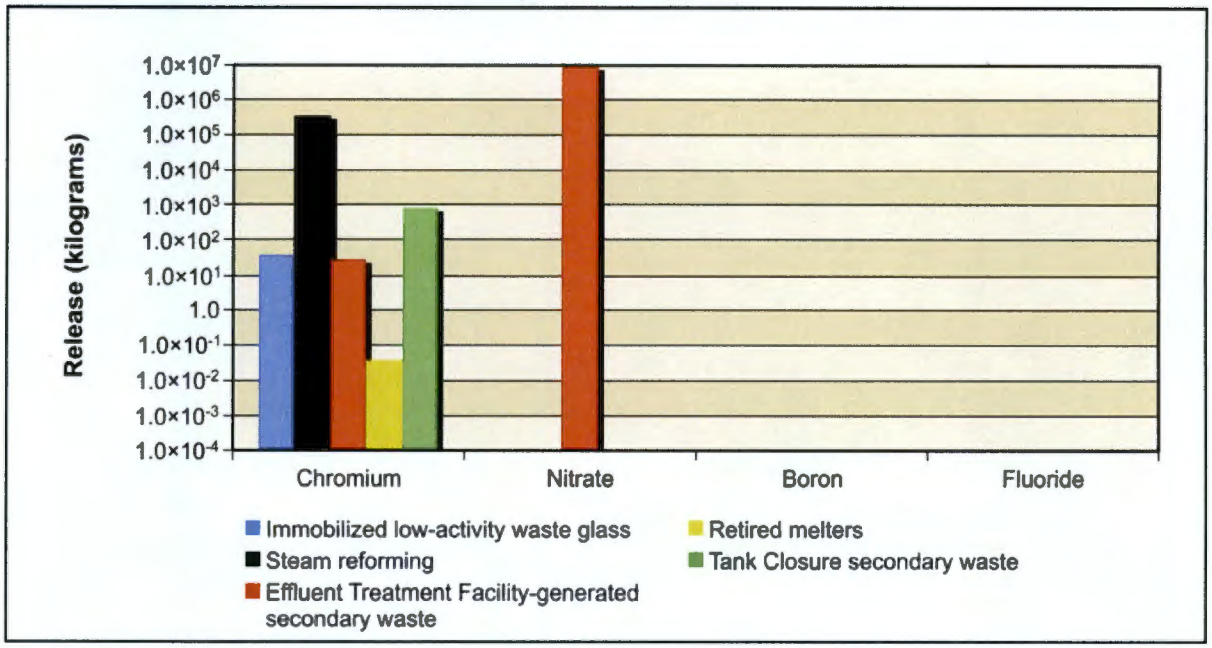


Figure 5–818. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

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.

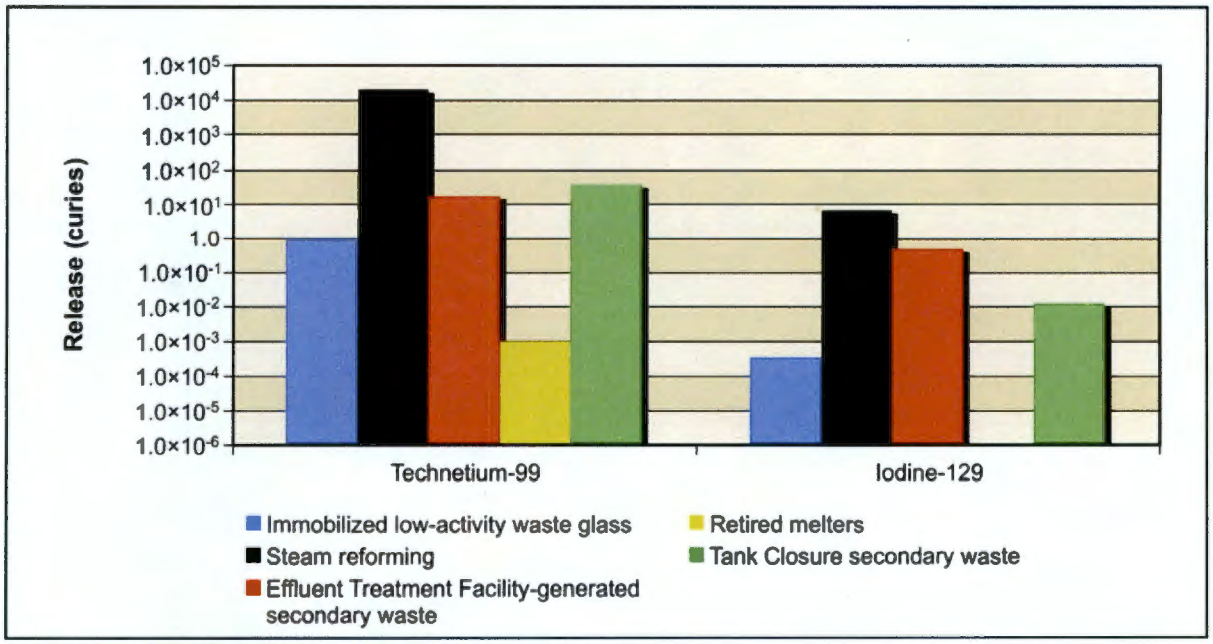


Figure 5–819. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

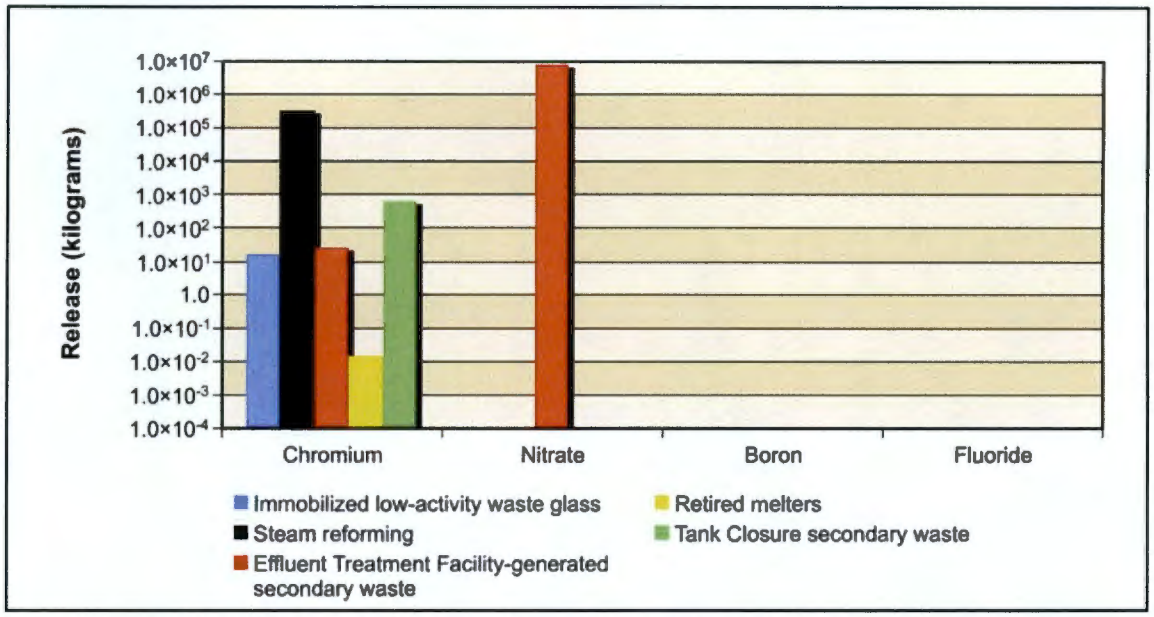


Figure 5–820. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

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.

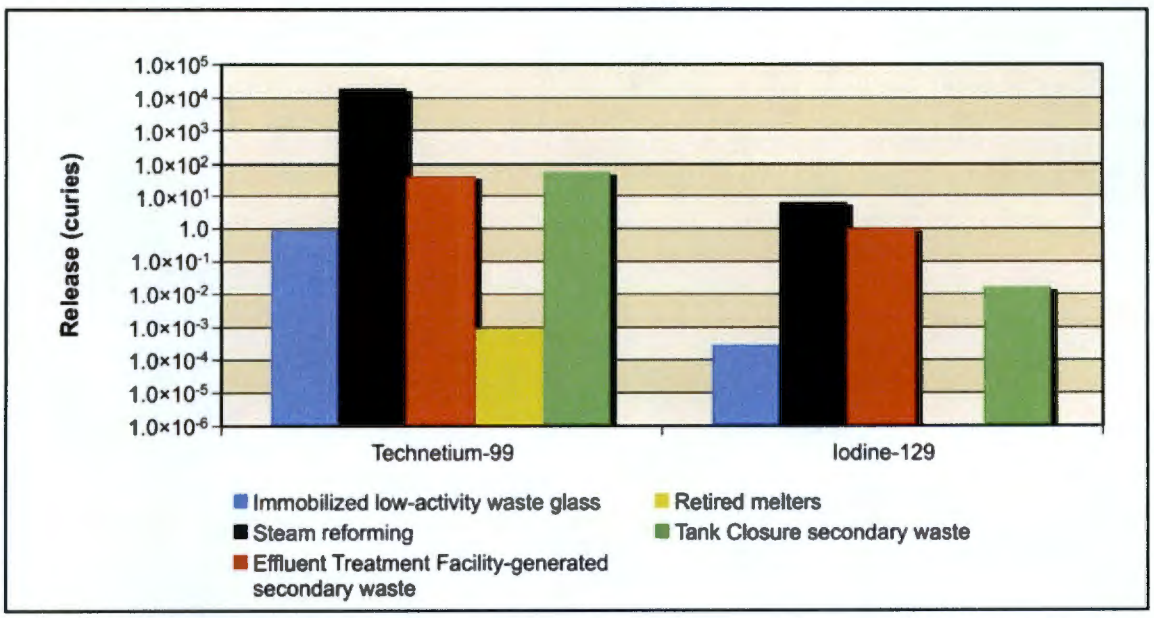


Figure 5–821. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

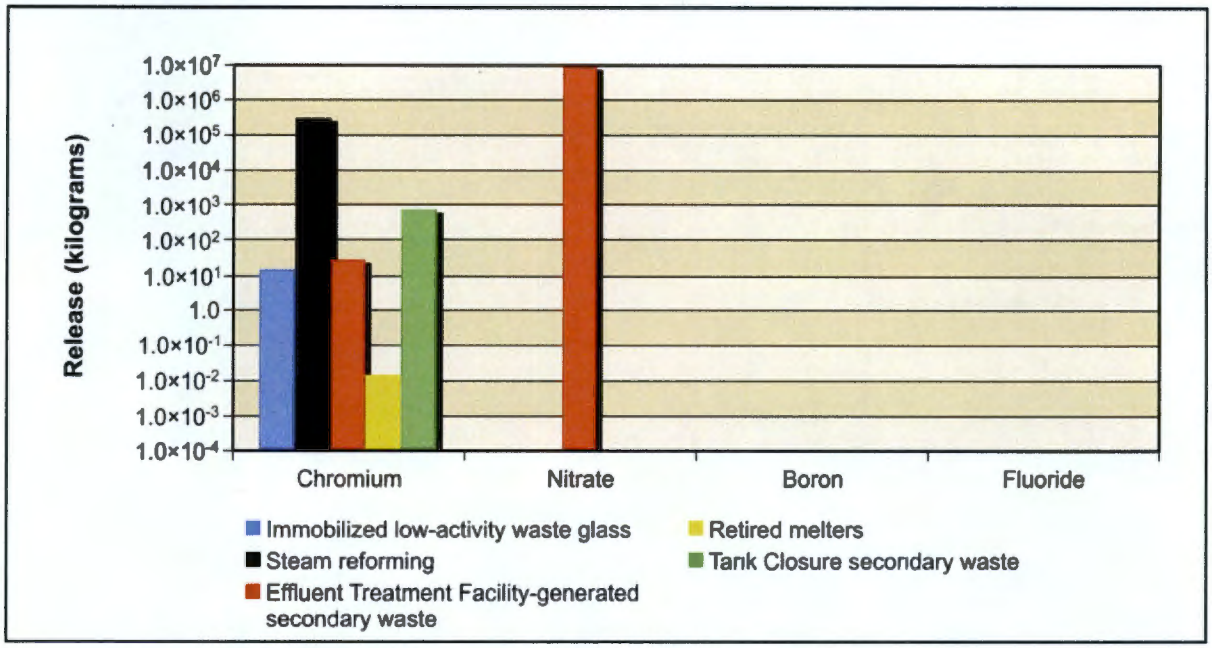


Figure 5–822. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

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).

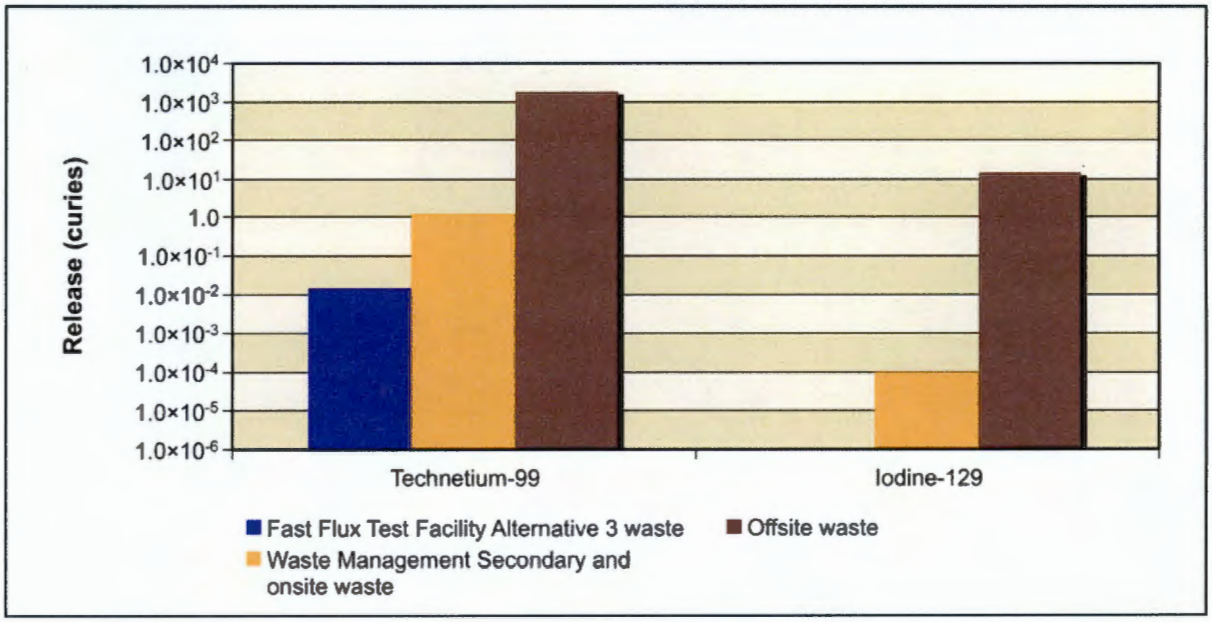


Figure 5–823. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

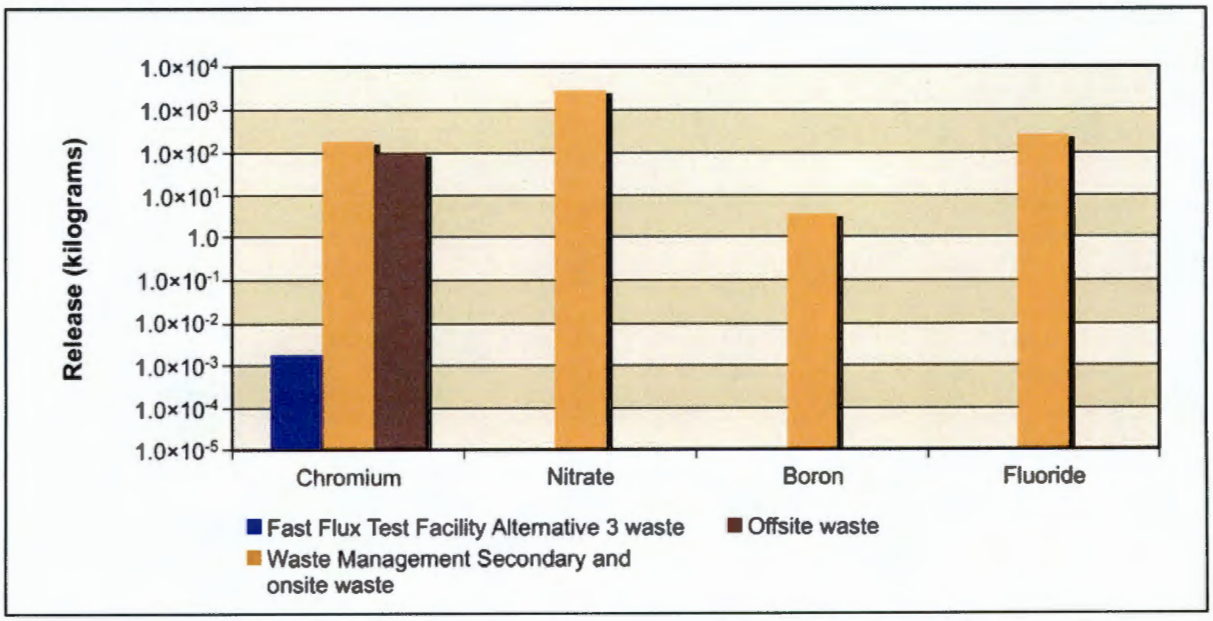


Figure 5–824. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

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.

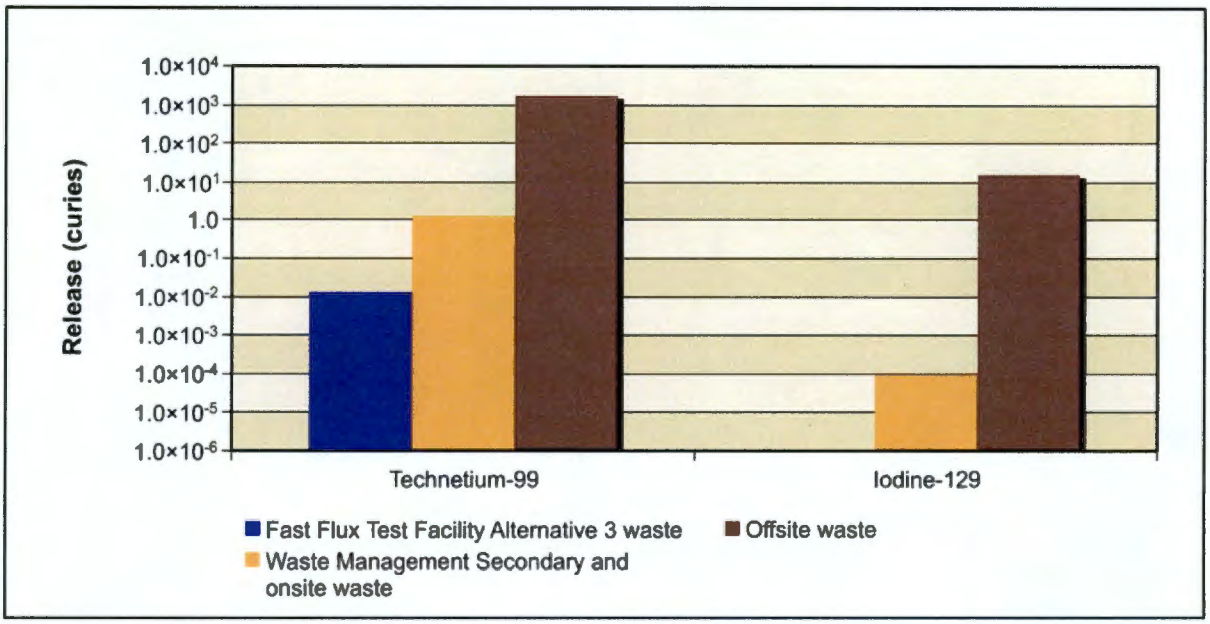


Figure 5–825. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

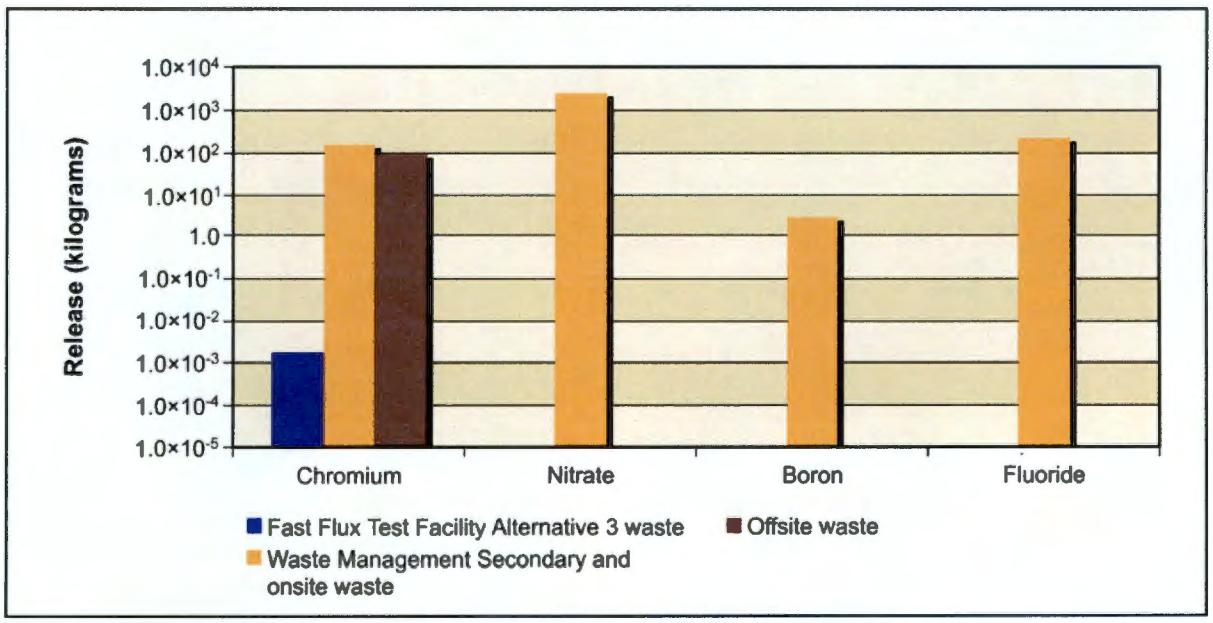


Figure 5–826. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

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.

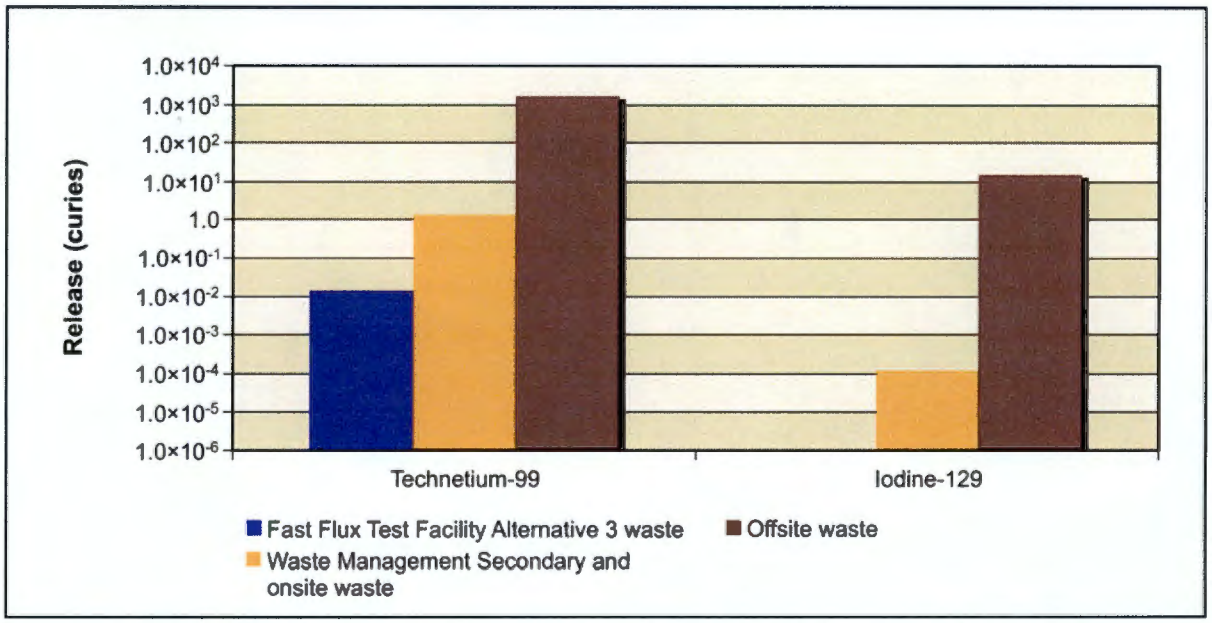


Figure 5–827. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

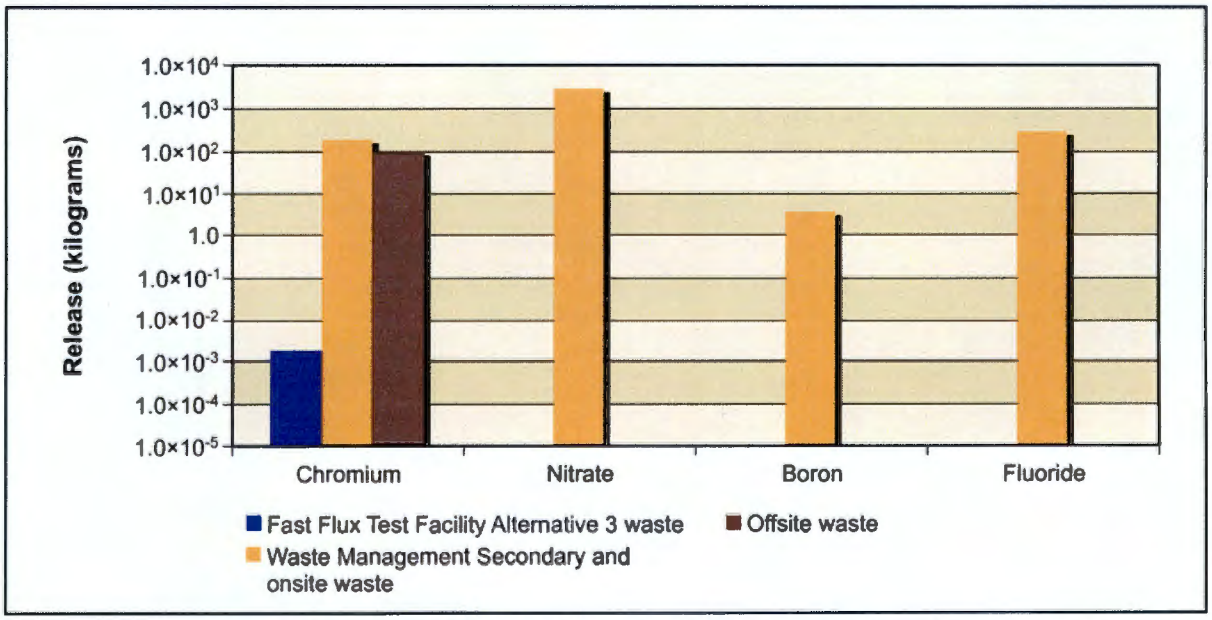


Figure 5–828. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

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.

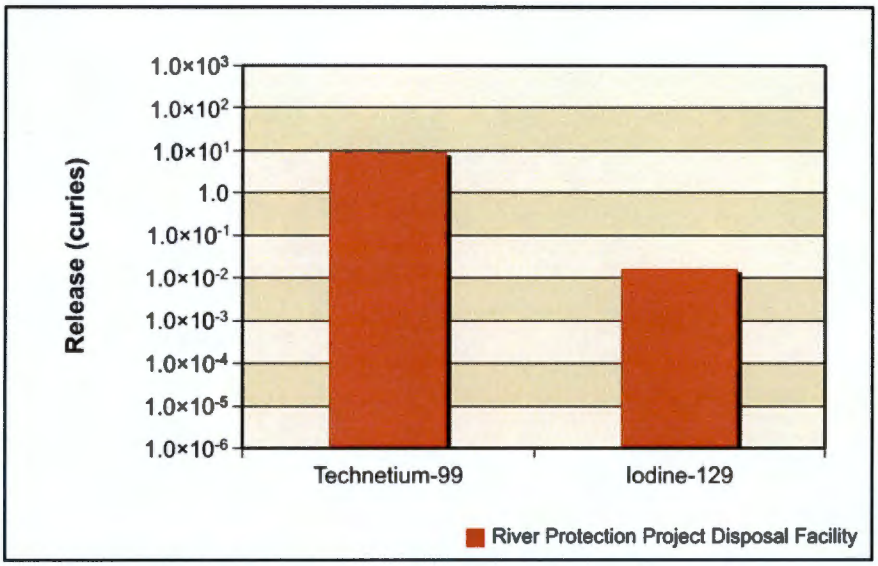


Figure 5–829. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

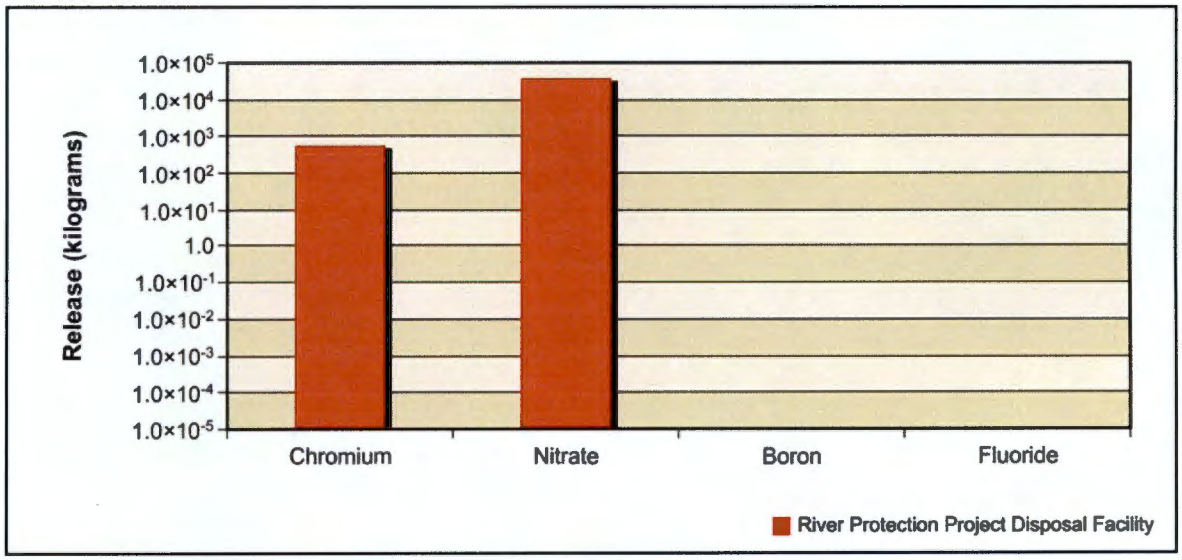


Figure 5–830. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

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.

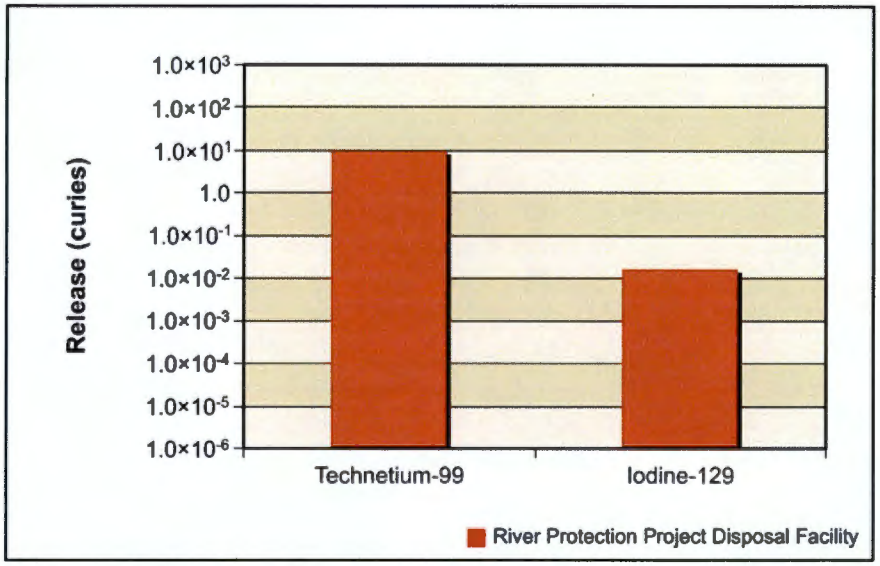


Figure 5–831. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Groundwater

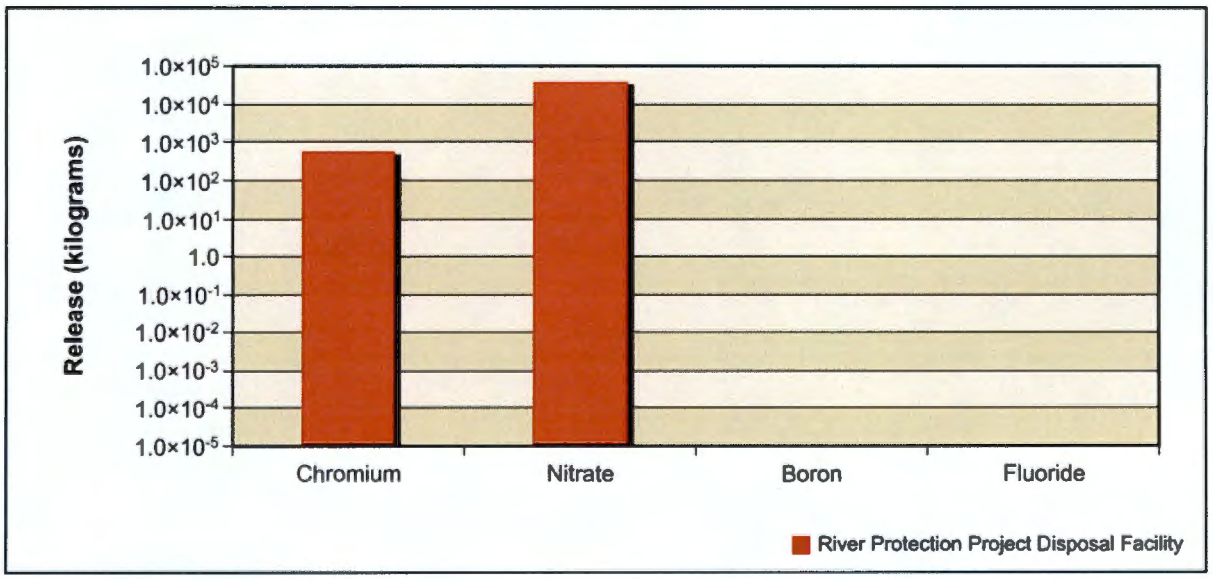


Figure 5–832. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Groundwater

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.

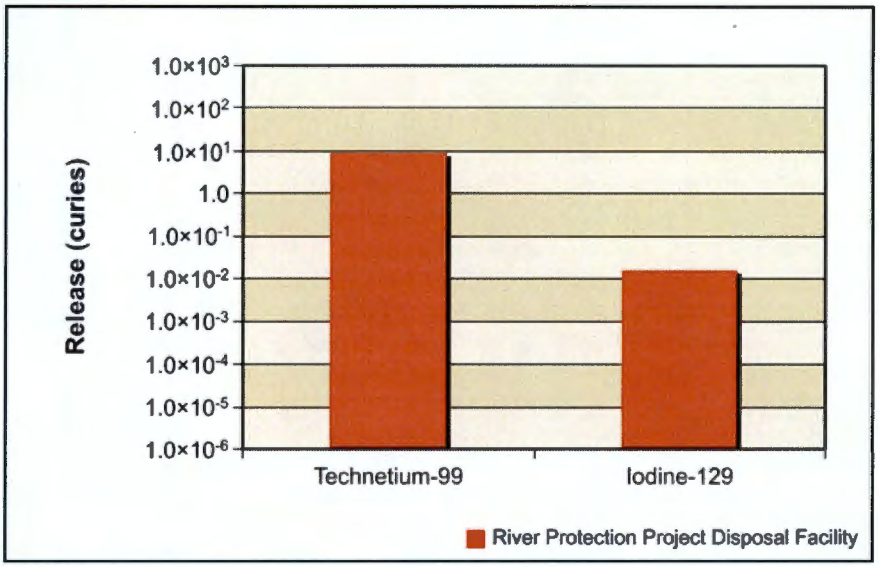


Figure 5–833. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Columbia River

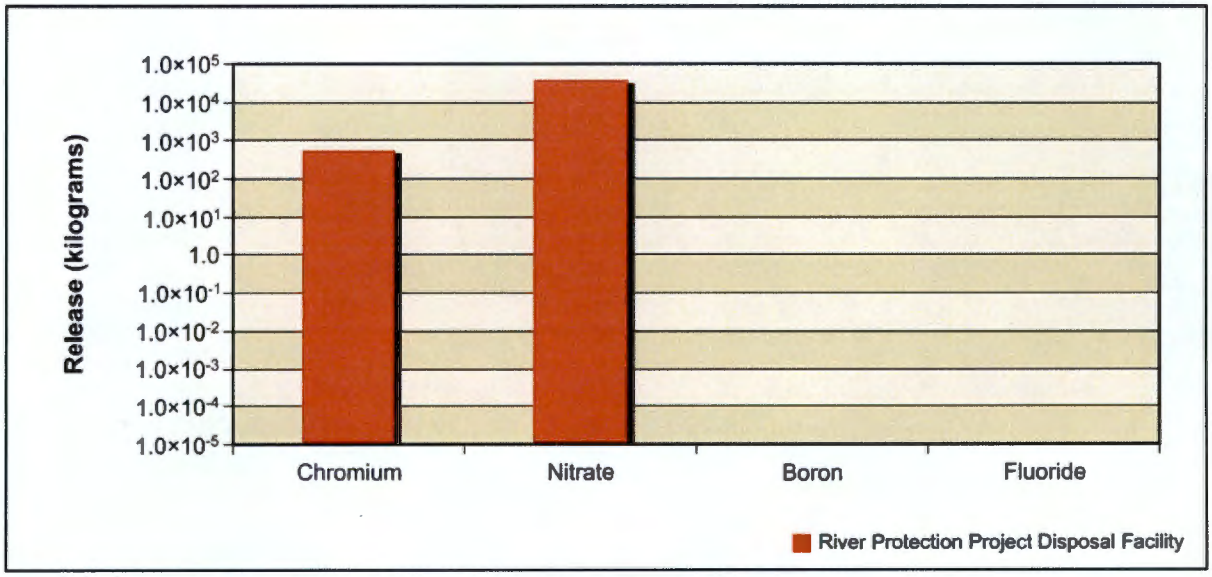


Figure 5–834. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Columbia River

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.

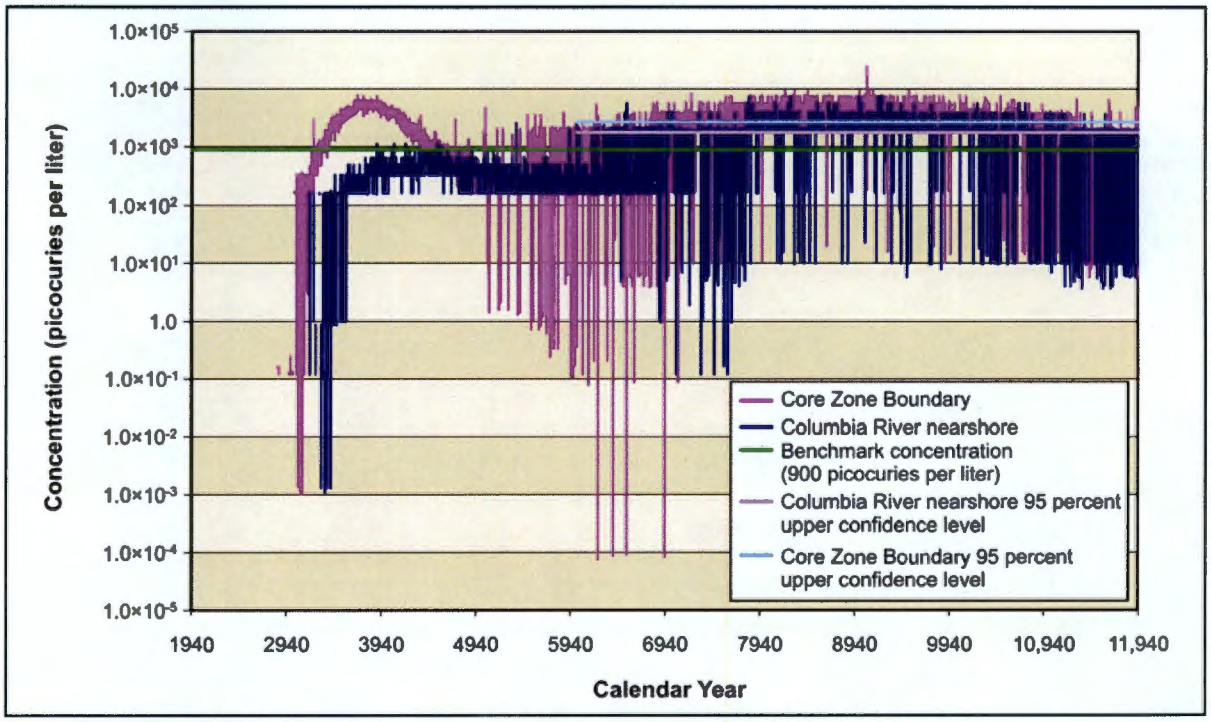


Figure 5–835. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Technetium-99 Concentration Versus Time

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.

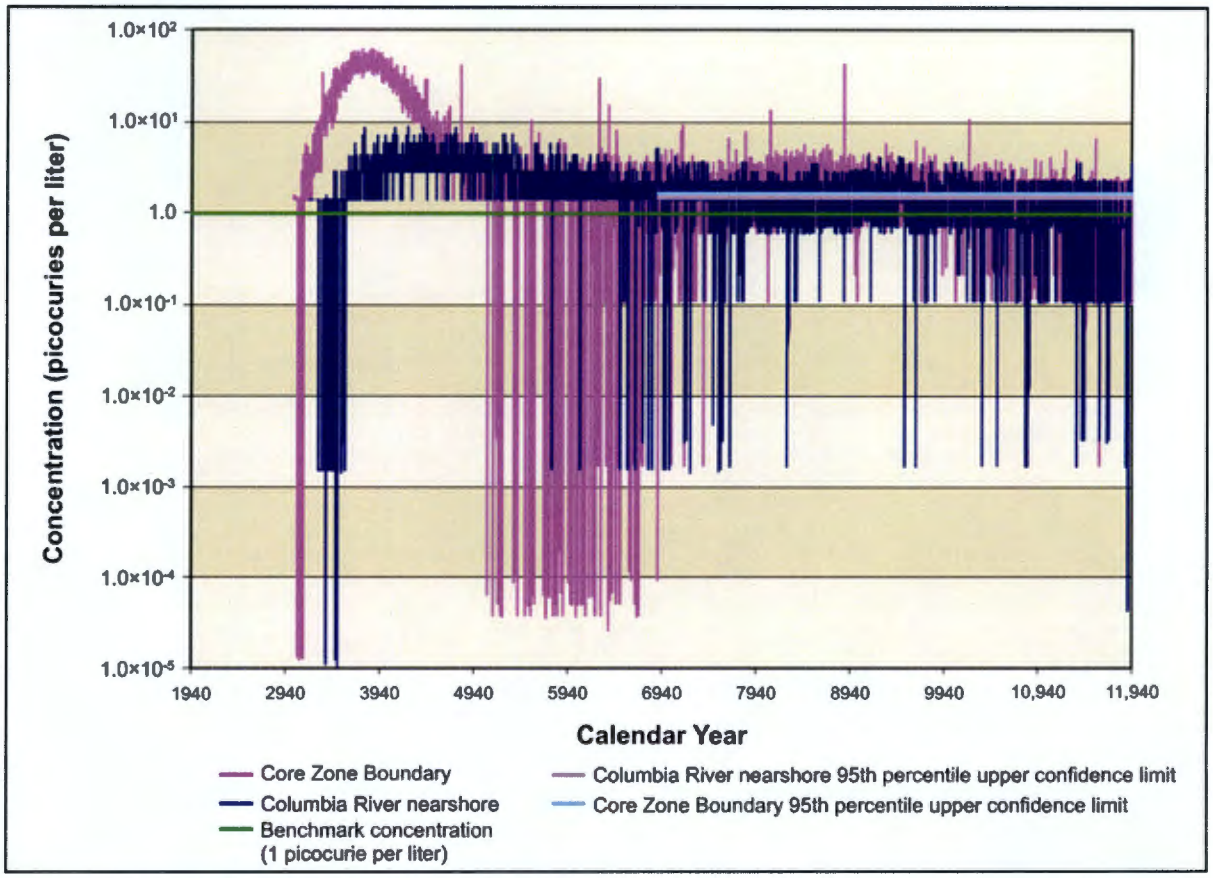


Figure 5–836. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Iodine-129 Concentration Versus Time

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.

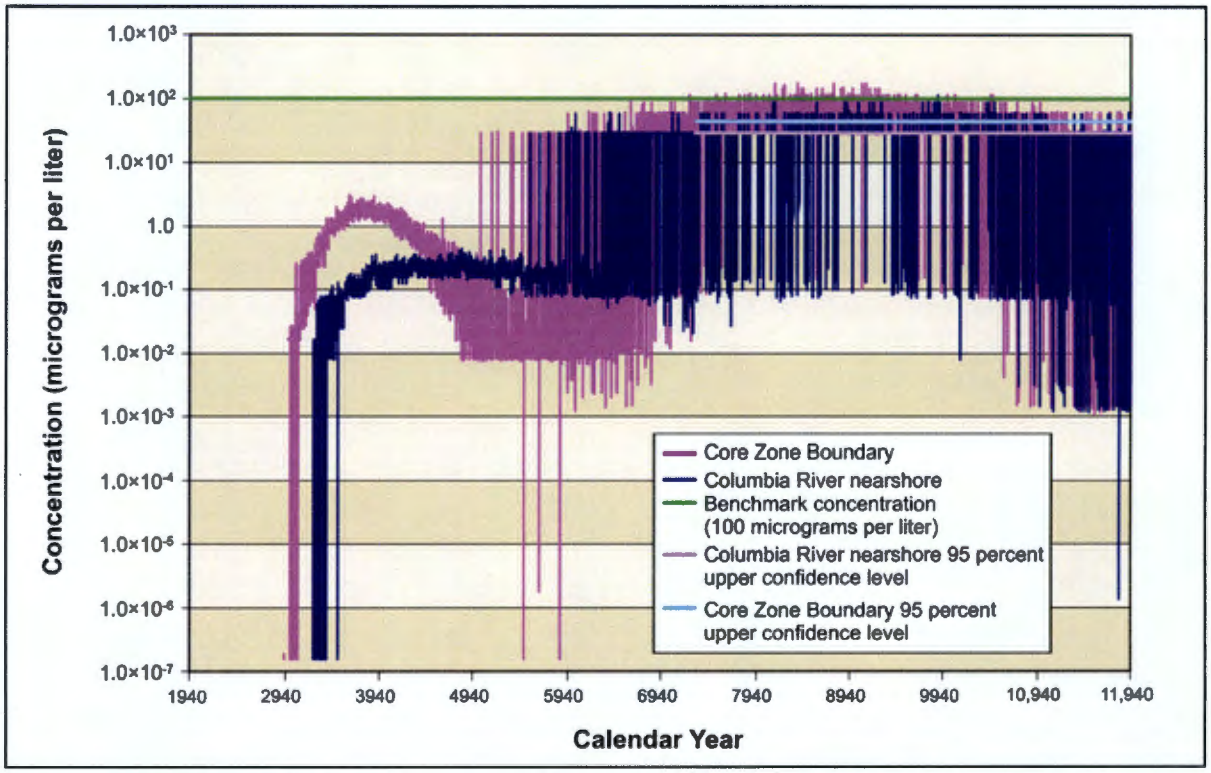


Figure 5–837. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Chromium Concentration Versus Time

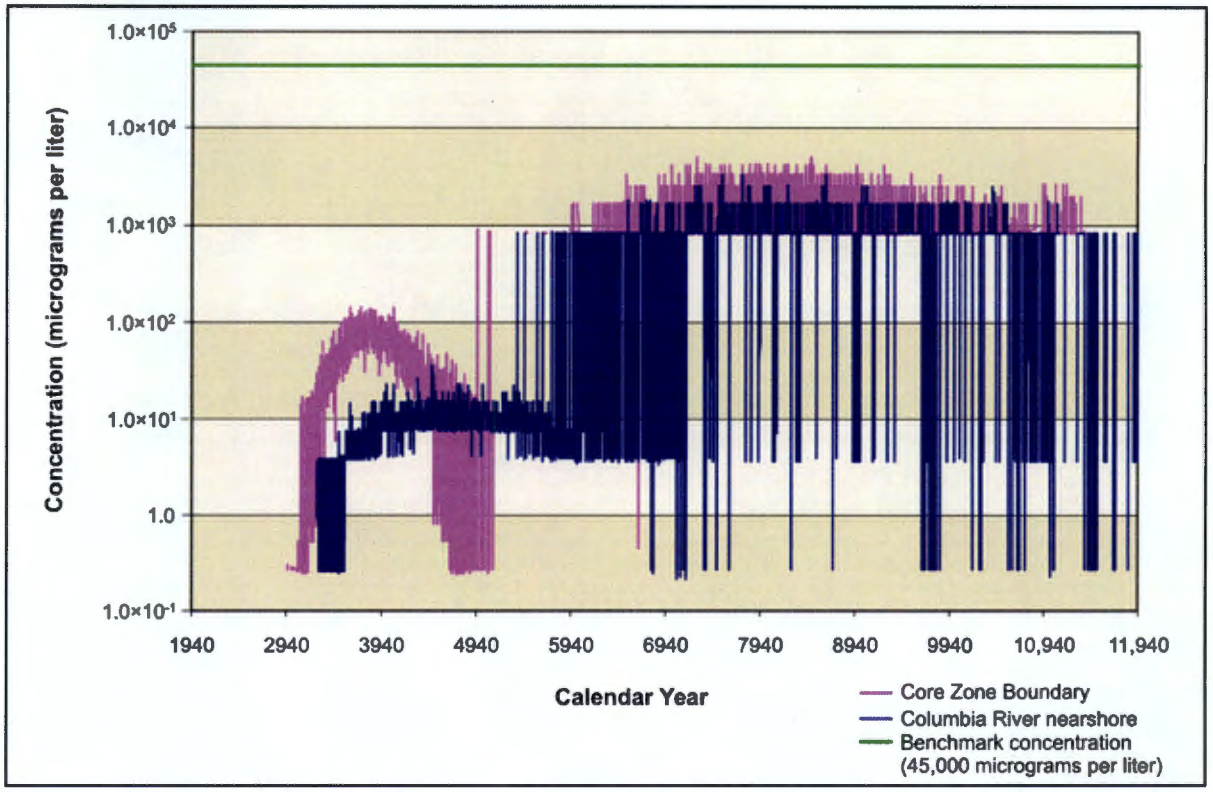


Figure 5–838. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Nitrate Concentration Versus Time

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.

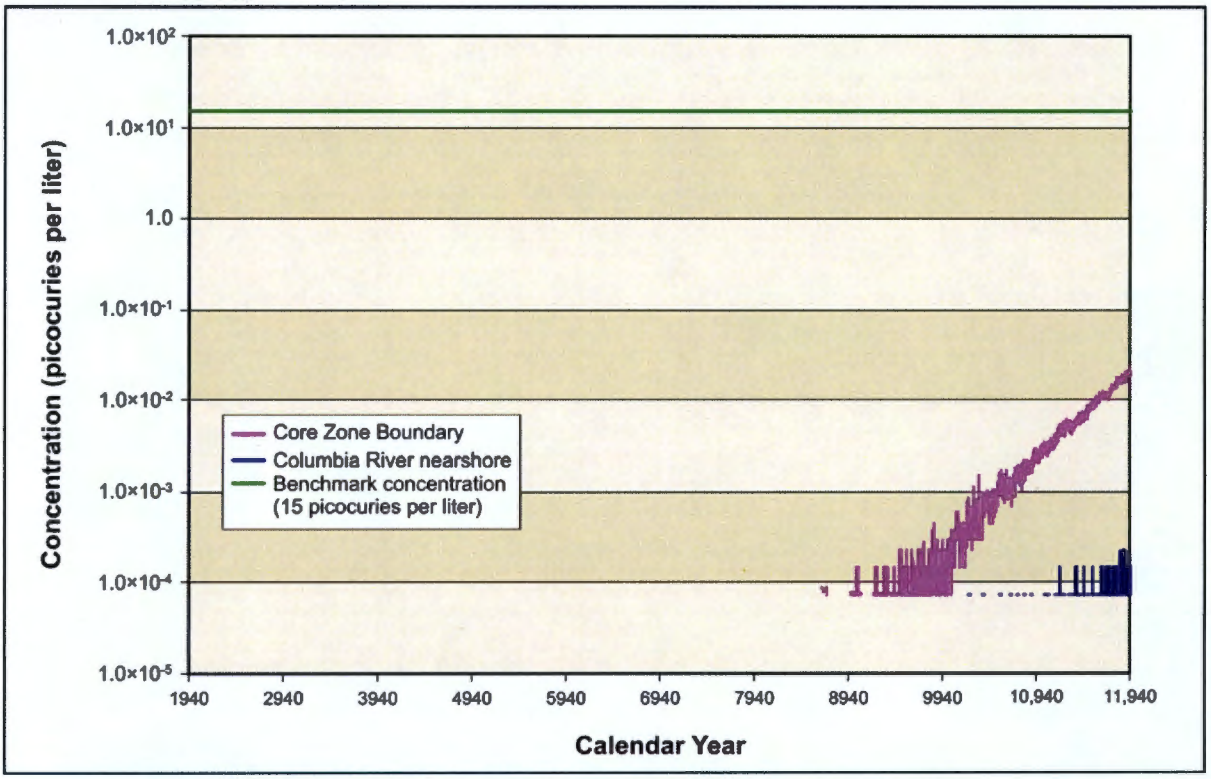


Figure 5–839. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Uranium-238 Concentration Versus Time

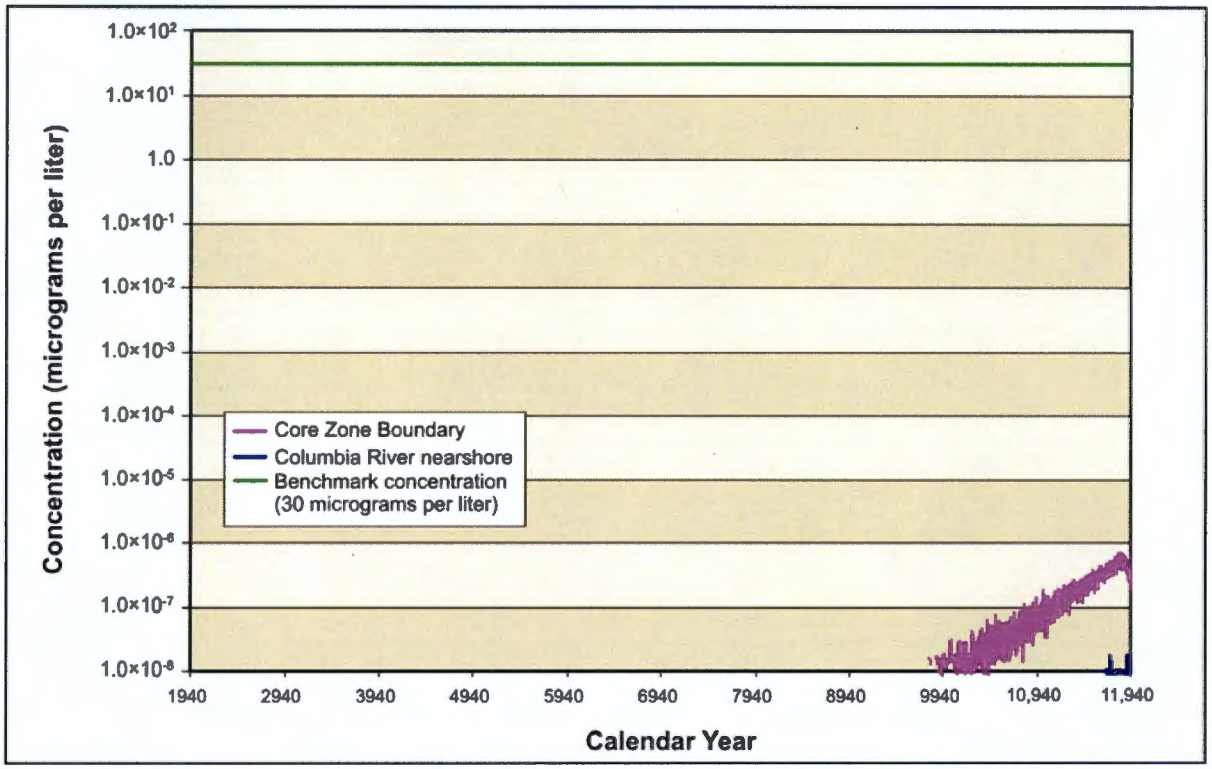


Figure 5–840. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Total Uranium Concentration Versus Time

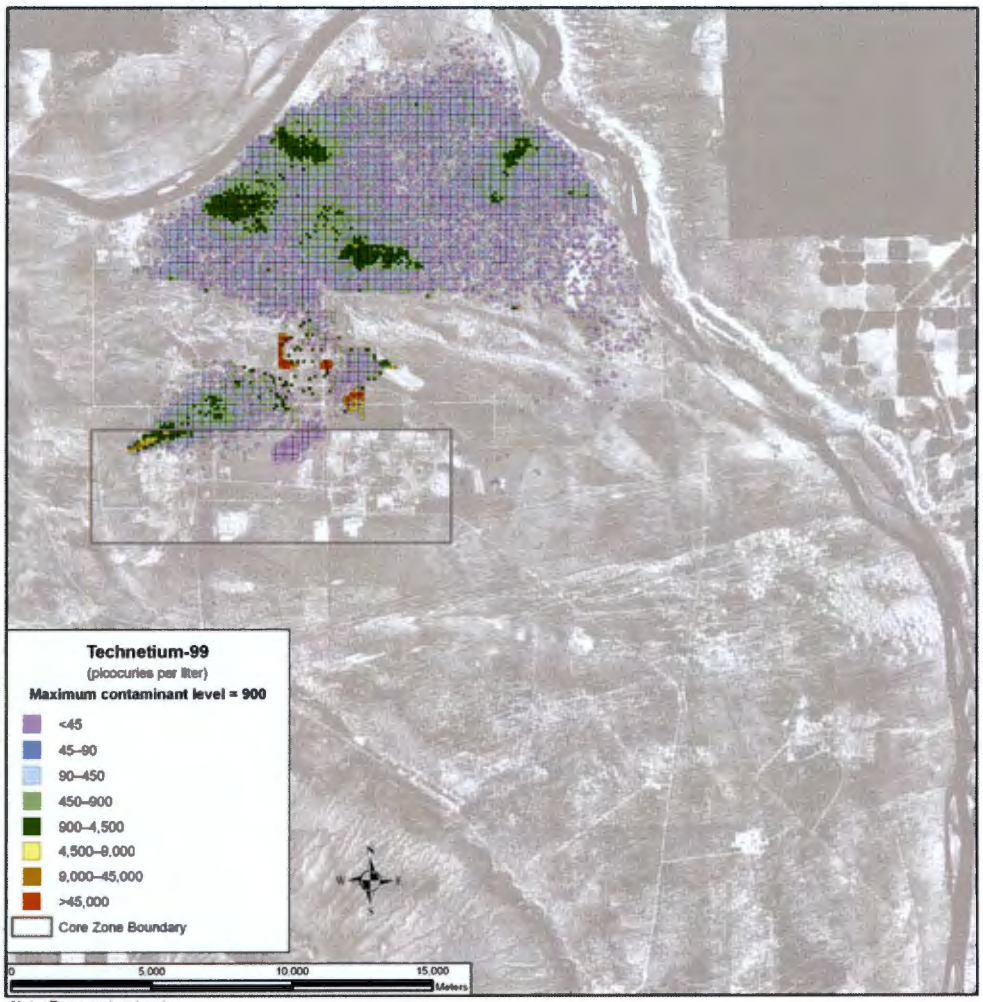
ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

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.

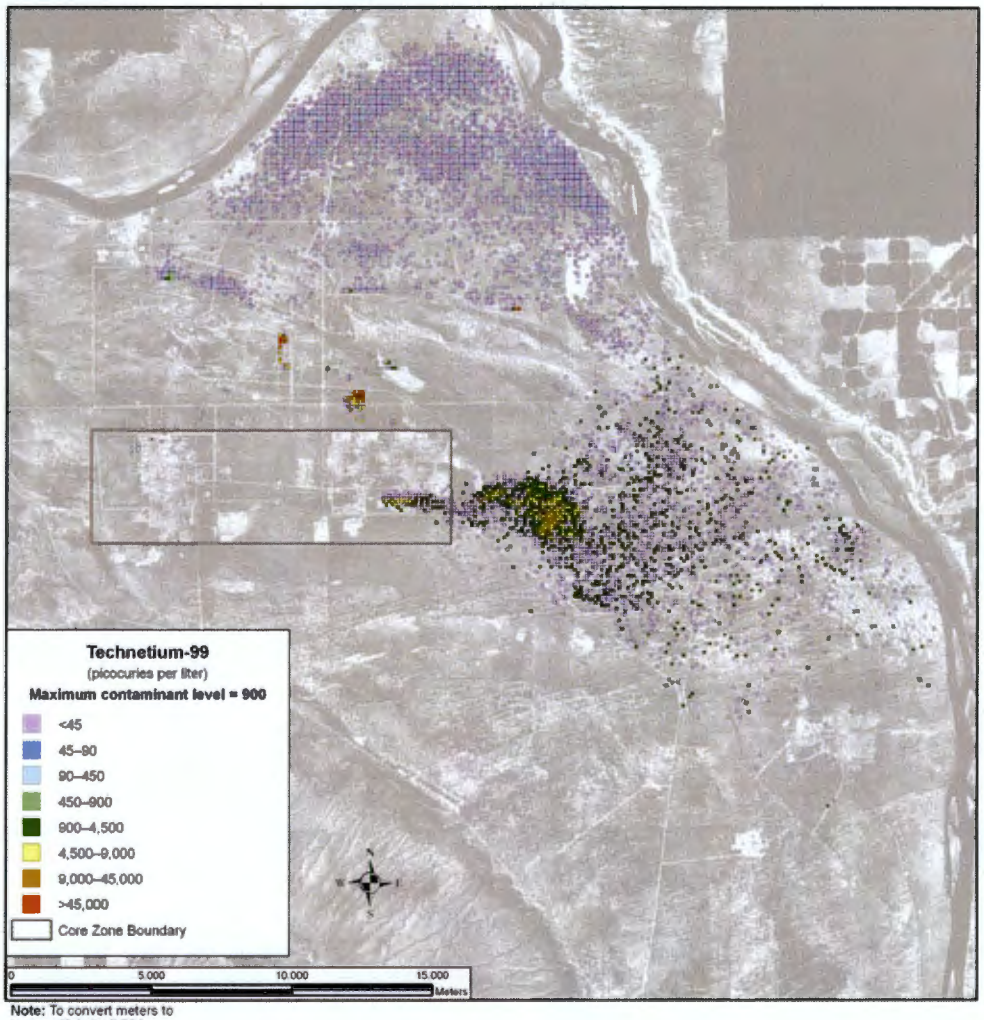
Figure 5–841 (CY 3890) shows the technetium-99 release from IDF-West and the RPPDF in CY 3890. This spatial distribution shows that technetium-99 exceeds the benchmark concentration within the Core Zone (due to the IDF-West release) and in several areas close to the Columbia River nearshore. There are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



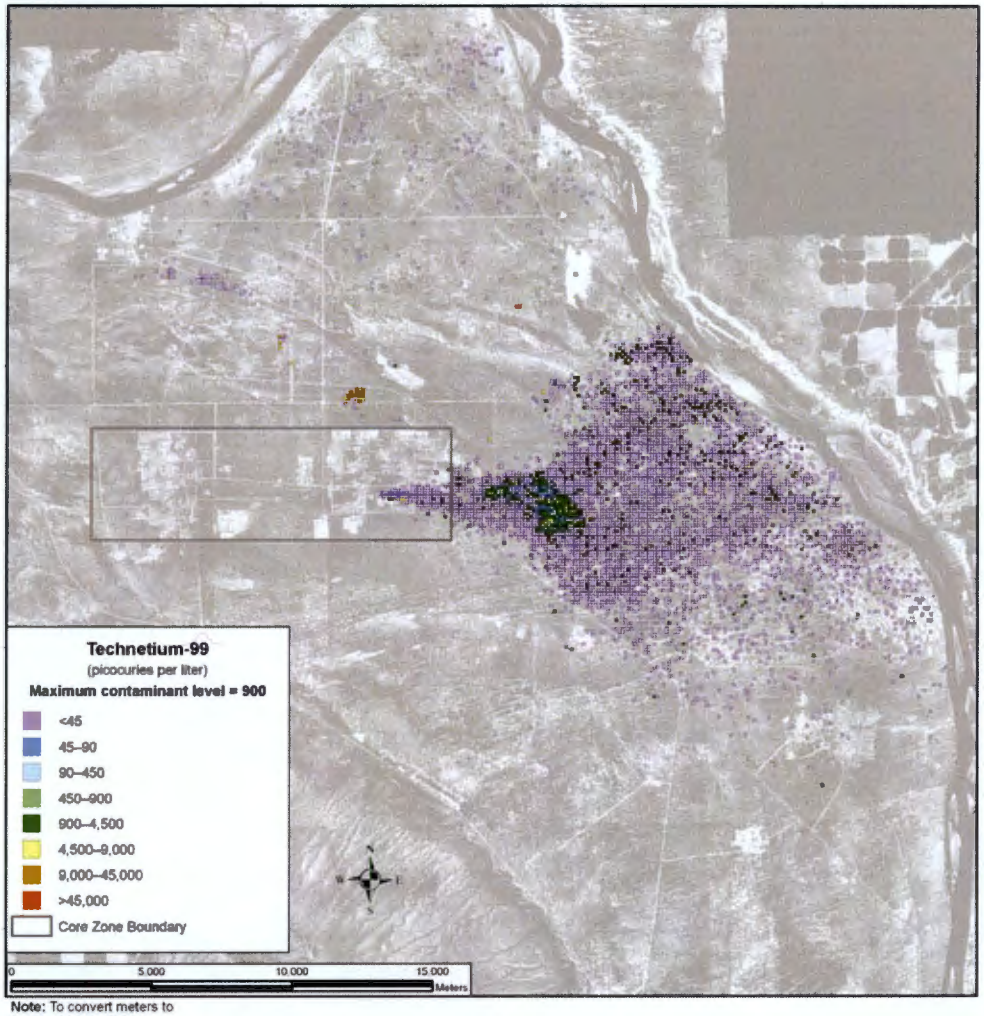
Note: To convert meters to feet, multiply by 3.281

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

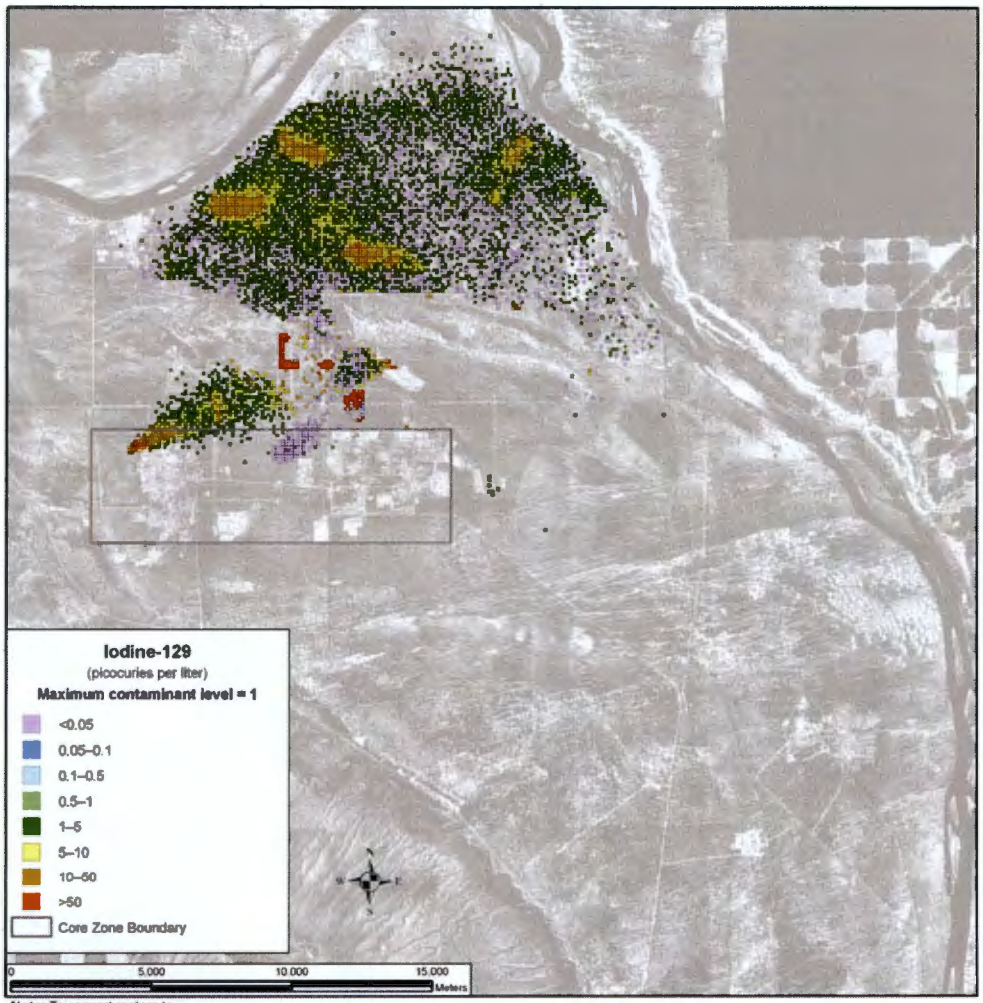
Figure 5–842. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During the Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

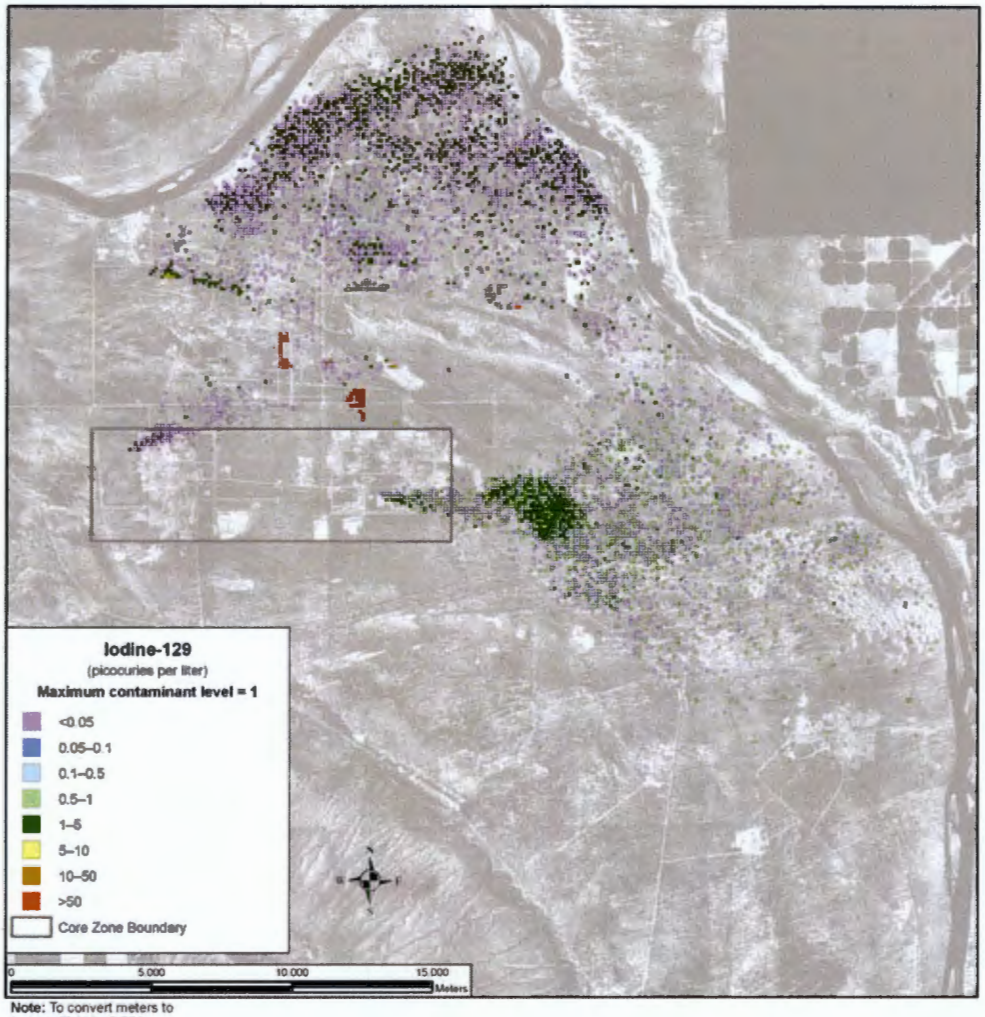
Figure 5–843. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During the Calendar Year 11,885

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.



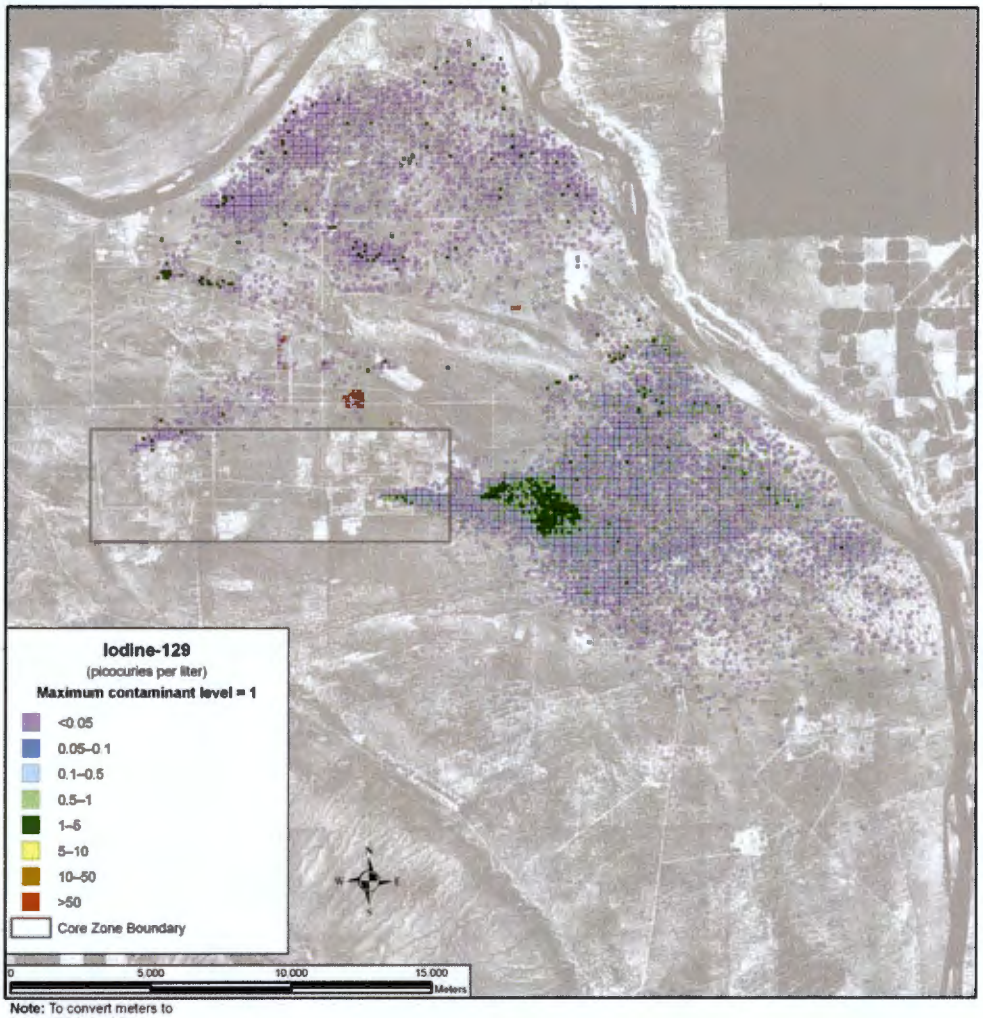
Note: To convert meters to feet, multiply by 3.281

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

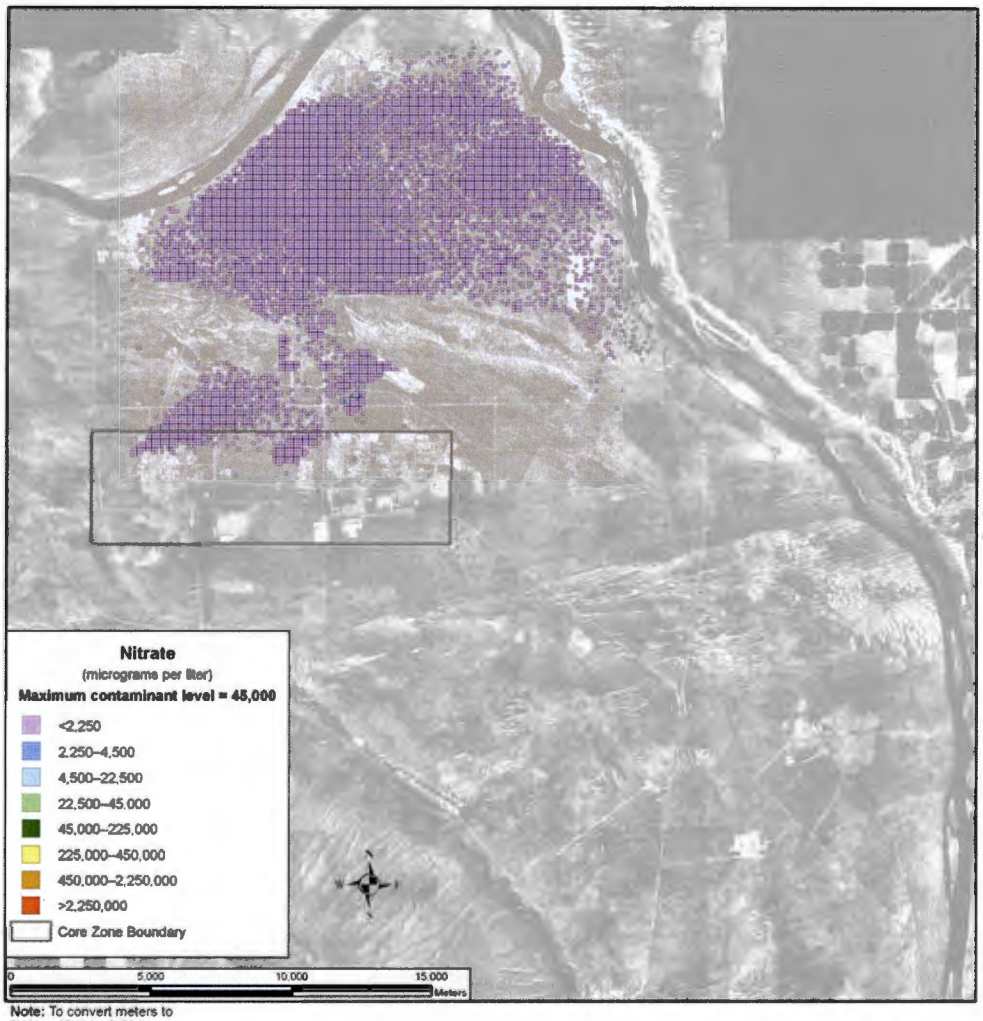
Figure 5–845. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During the Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

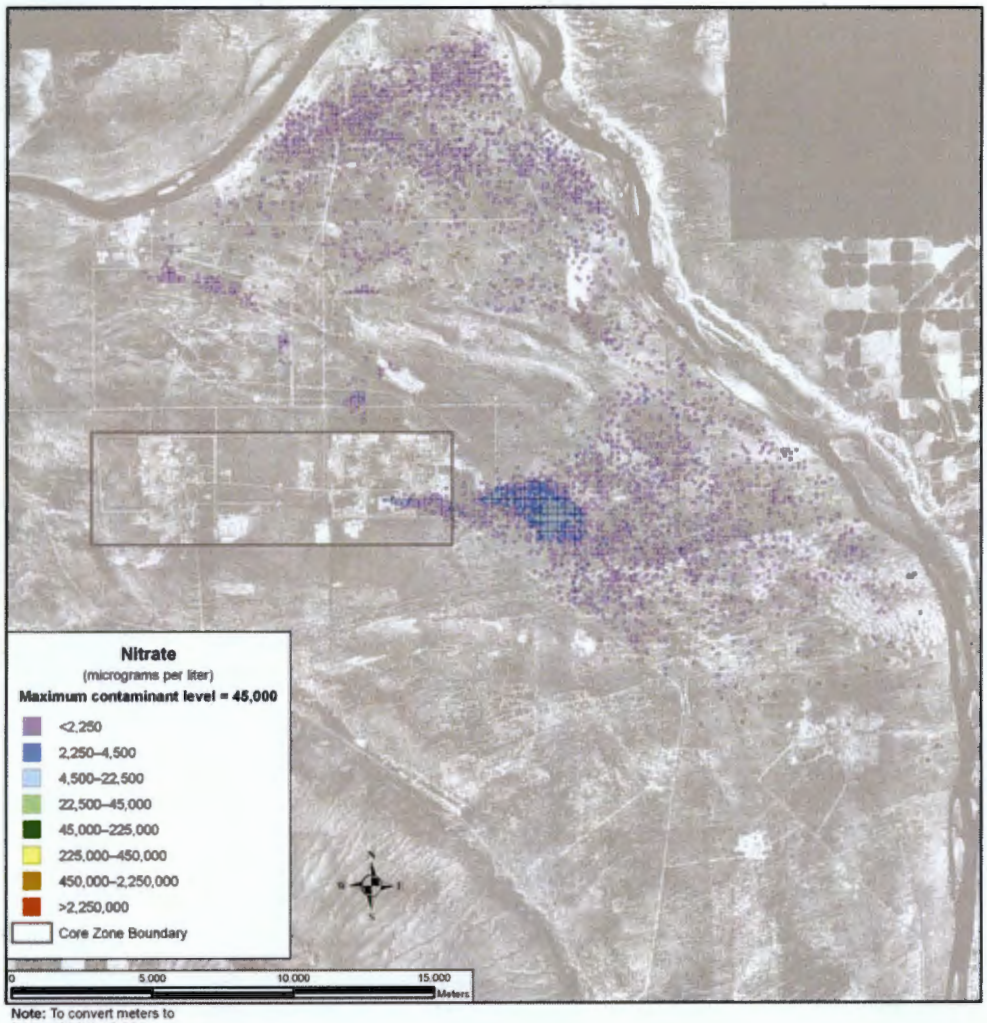
Figure 5–846. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During the Calendar Year 11,885

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.



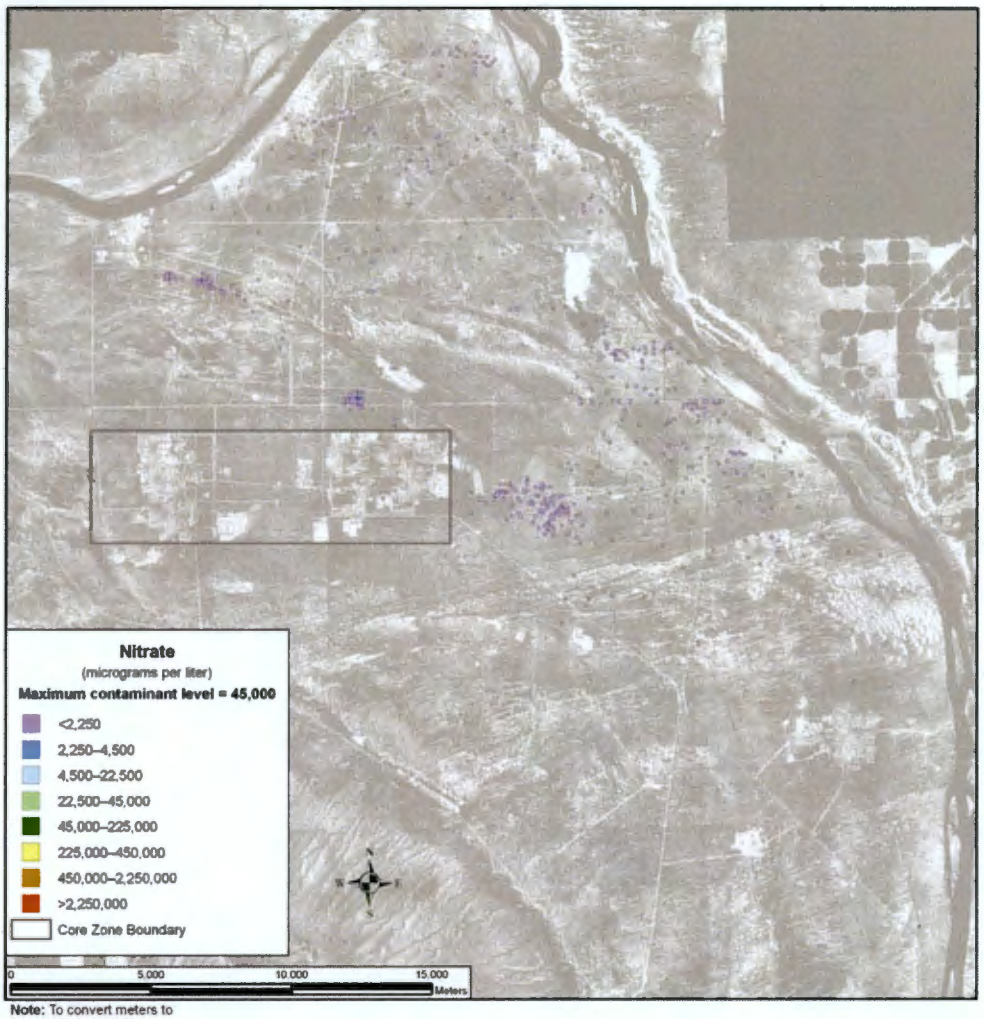
Note: To convert meters to feet, multiply by 3.281

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

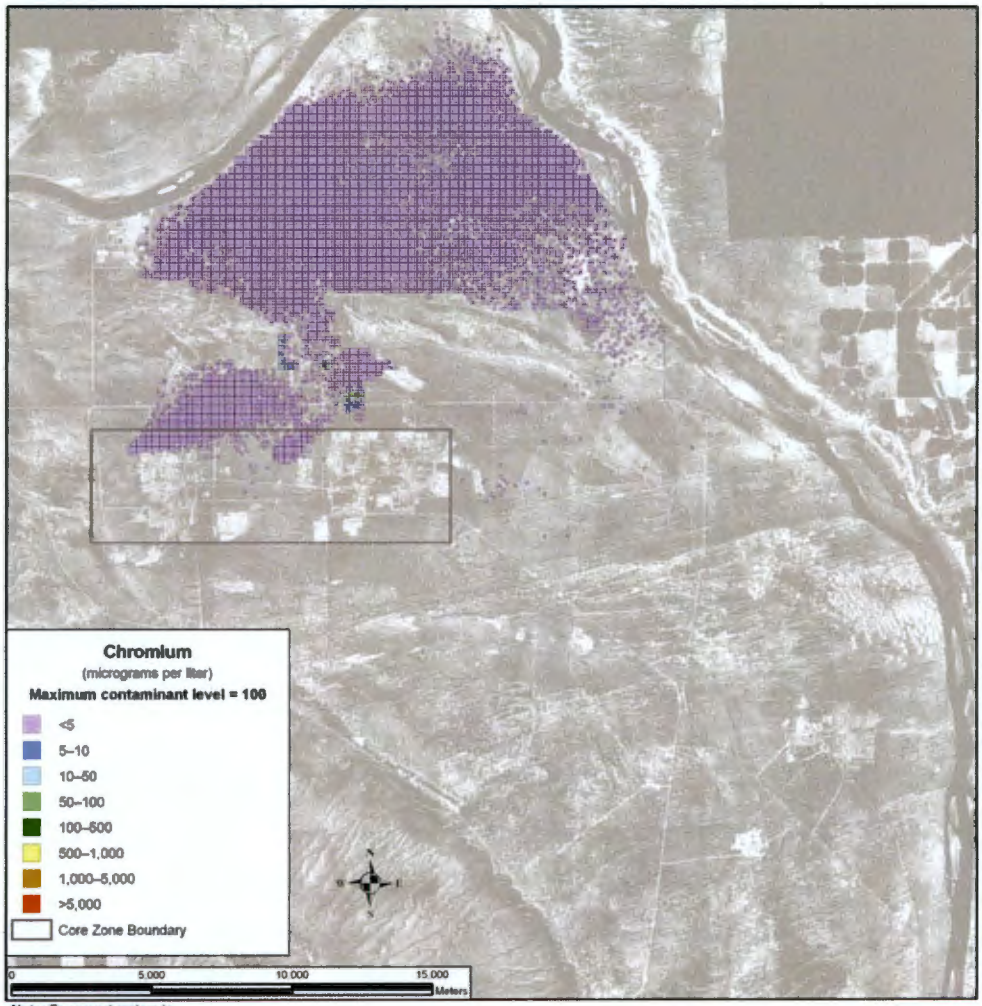
Figure 5–848. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During the Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

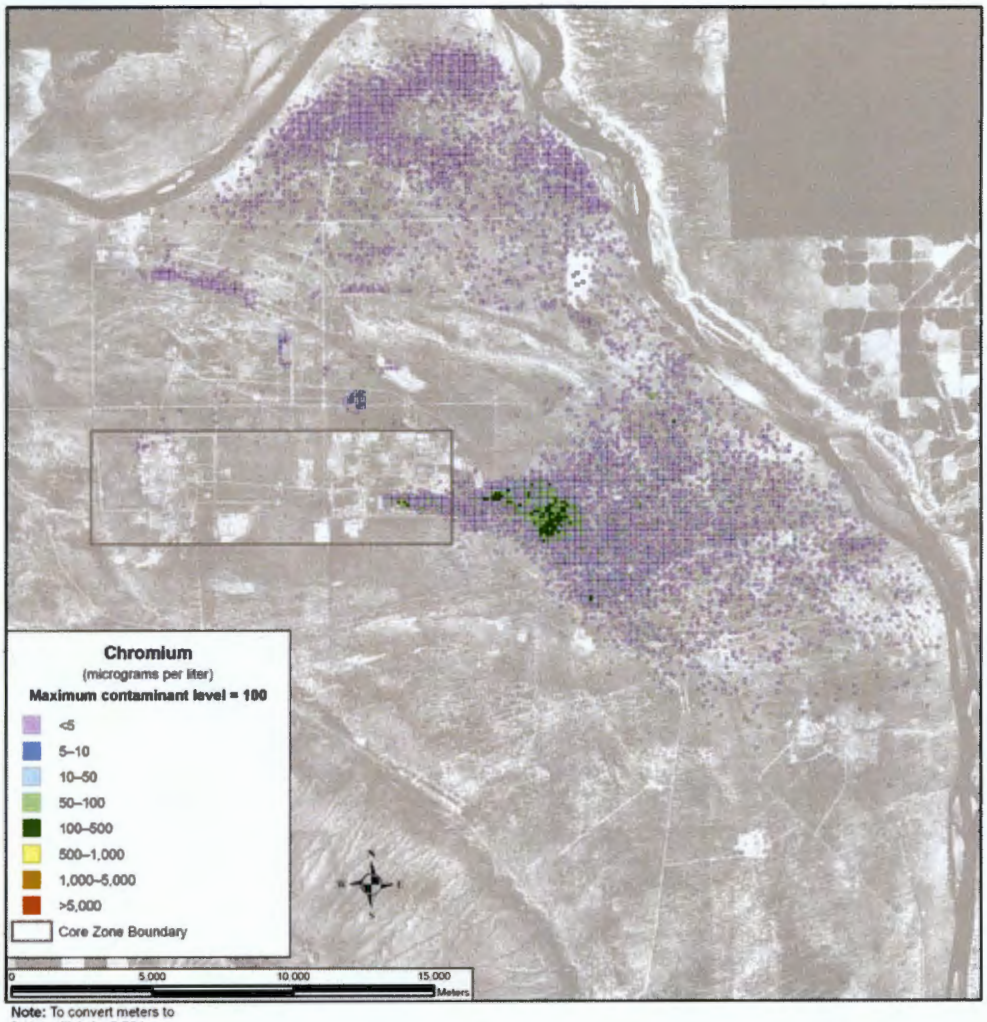
Figure 5–849. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During the Calendar Year 11,885

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.



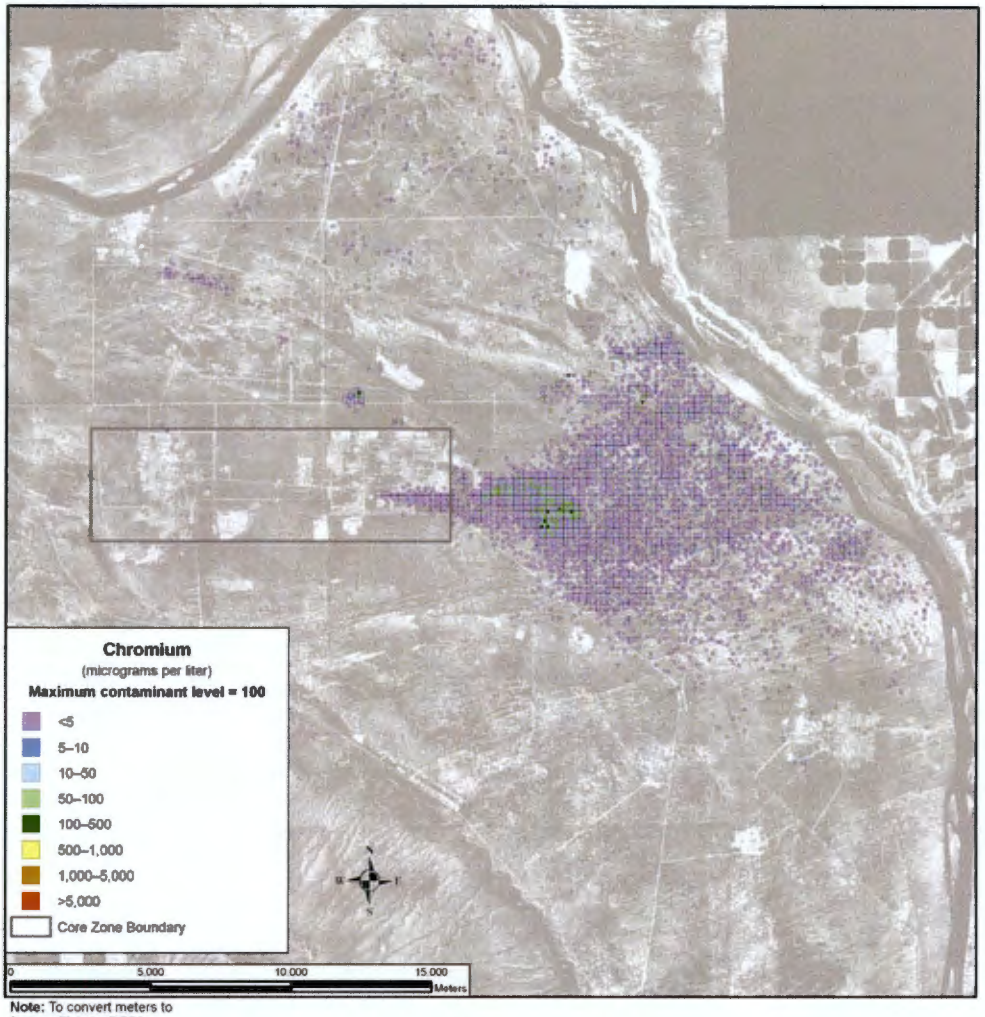
Note: To convert meters to feet, multiply by 3.281

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

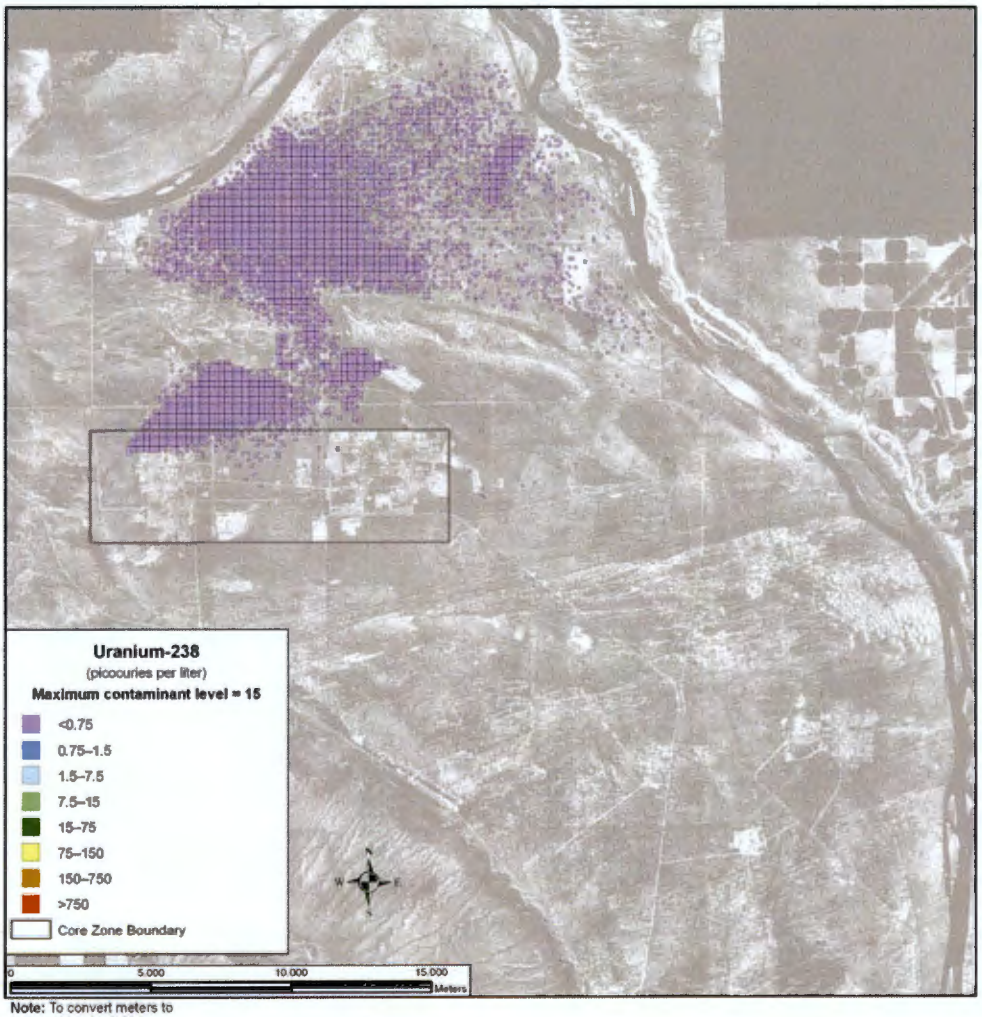
Figure 5–851. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During the Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

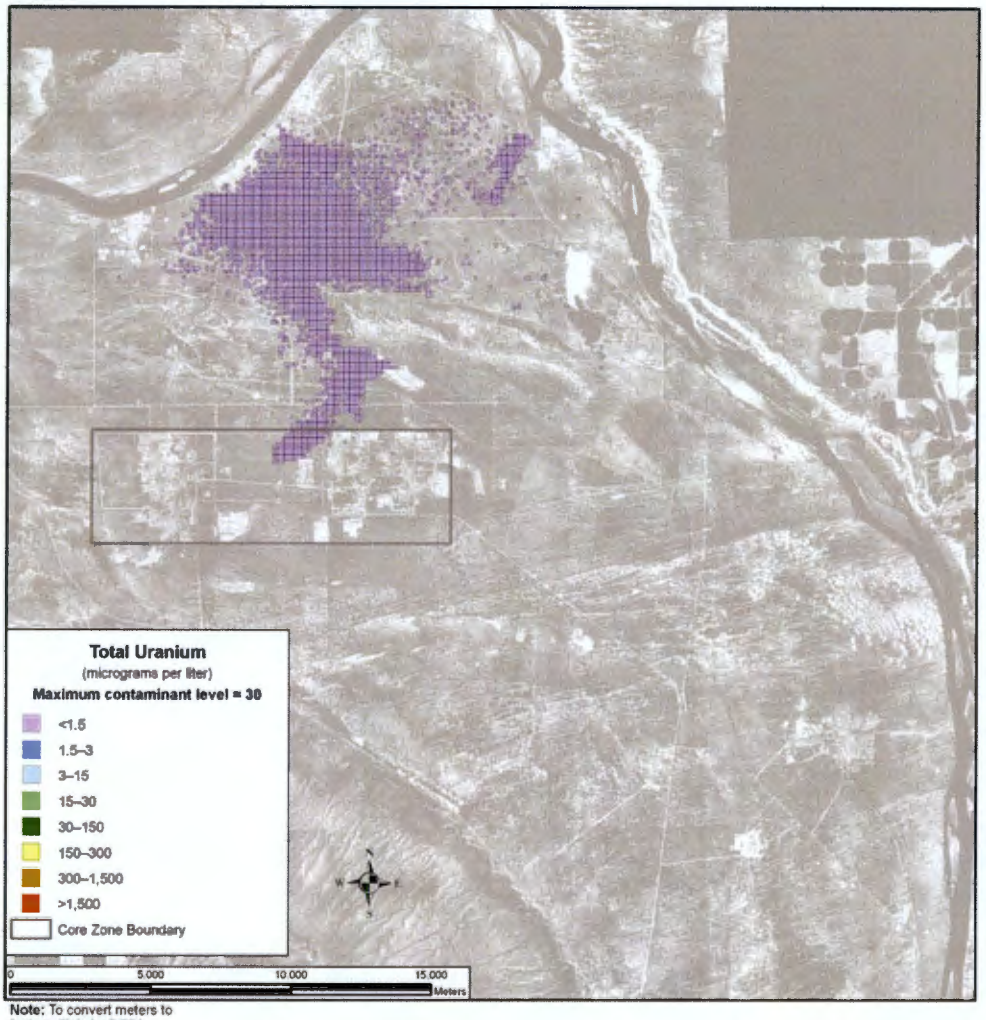
Figure 5–852. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During the Calendar Year 11,885

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.

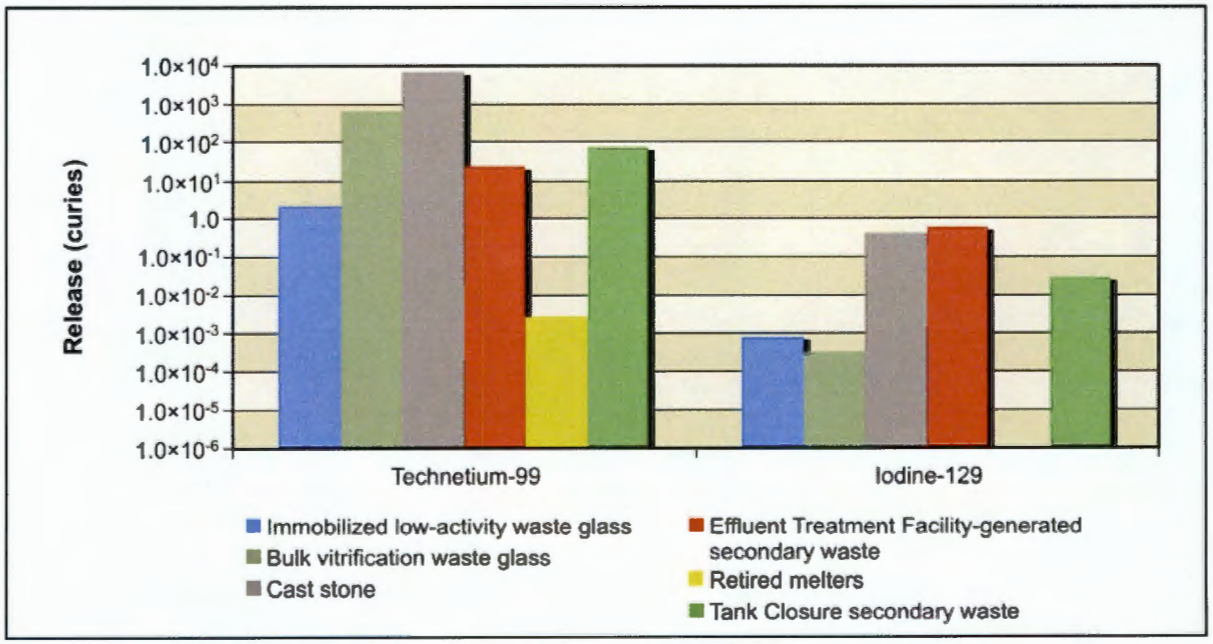


Figure 5–855. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

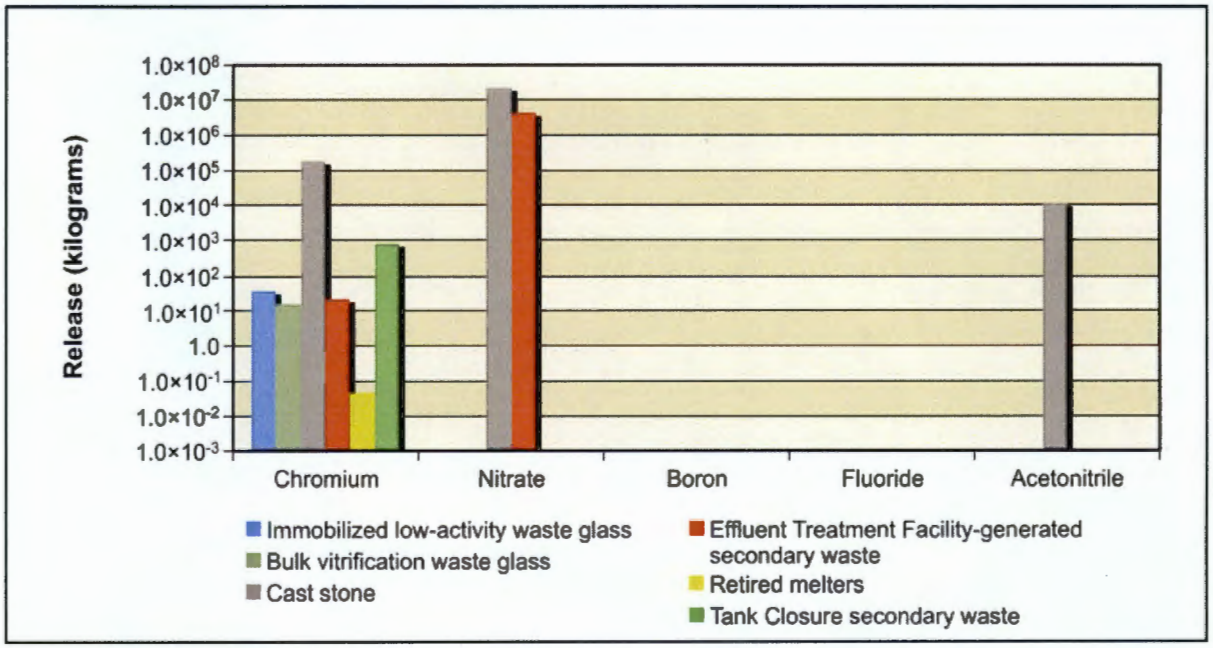


Figure 5–856. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

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.

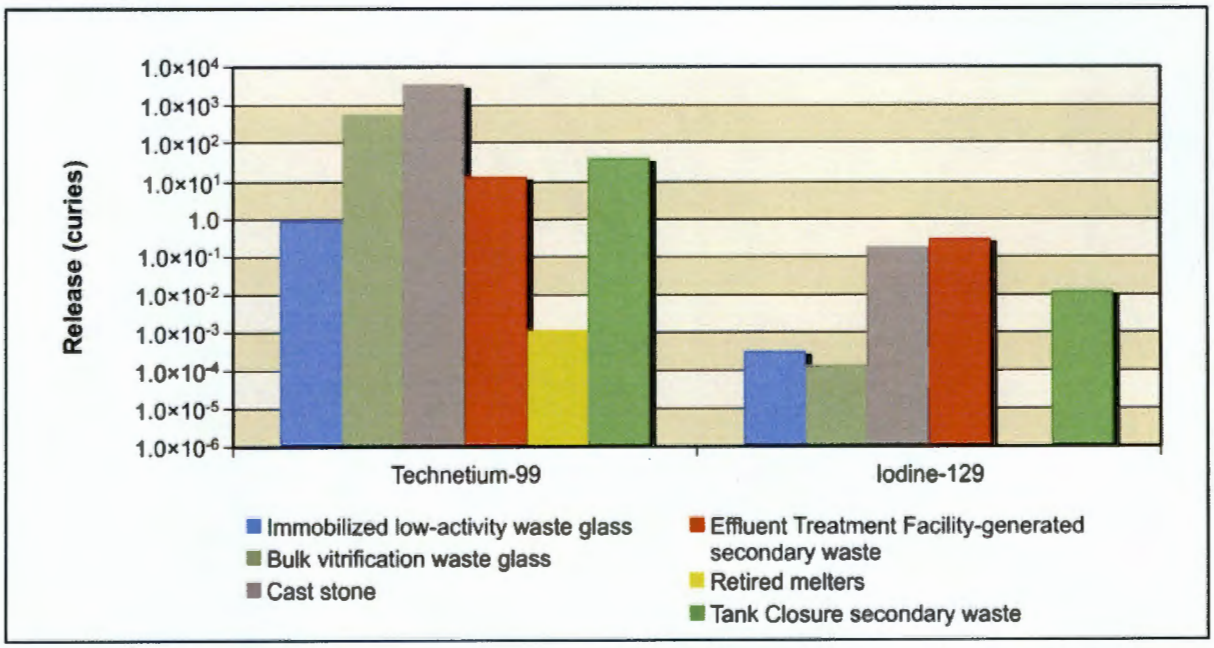


Figure 5–857. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

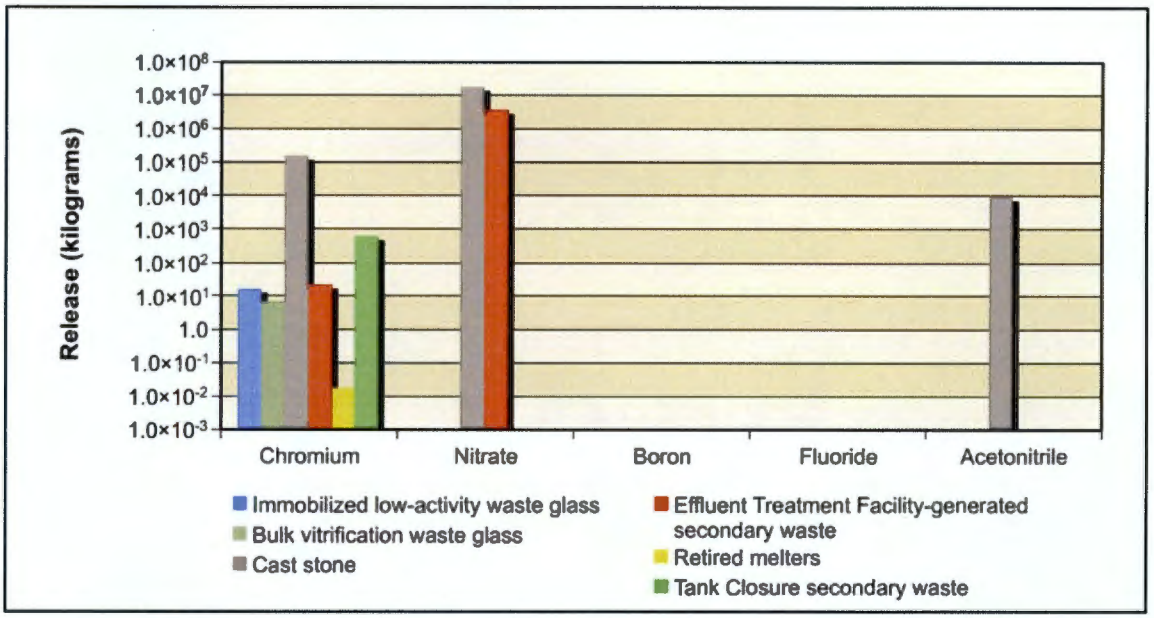


Figure 5–858. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

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.

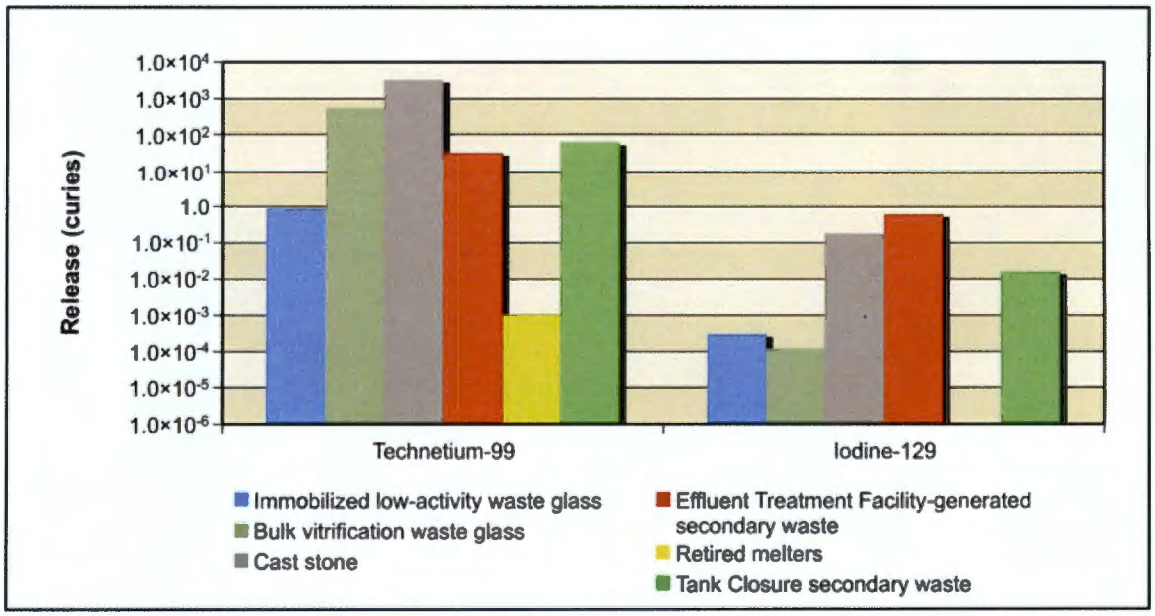


Figure 5–859. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

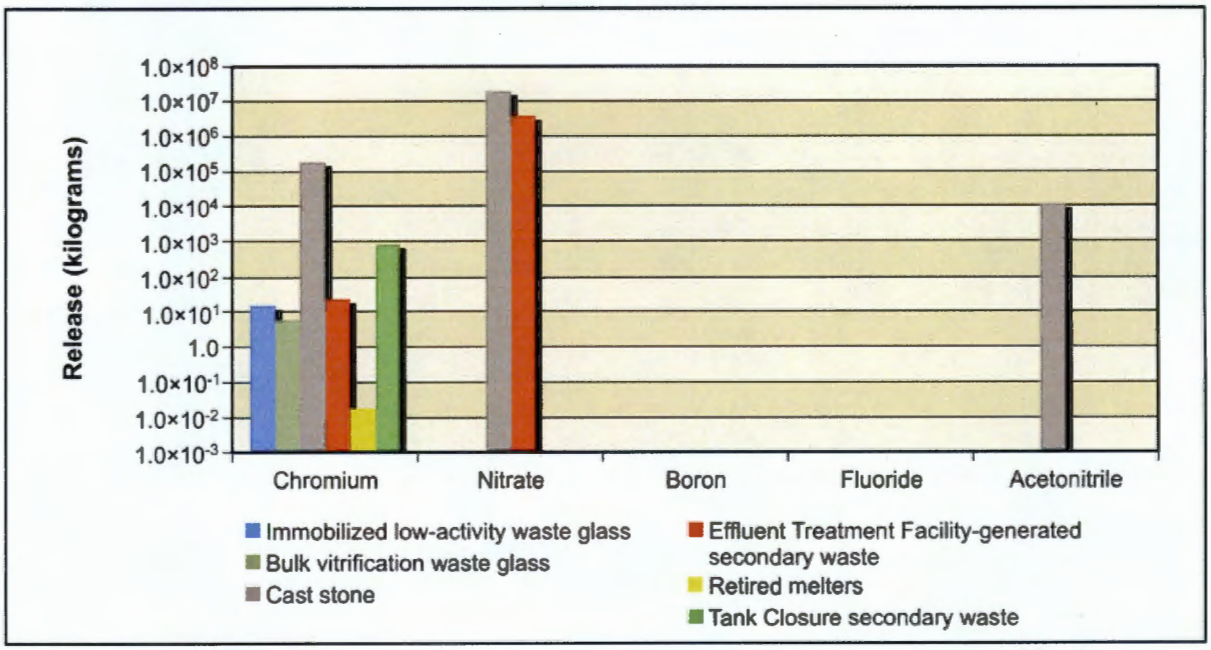


Figure 5–860. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

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.

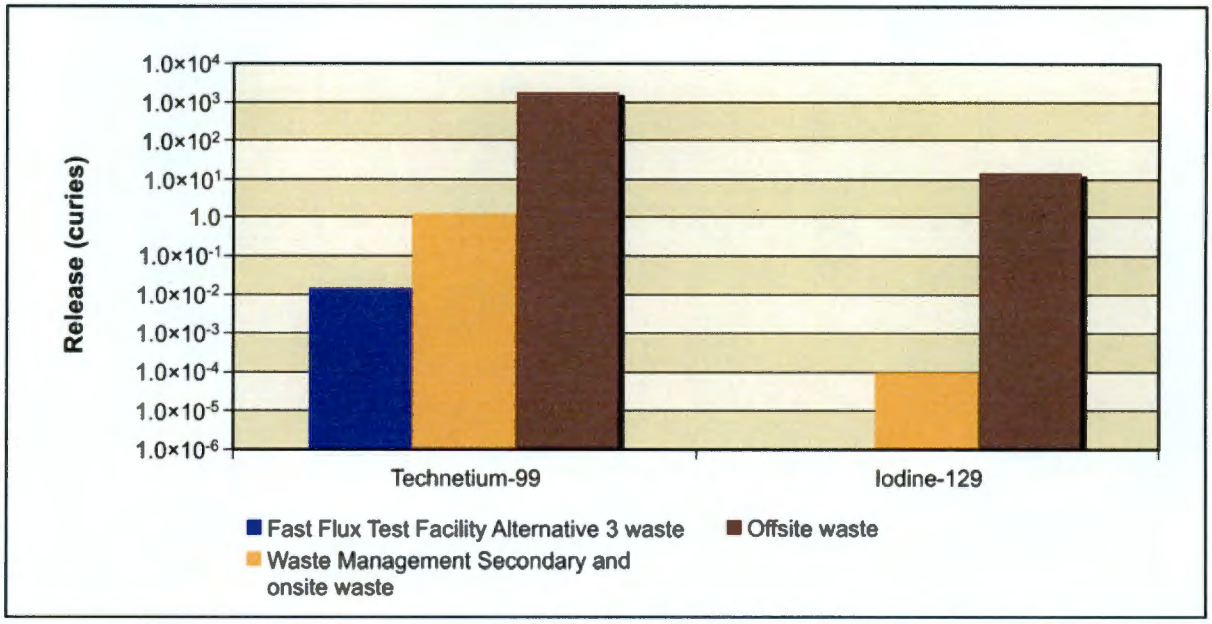


Figure 5–861. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

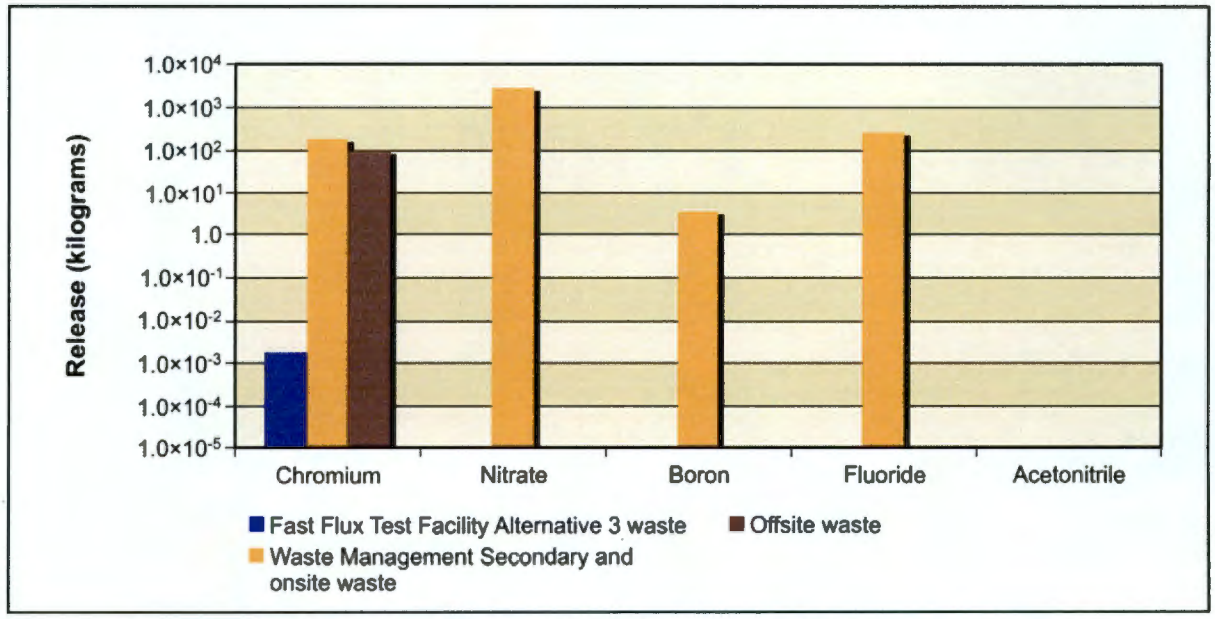


Figure 5–862. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

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.

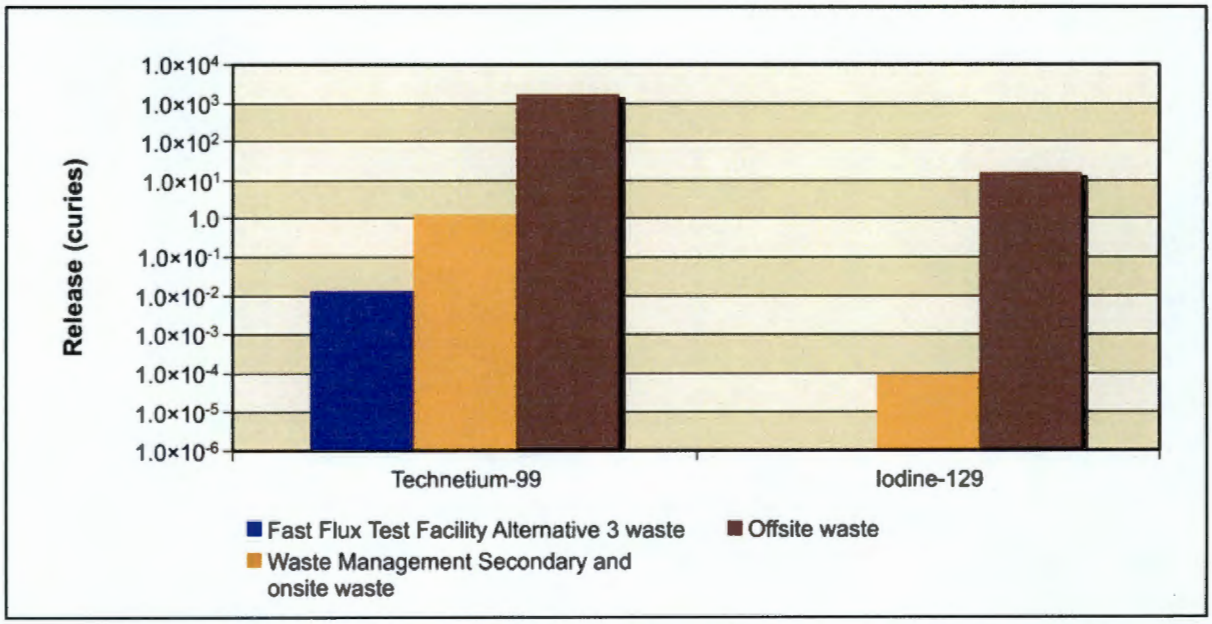


Figure 5–863. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

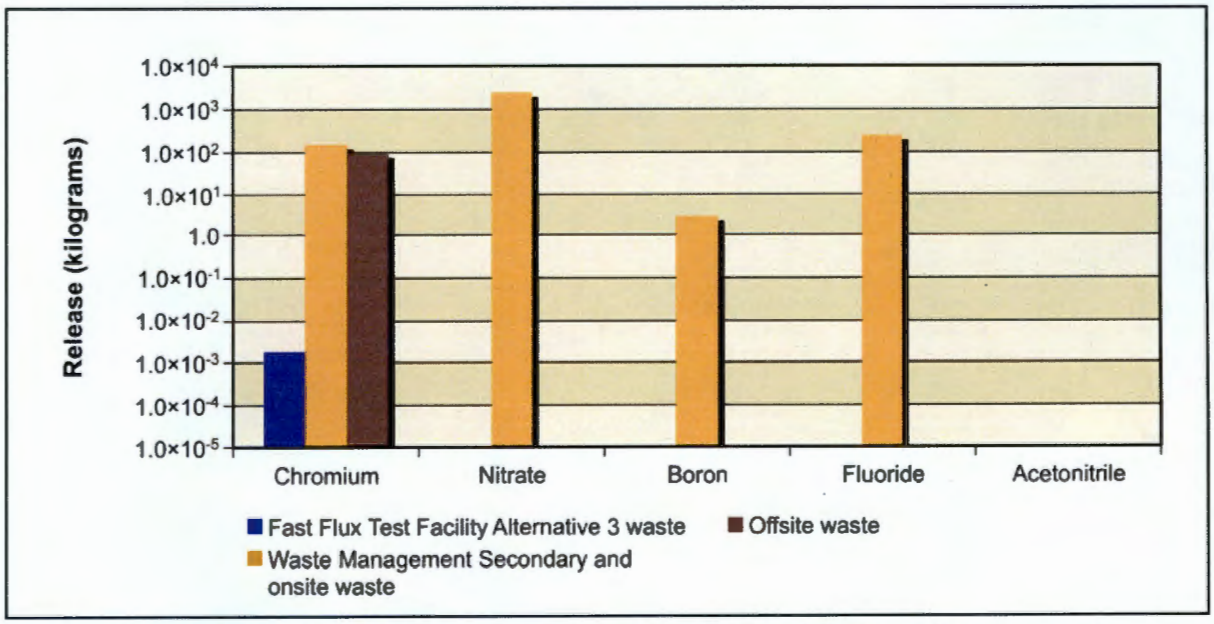


Figure 5–864. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

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.

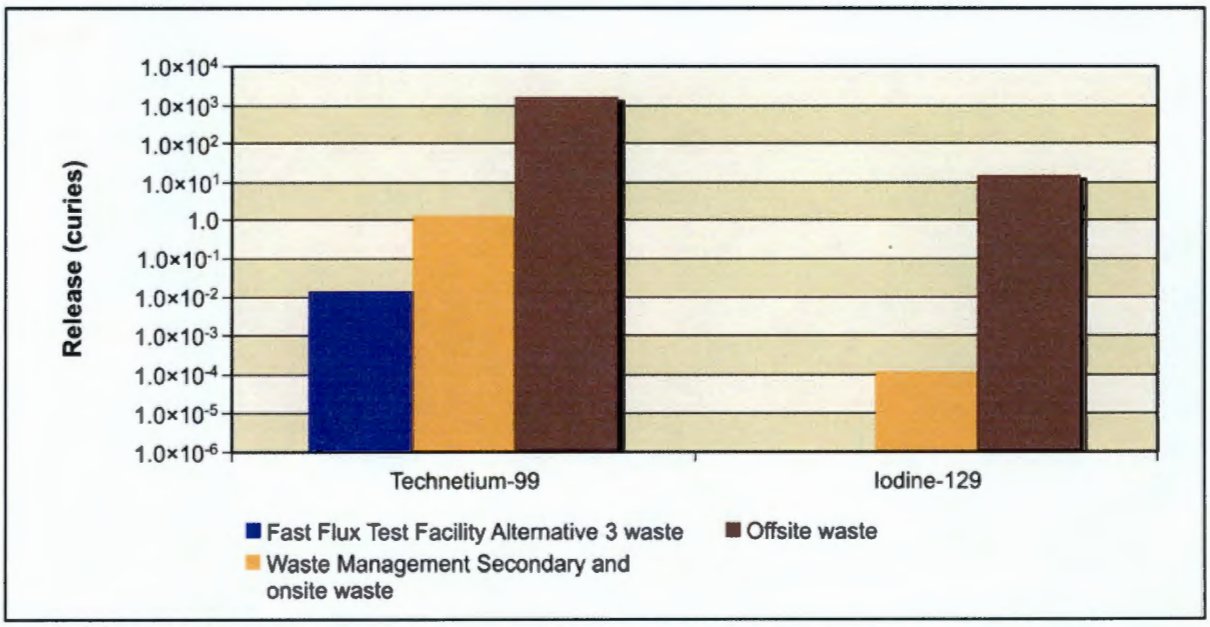


Figure 5–865. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

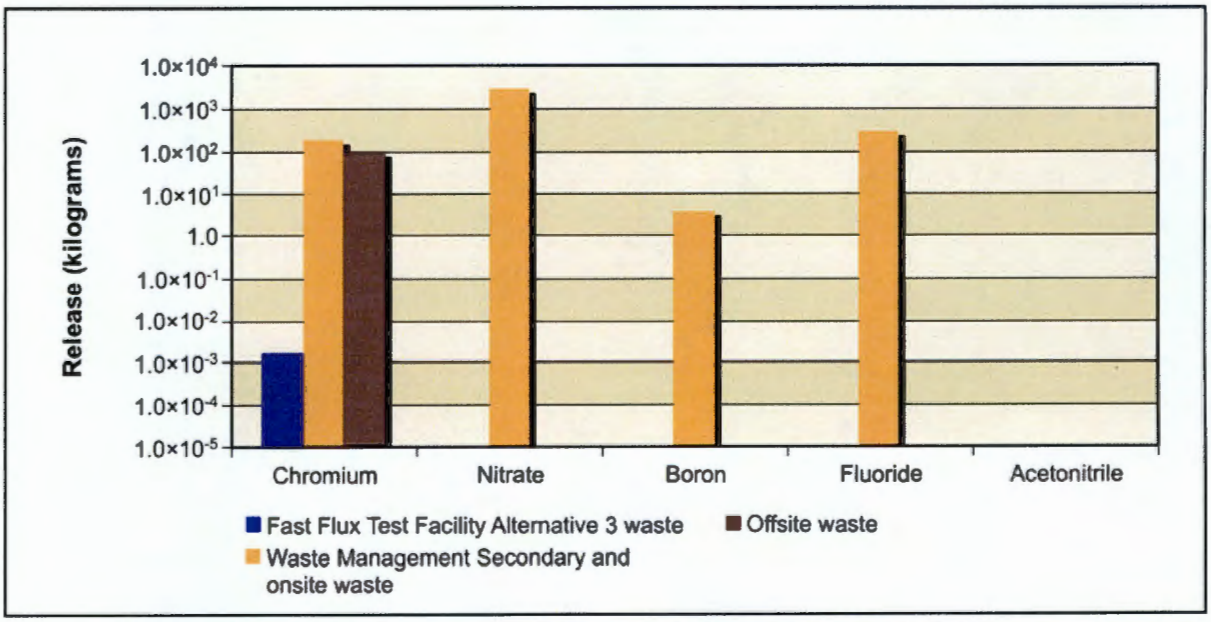


Figure 5–866. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

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.

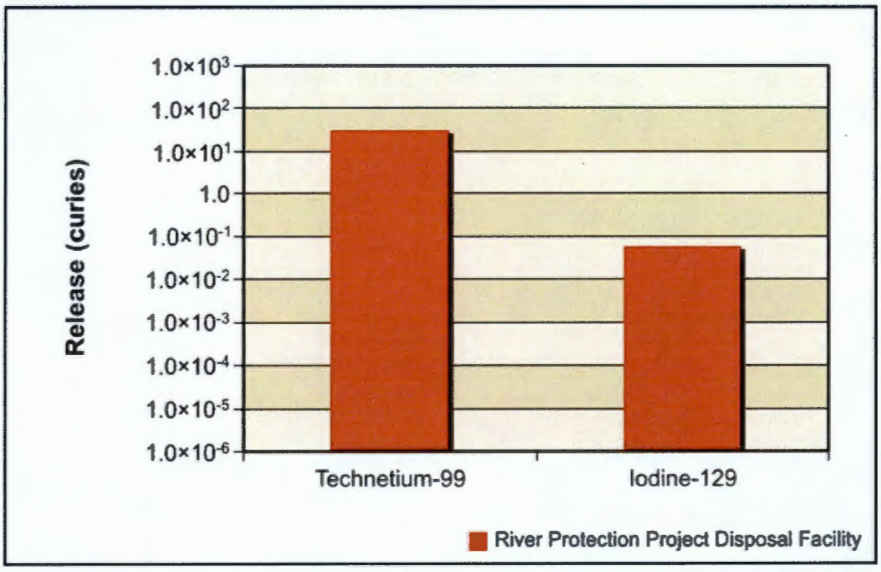


Figure 5–867. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

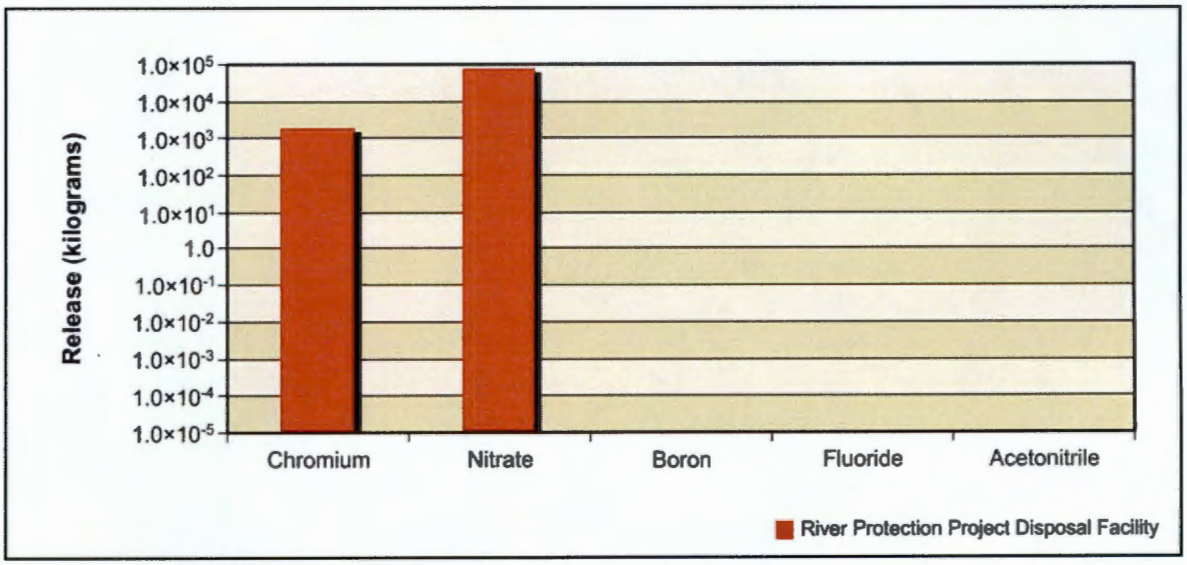


Figure 5–868. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

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.

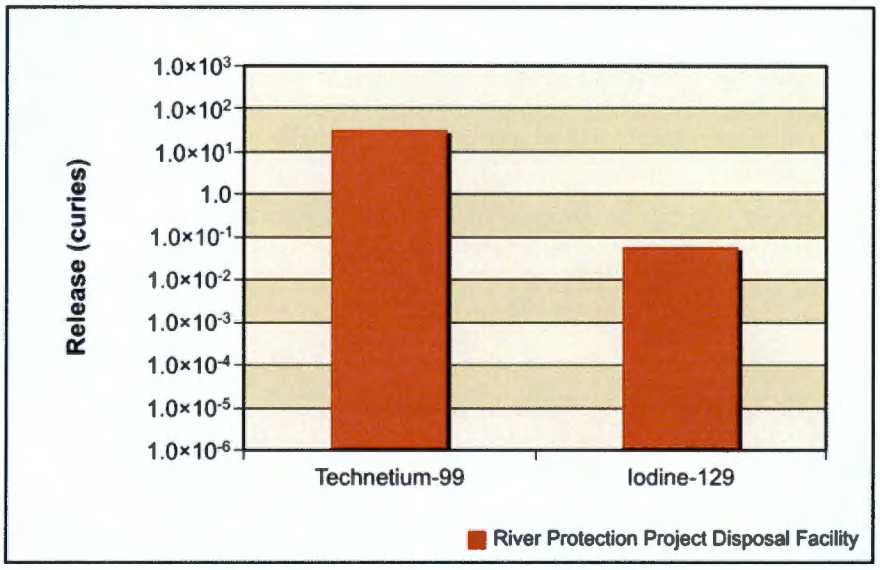


Figure 5–869. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at River Protection Project Disposal Facility to Groundwater

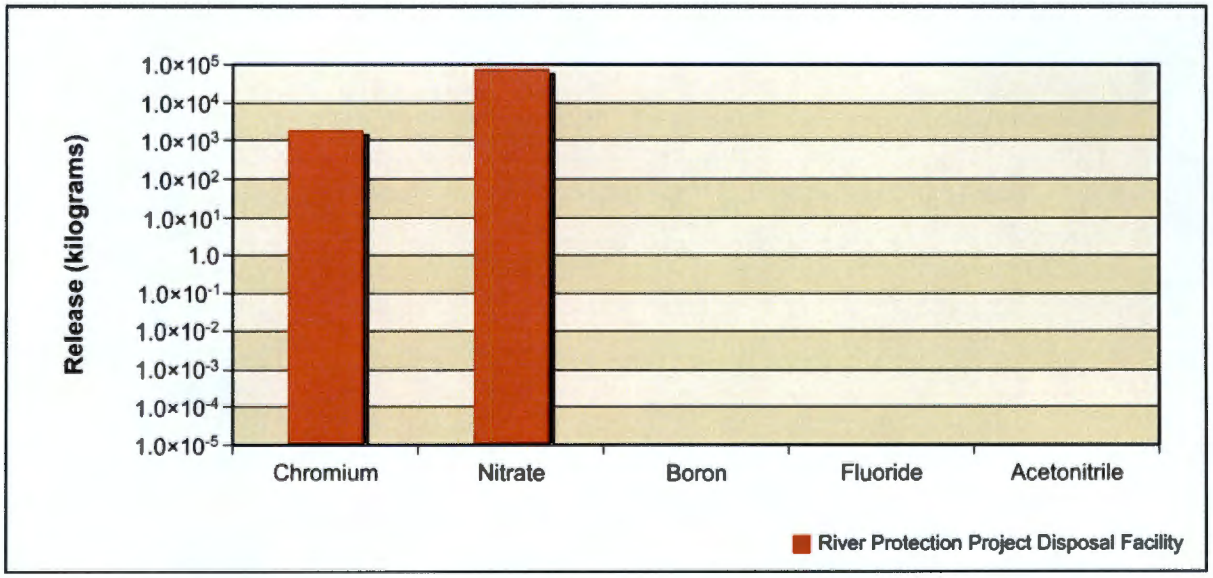


Figure 5–870. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at River Protection Project Disposal Facility to Groundwater

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.

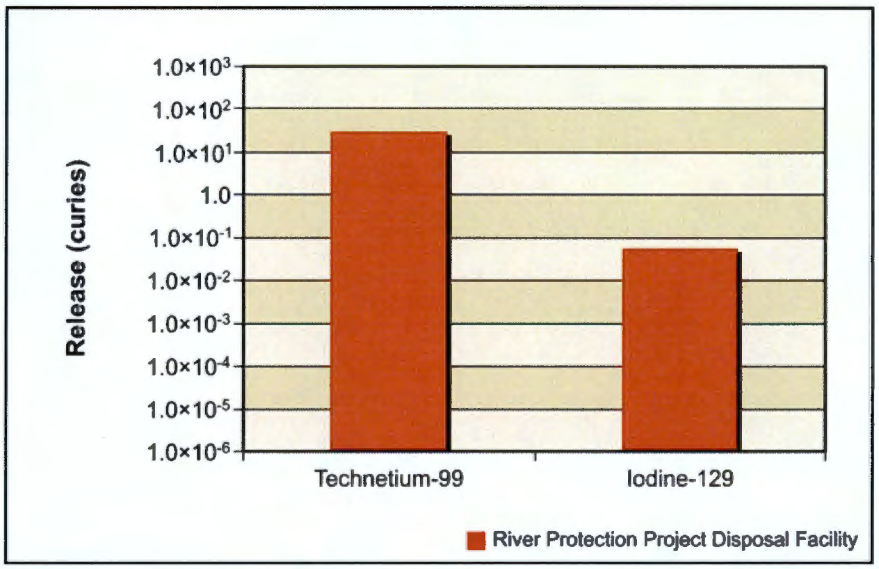


Figure 5–871. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Radiological Releases at River Protection Project Disposal Facility to Columbia River

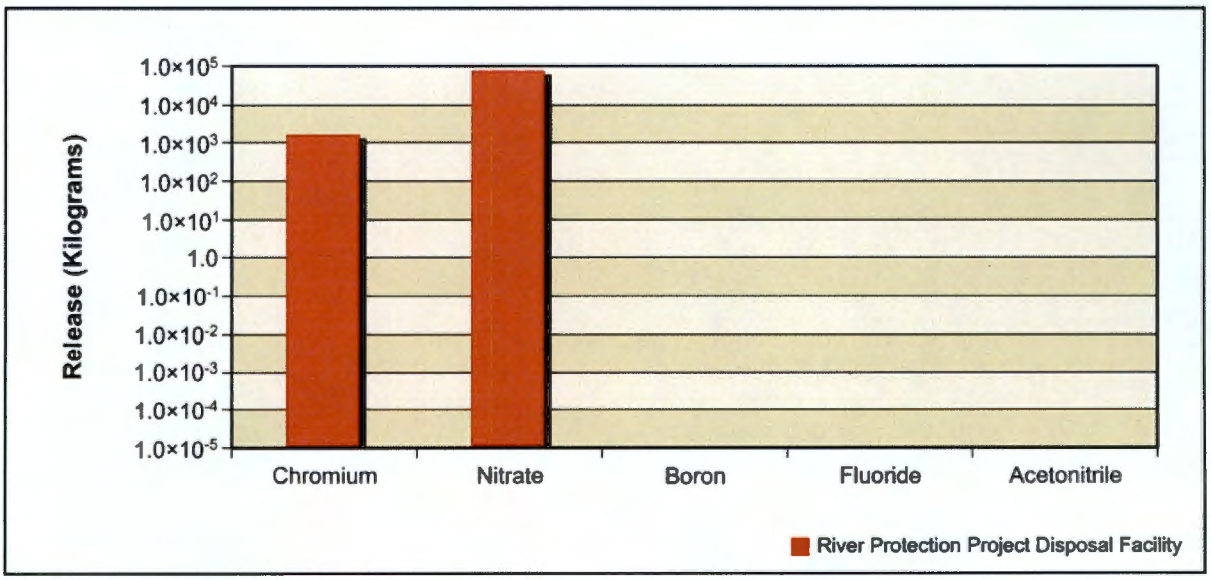


Figure 5–872. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chemical Releases at River Protection Project Disposal Facility to Columbia River

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).

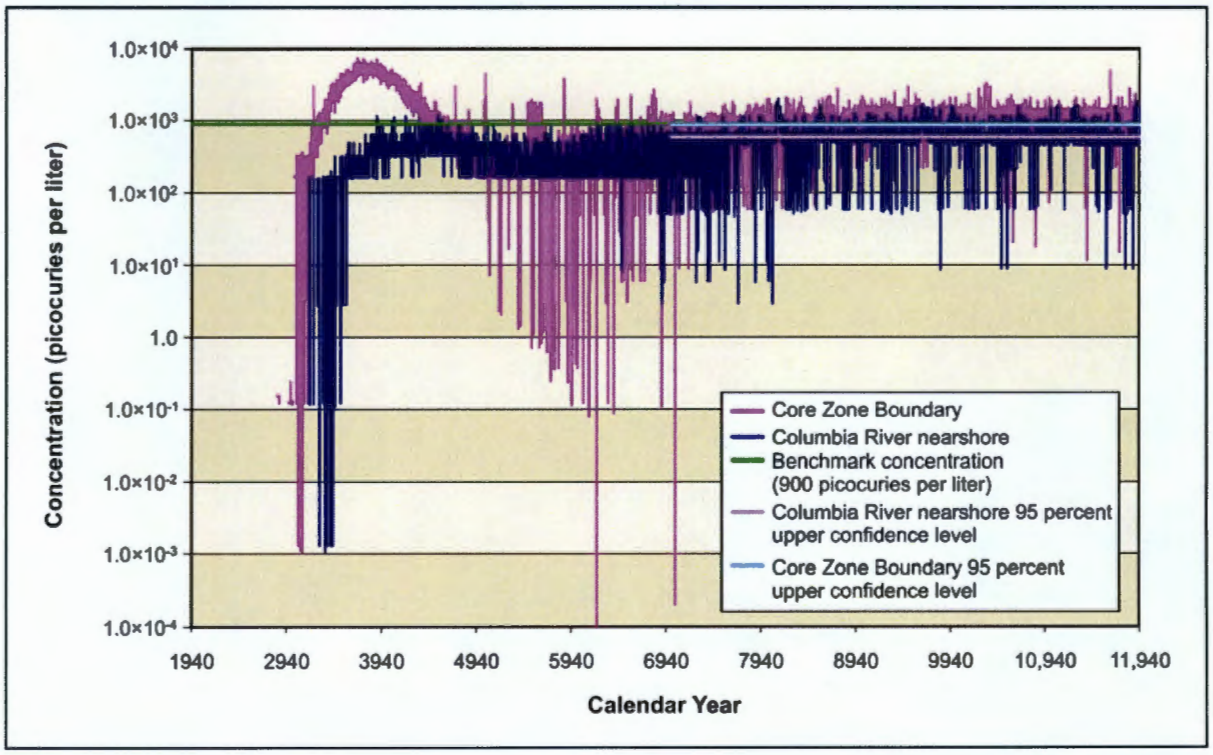


Figure 5–873. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Technetium-99 Concentration Versus Time

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).

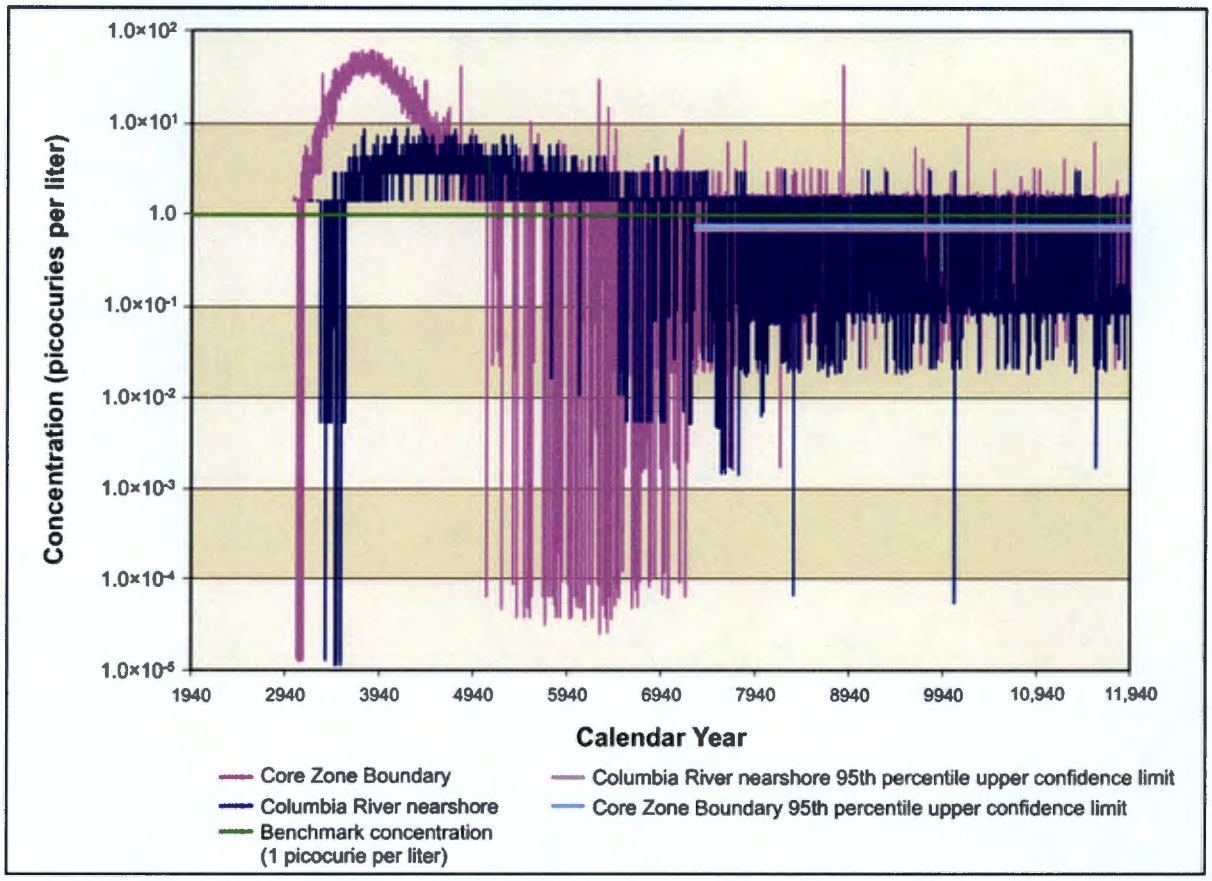


Figure 5–874. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Iodine-129 Concentration Versus Time

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.

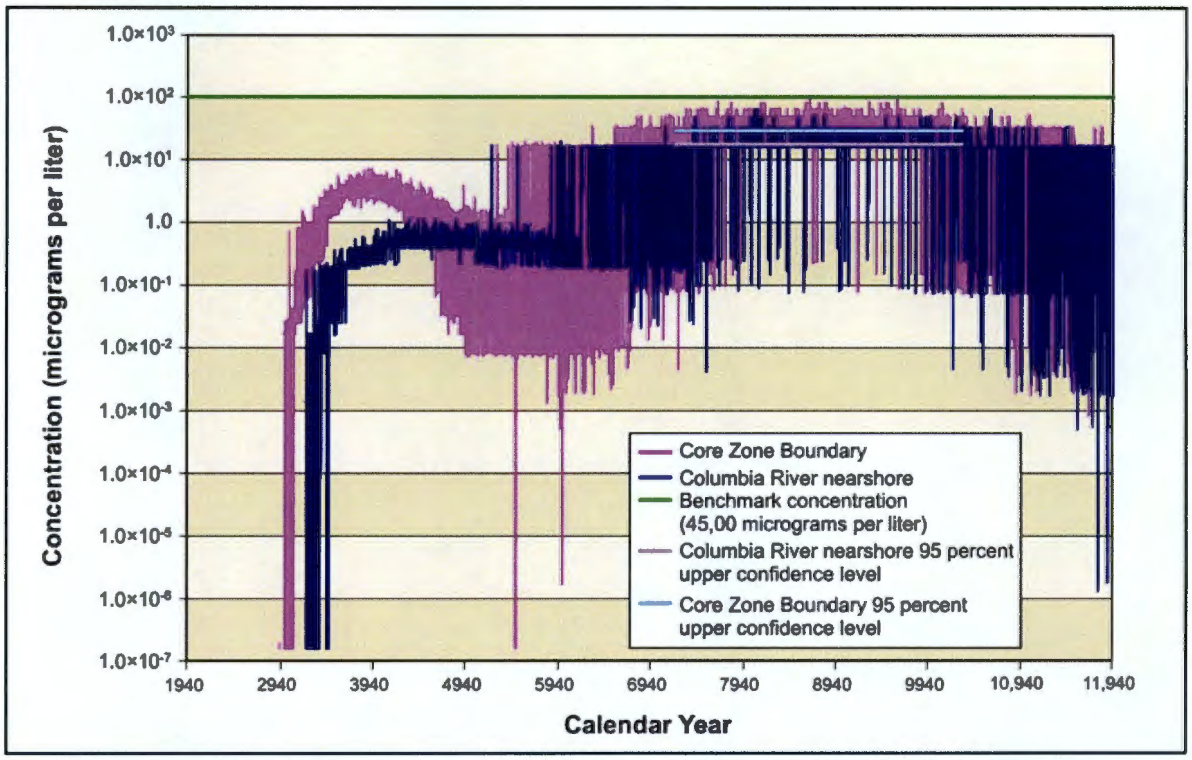


Figure 5–875. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Chromium Concentration Versus Time

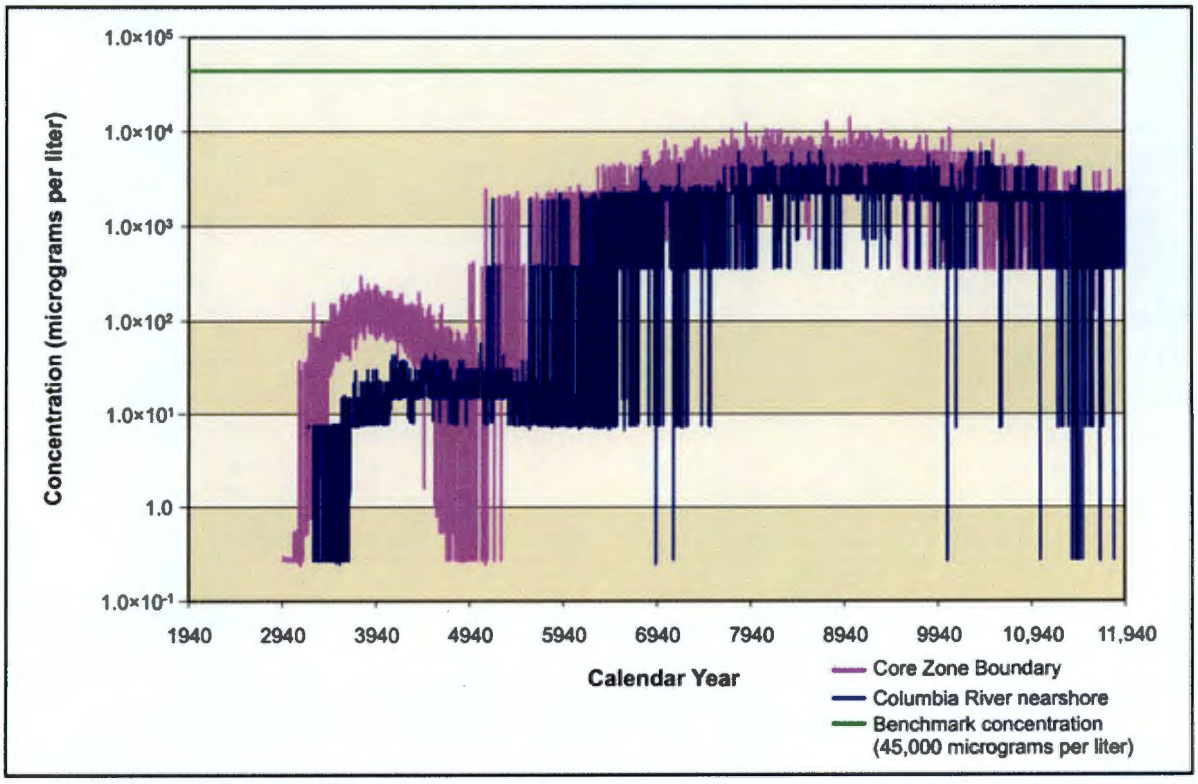


Figure 5–876. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Nitrate Concentration Versus Time

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.

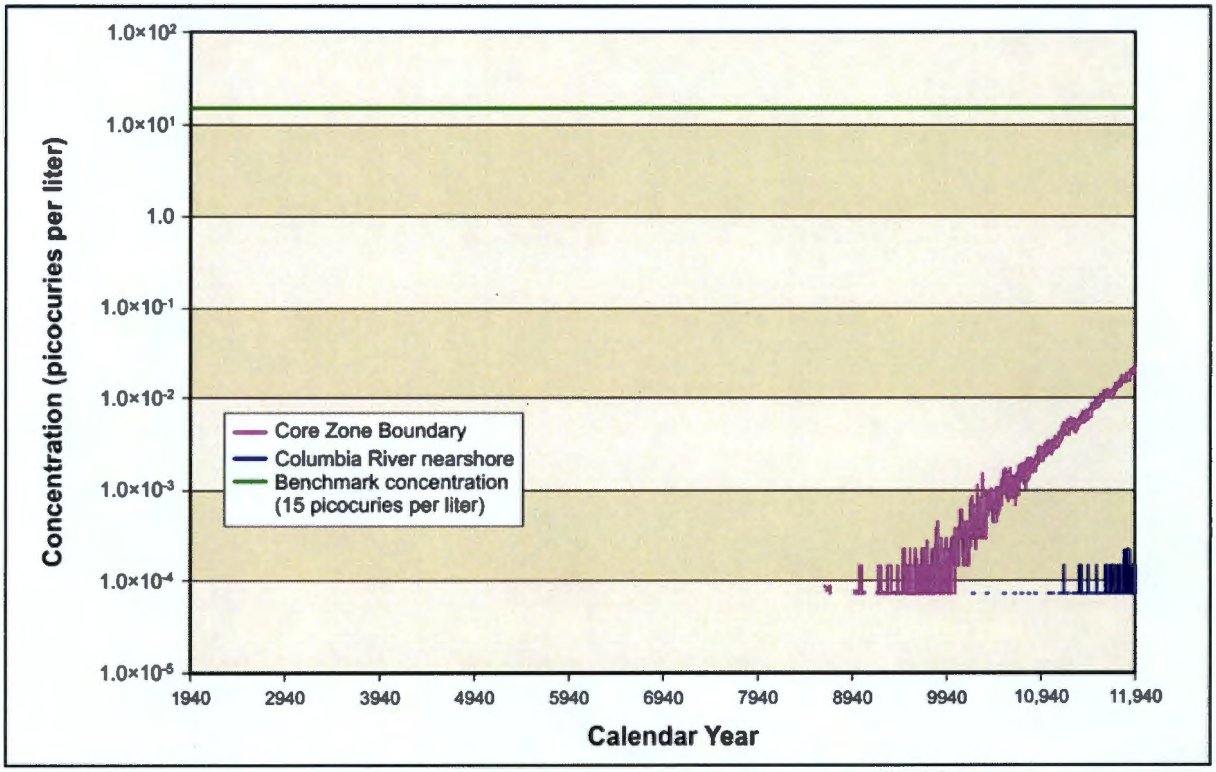


Figure 5–877. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Uranium-238 Concentration Versus Time

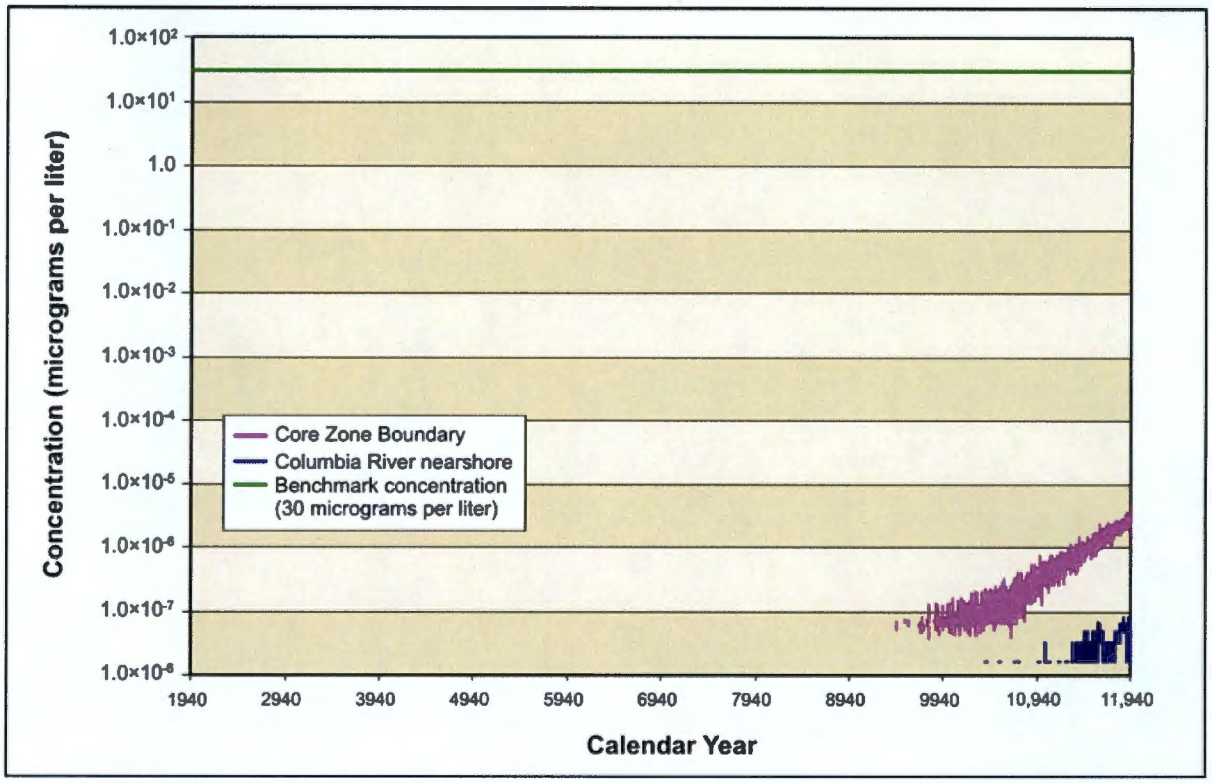


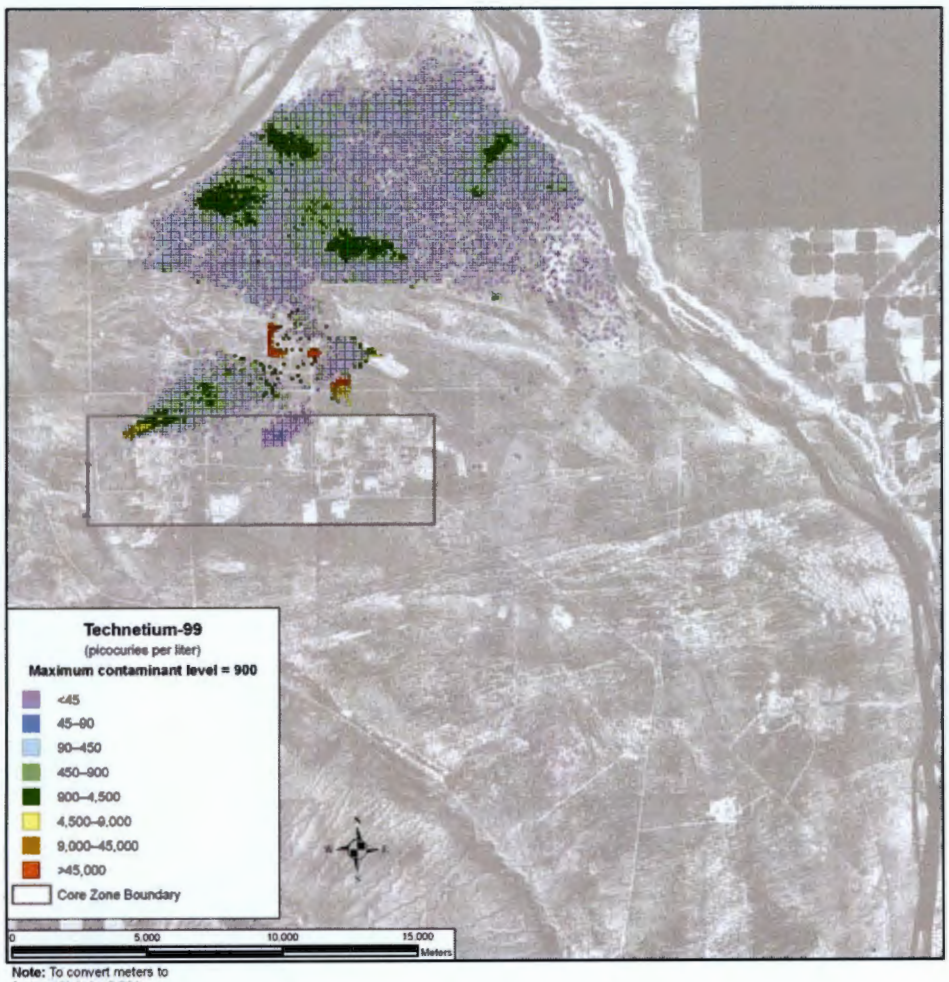
Figure 5–878. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Total Uranium Concentration Versus Time

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.

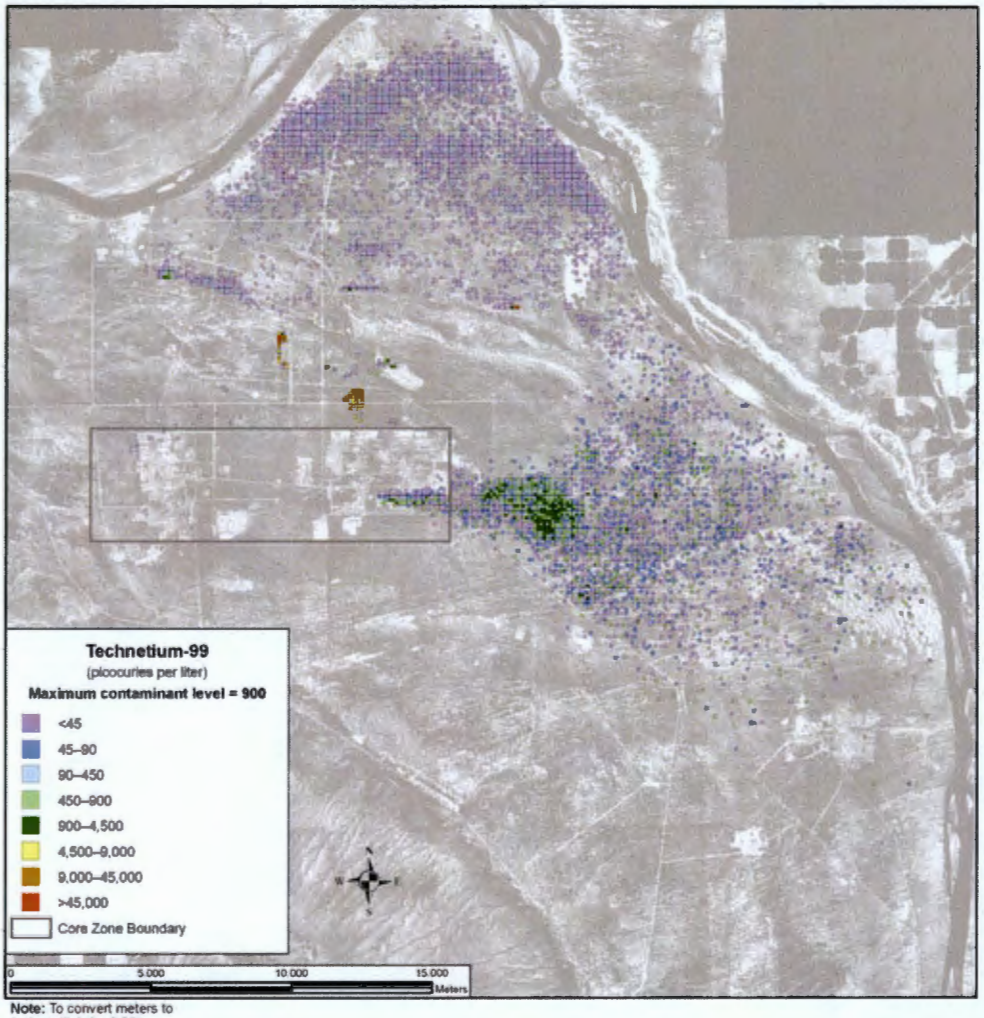
Figures 5–879 through 5–890 show concentration distributions at CYs 3890, 7140, and 11,885 for technetium-99, iodine-129, nitrate, and chromium. Figures 5–891 and 5–892 show the concentration distribution for uranium-238 and total uranium at CY 11,885. These data show the groundwater releases from the 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.



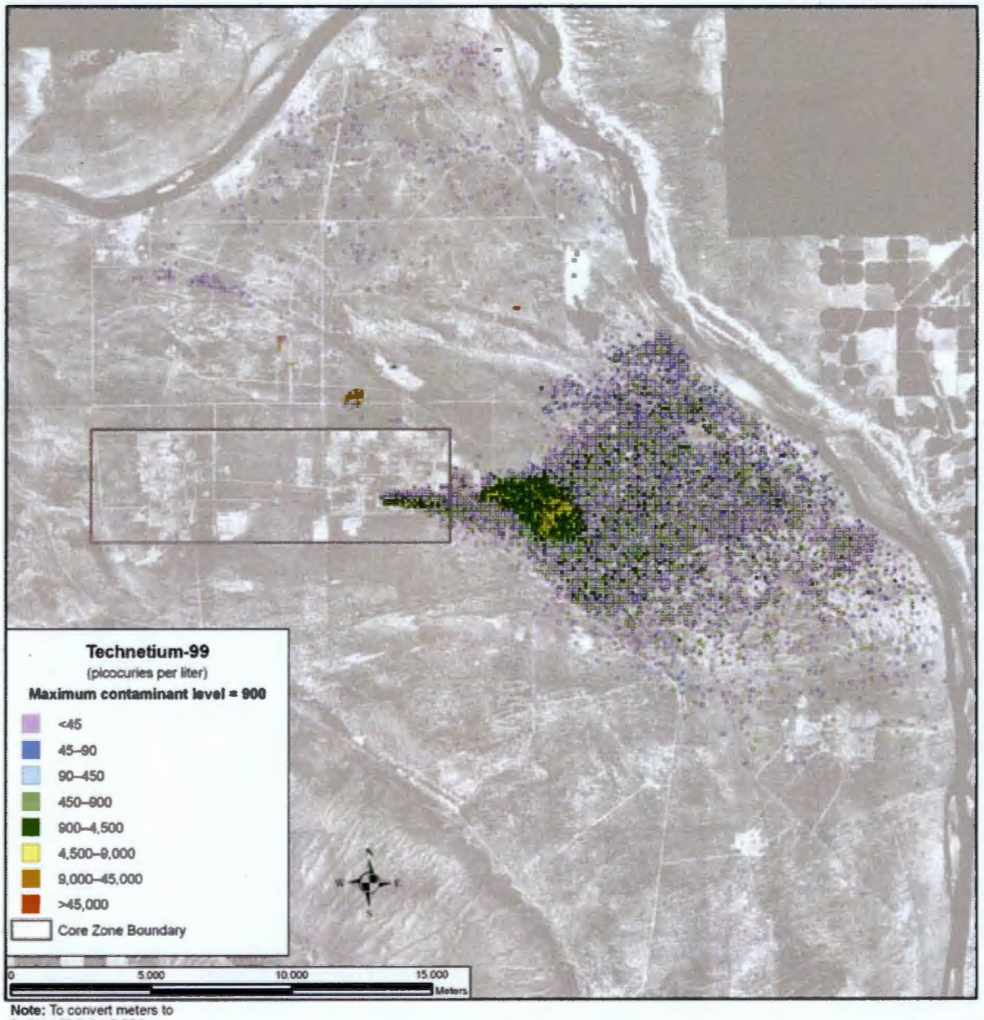
Note: To convert meters to feet, multiply by 3.281

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

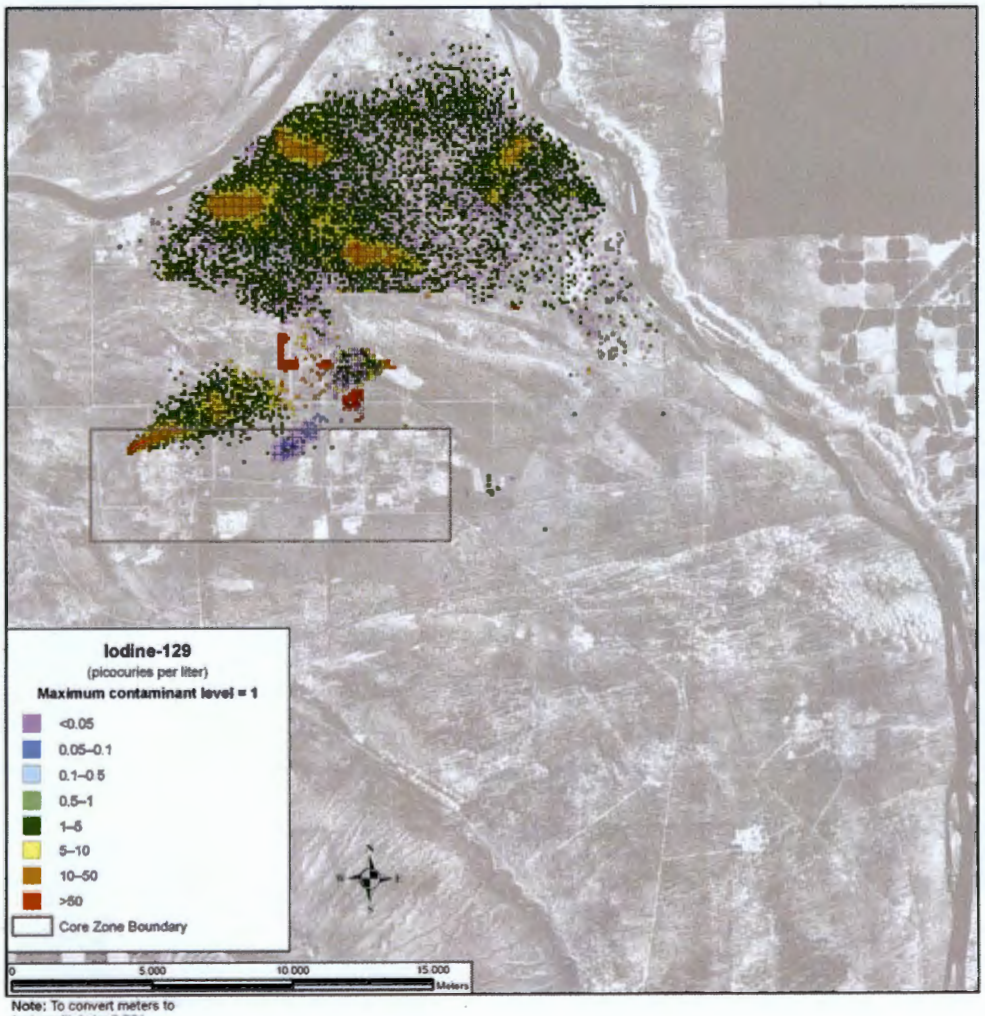
Figure 5–880. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

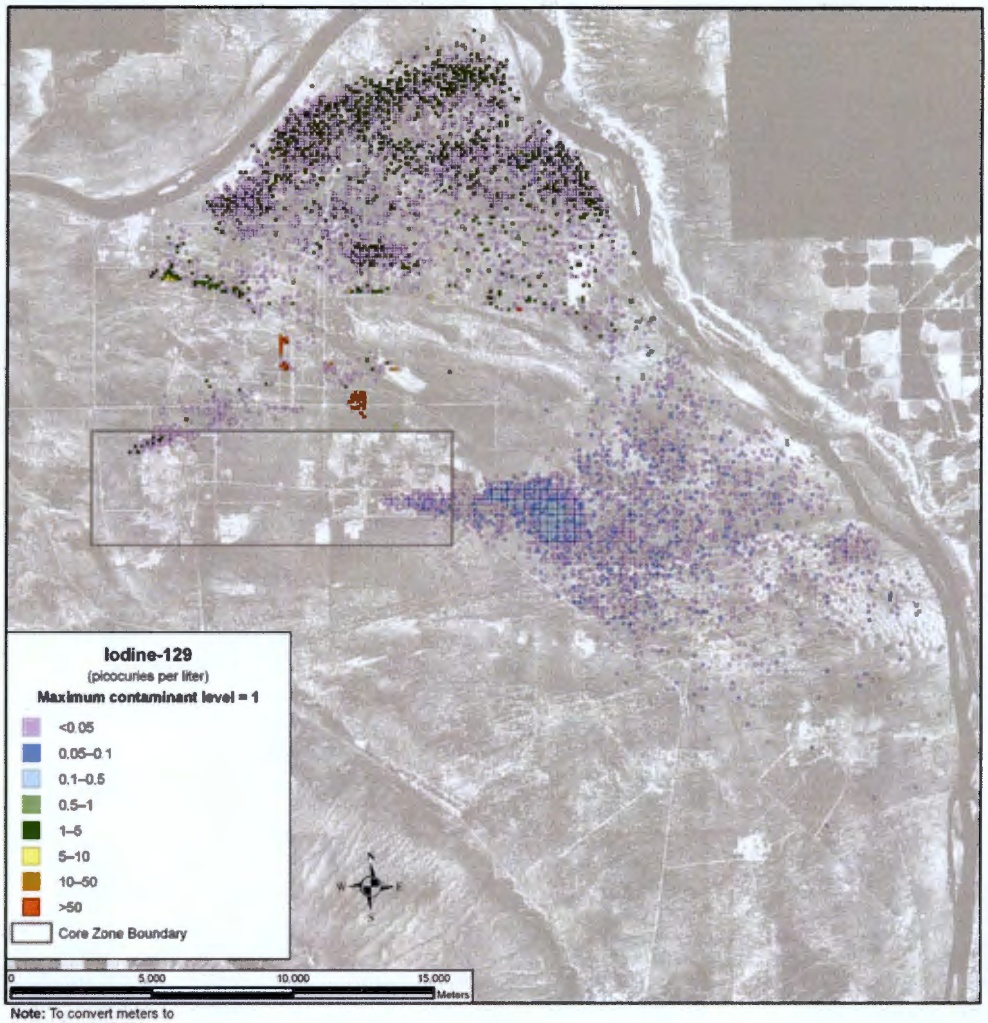
Figure 5–881. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

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.



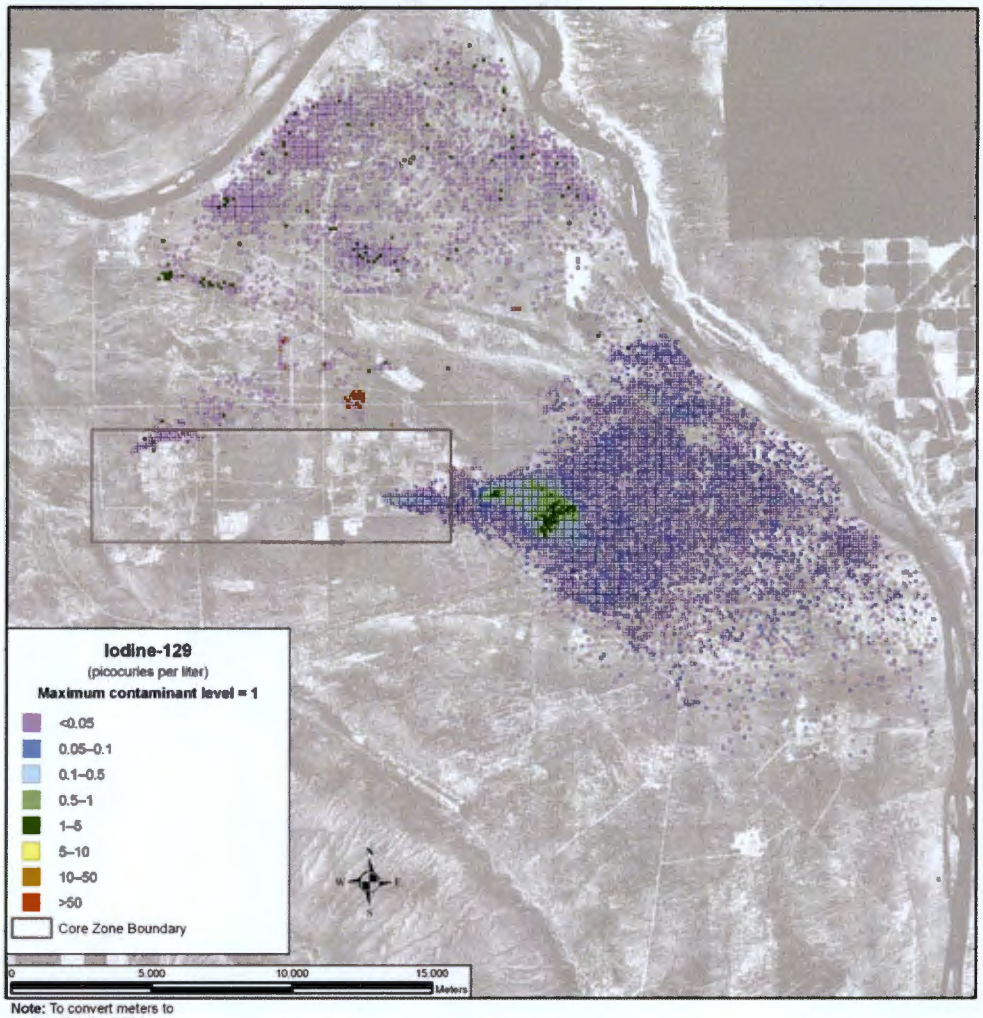
Note: To convert meters to feet, multiply by 3.281

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

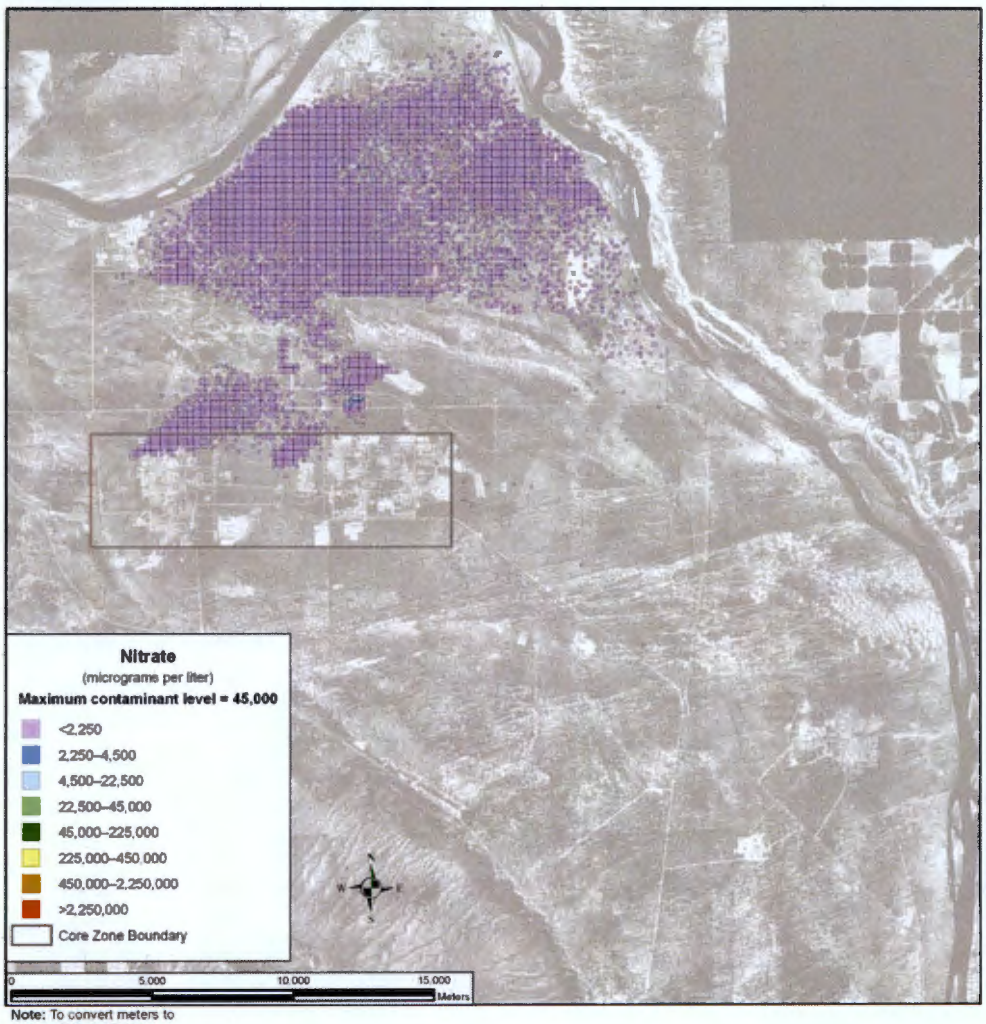
Figure 5–883. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

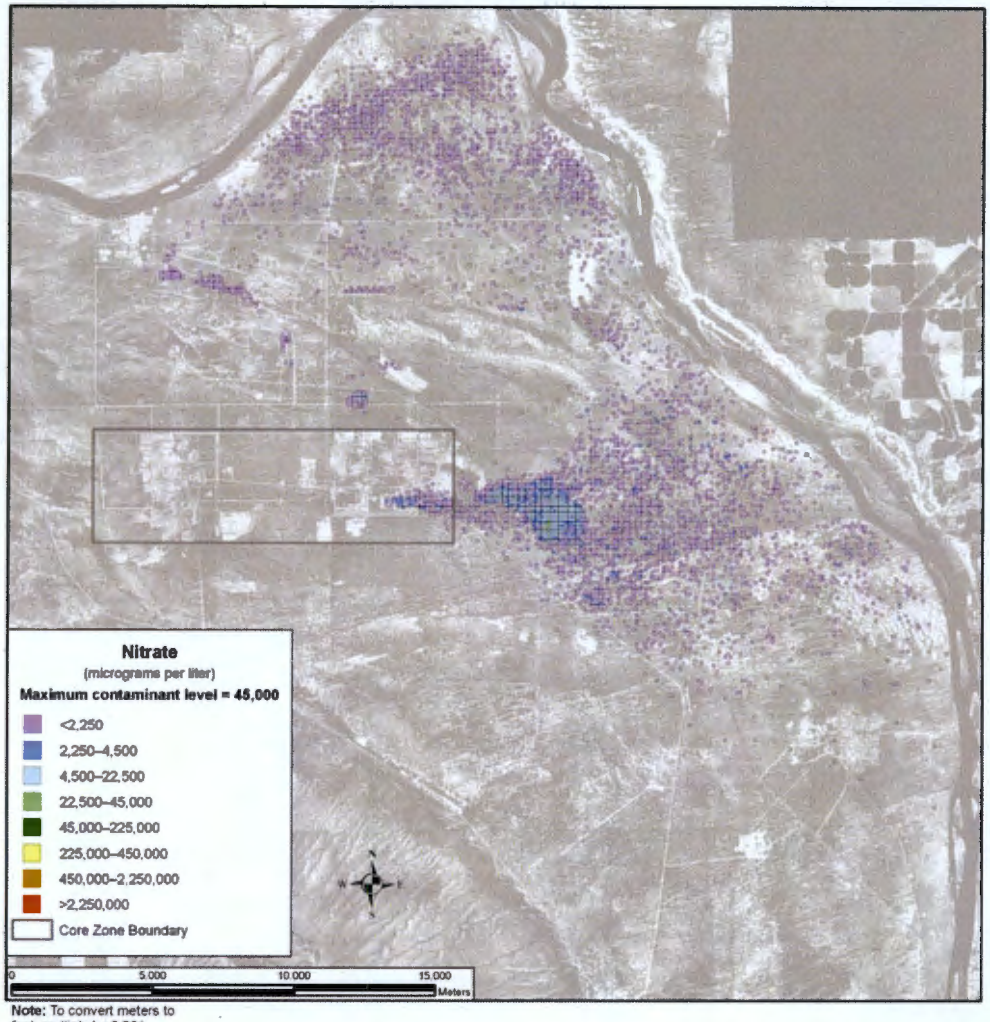
Figure 5–884. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

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.



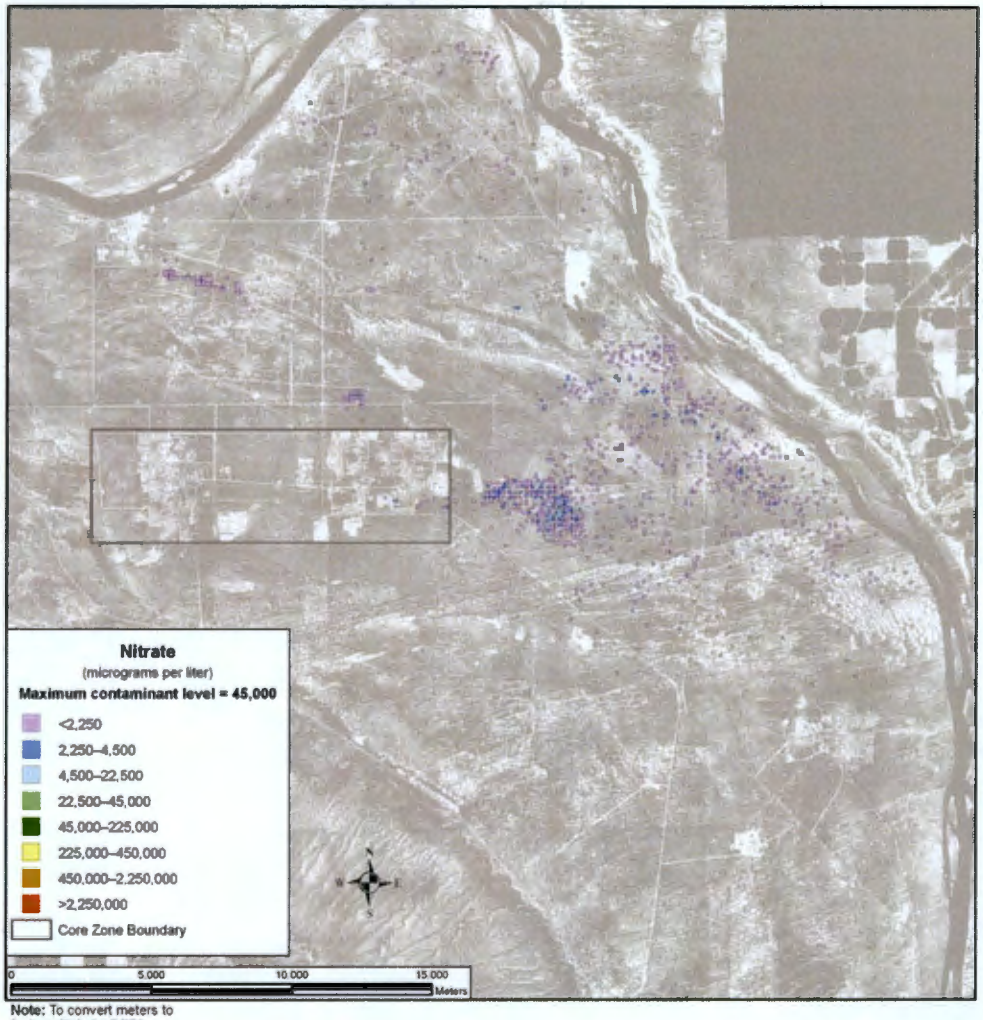
Note: To convert meters to feet, multiply by 3.281

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

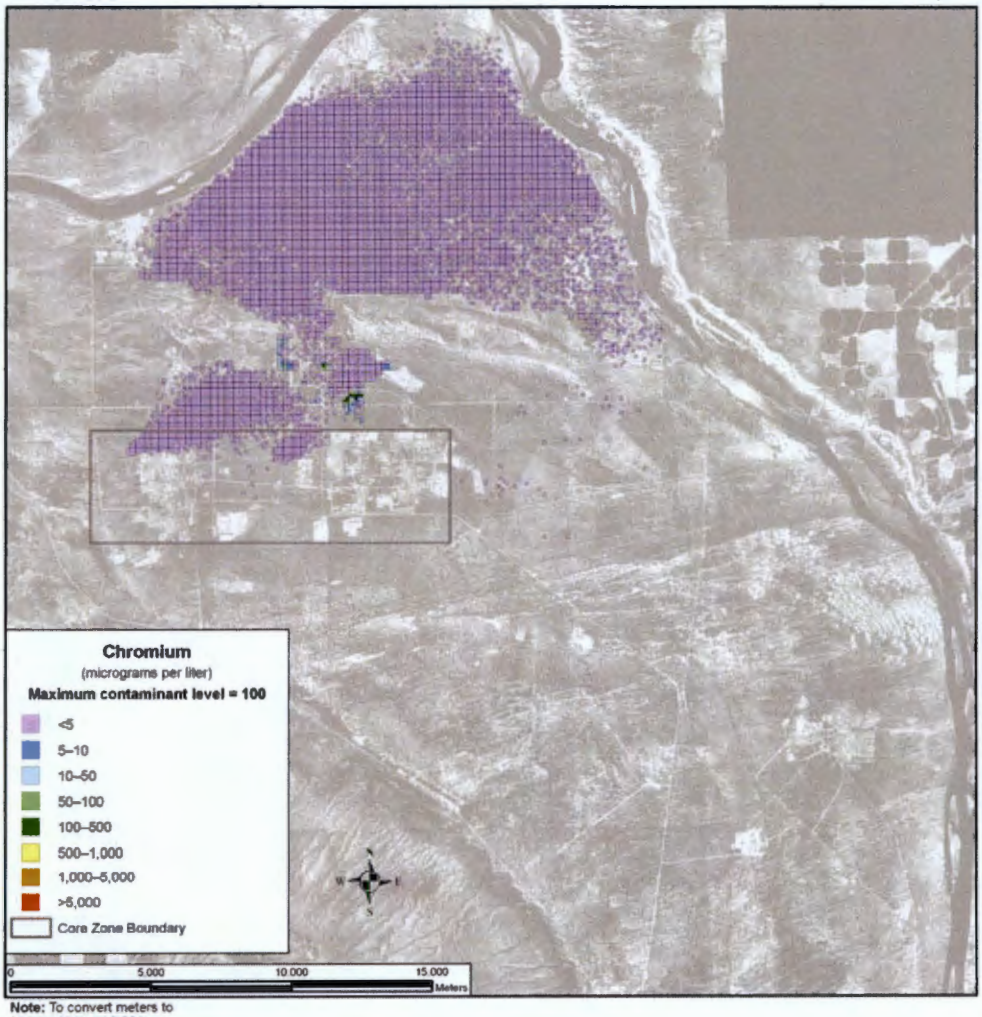
Figure 5–886. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

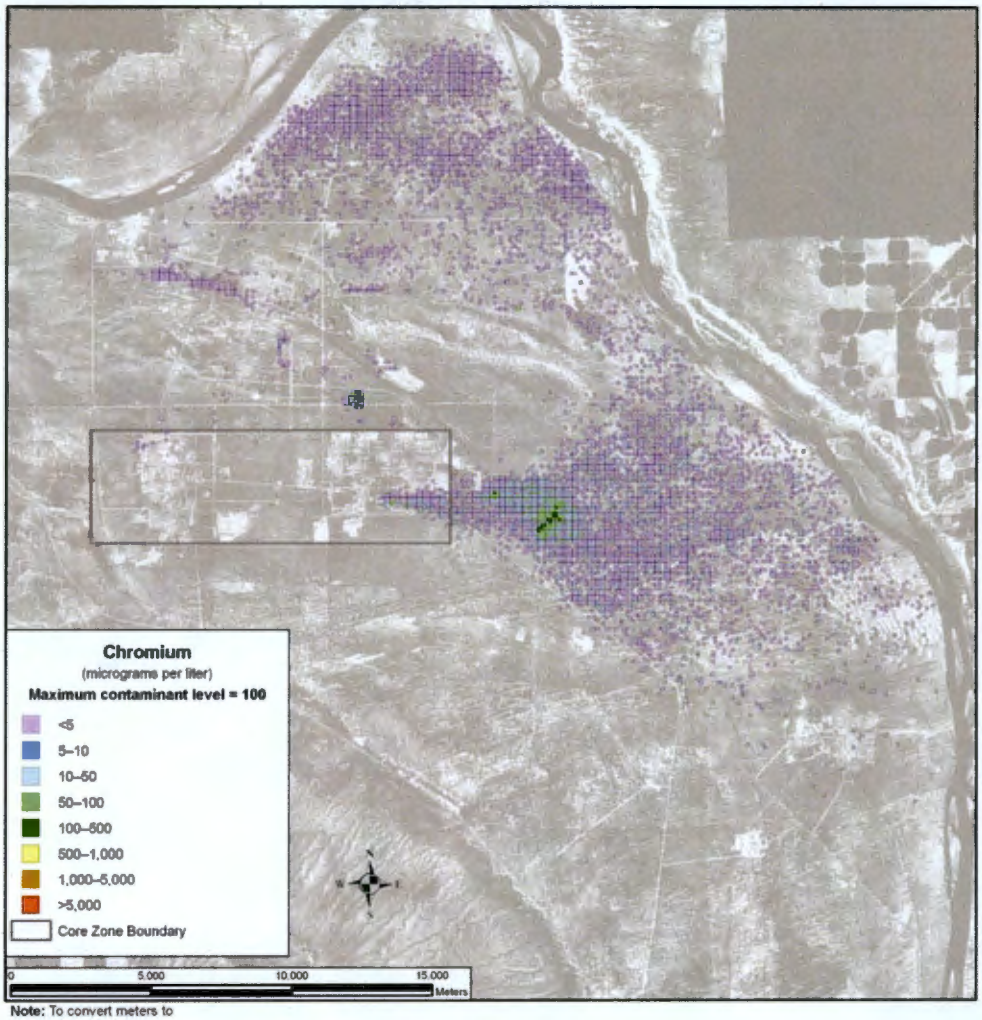
Figure 5–887. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

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.



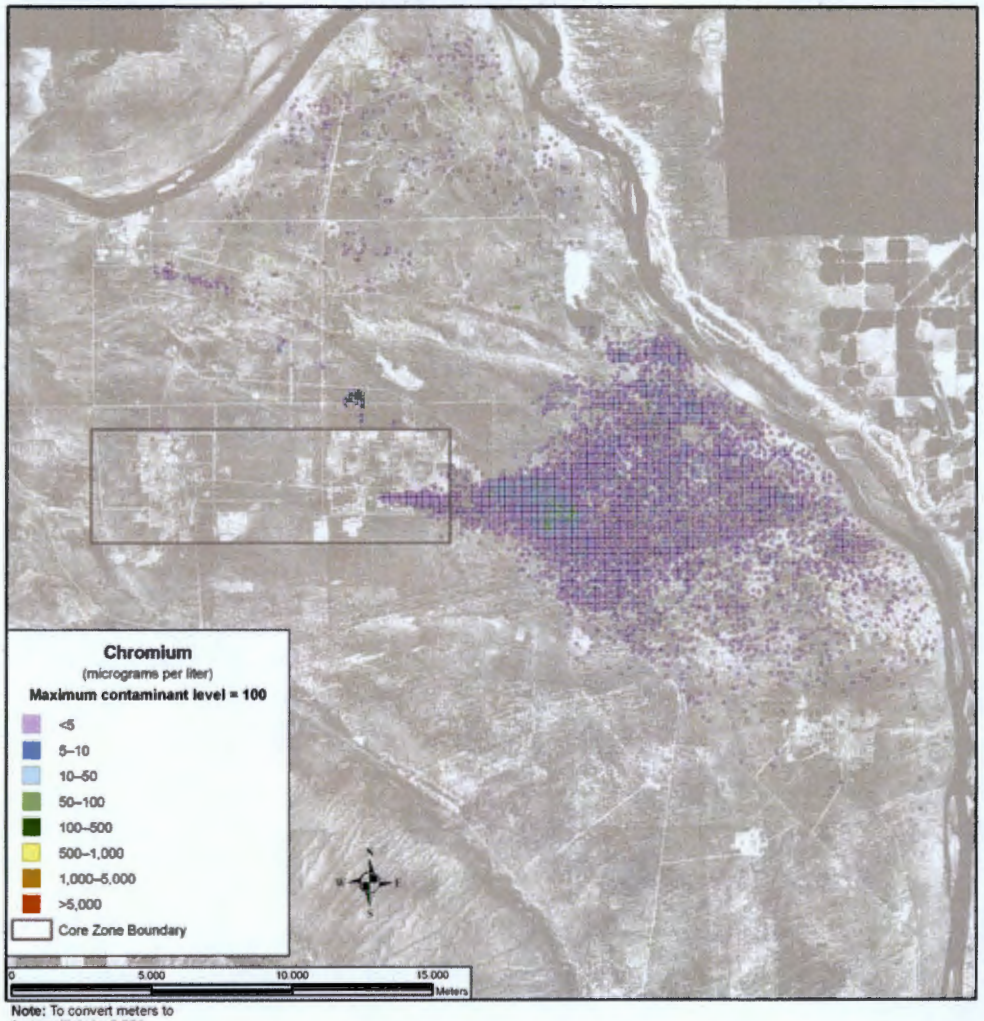
Note: To convert meters to feet, multiply by 3.281

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

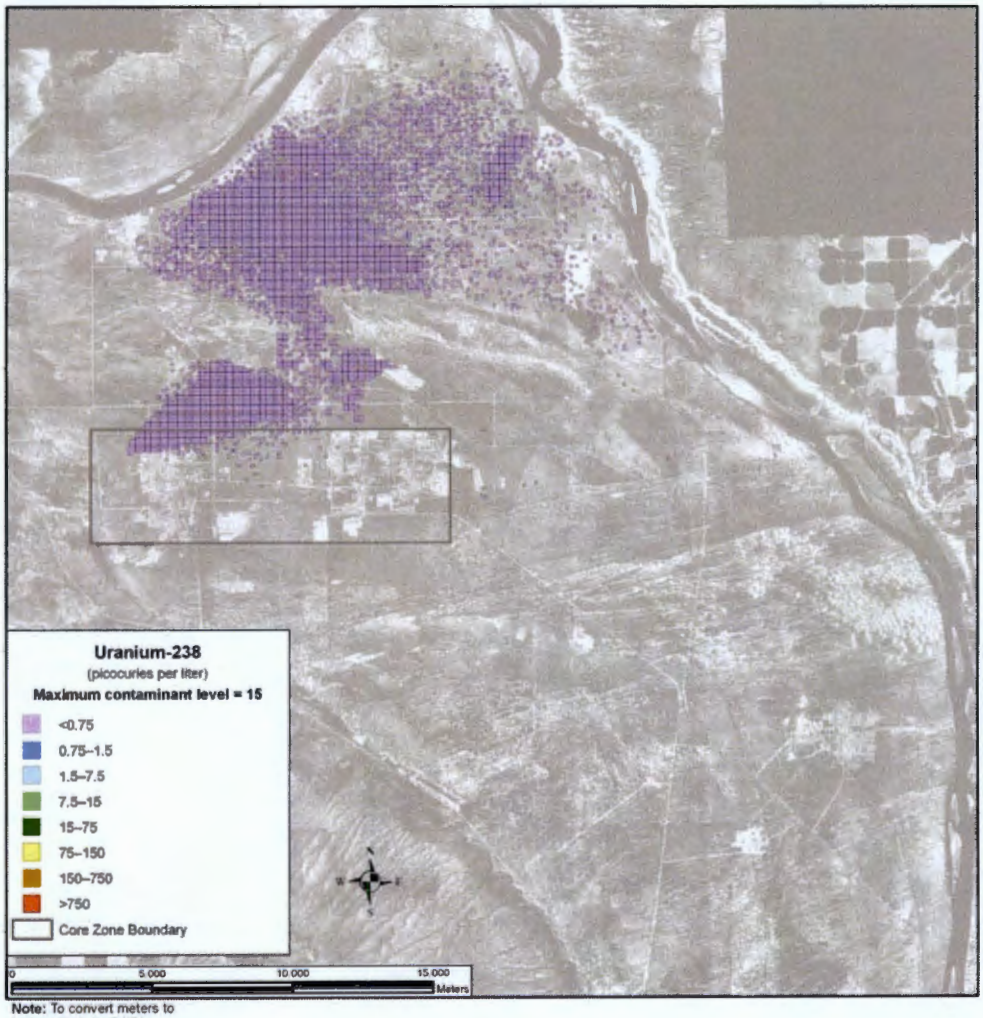
Figure 5–889. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

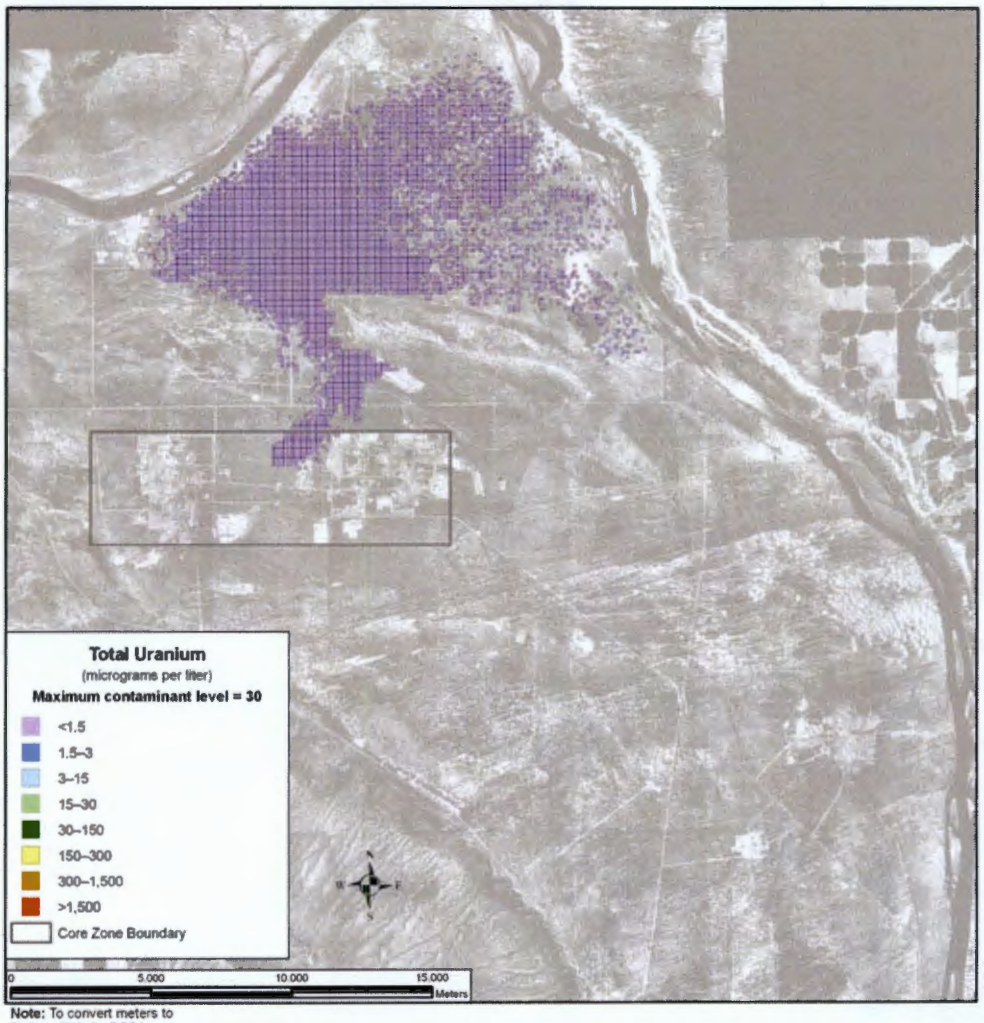
Figure 5–890. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885

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.

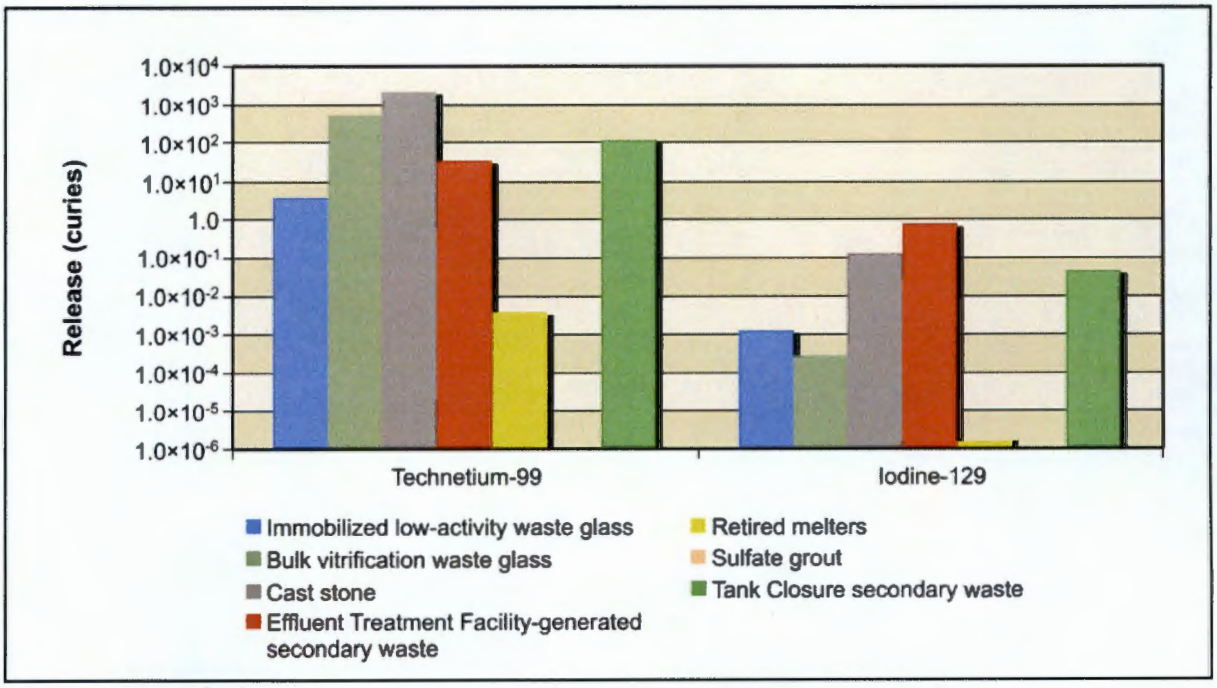


Figure 5–893. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

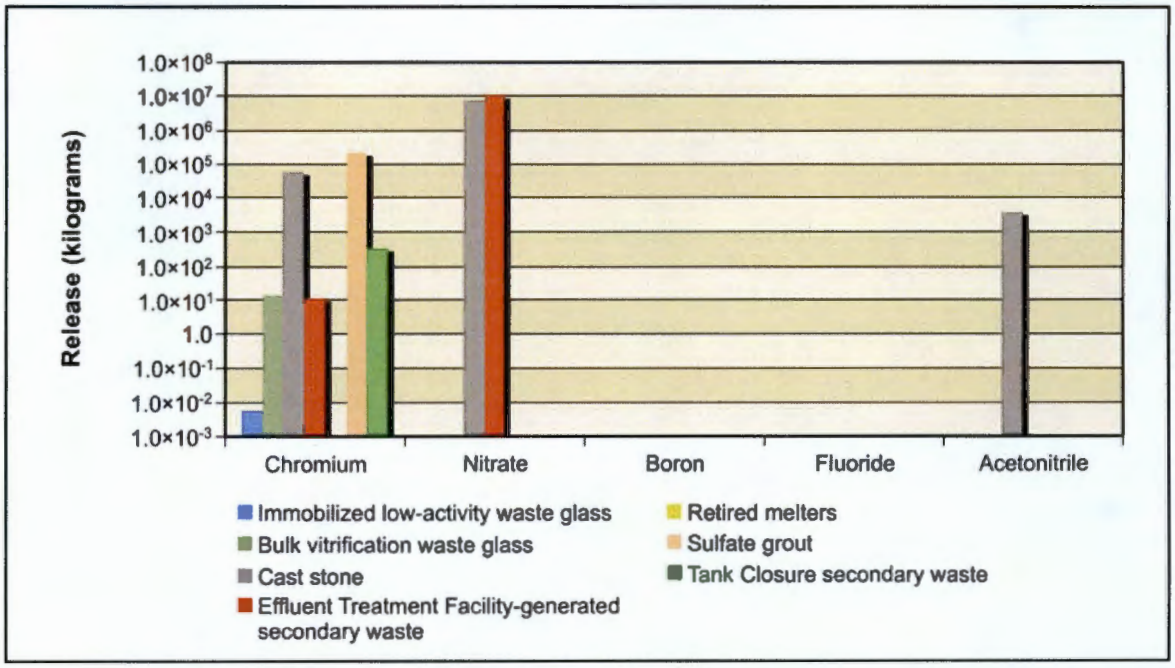


Figure 5–894. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

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.

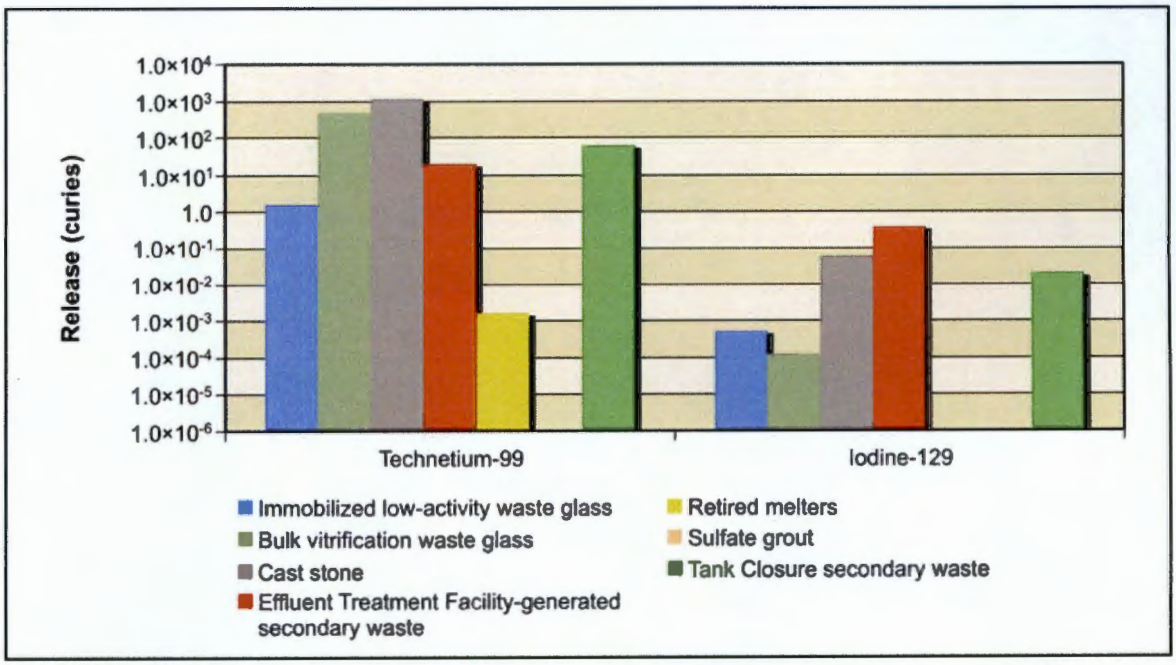


Figure 5–895. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

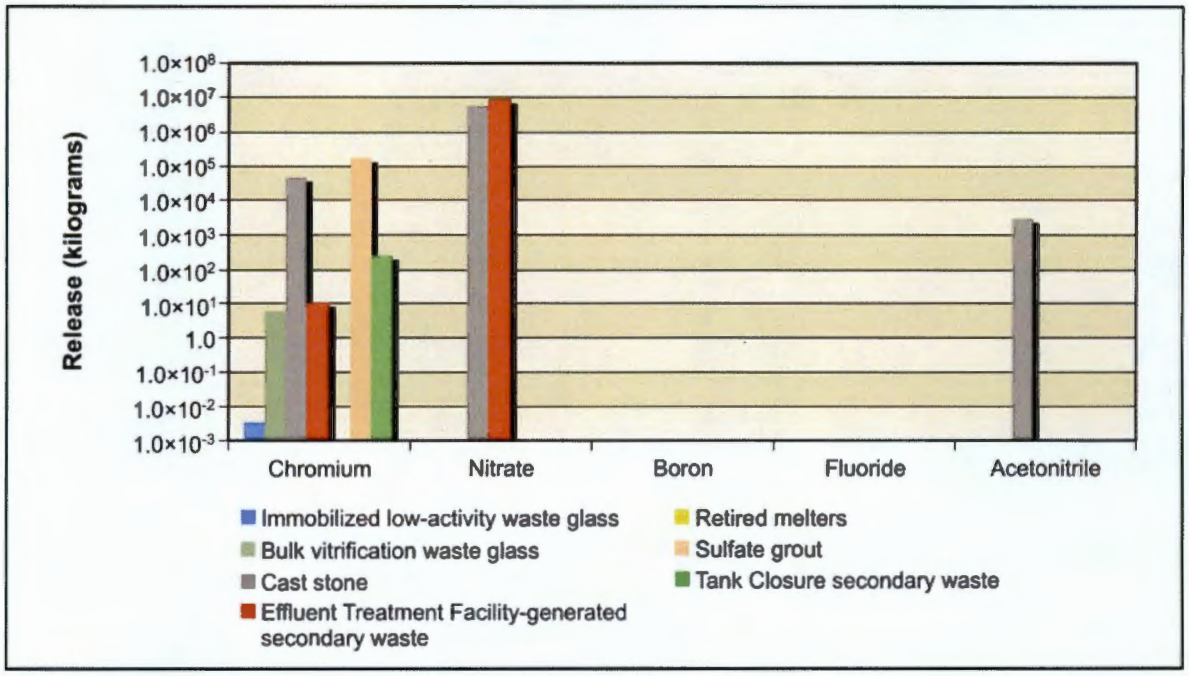


Figure 5–896. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

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.

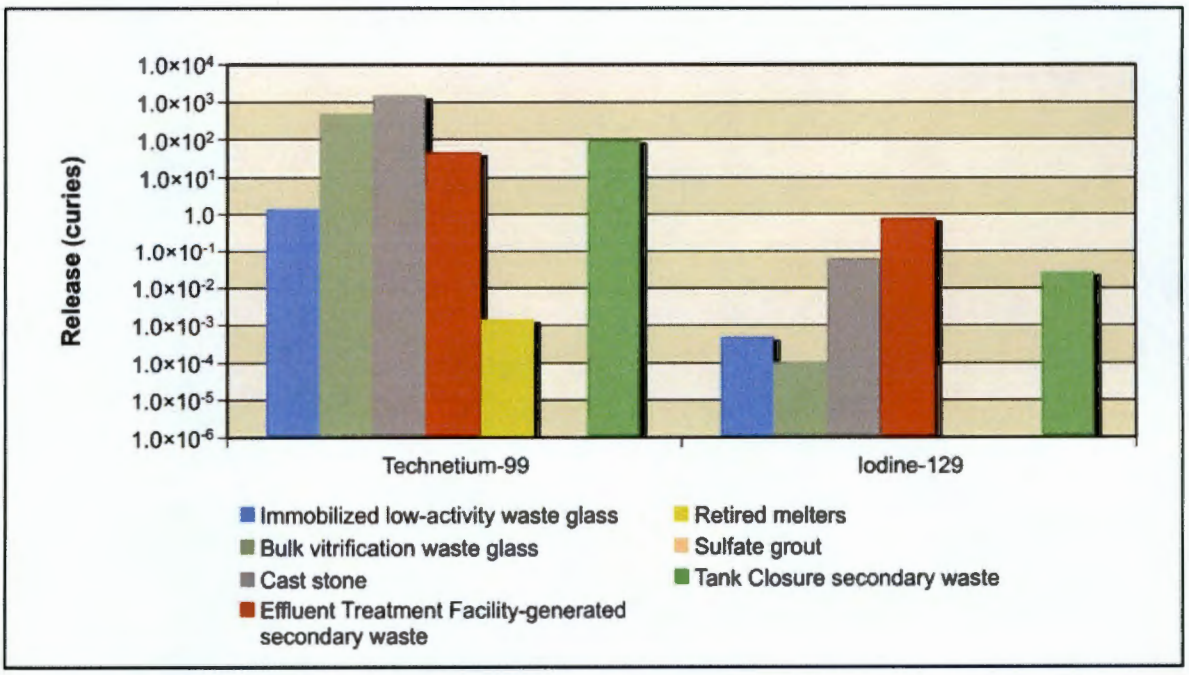


Figure 5–897. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

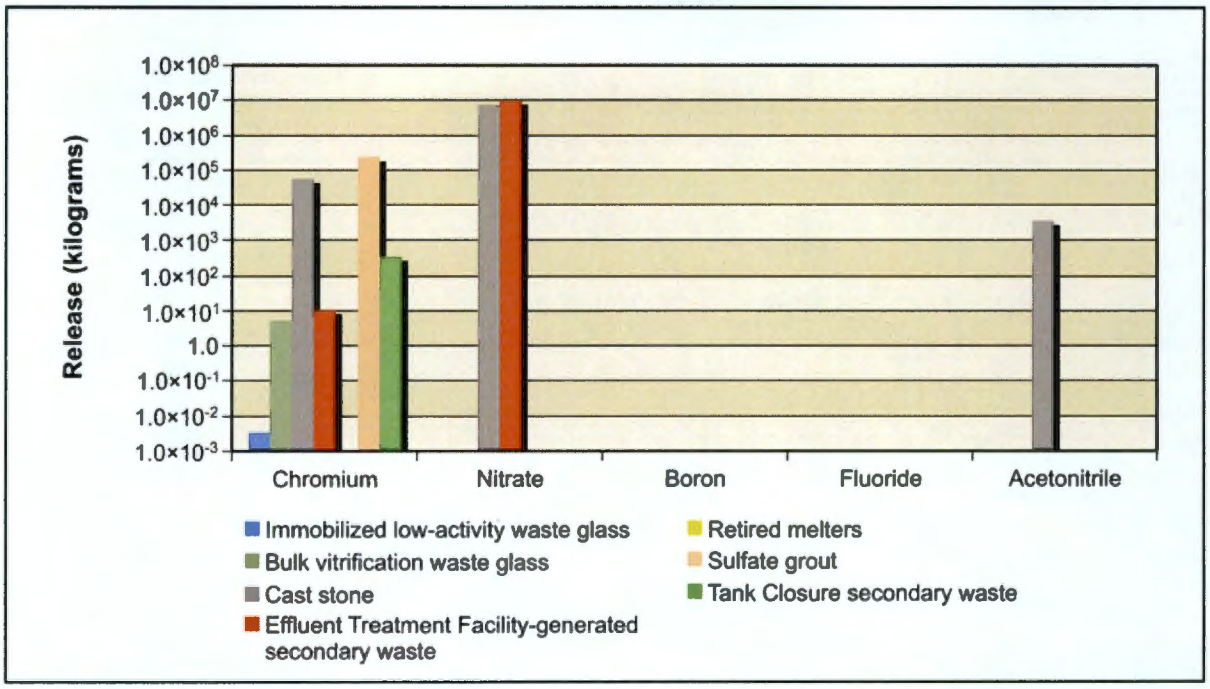


Figure 5–898. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

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.

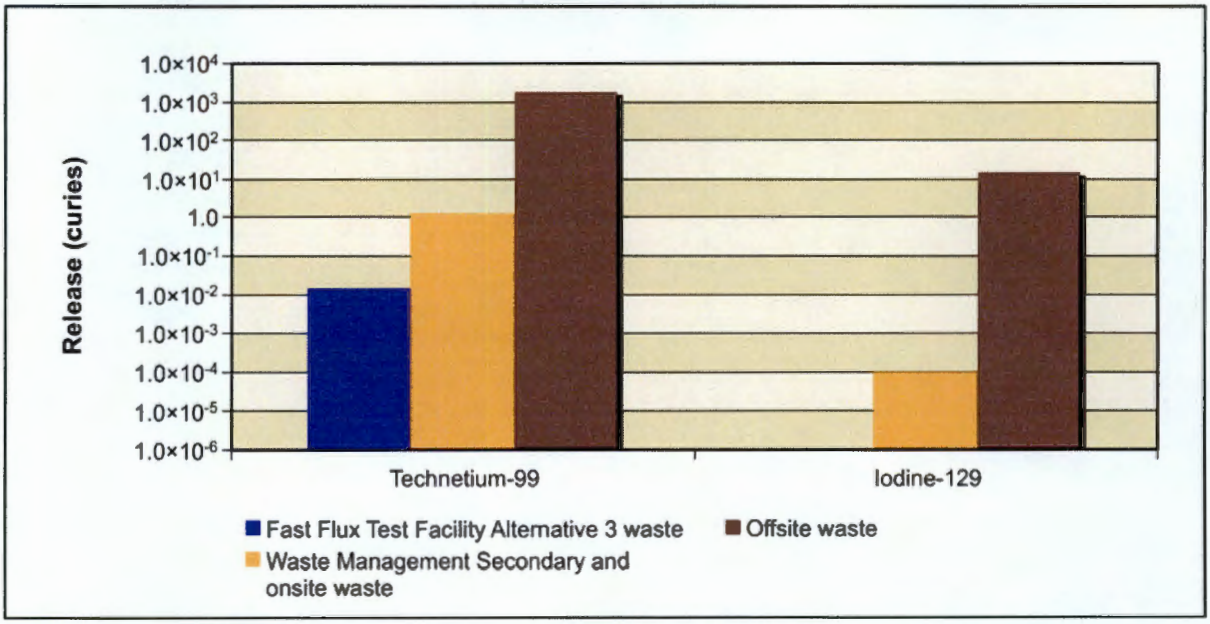


Figure 5–899. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

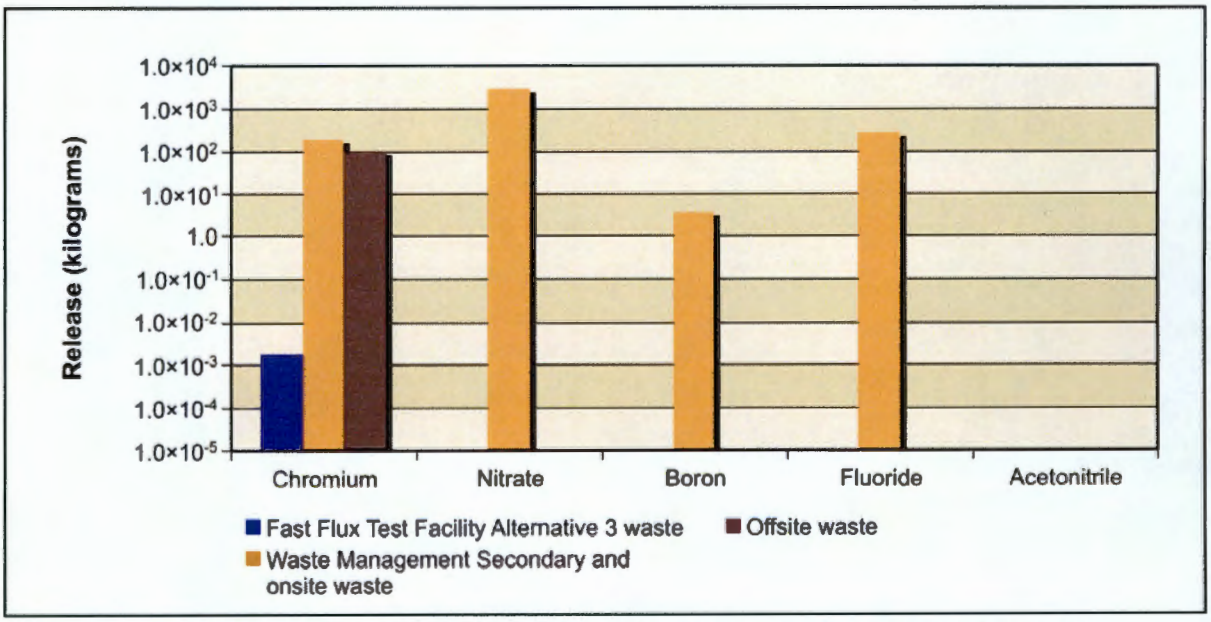


Figure 5–900. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

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.

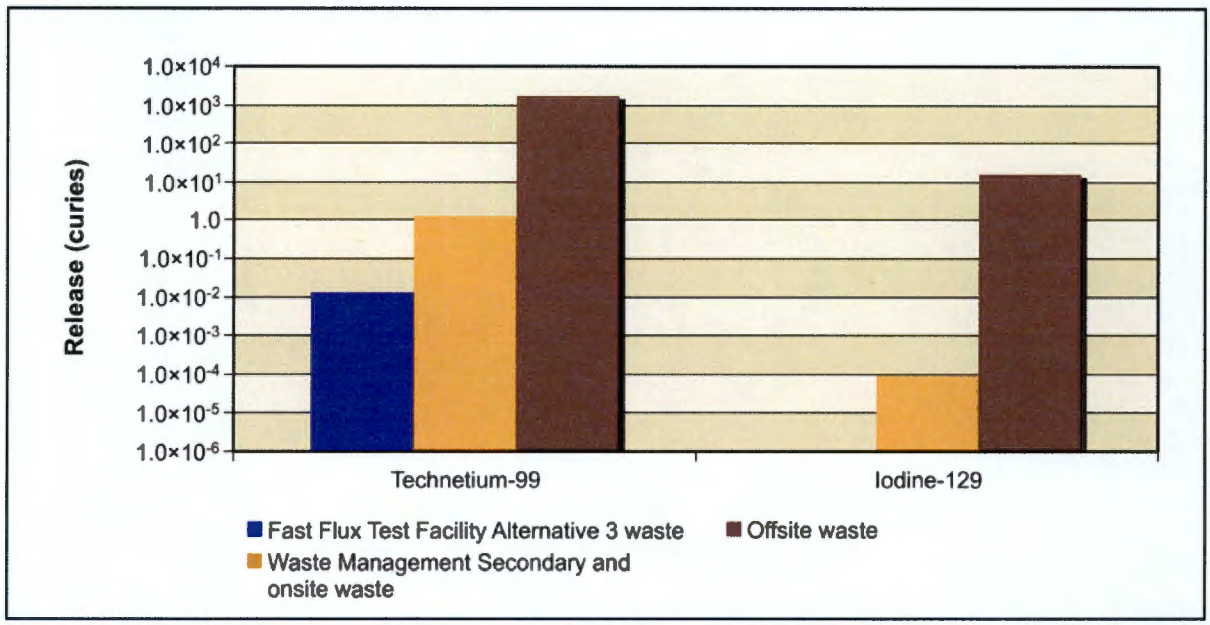


Figure 5–901. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

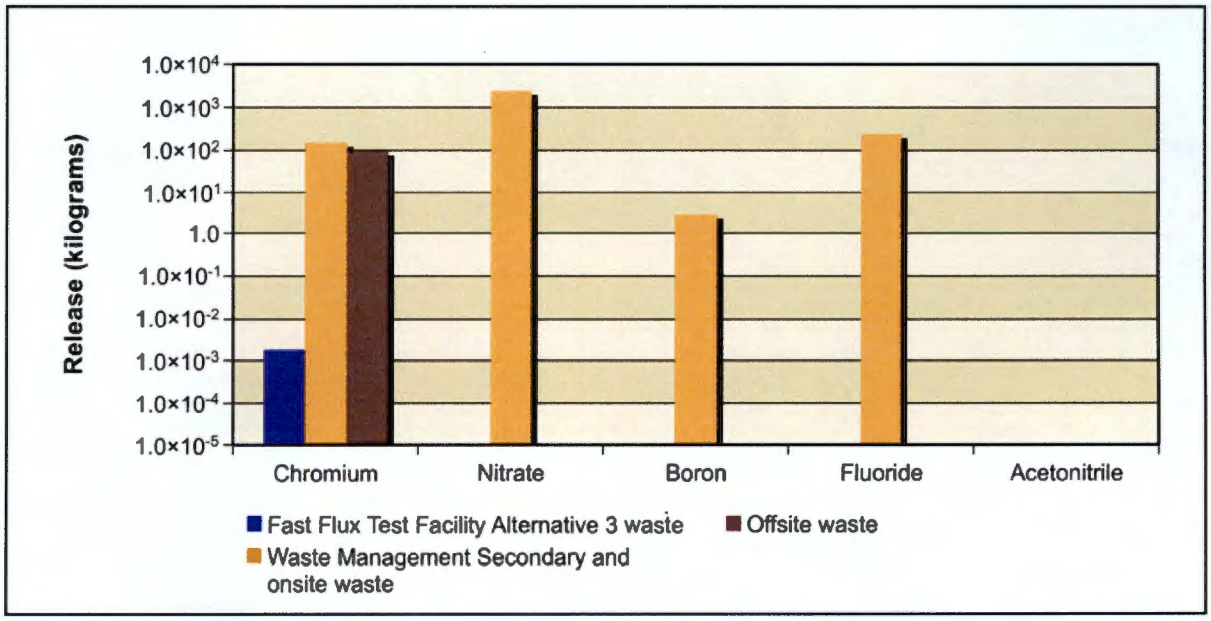


Figure 5–902. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

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.

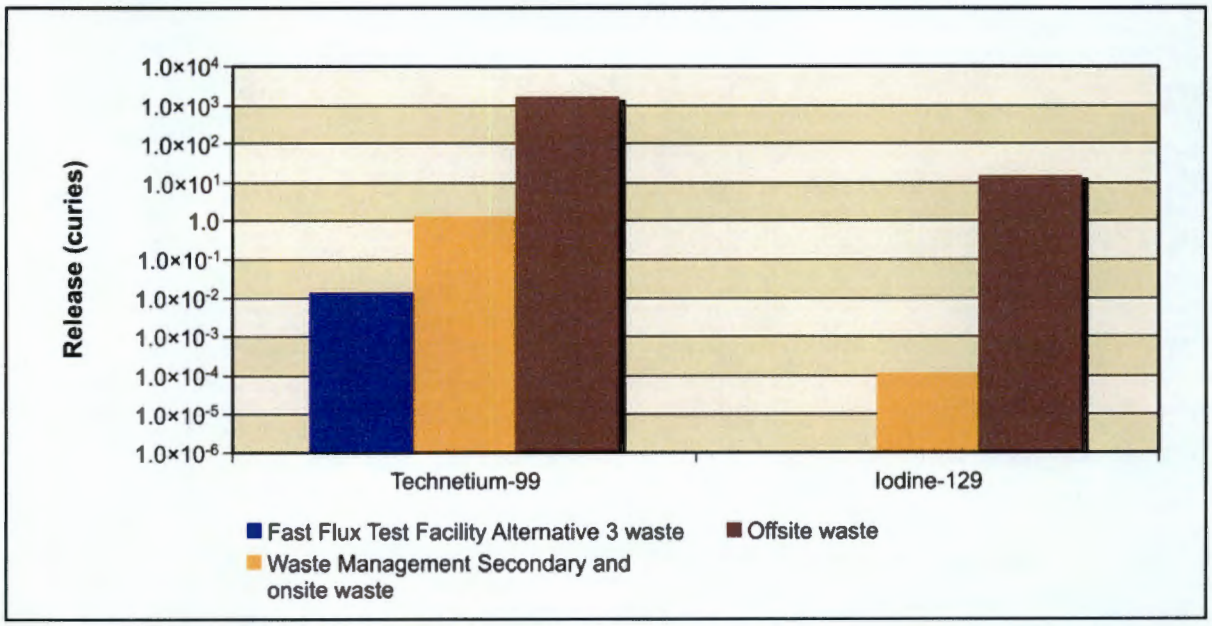


Figure 5–903. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

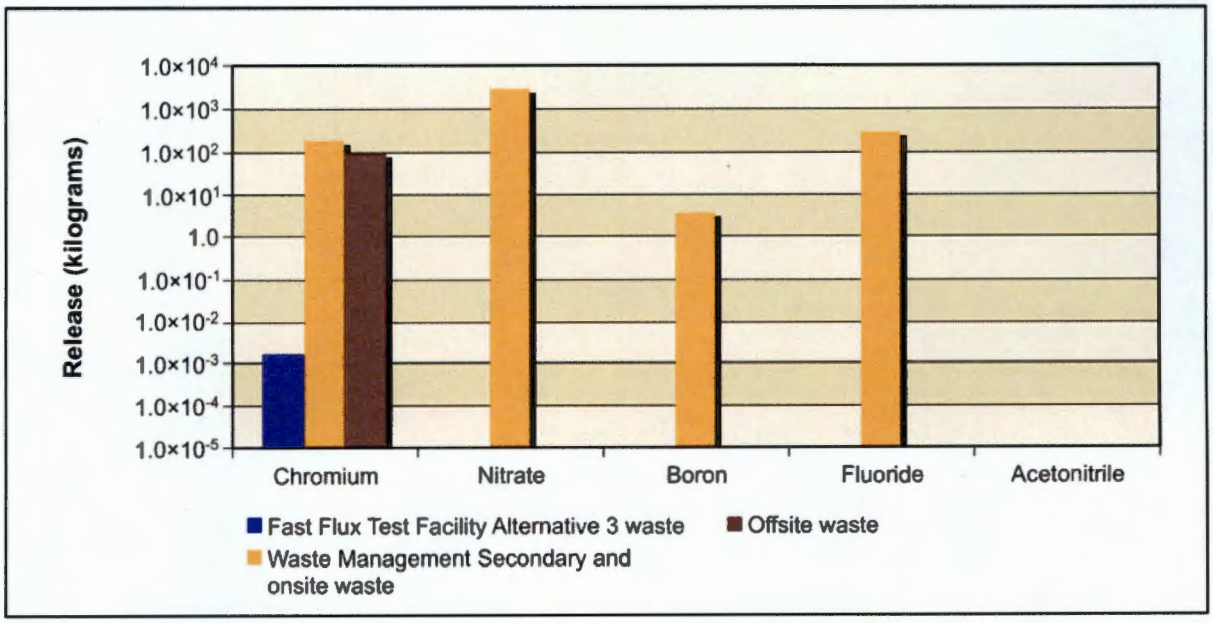


Figure 5–904. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

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).

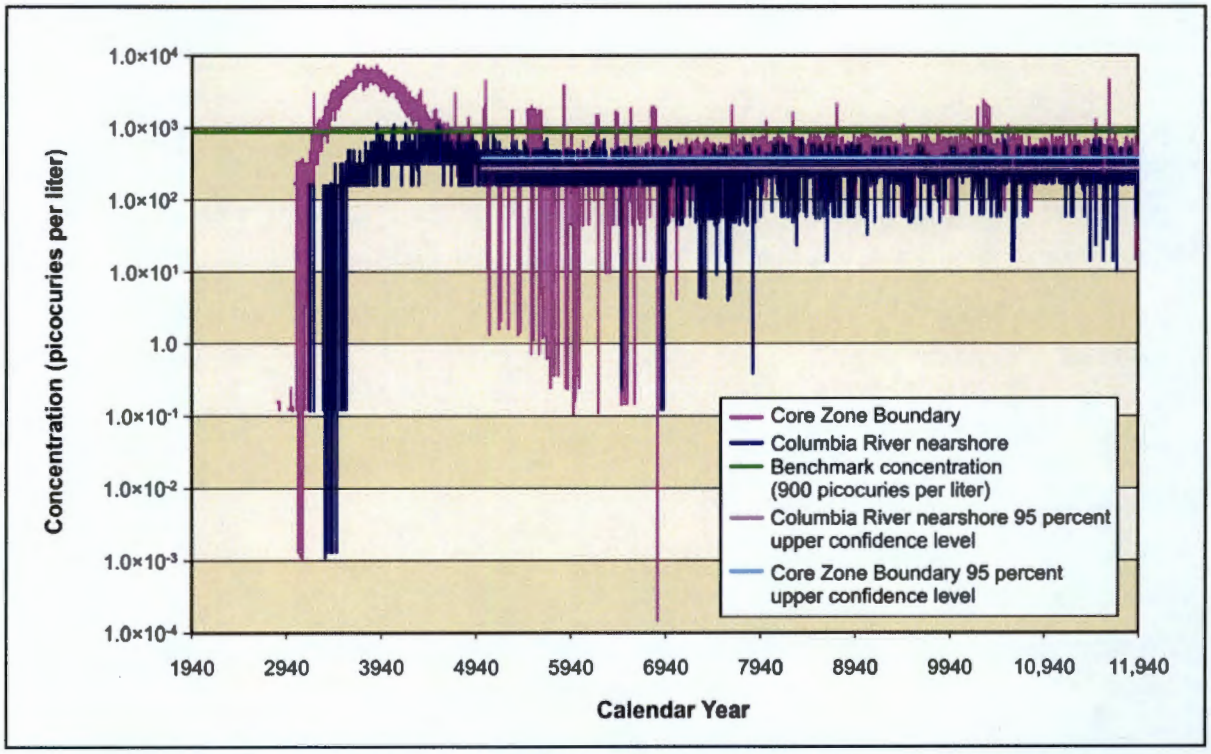


Figure 5–905. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Technetium-99 Concentration Versus Time

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.

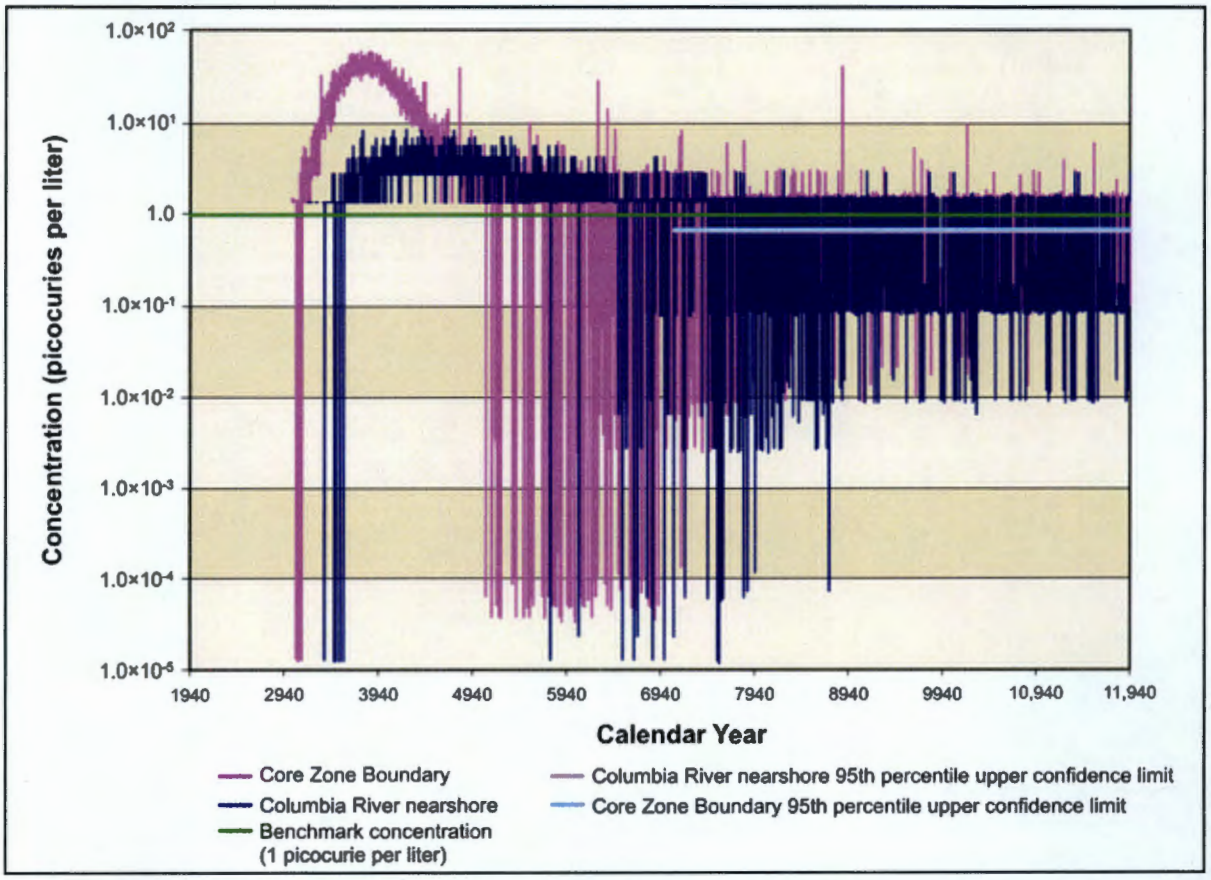


Figure 5–906. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Iodine-129 Concentration Versus Time

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.

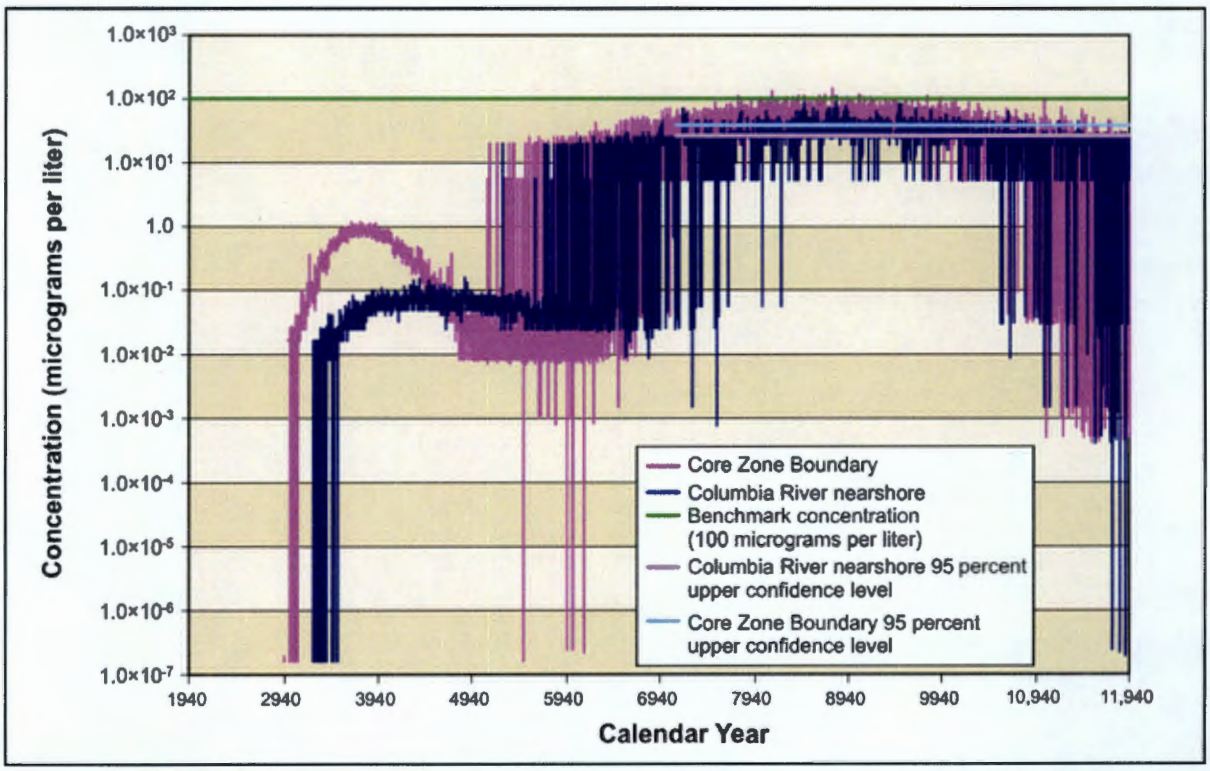


Figure 5–907. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Chromium Concentration Versus Time

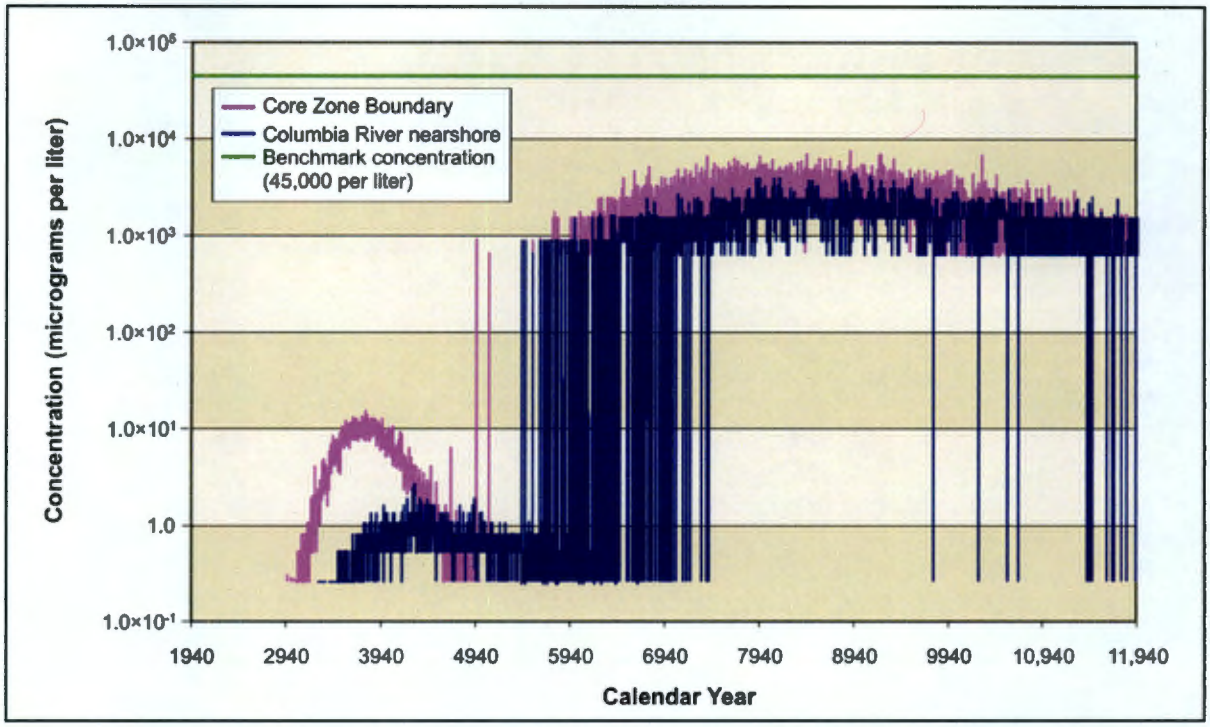


Figure 5–908. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Nitrate Concentration Versus Time

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).

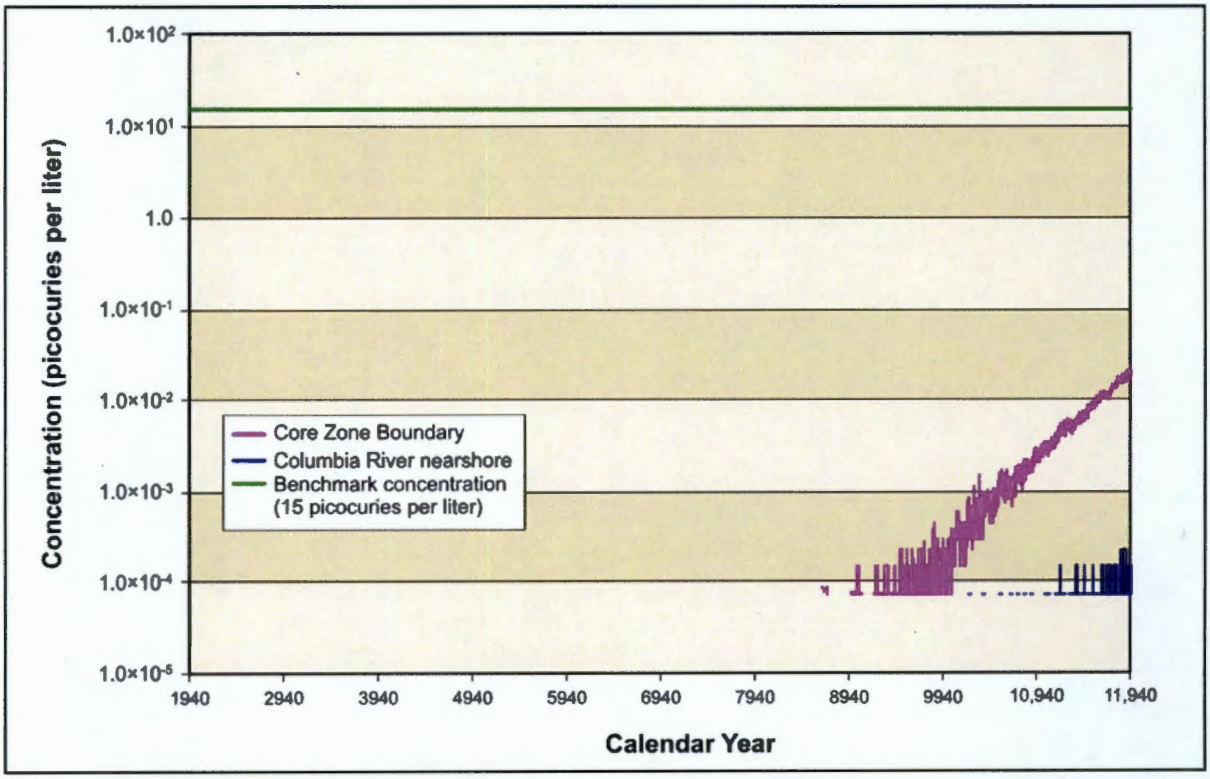


Figure 5–909. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Uranium-238 Concentration Versus Time

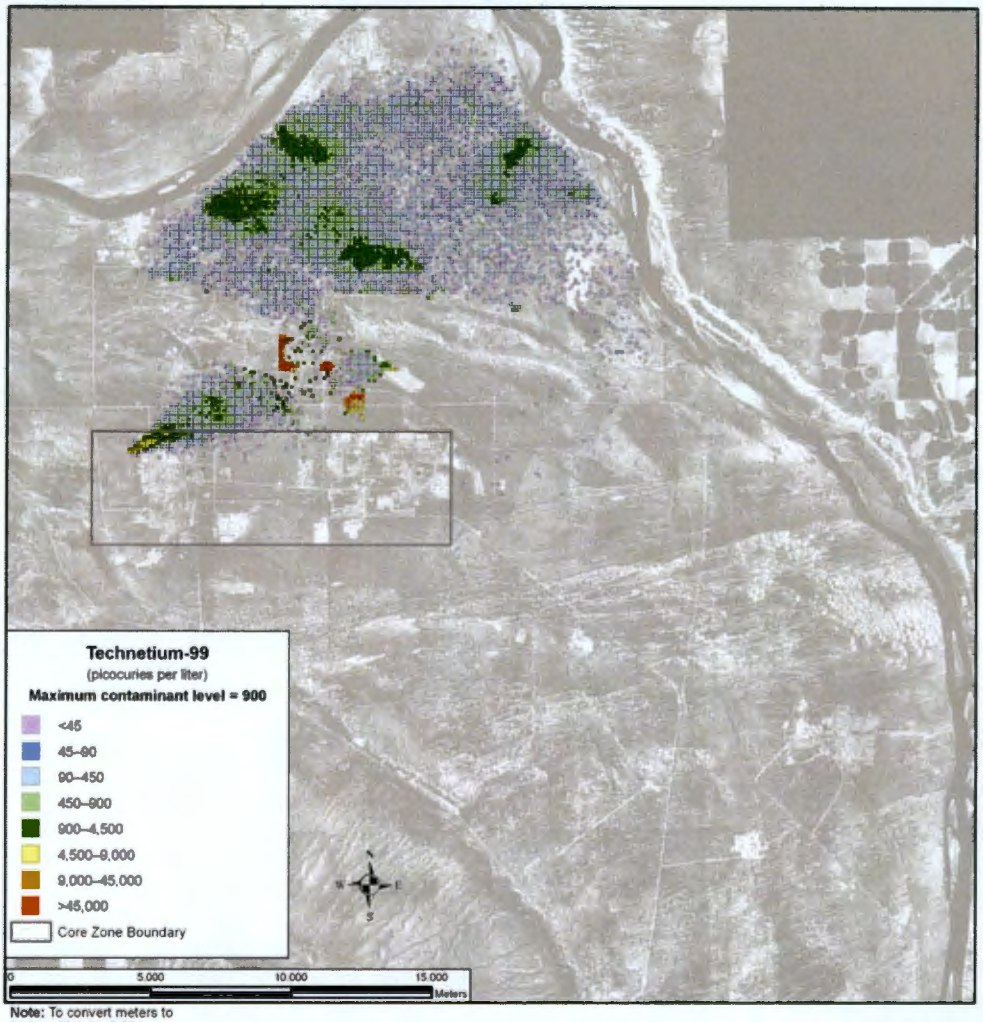
ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

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

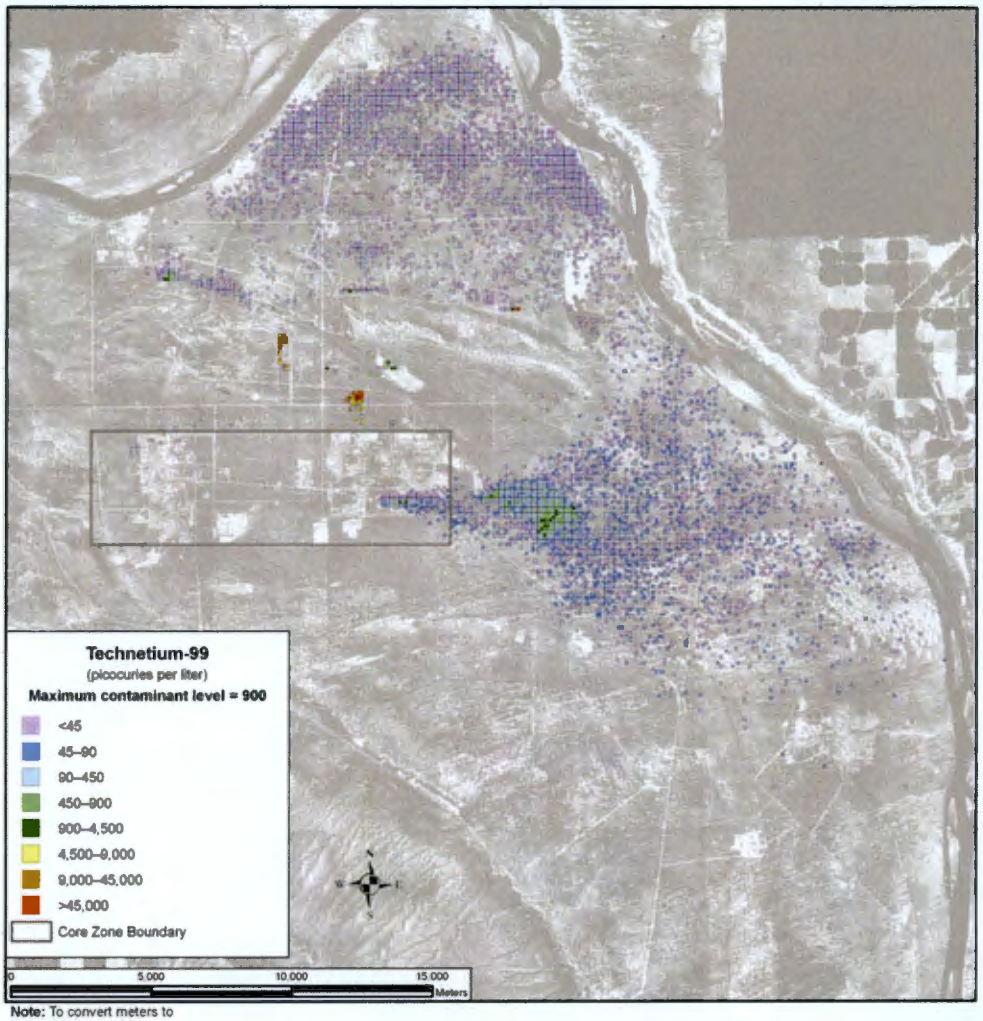
remaining in a fairly narrow channel (Gable Gap) until about halfway to the Columbia River nearshore. The IDF-East releases remained in a relatively narrow channel until they reached about the one-quarter distance point to the Columbia River, where they broadened and continued to the Columbia River nearshore. 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.



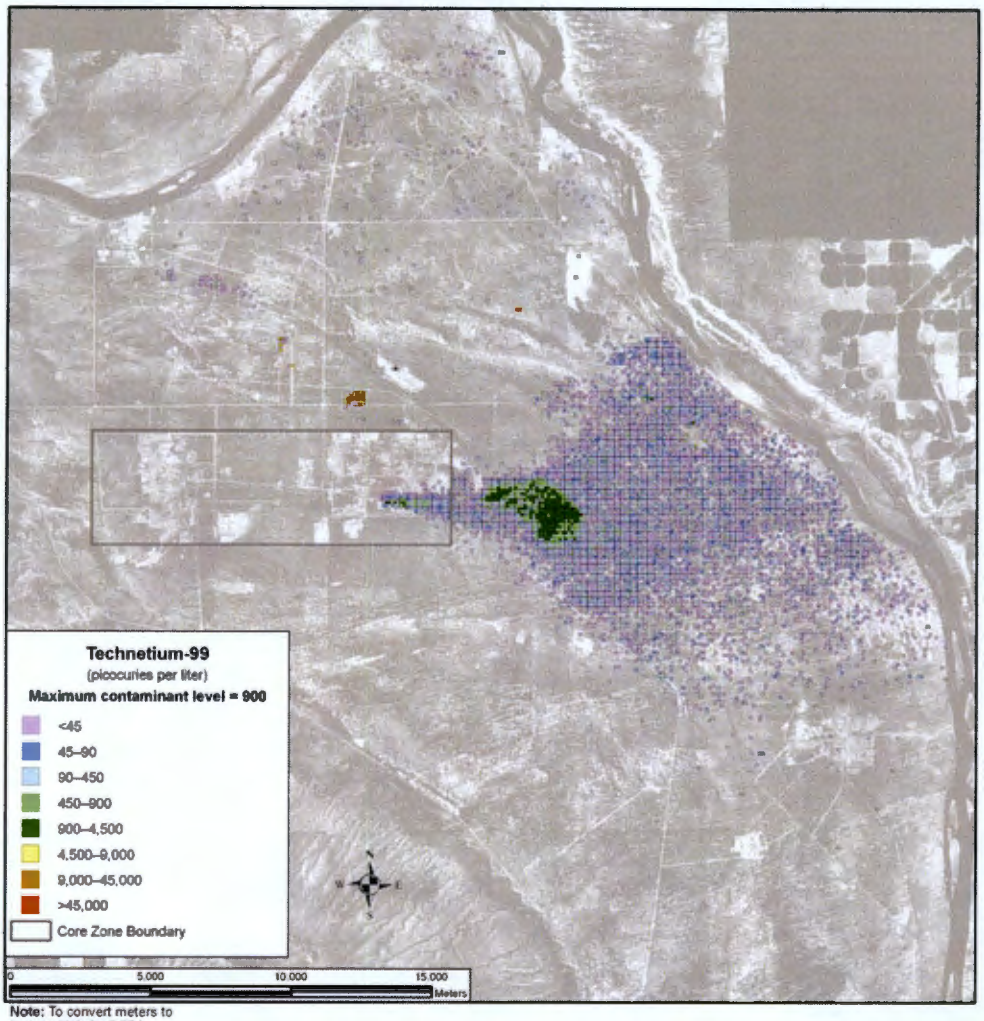
Note: To convert meters to feet, multiply by 3.281

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

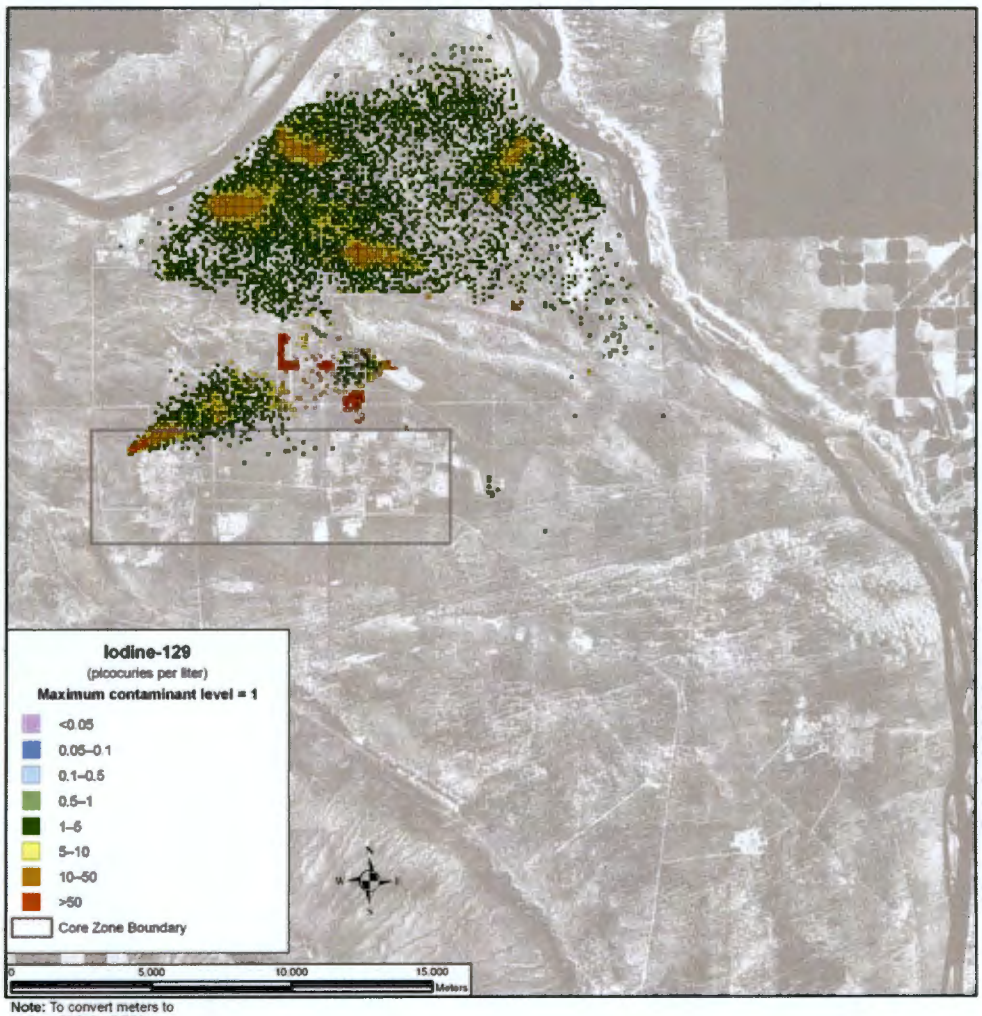
Figure 5–911. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

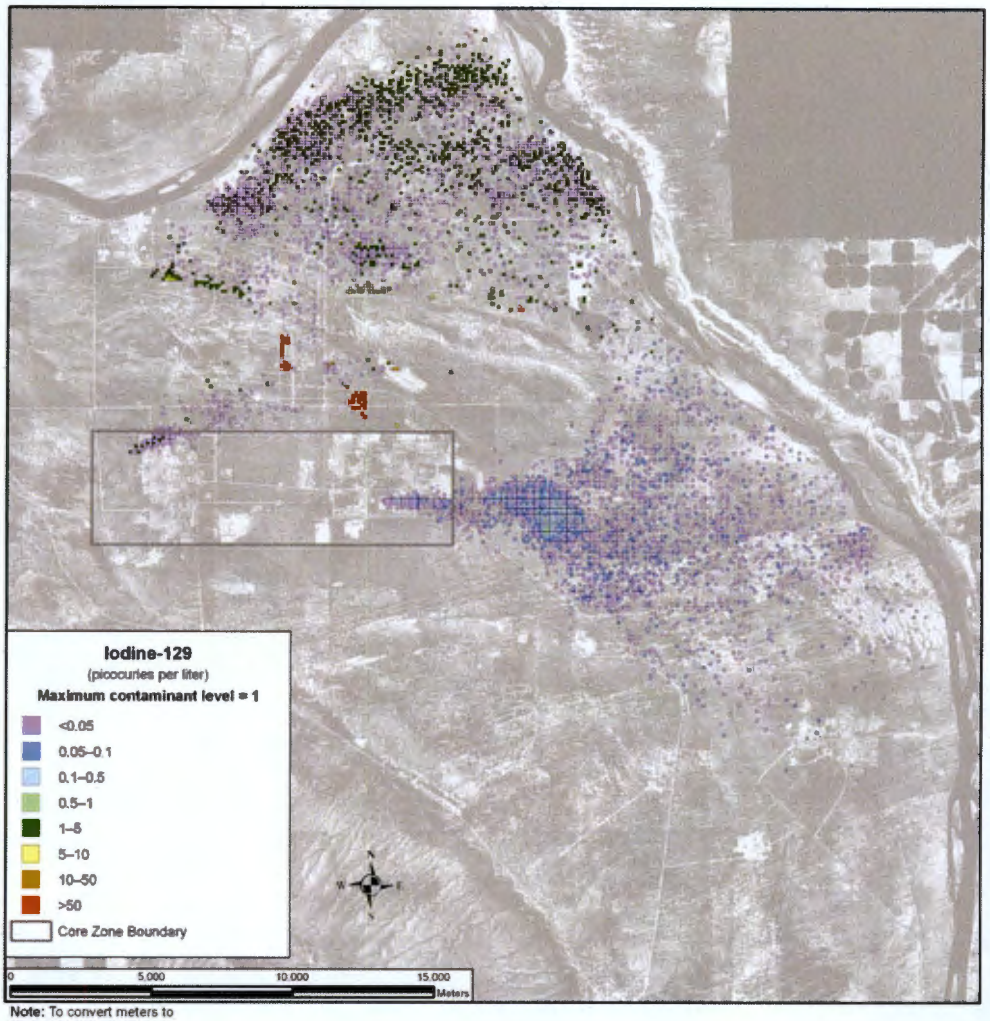
Figure 5–912. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885

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.



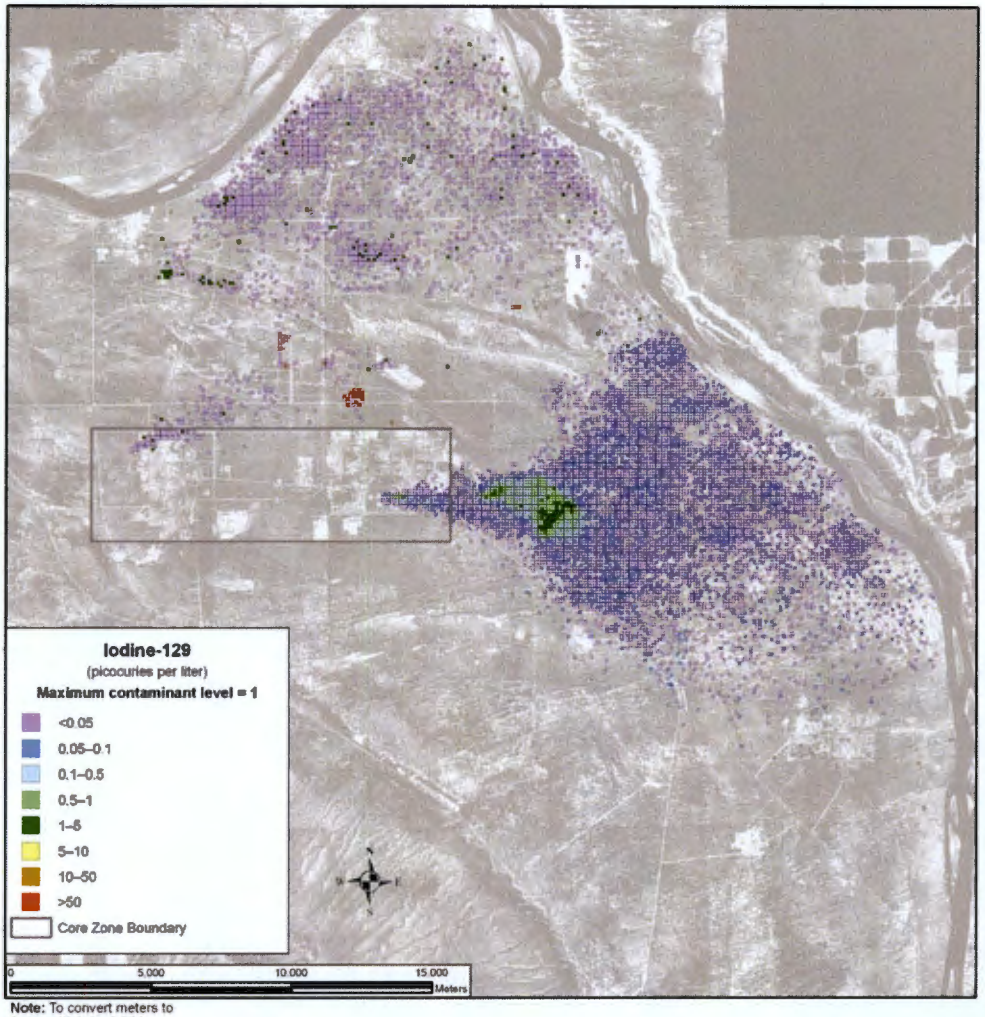
Note: To convert meters to feet, multiply by 3.281

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

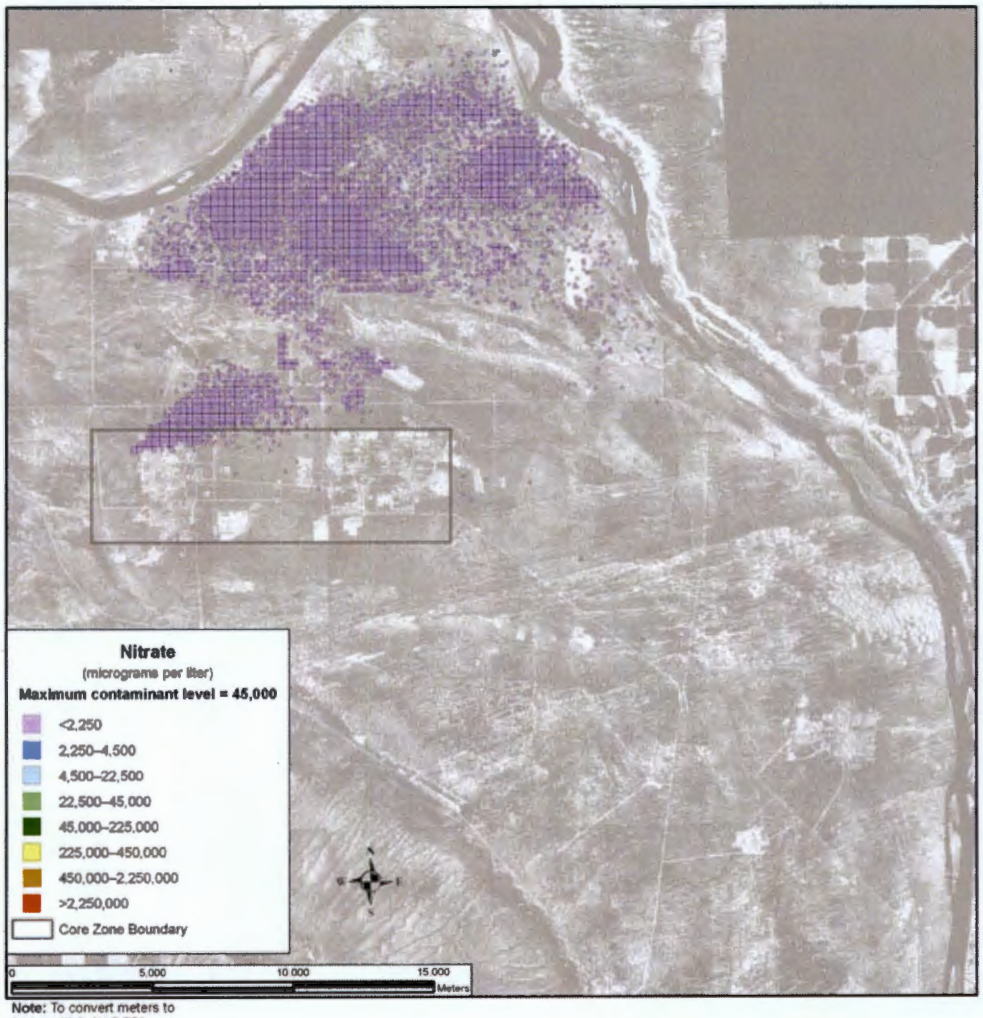
Figure 5–914. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

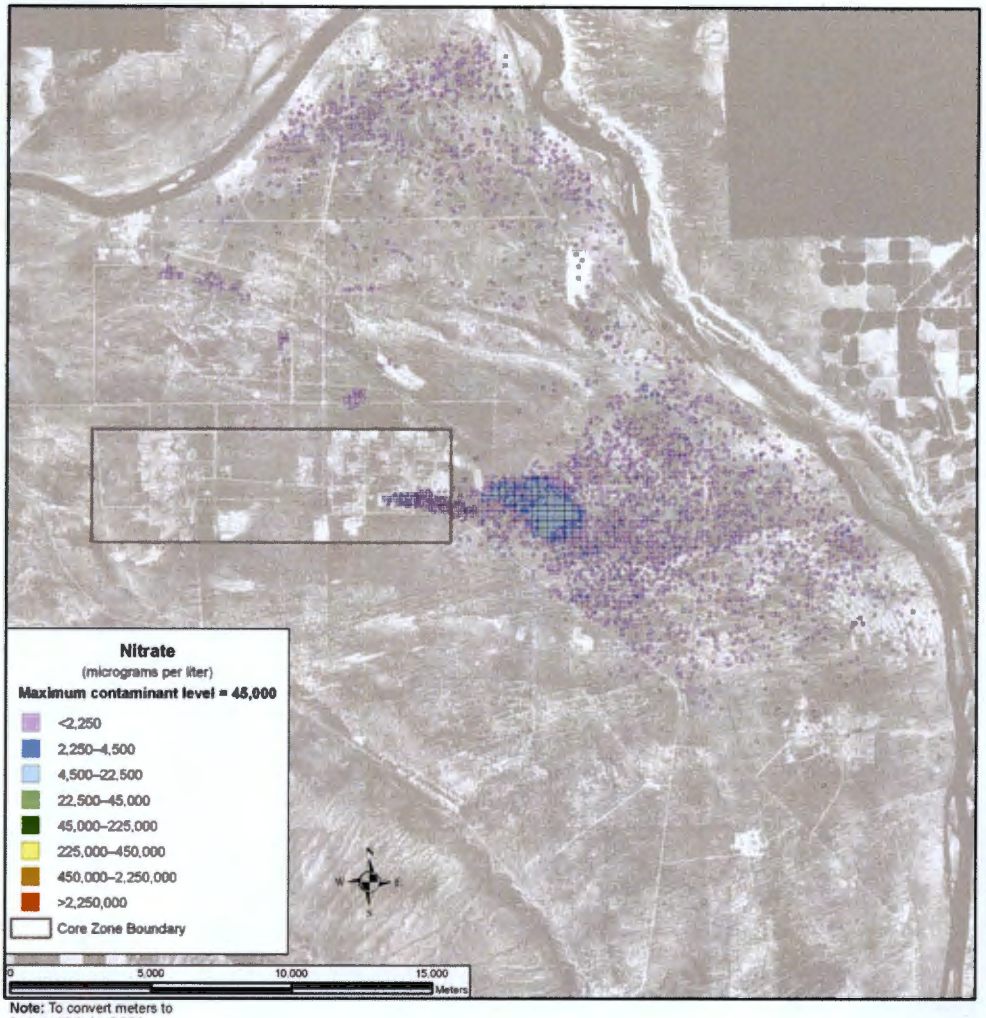
Figure 5–915. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885

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.



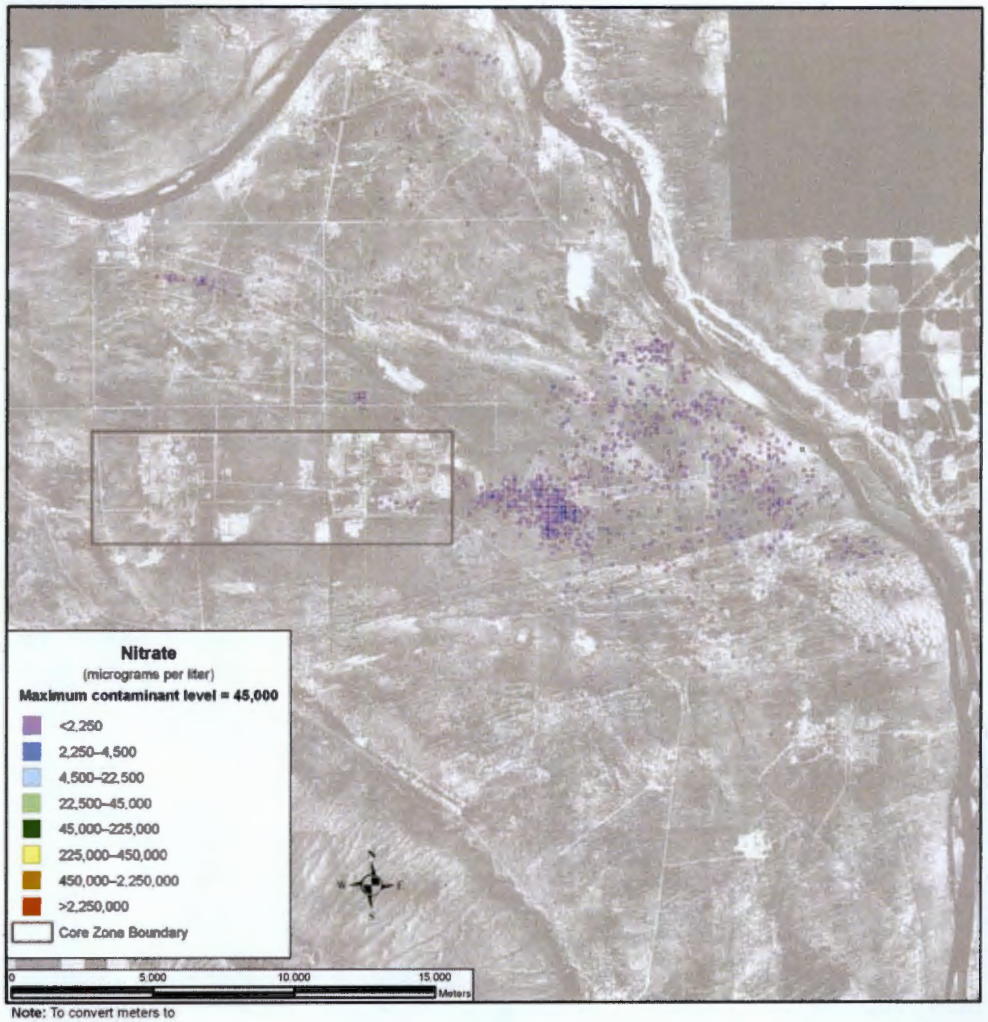
Note: To convert meters to feet, multiply by 3.281

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

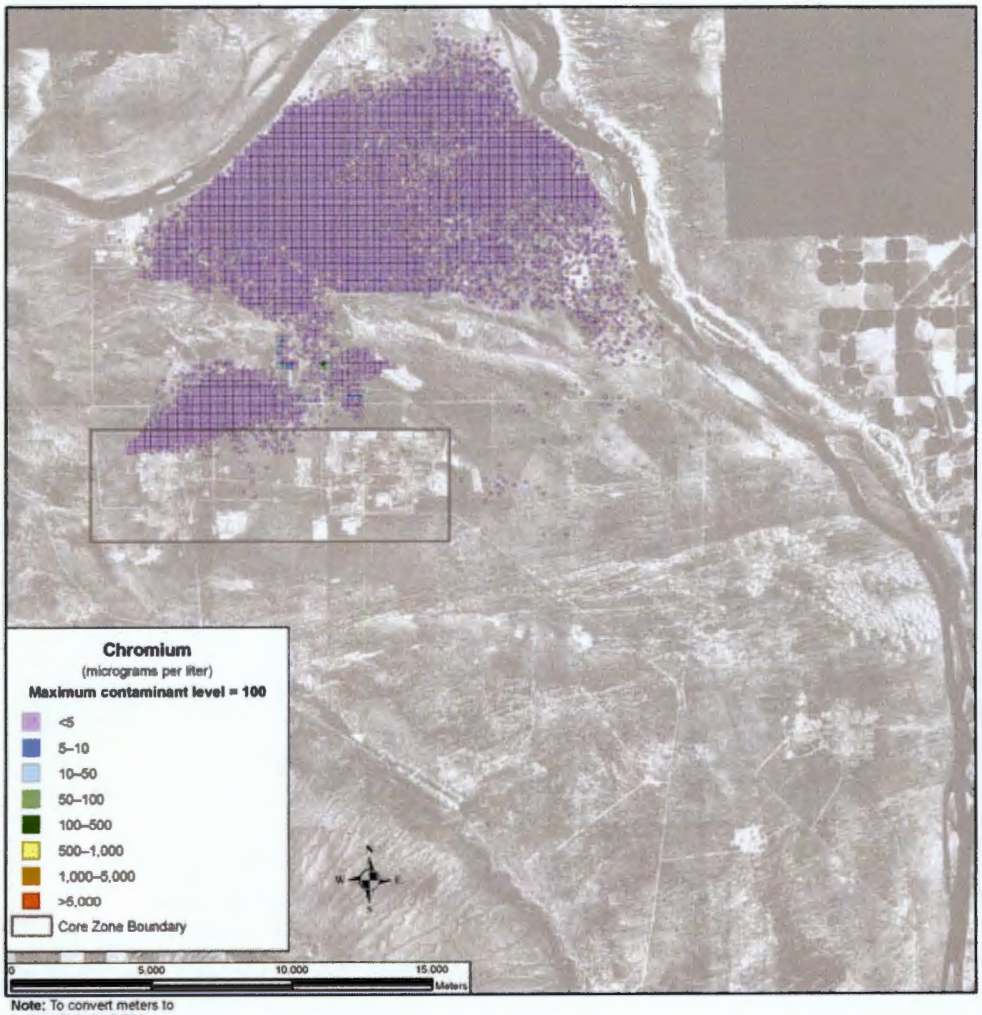
Figure 5–917. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

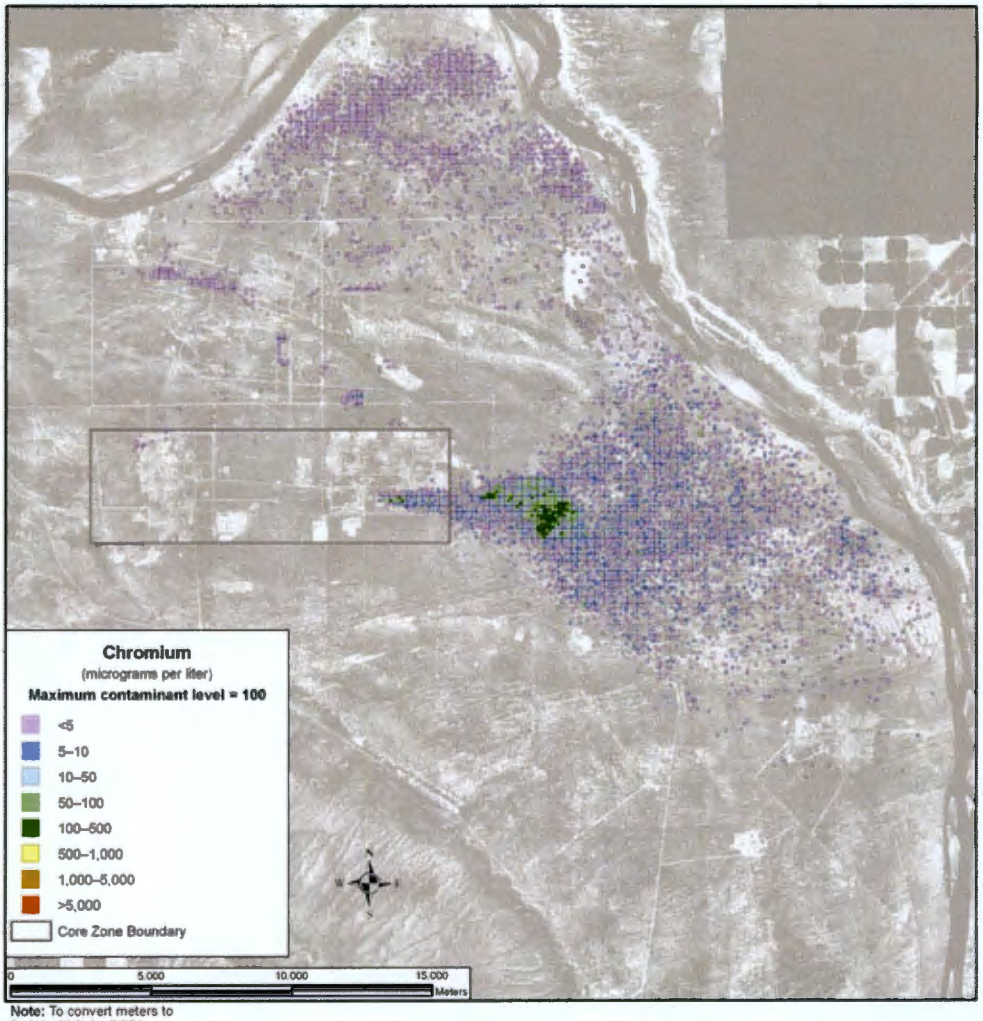
Figure 5–918. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

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.



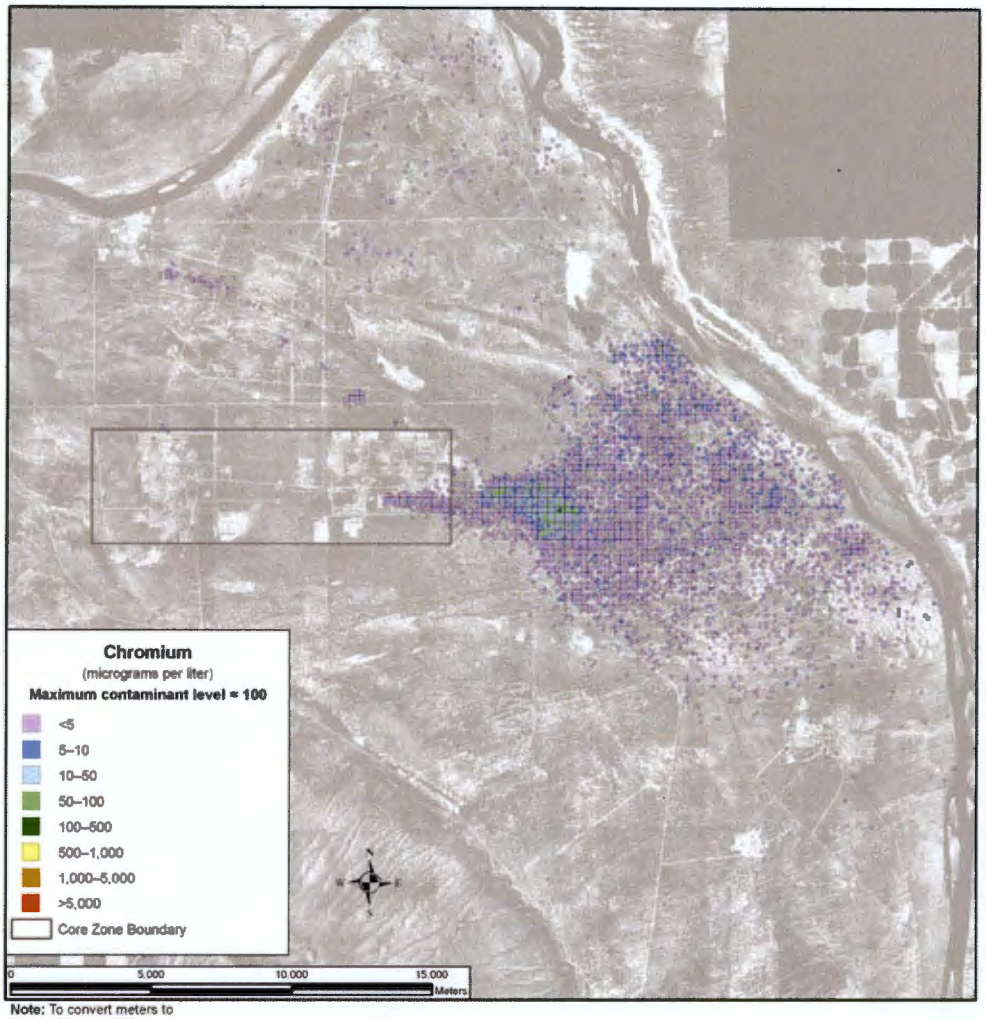
Note: To convert meters to feet, multiply by 3.281

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

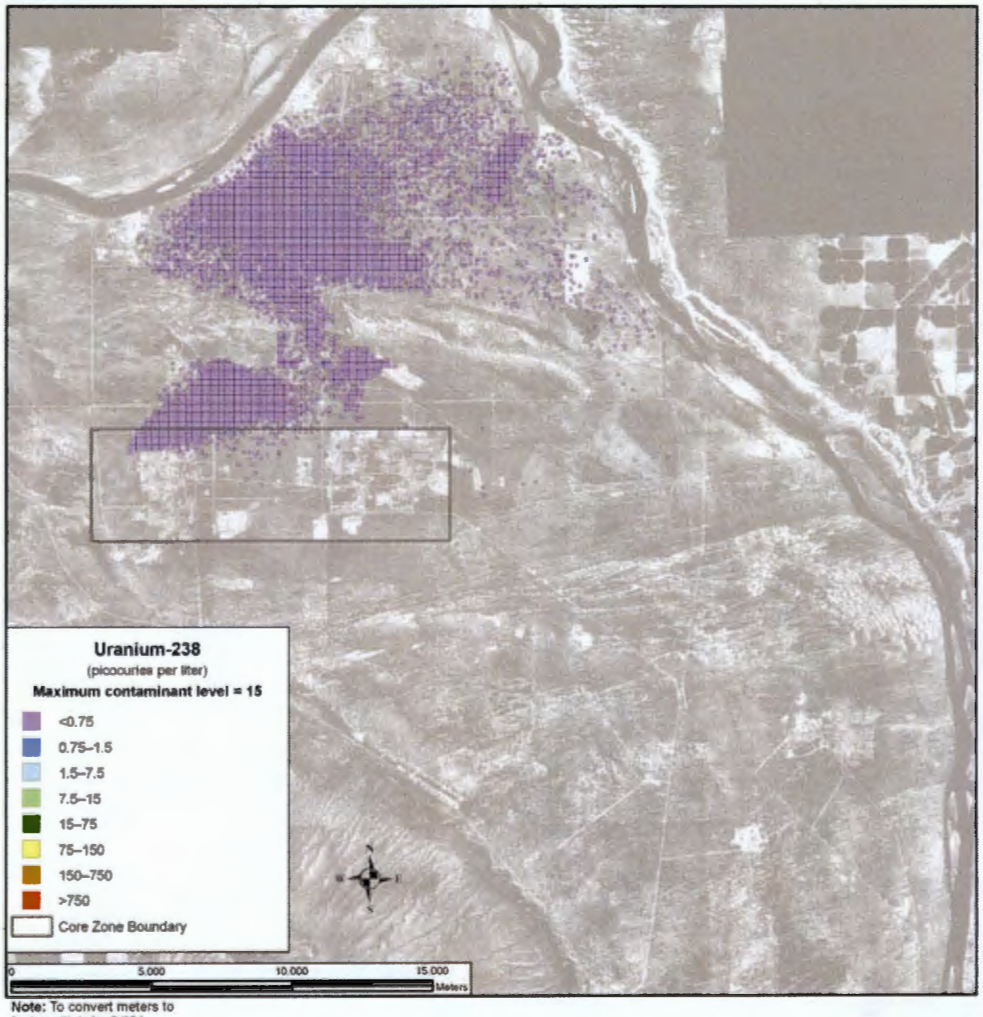
Figure 5–920. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



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.

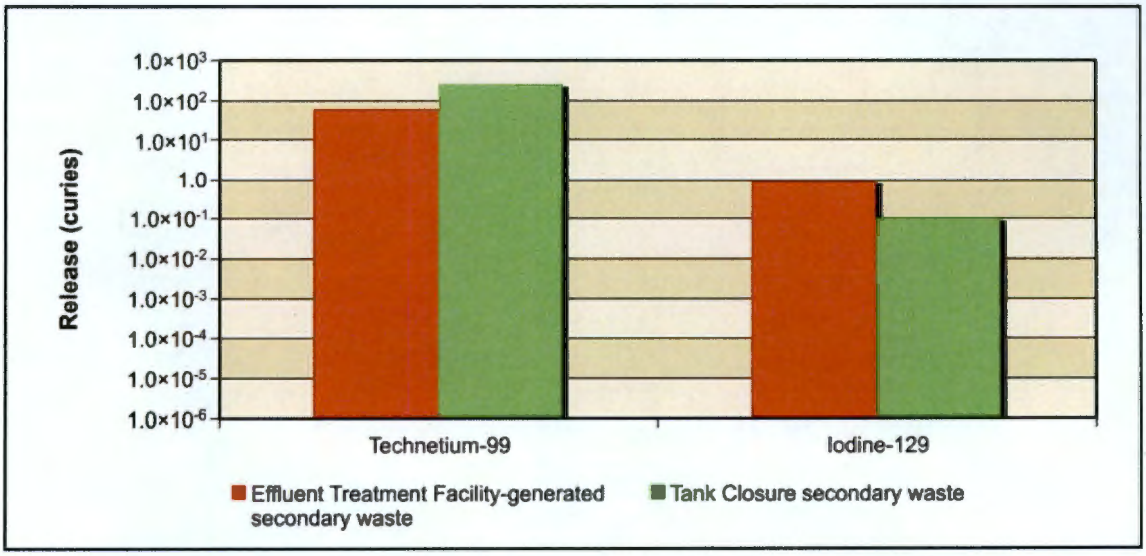


Figure 5–923. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

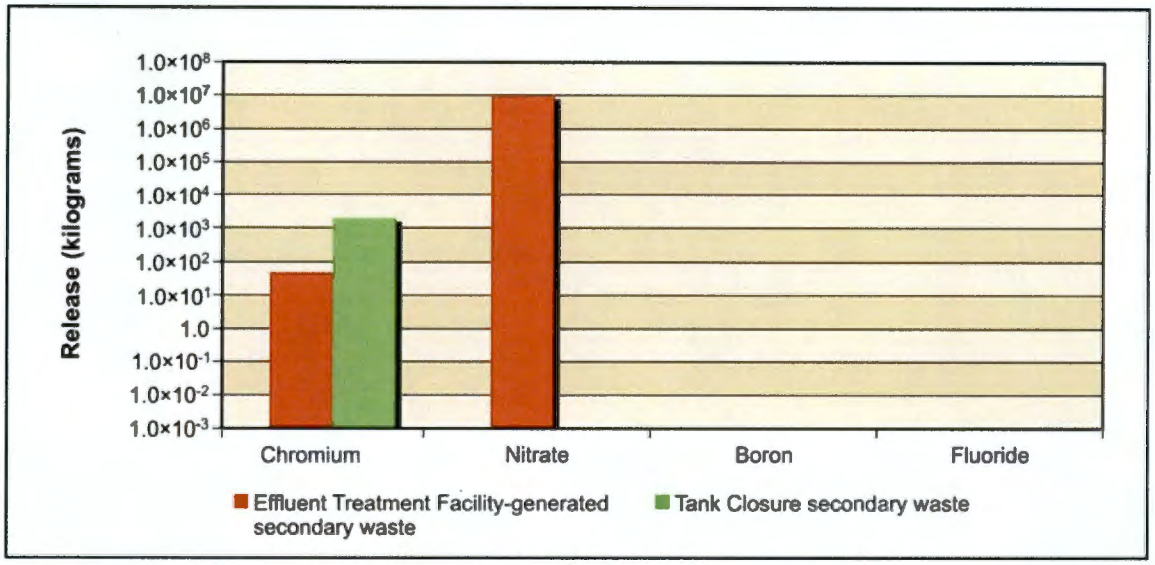


Figure 5–924. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

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.

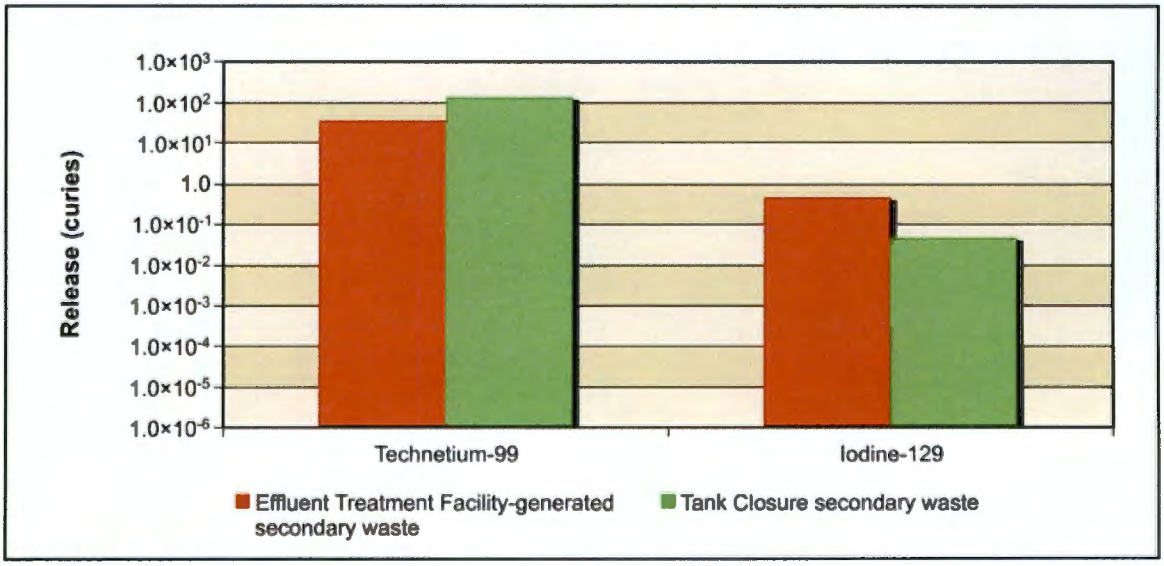


Figure 5–925. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

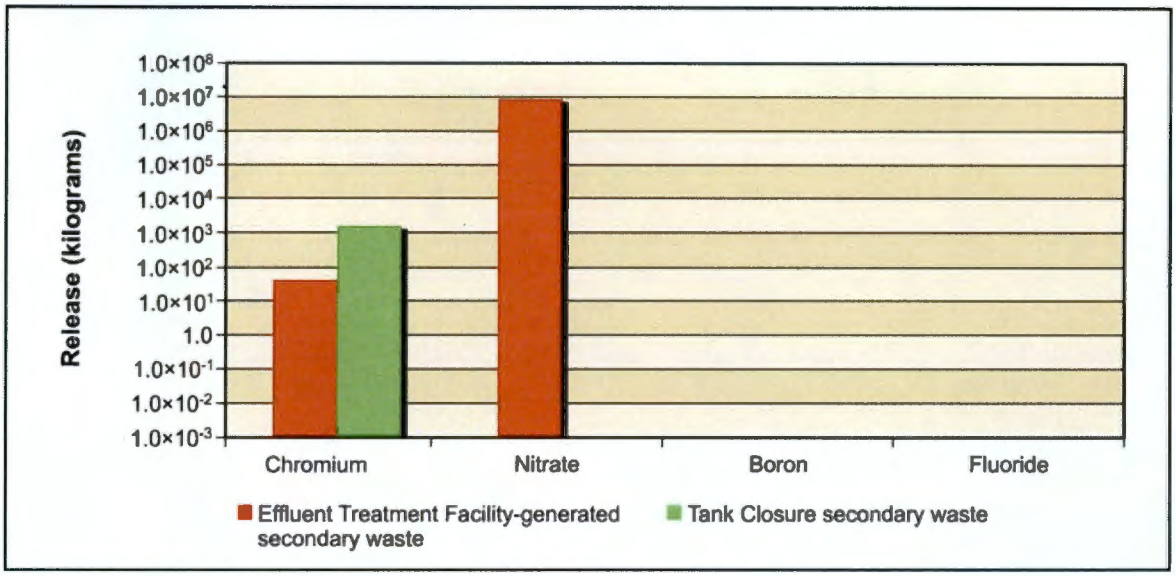


Figure 5–926. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

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.

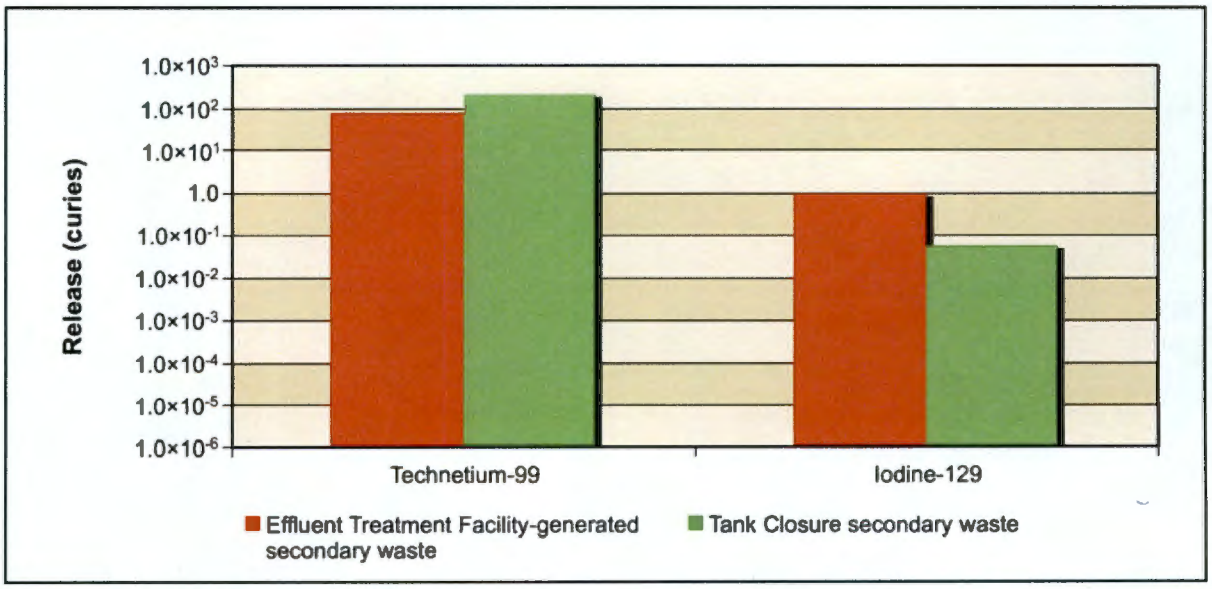


Figure 5–927. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

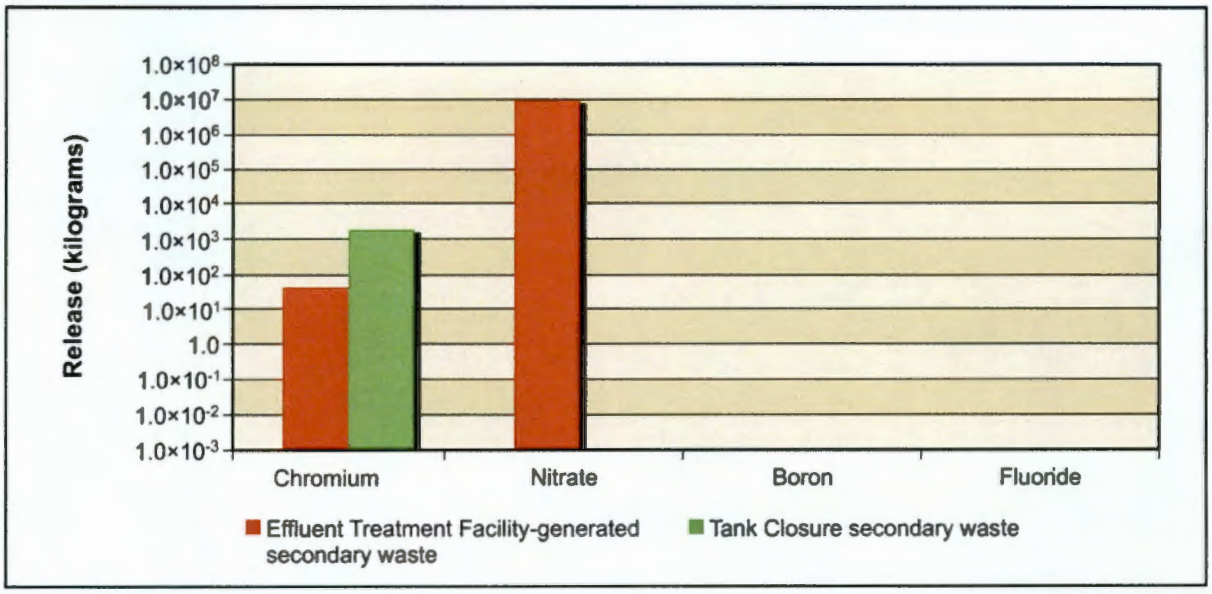


Figure 5–928. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

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.

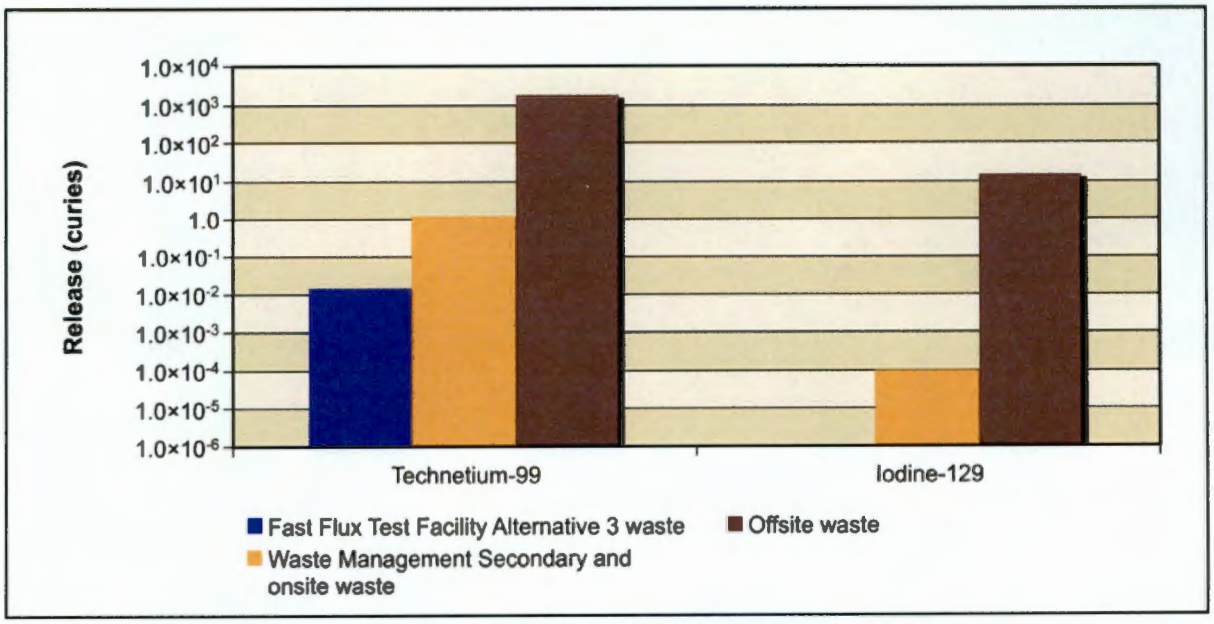


Figure 5–929. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

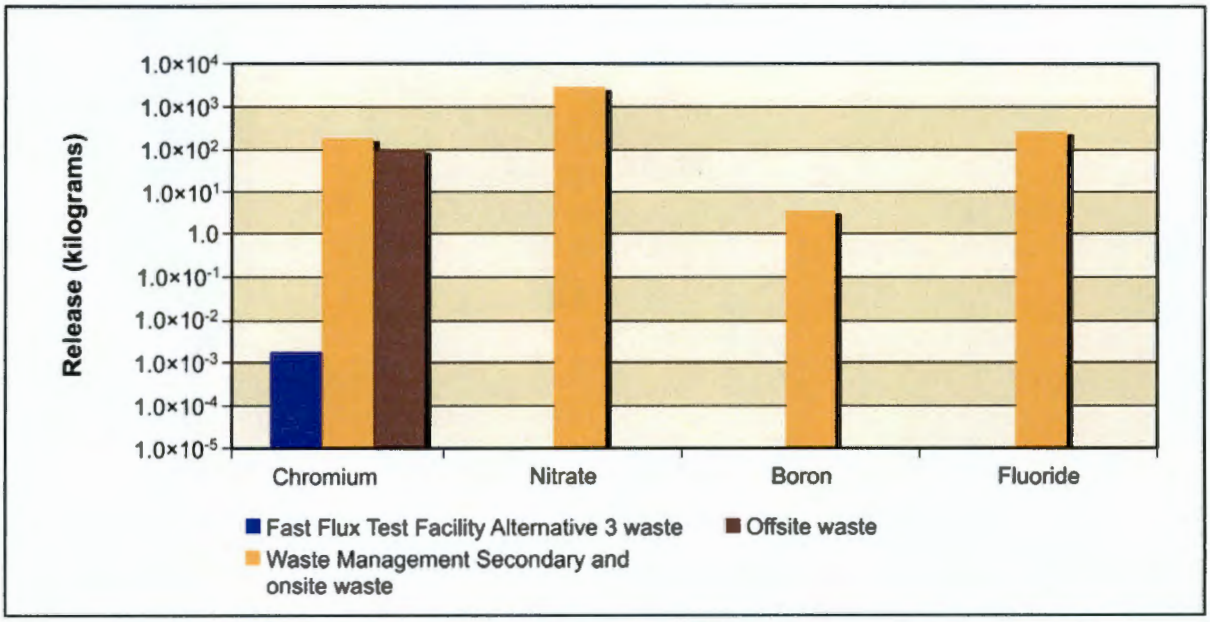


Figure 5–930. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

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.

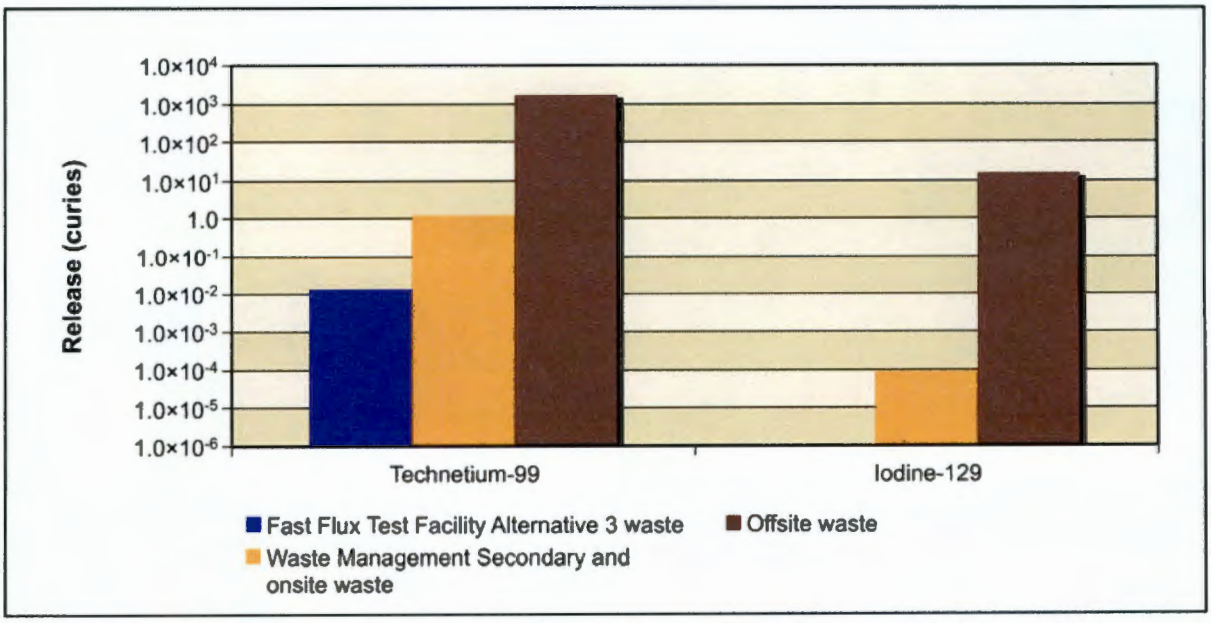


Figure 5–931. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

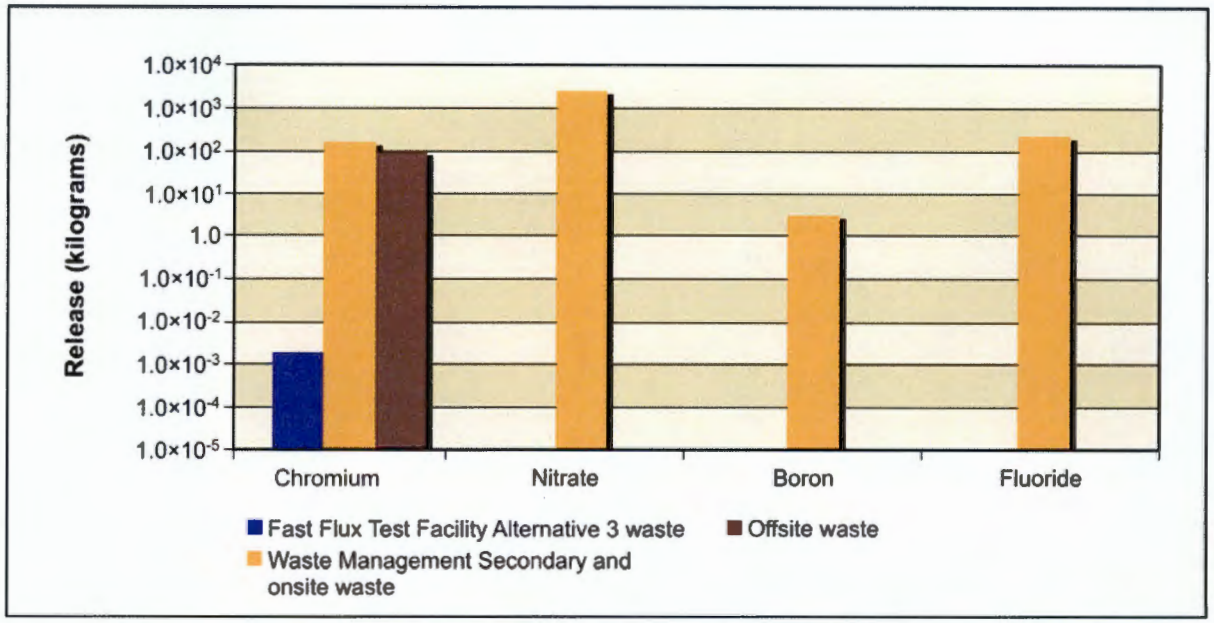


Figure 5–932. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

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.

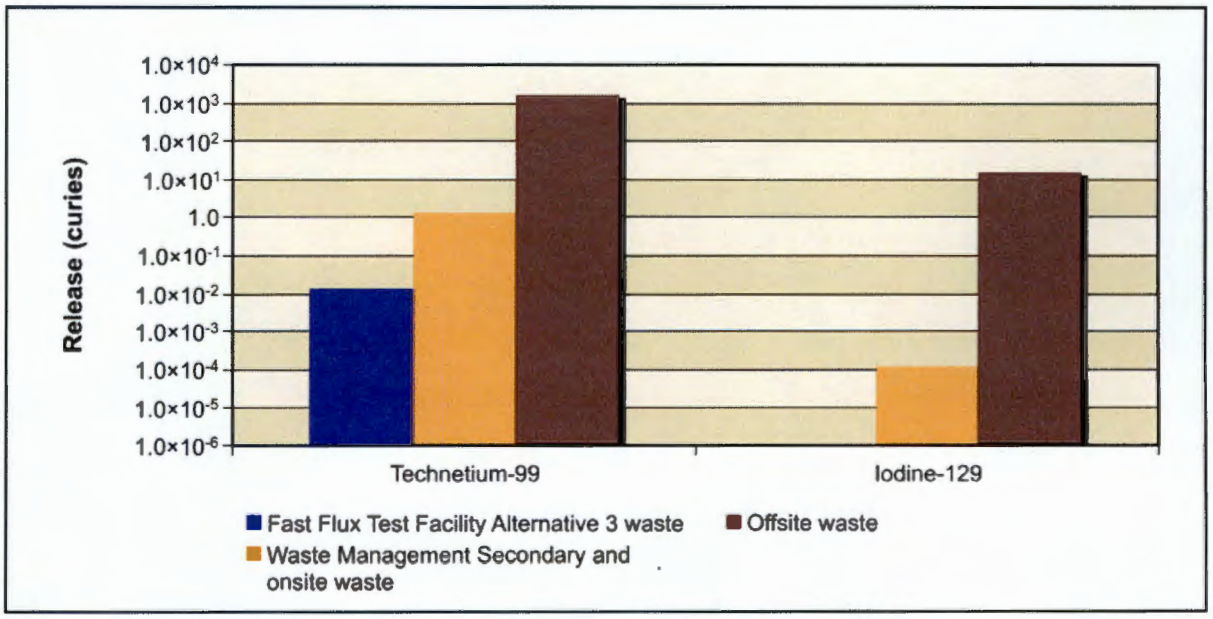


Figure 5–933. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

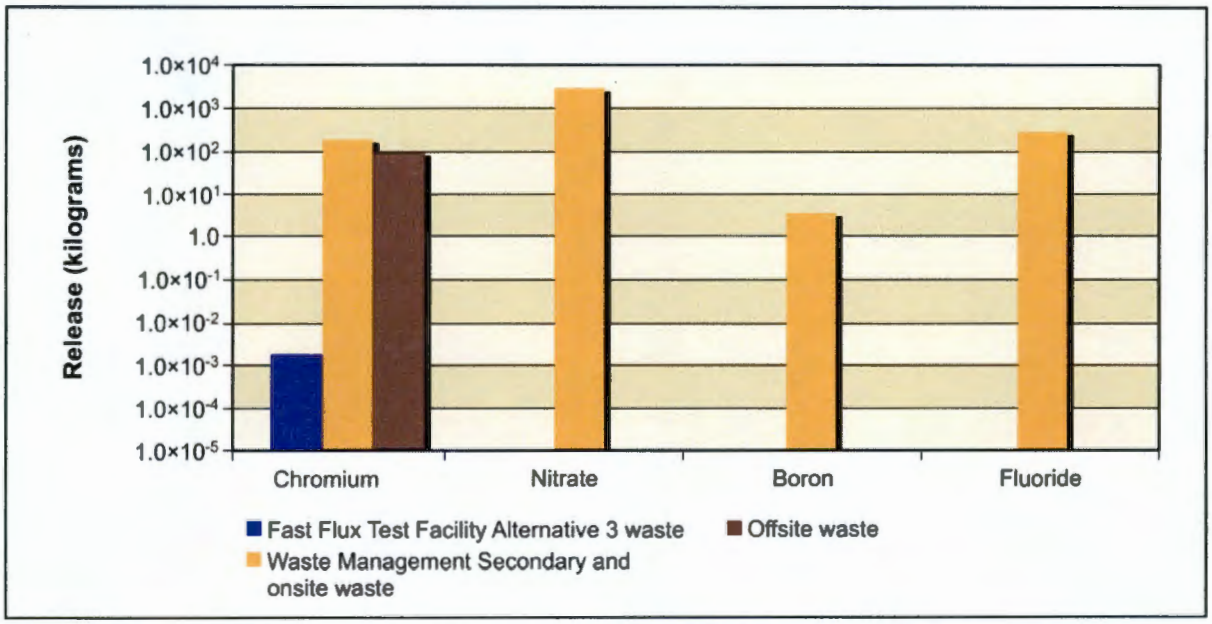


Figure 5–934. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

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.

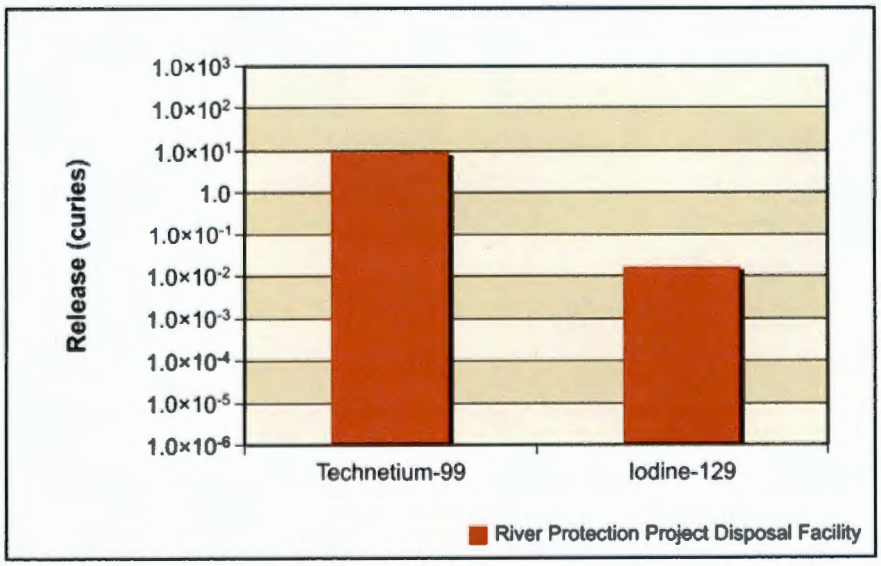


Figure 5–935. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

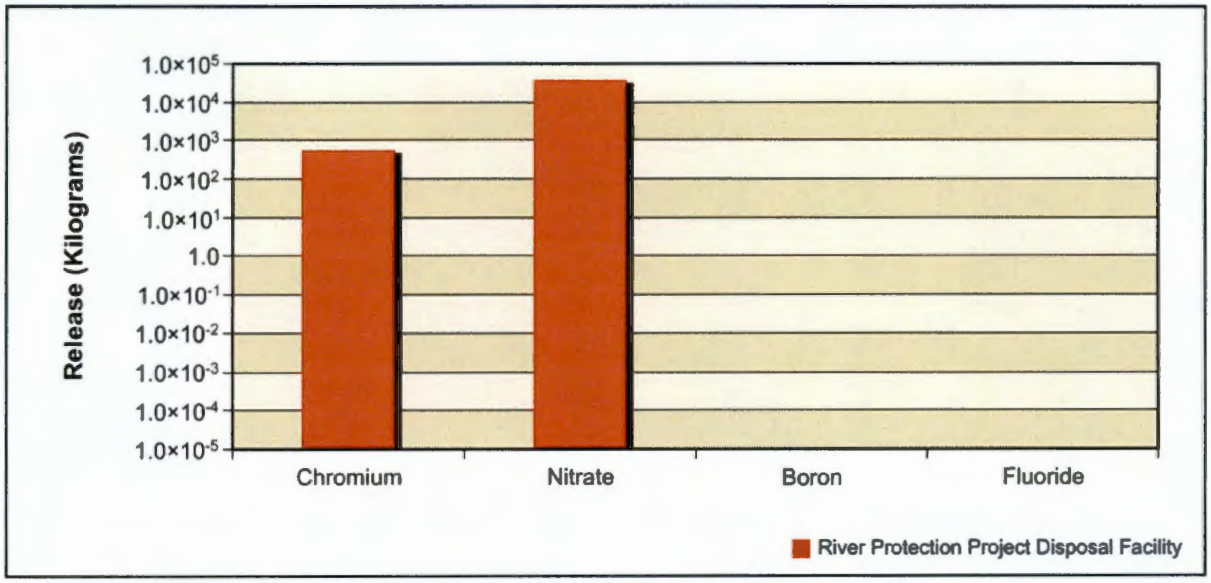


Figure 5–936. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

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.

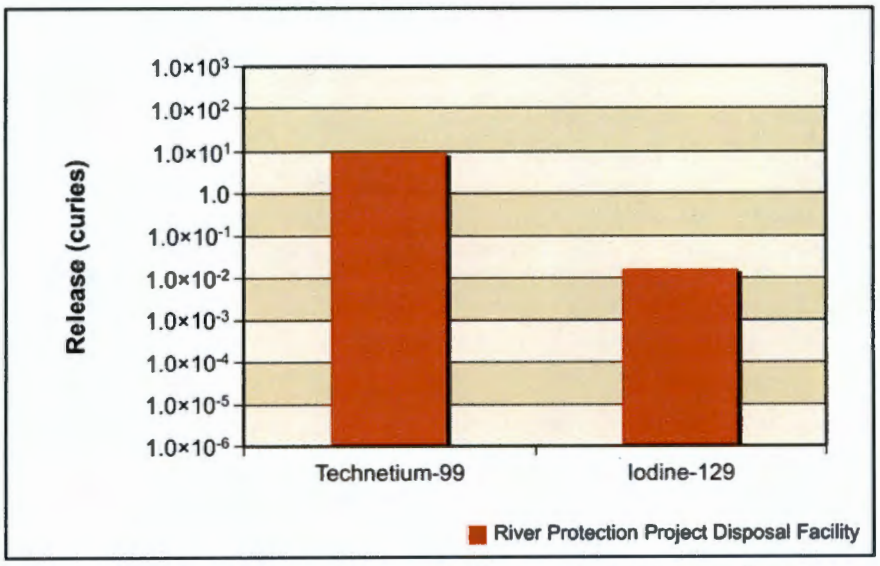


Figure 5–937. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at River Protection Project Disposal Facility to Groundwater

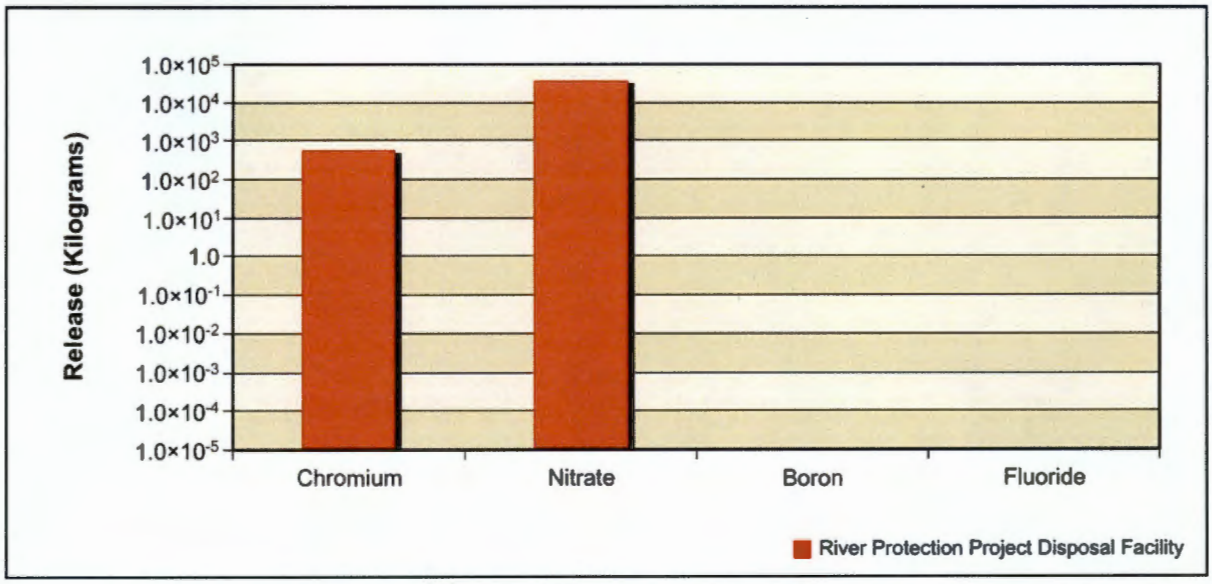


Figure 5–938. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at River Protection Project Disposal Facility to Groundwater

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.

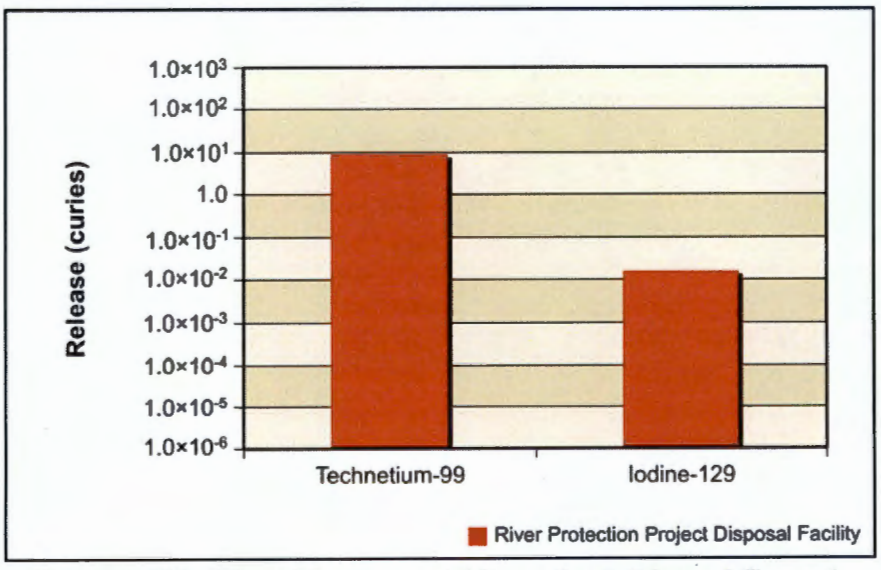


Figure 5–939. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Radiological Releases at River Protection Project Disposal Facility to Columbia River

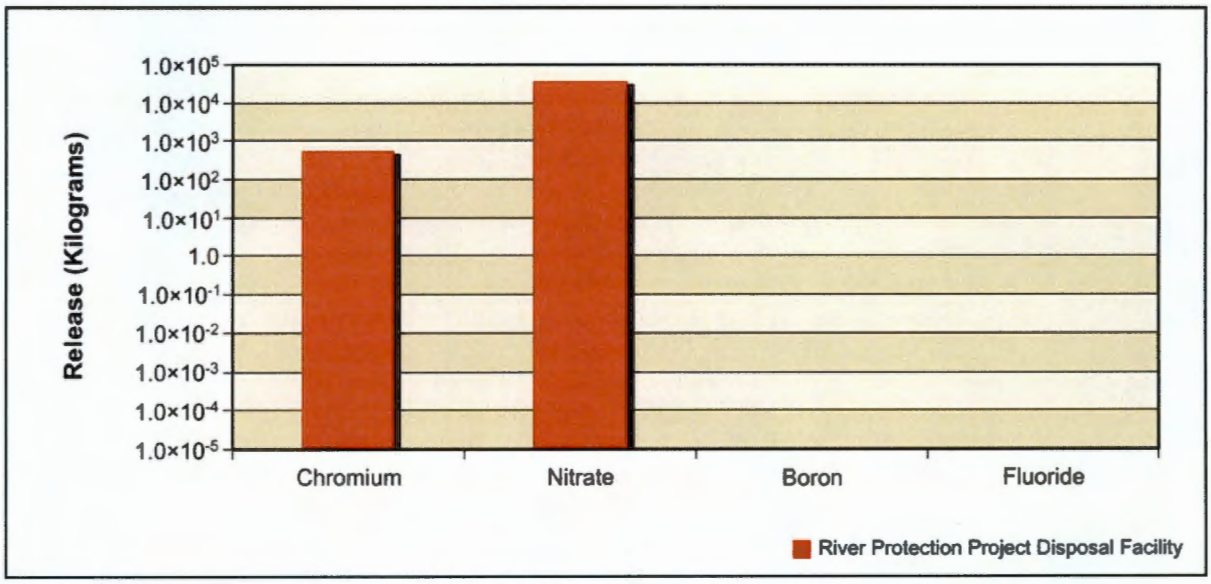


Figure 5–940. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chemical Releases at River Protection Project Disposal Facility to Columbia River

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.

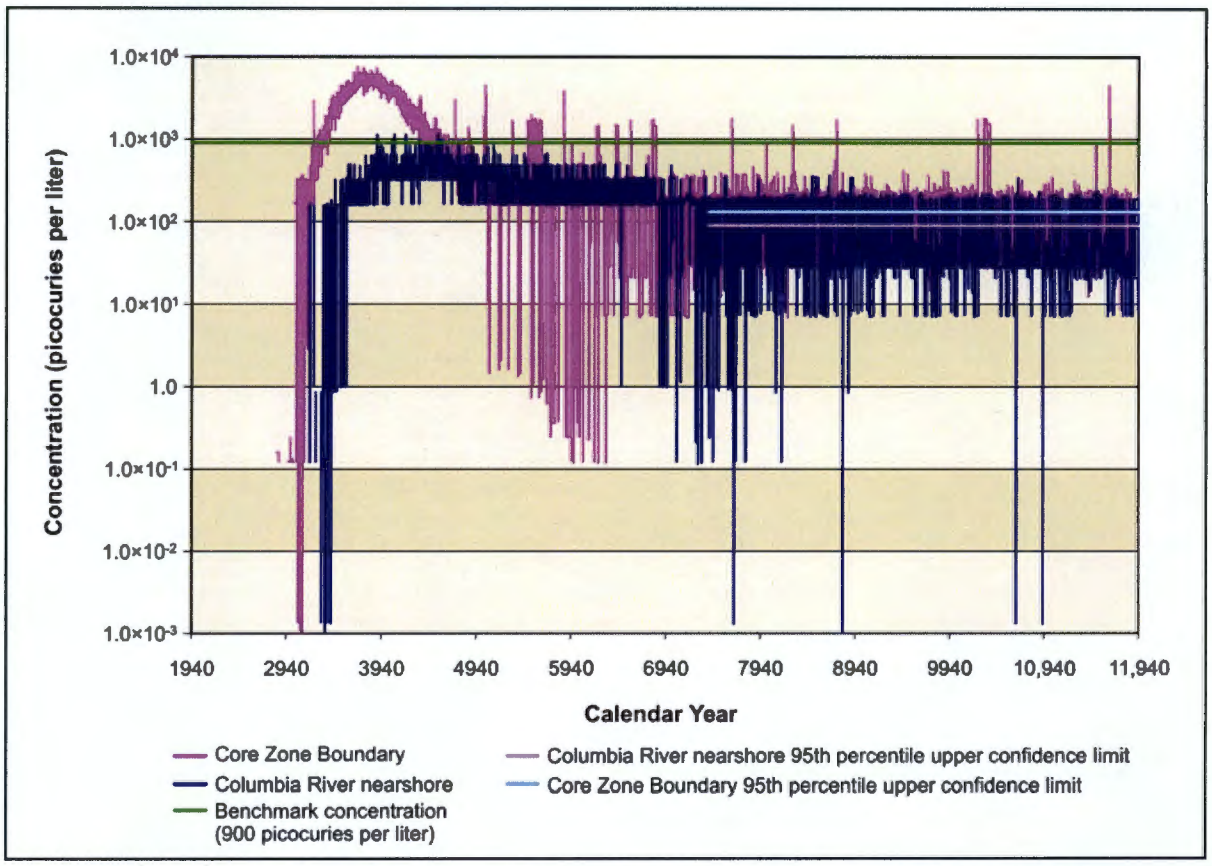


Figure 5–941. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Technetium-99 Concentration Versus Time

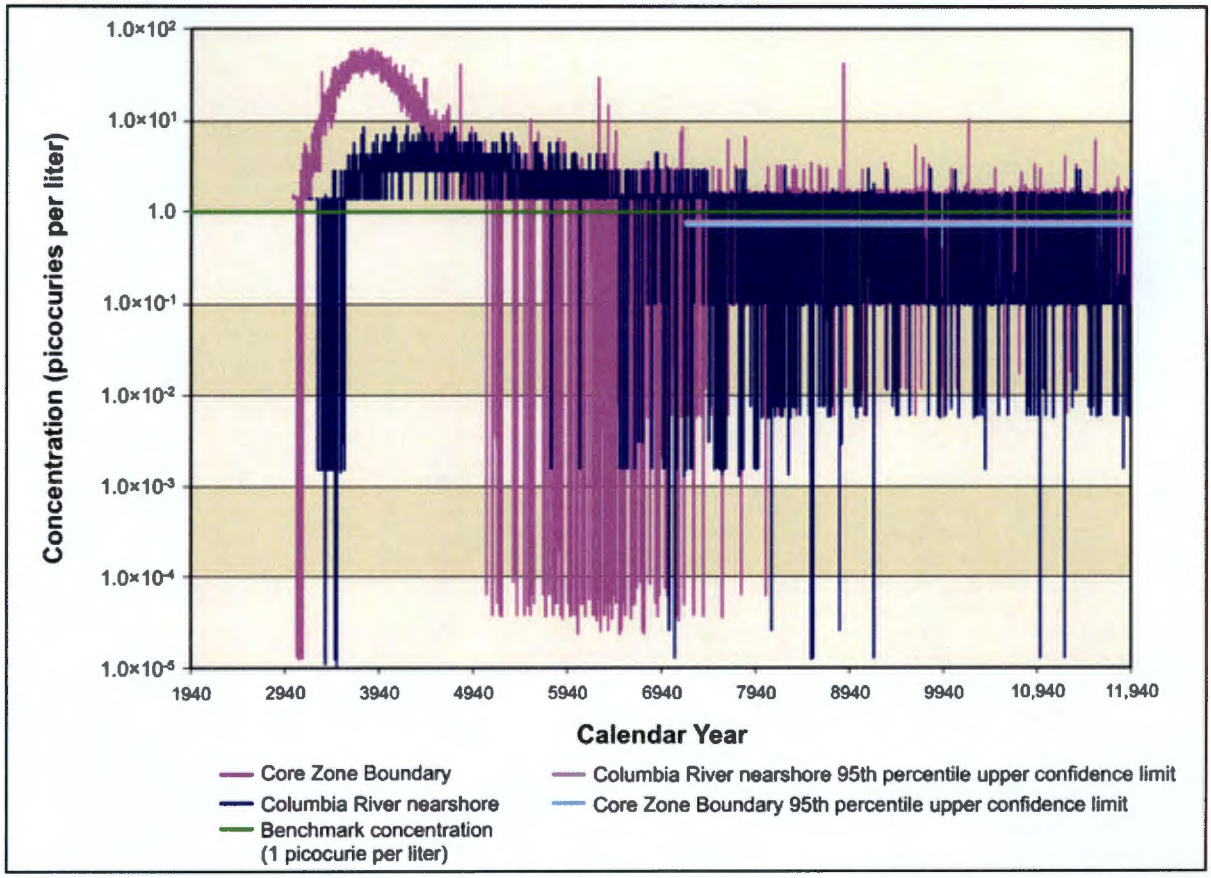


Figure 5–942. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Iodine-129 Concentration Versus Time

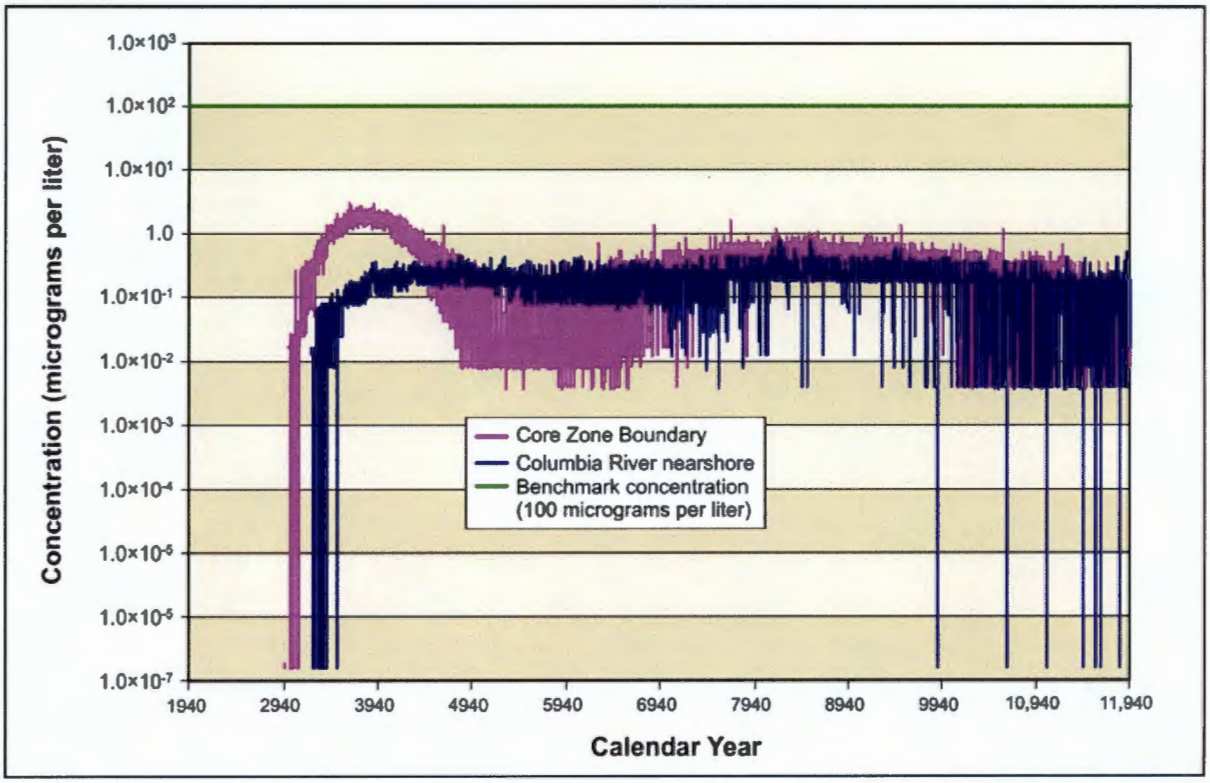


Figure 5–943. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Chromium Concentration Versus Time

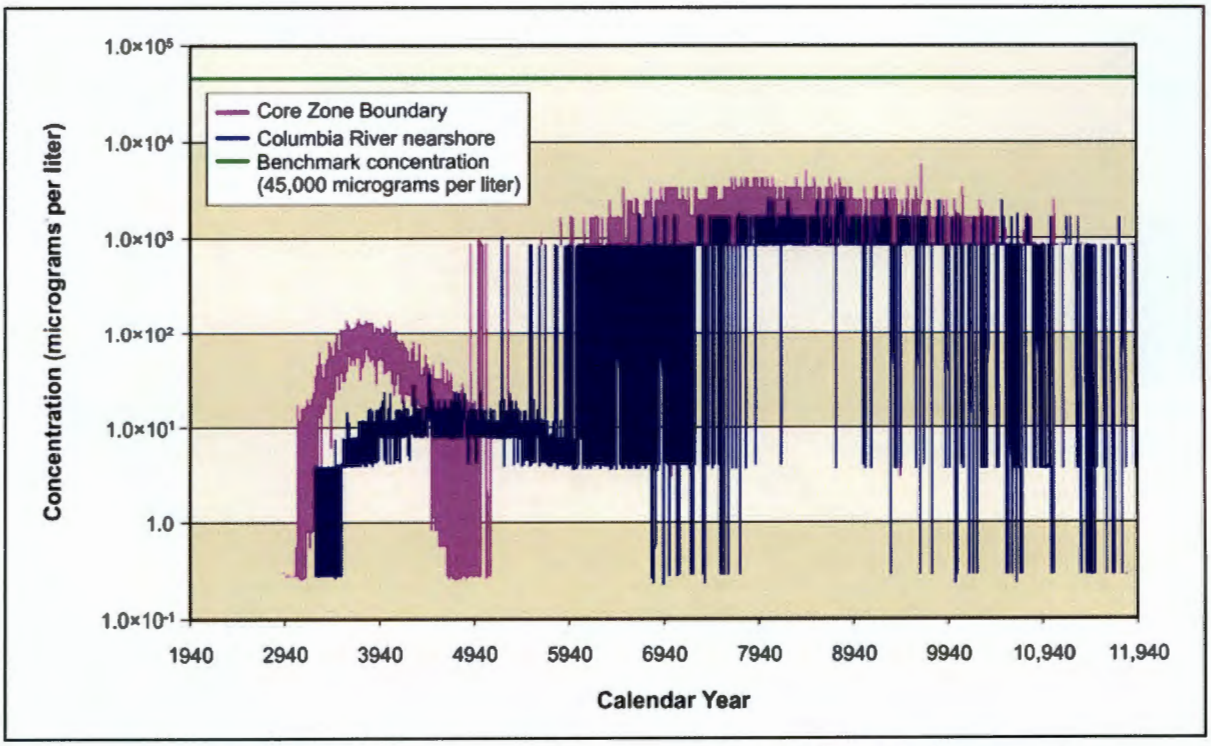


Figure 5–944. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Nitrate Concentration Versus Time

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.

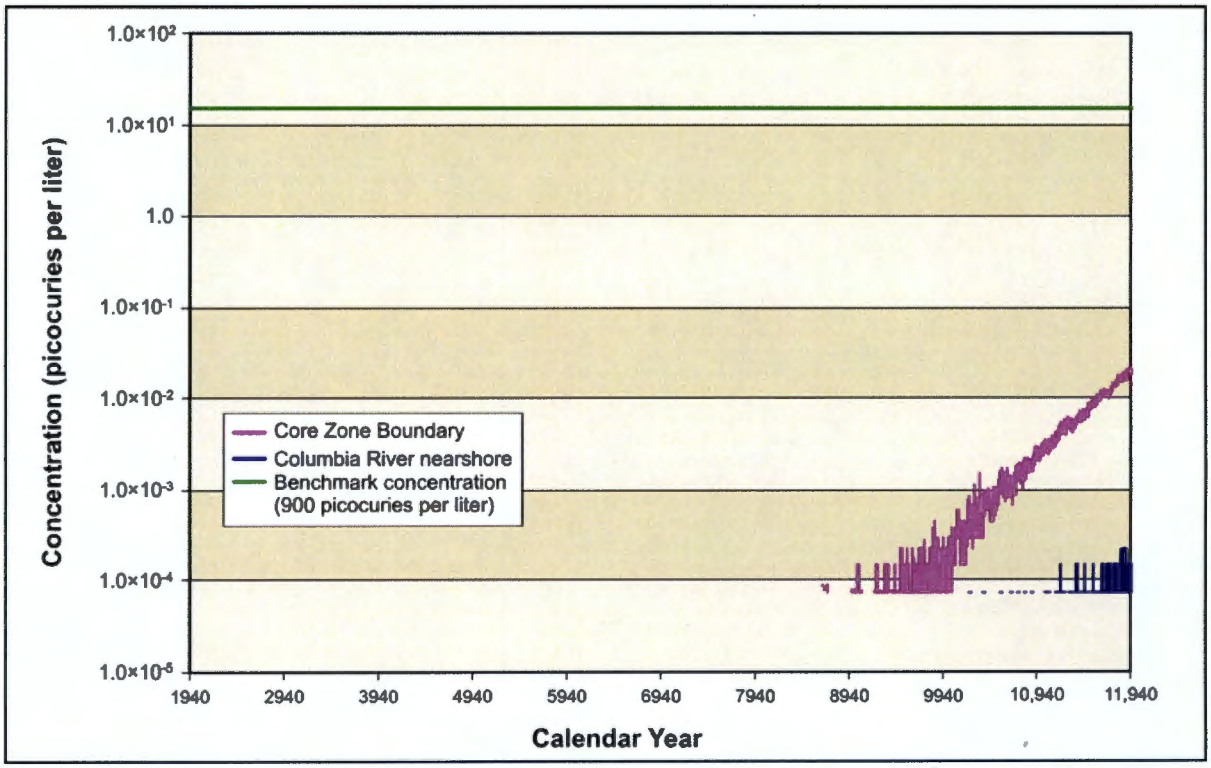


Figure 5–945. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Uranium-238 Concentration Versus Time

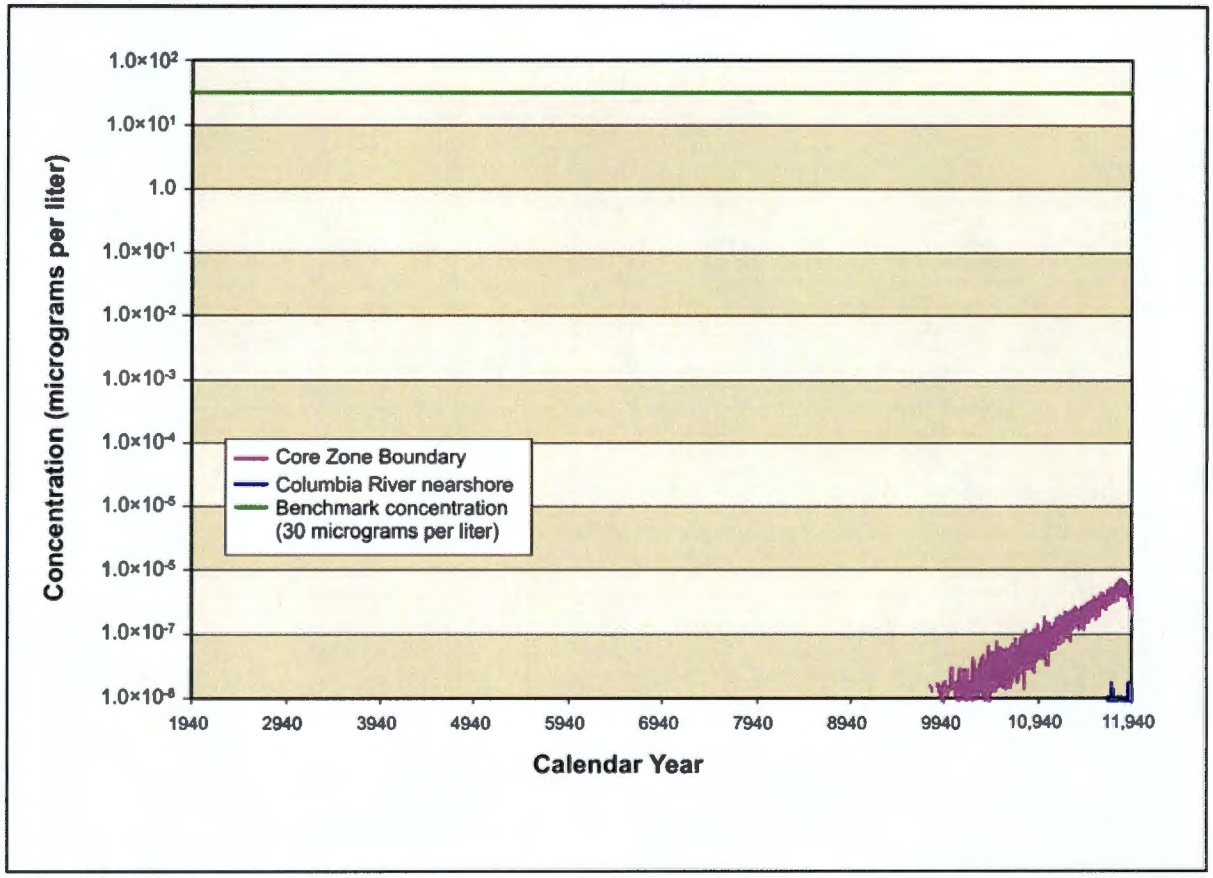


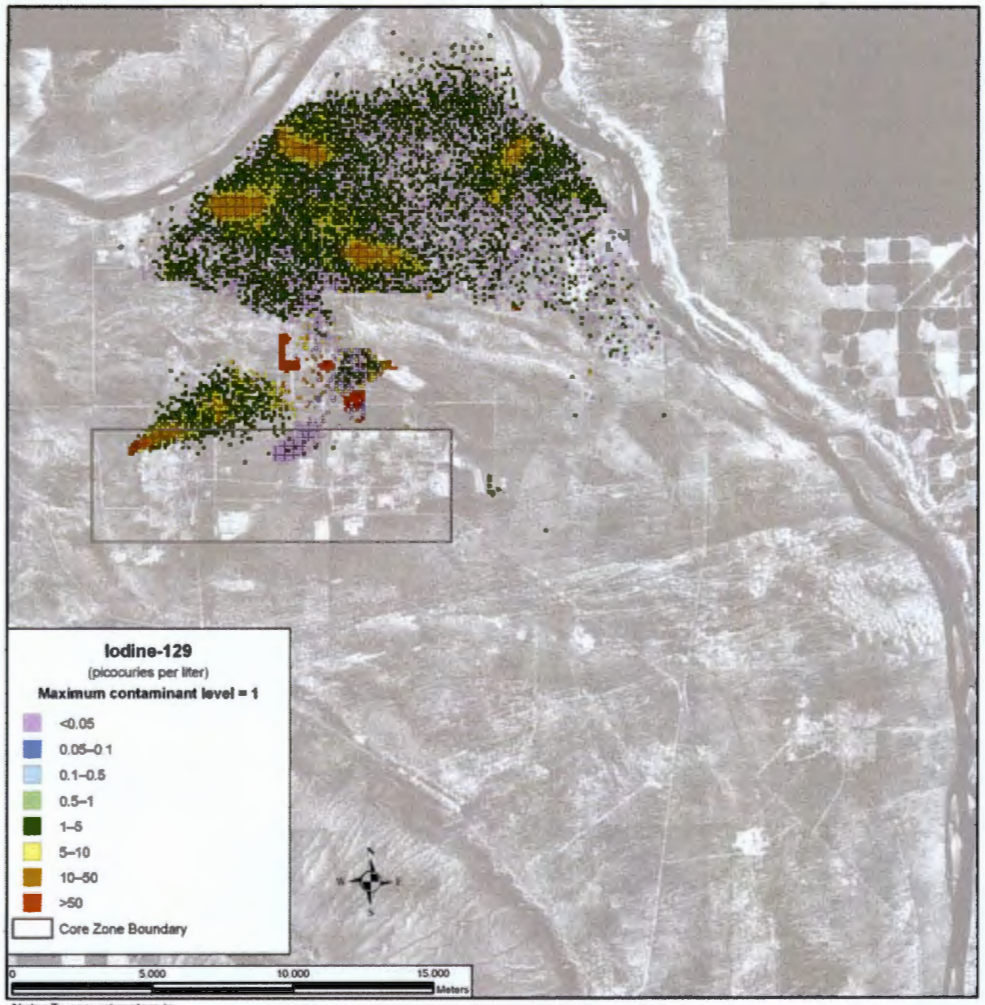
Figure 5–946. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Total Uranium Concentration Versus Time

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.

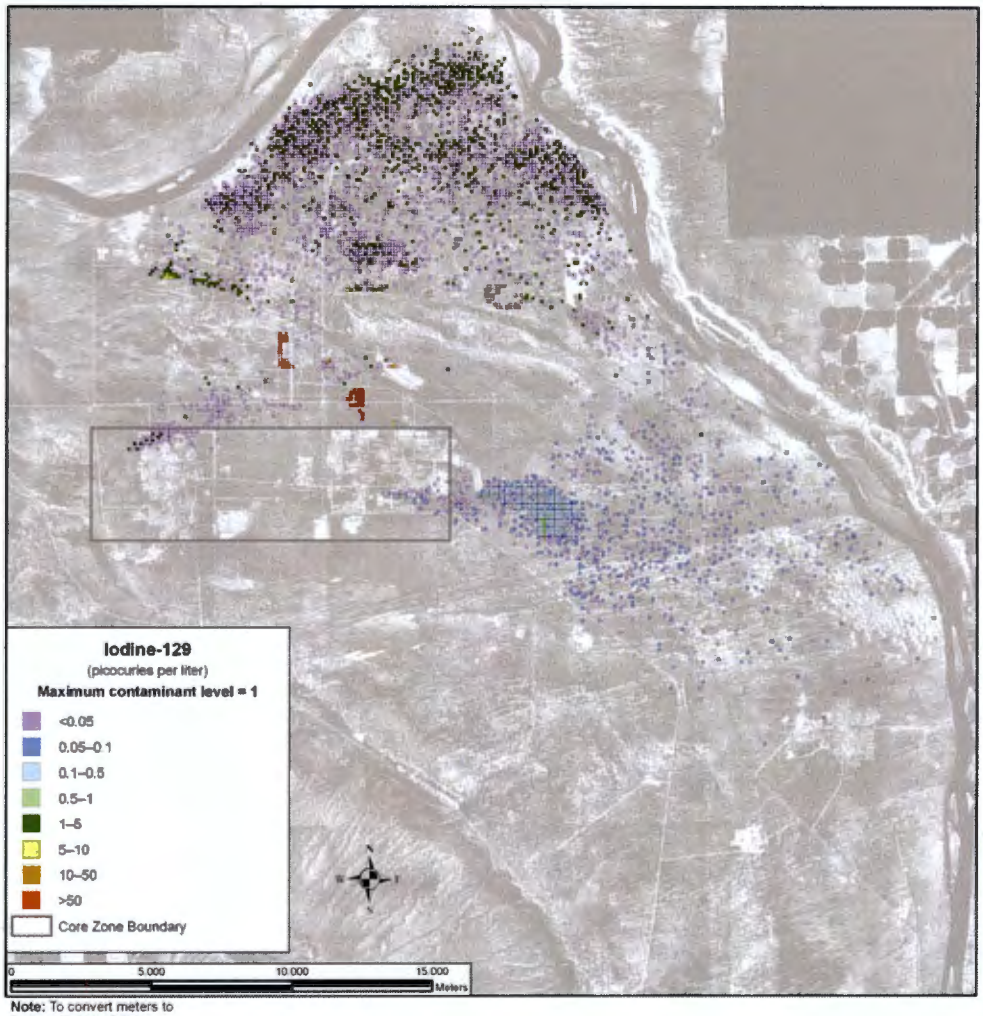
At CY 3890 (see Figure 5–947), there is a high-concentration plume of iodine-129 stretching northeast of IDF-West, and a low-concentration plume that stretches north from the RPPDF through Gable Gap. Four separate high-concentration areas have also formed north of Gable Mountain and Gable Butte. By CY 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).



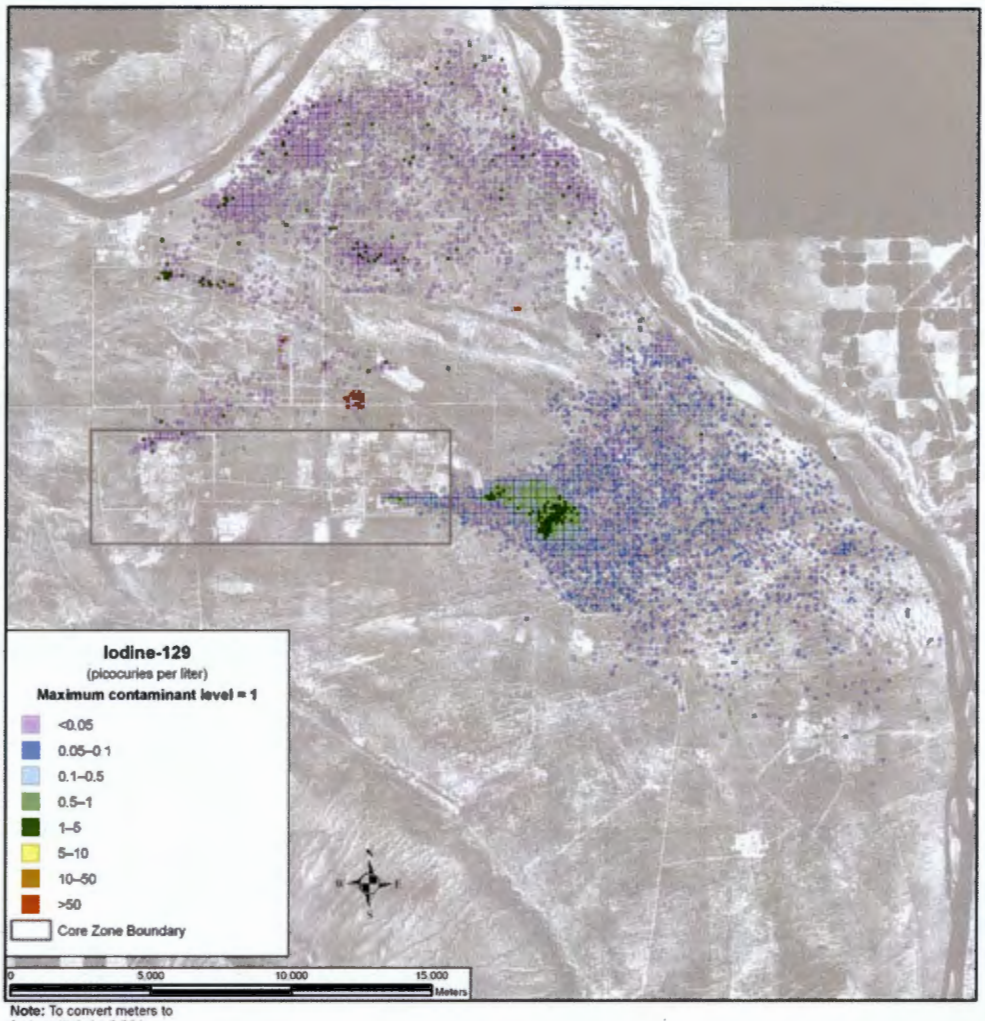
Note: To convert meters to feet, multiply by 3.281

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



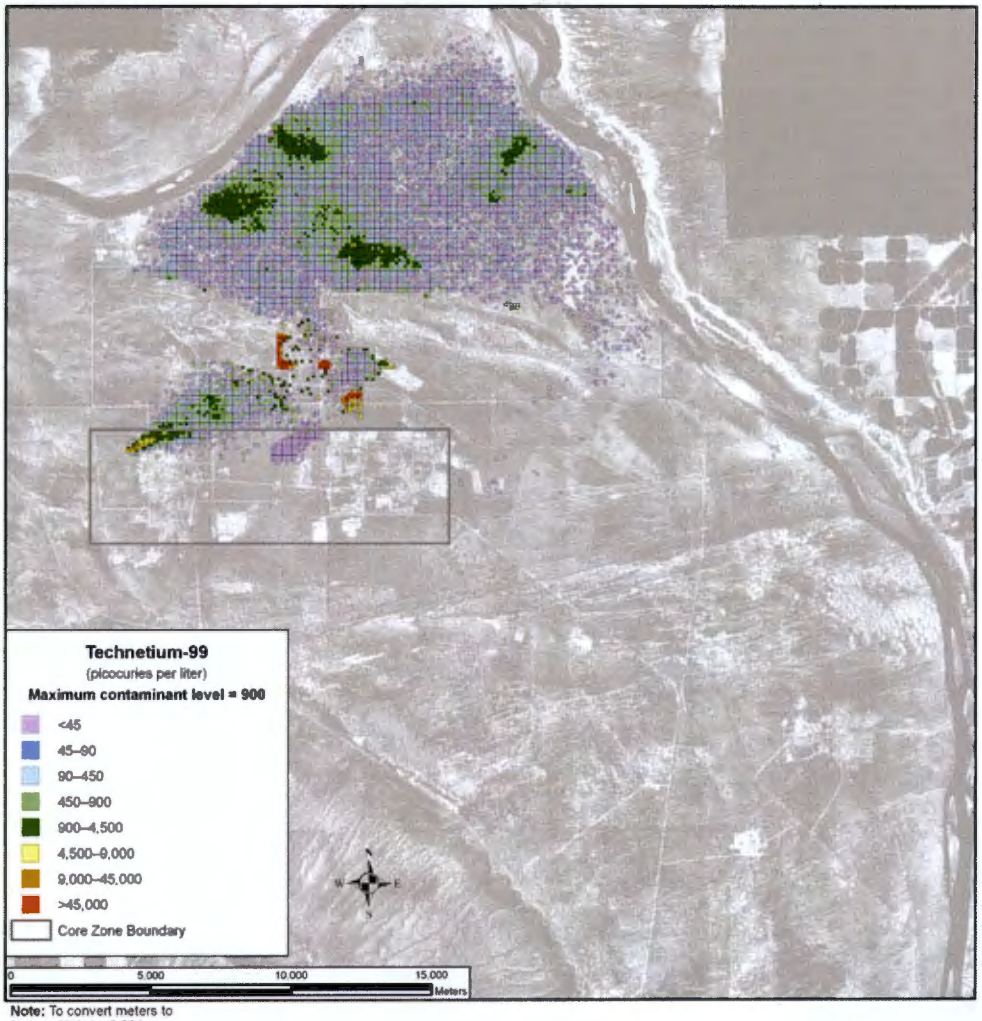
Note: To convert meters to feet, multiply by 3.281

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



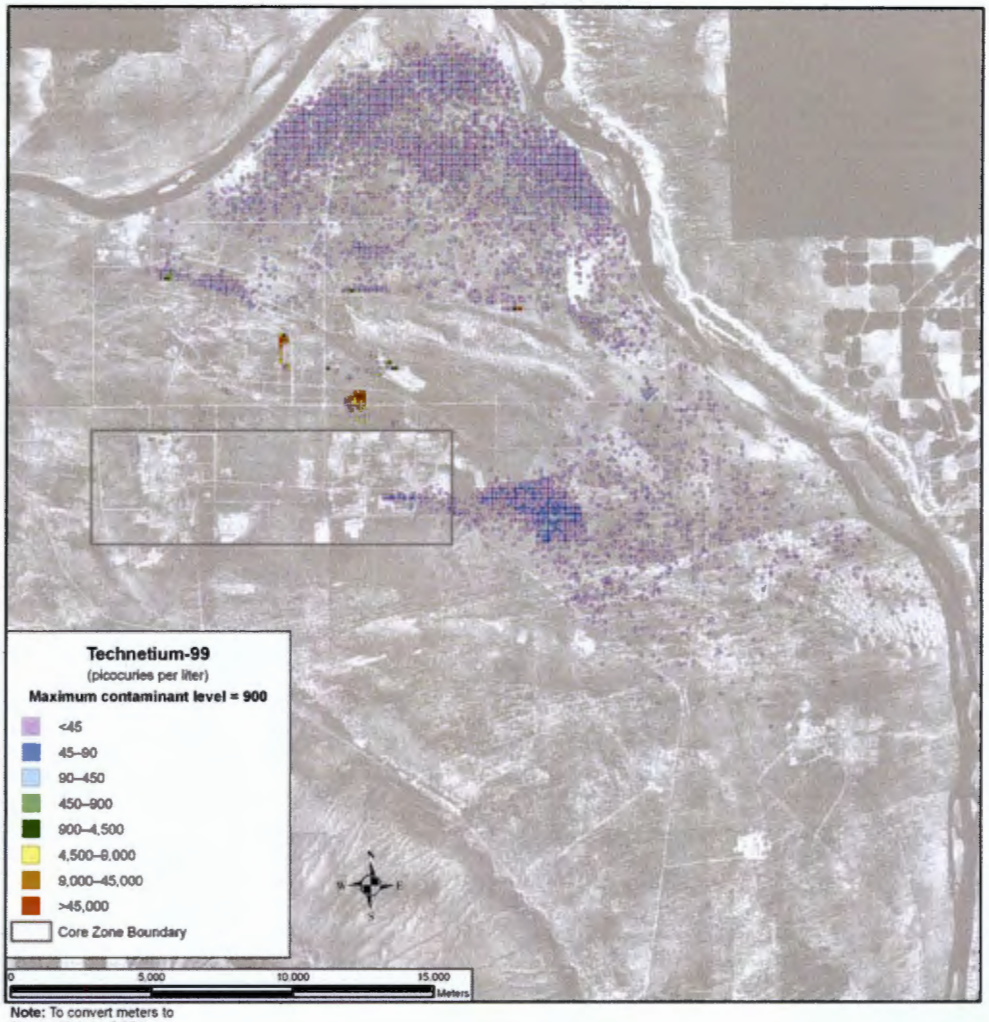
Note: To convert meters to feet, multiply by 3.281

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



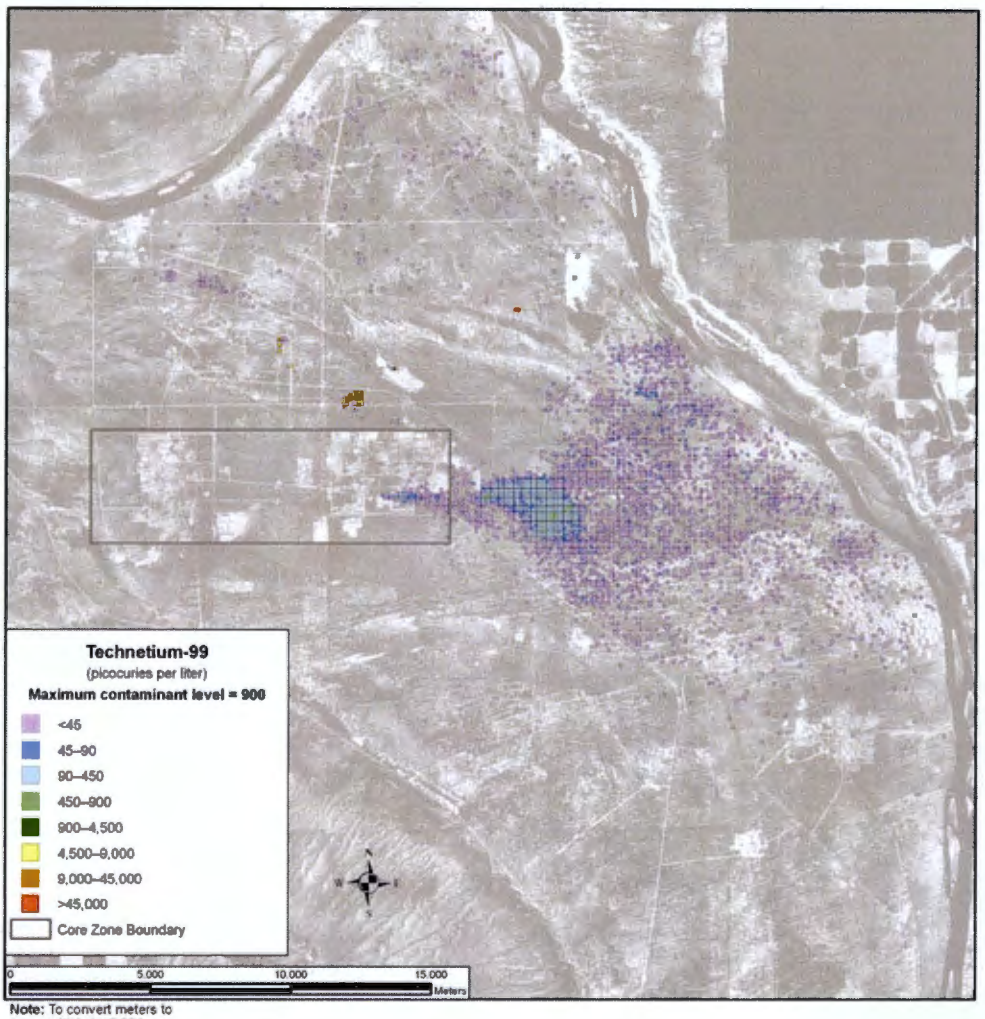
Note: To convert meters to feet, multiply by 3.281

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



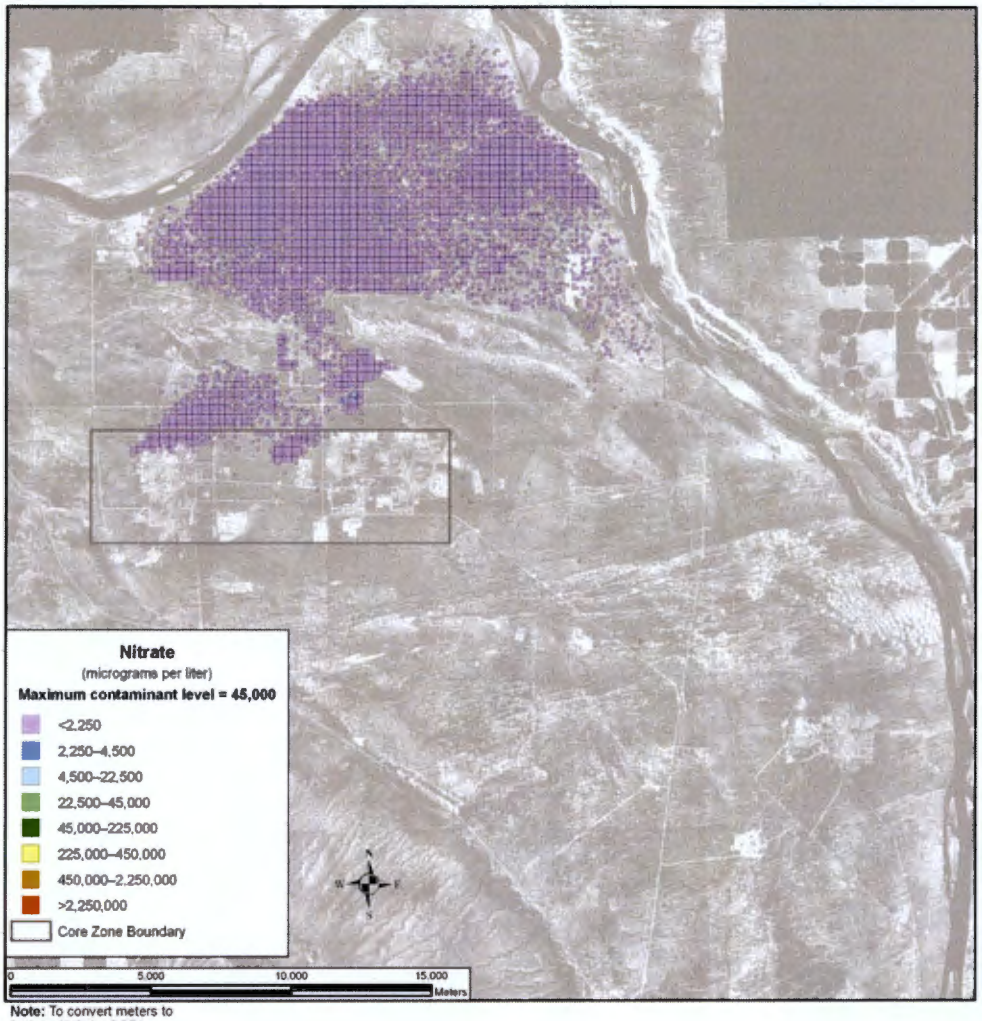
Note: To convert meters to feet, multiply by 3.281

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



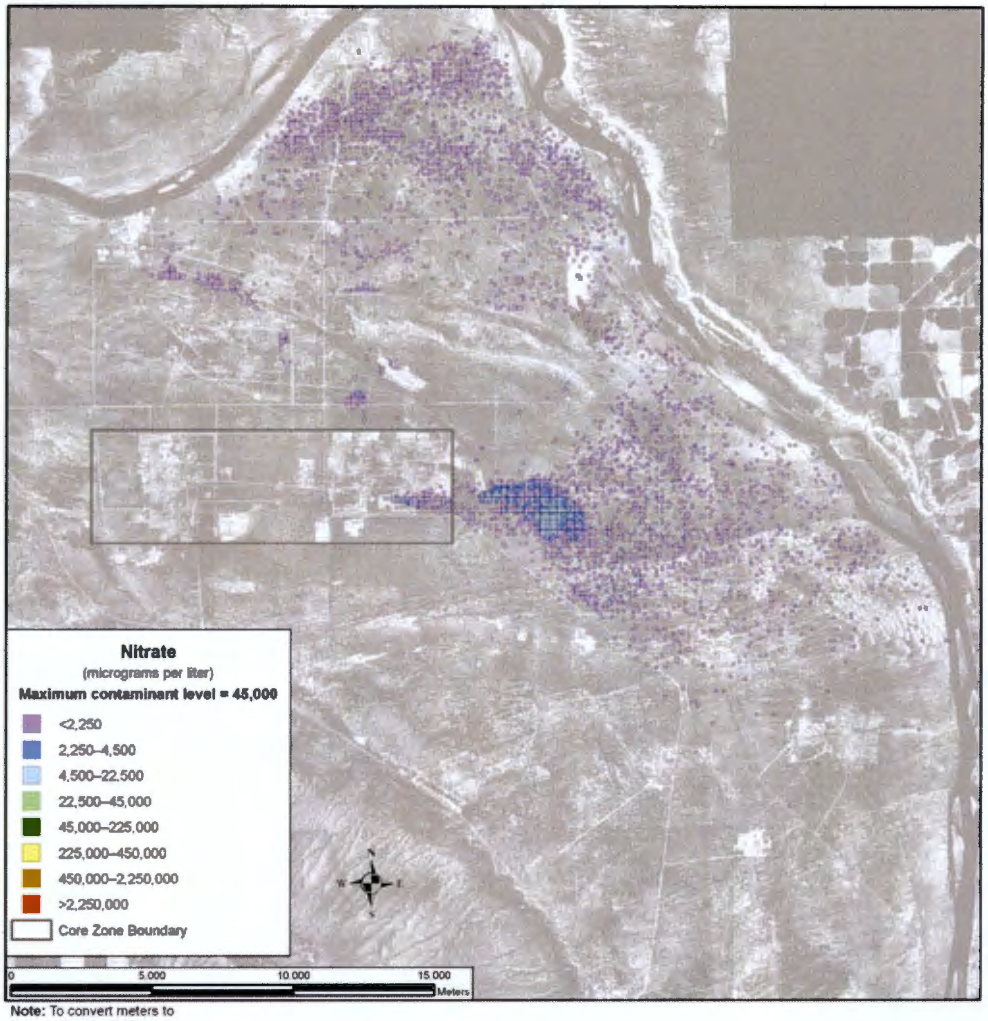
Note: To convert meters to feet, multiply by 3.281

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



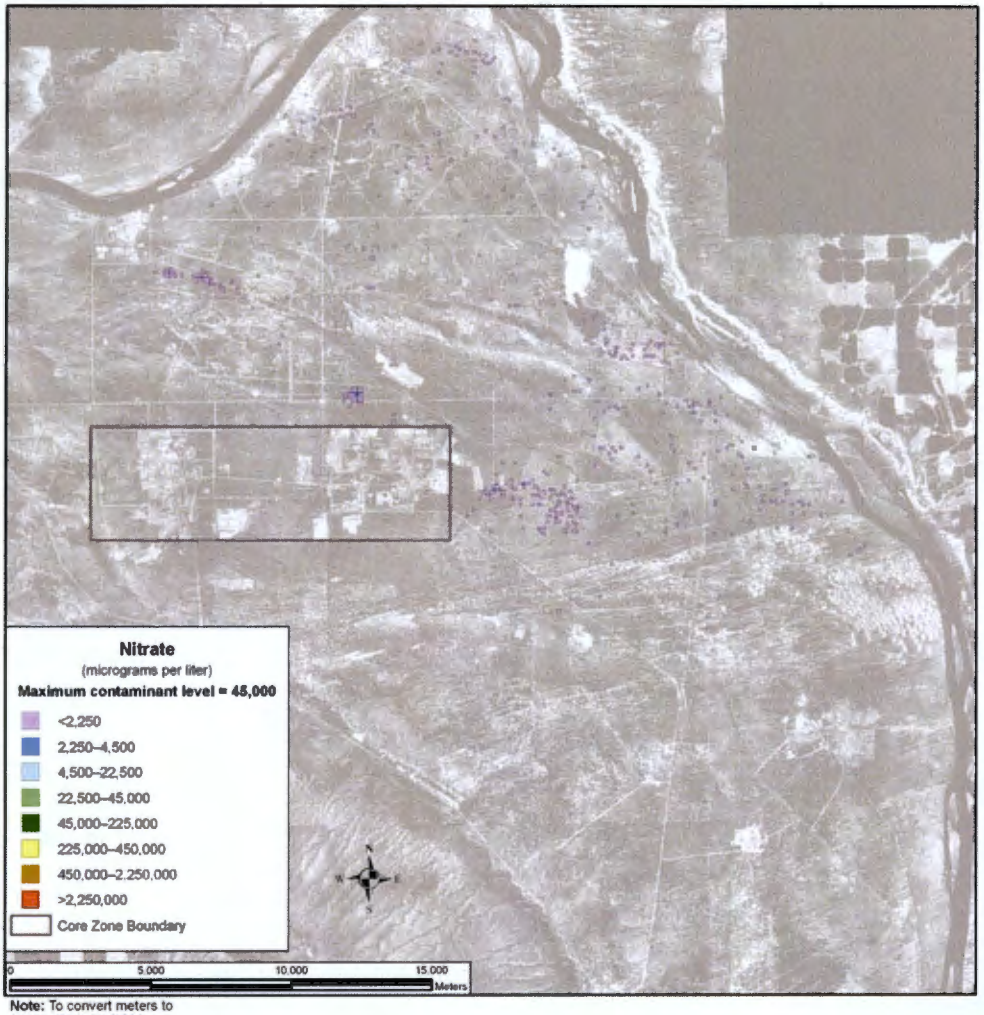
Note: To convert meters to feet, multiply by 3.281

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



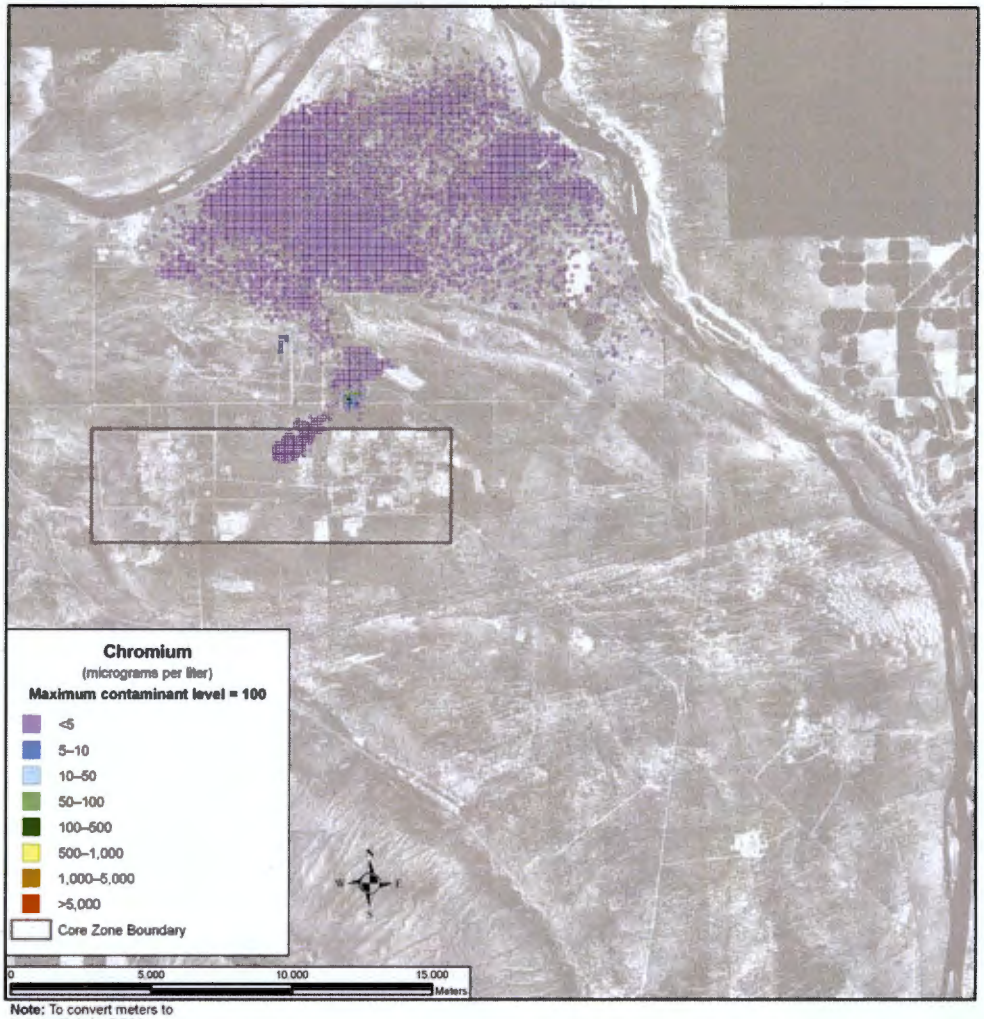
Note: To convert meters to feet, multiply by 3.281

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



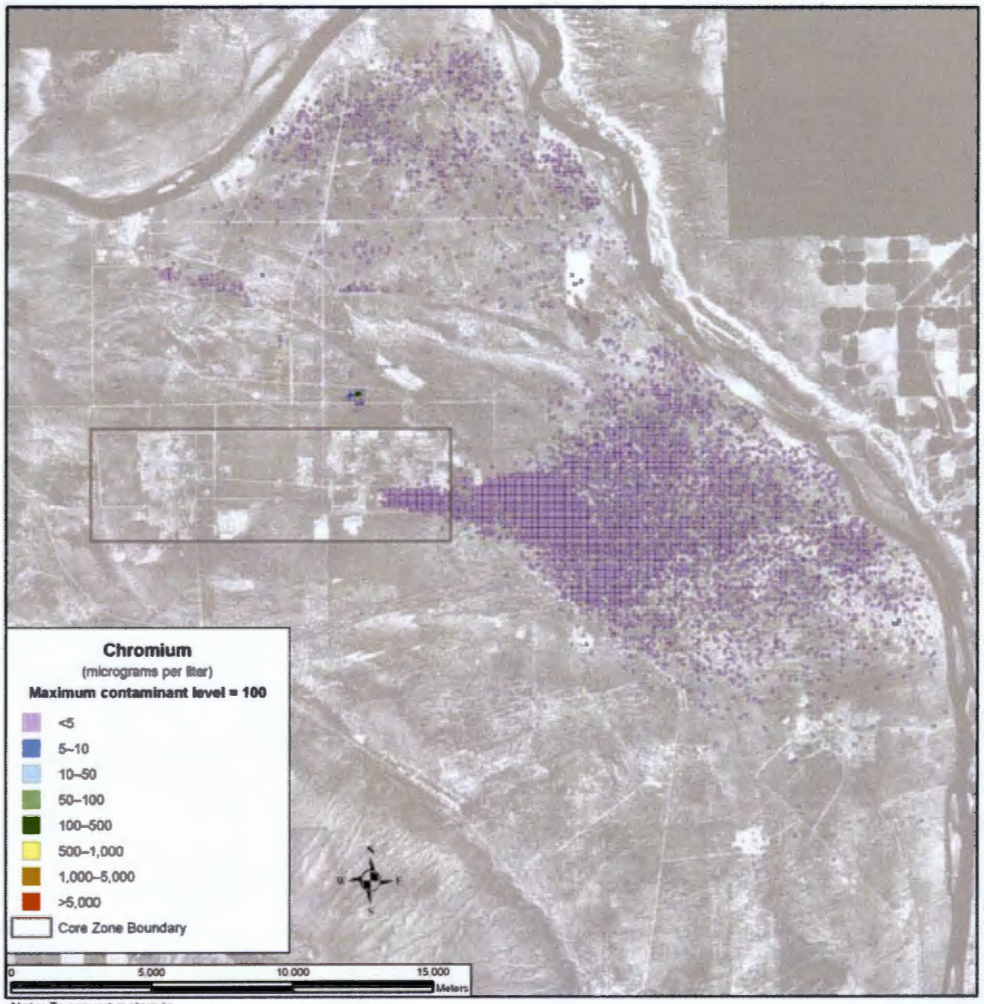
Note: To convert meters to feet, multiply by 3.281

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



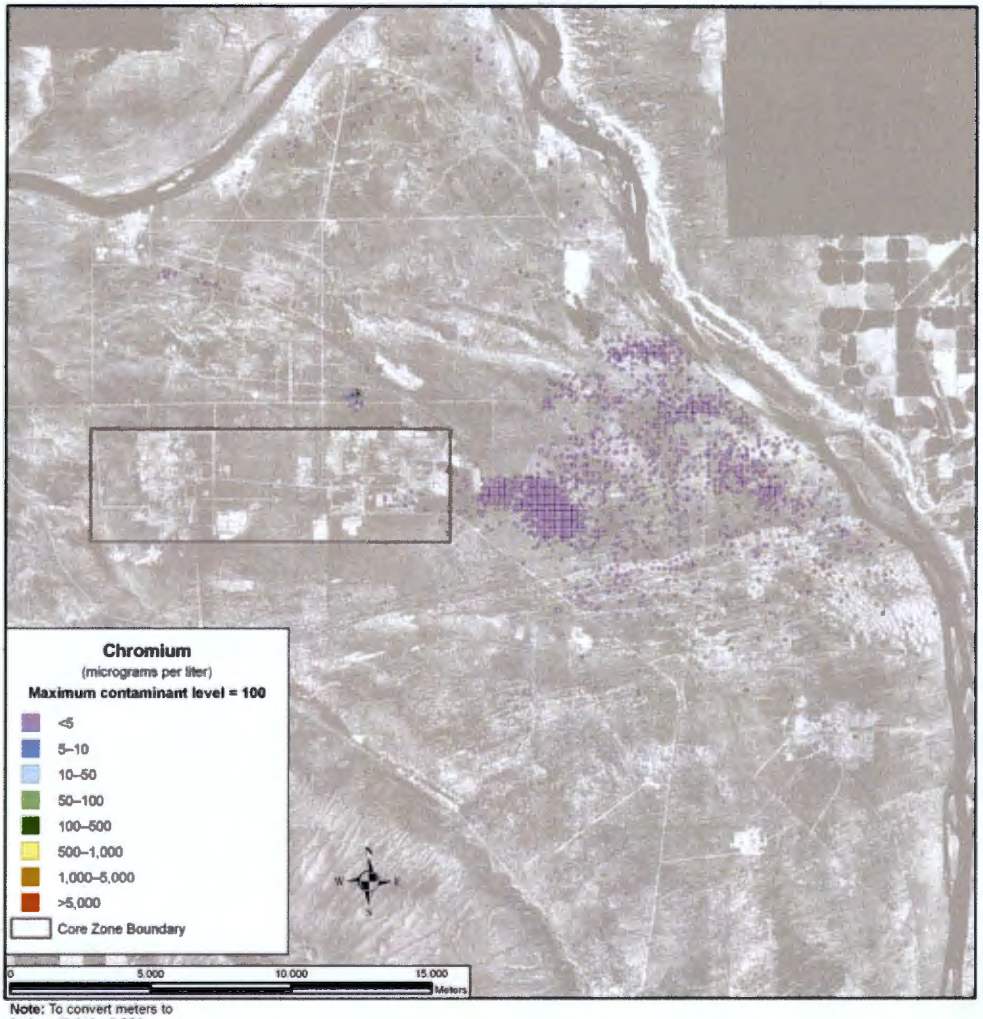
Note: To convert meters to feet, multiply by 3.281

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

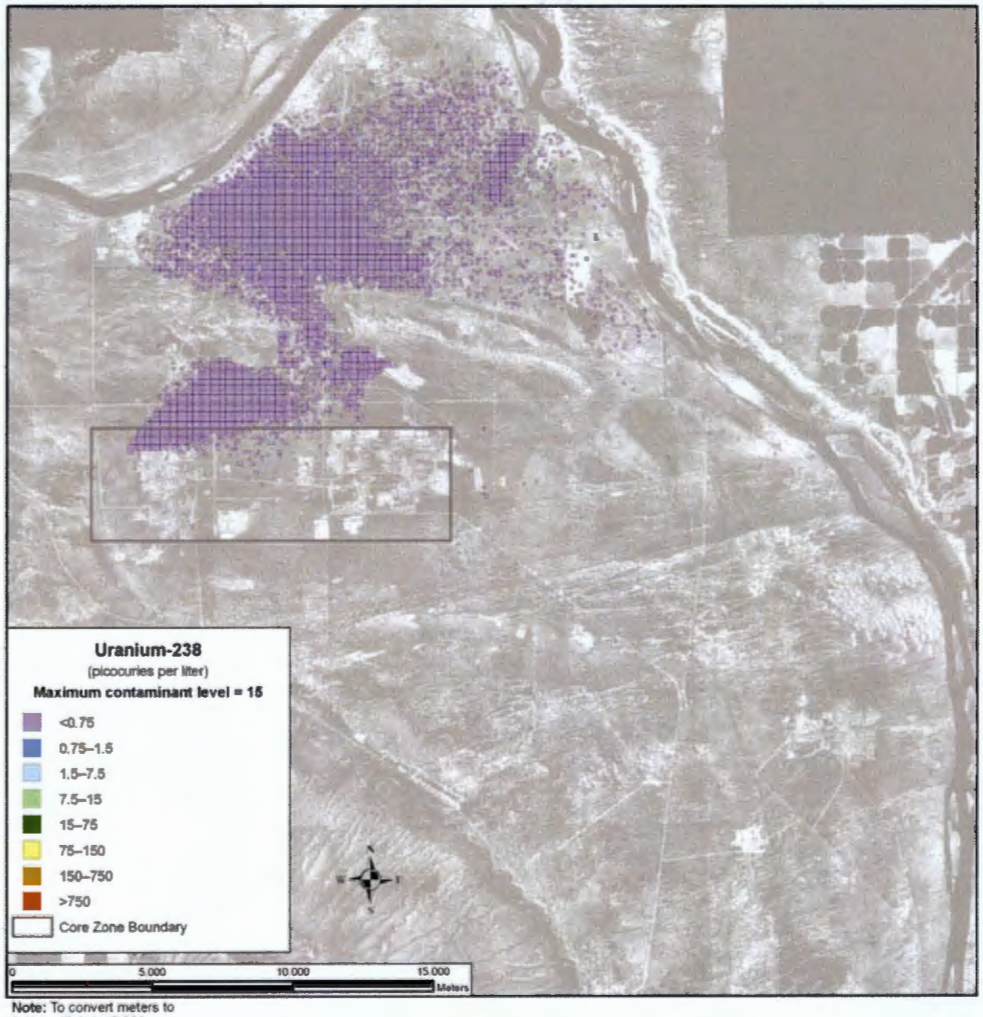
Figure 5–957. Waste Management Alternative 3, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



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.

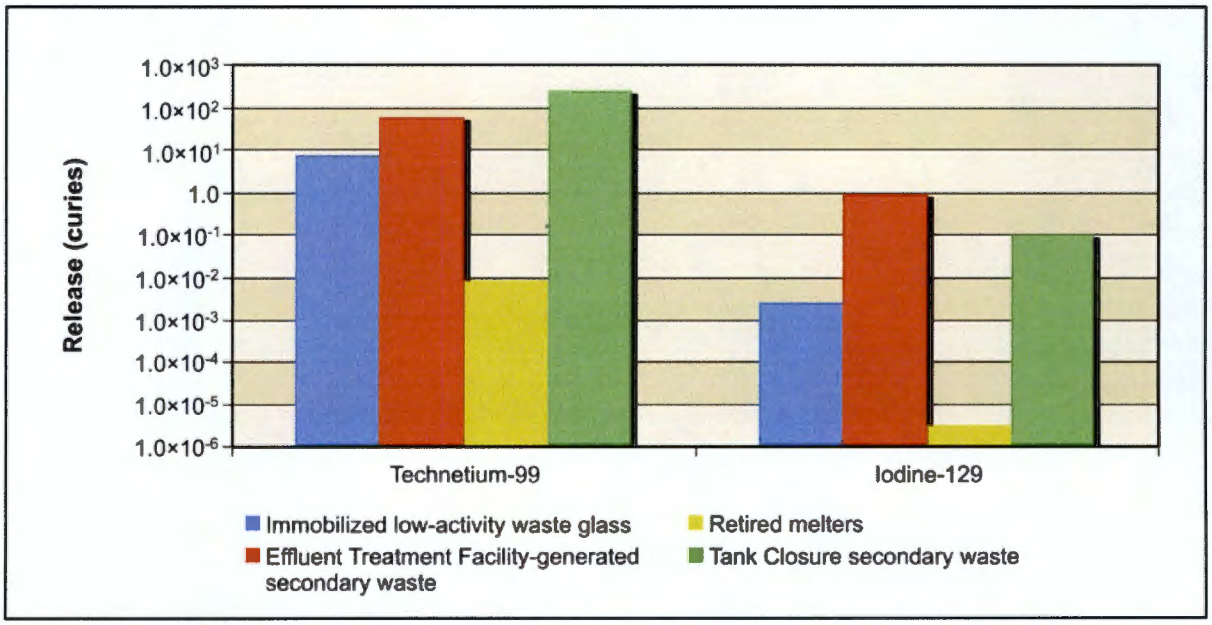


Figure 5–960. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

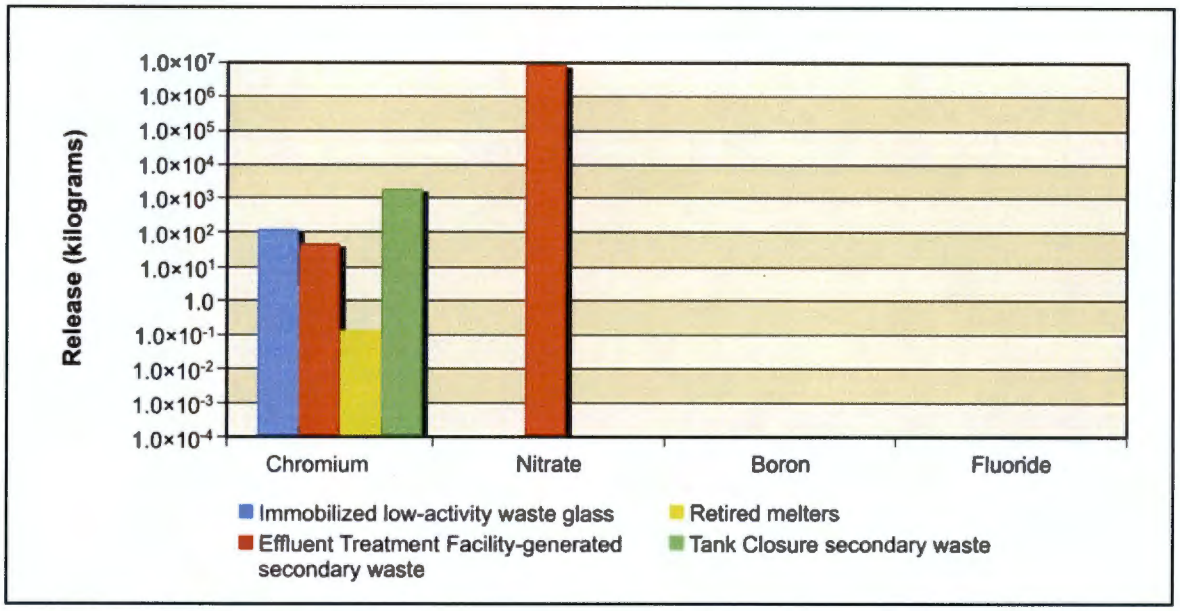


Figure 5–961. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

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.

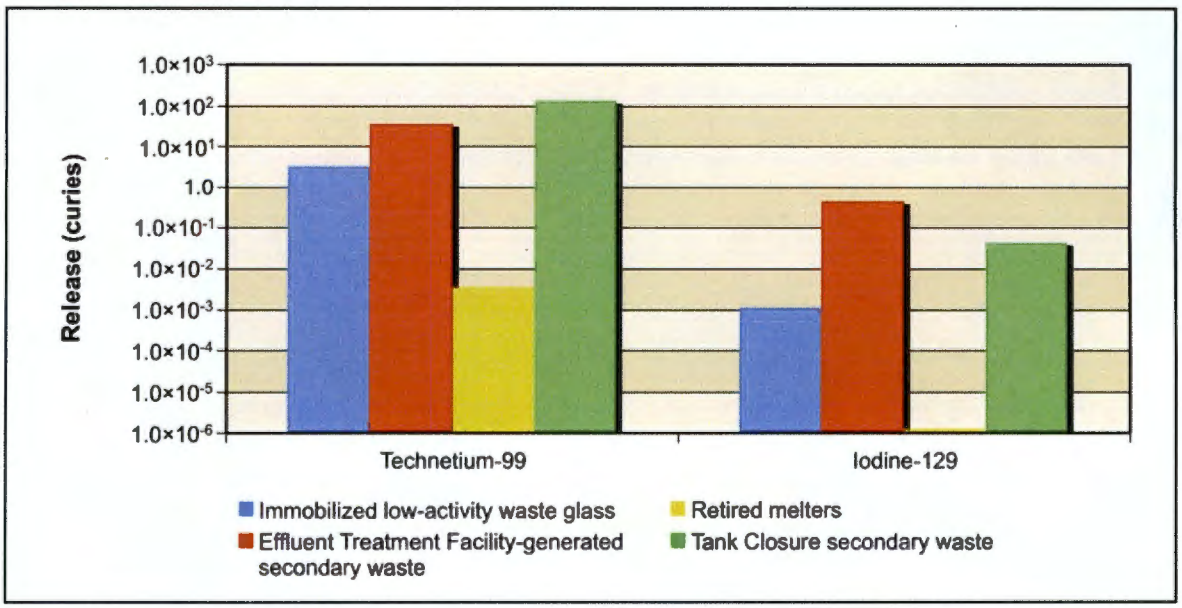


Figure 5–962. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

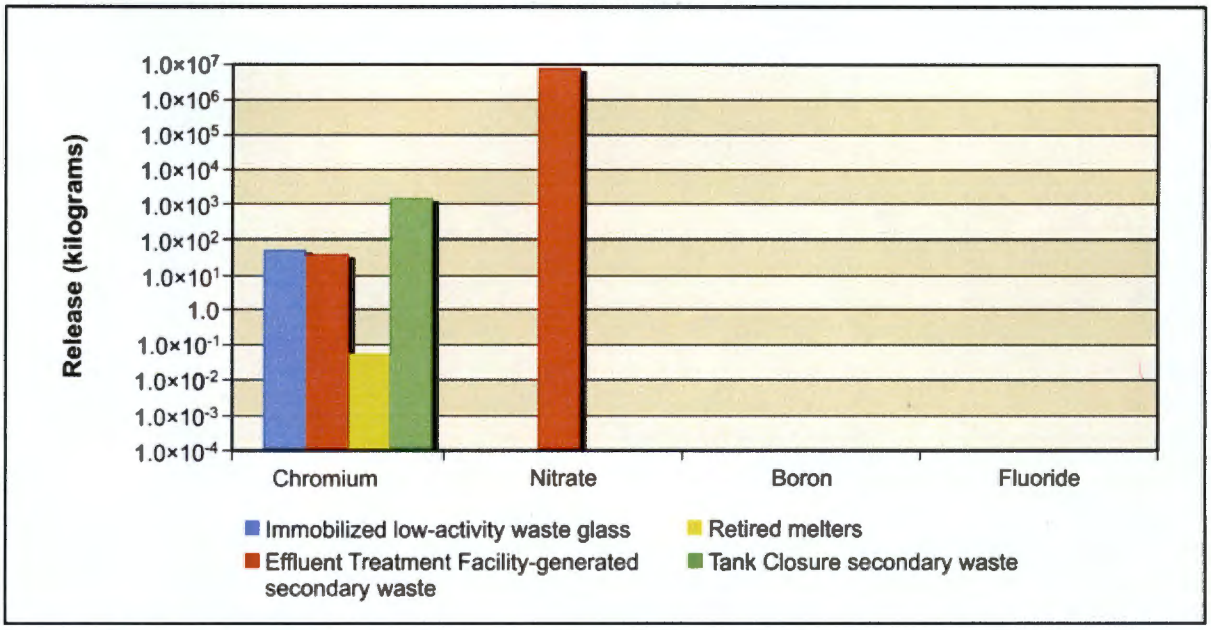


Figure 5–963. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

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.

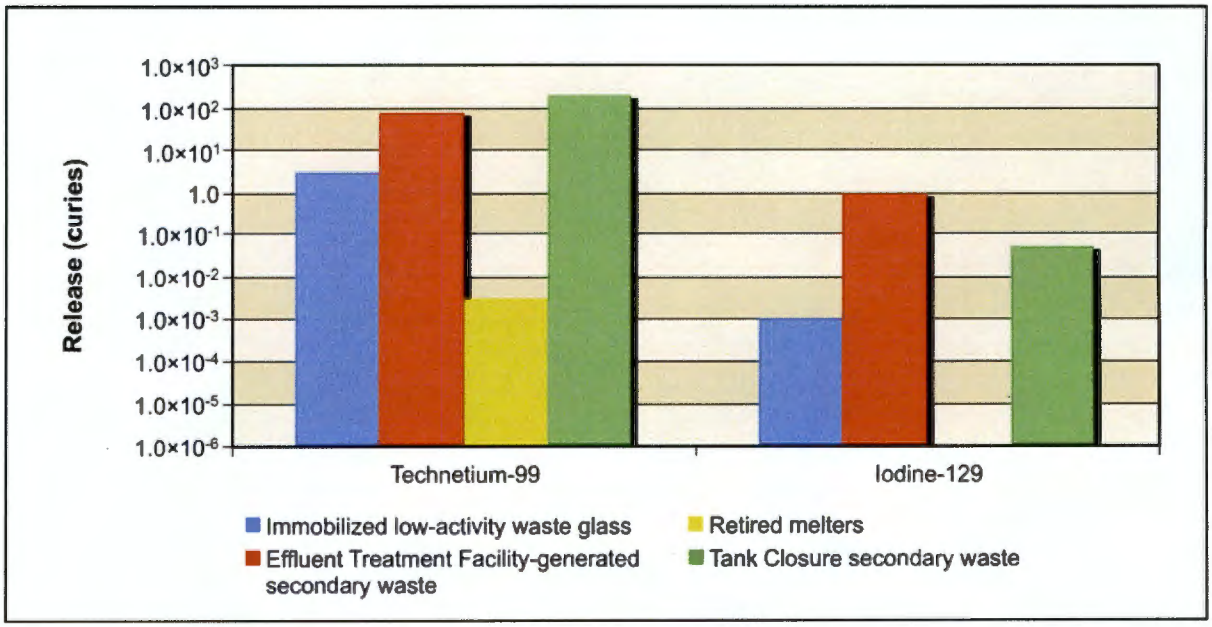


Figure 5–964. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

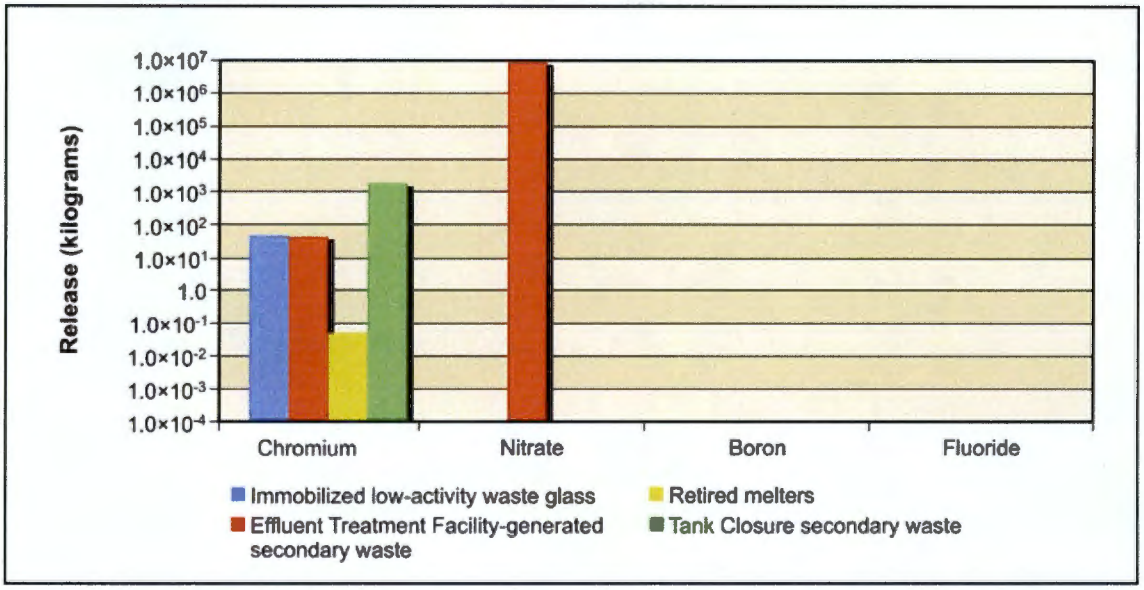


Figure 5–965. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

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.

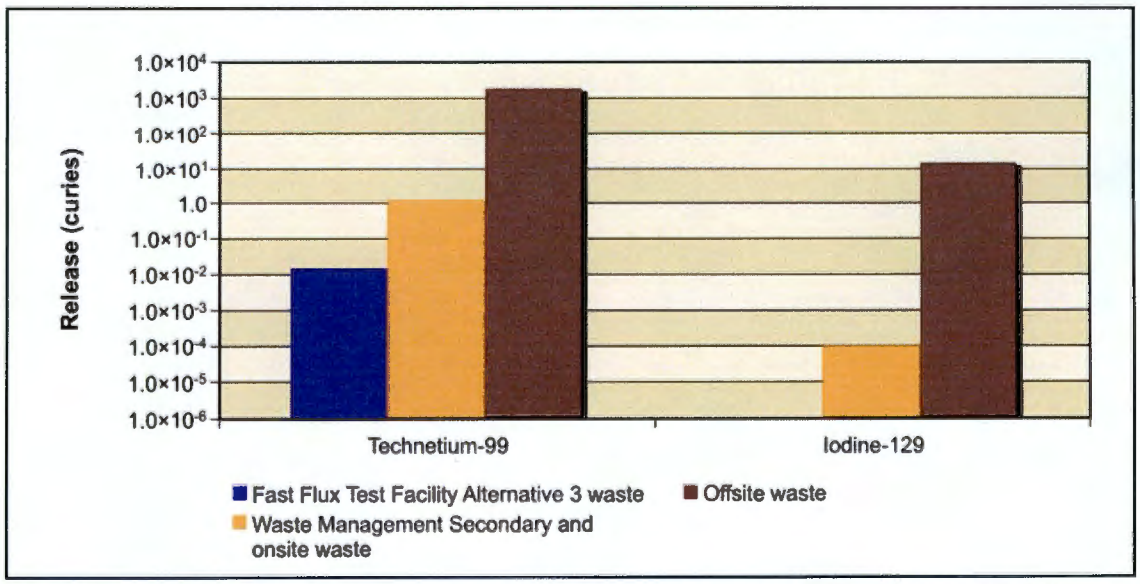


Figure 5–966. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

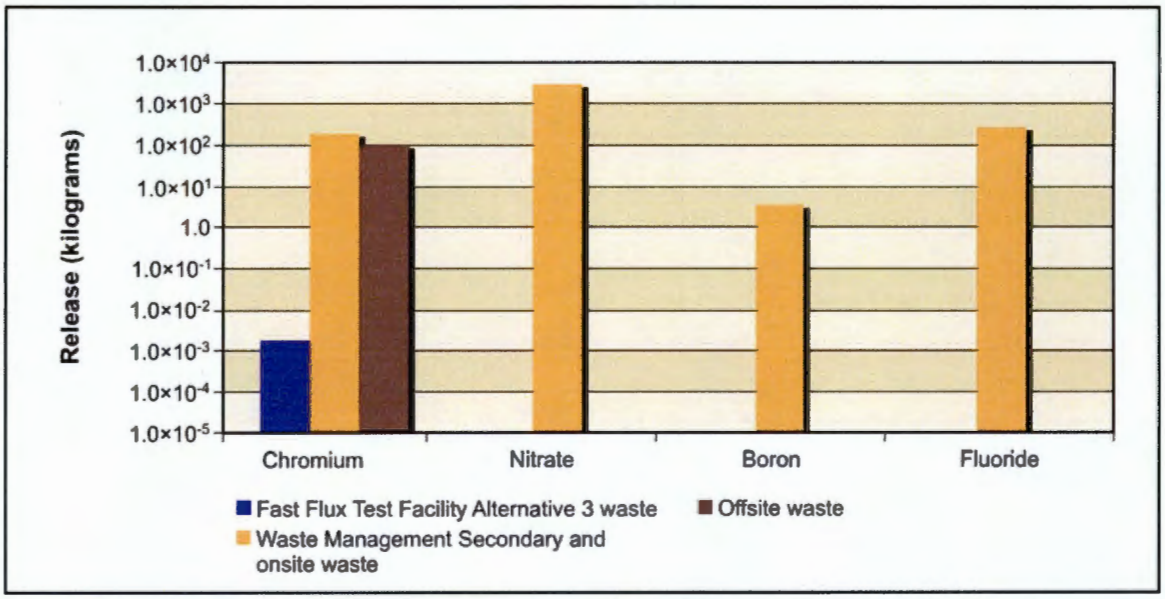


Figure 5–967. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

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.

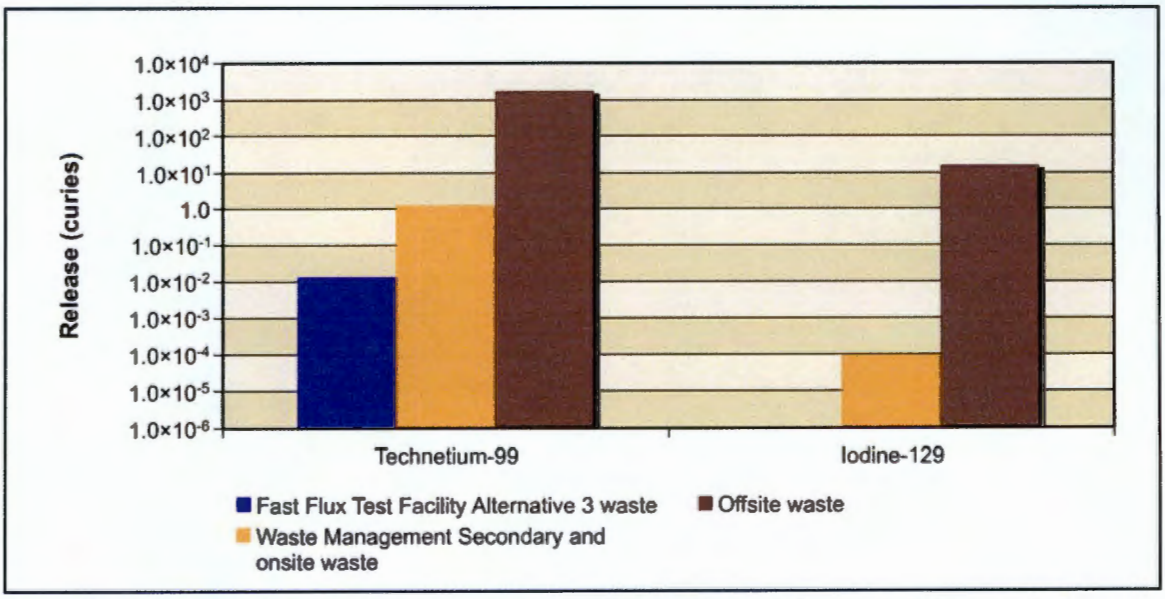


Figure 5–968. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

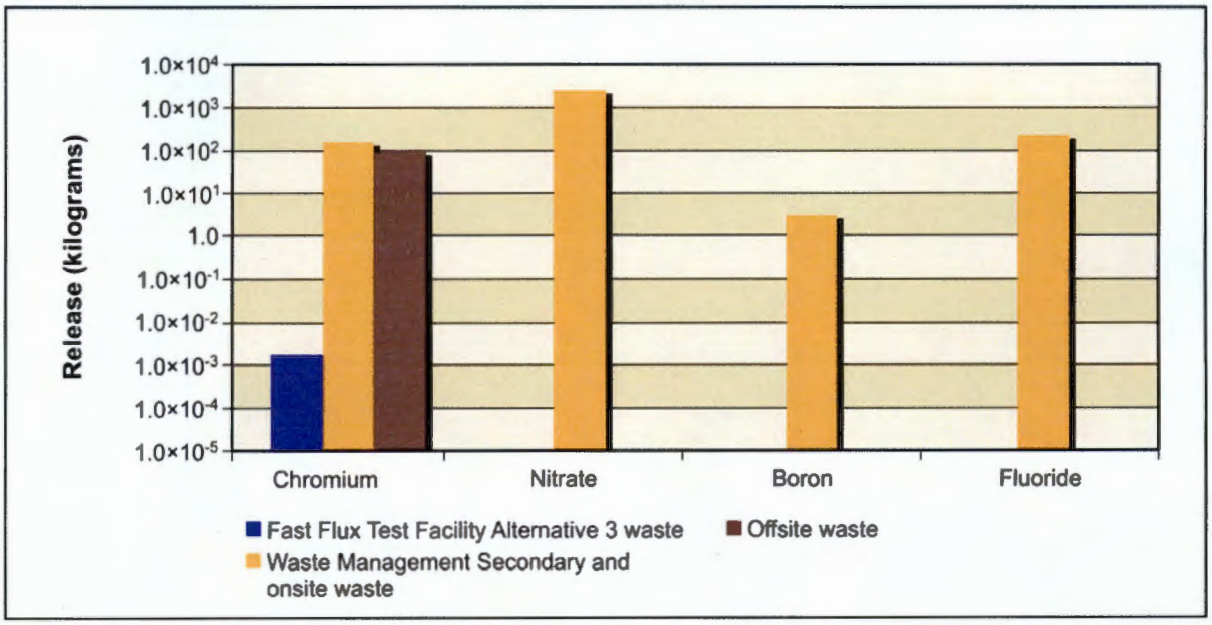


Figure 5–969. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

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.

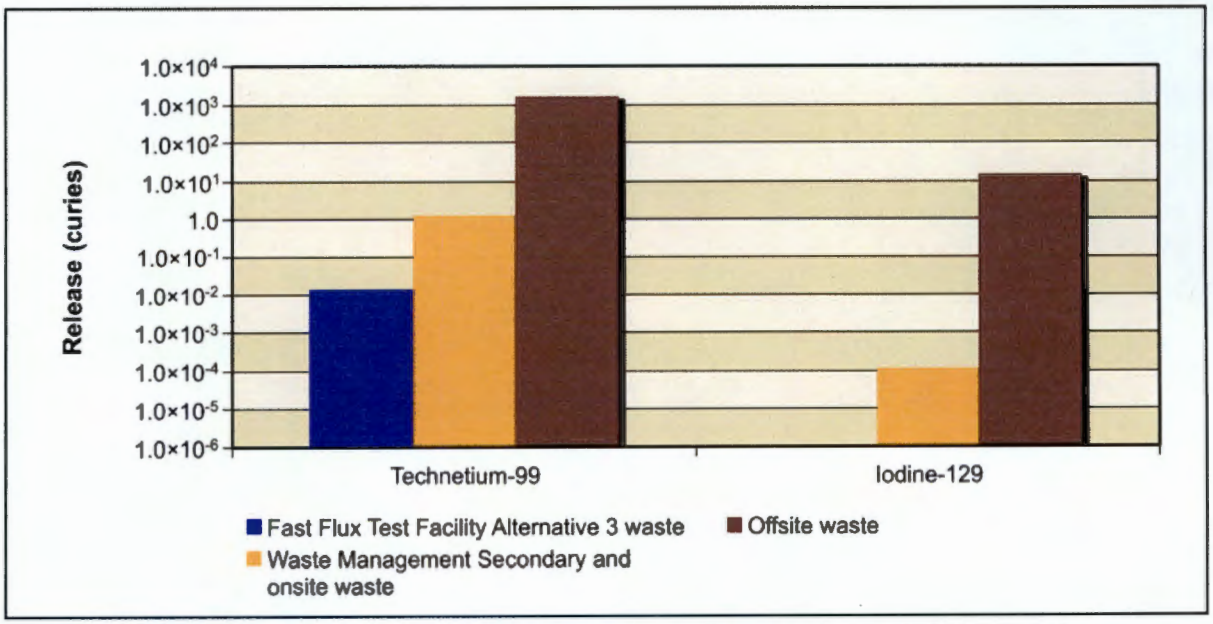


Figure 5–970. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

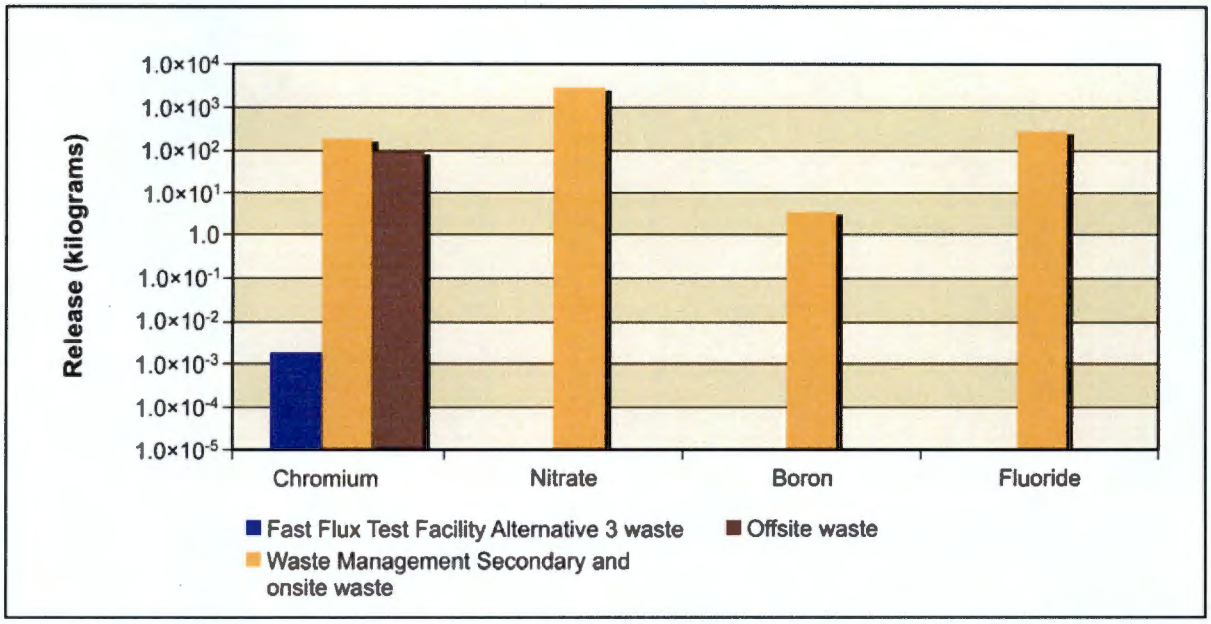


Figure 5–971. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

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.

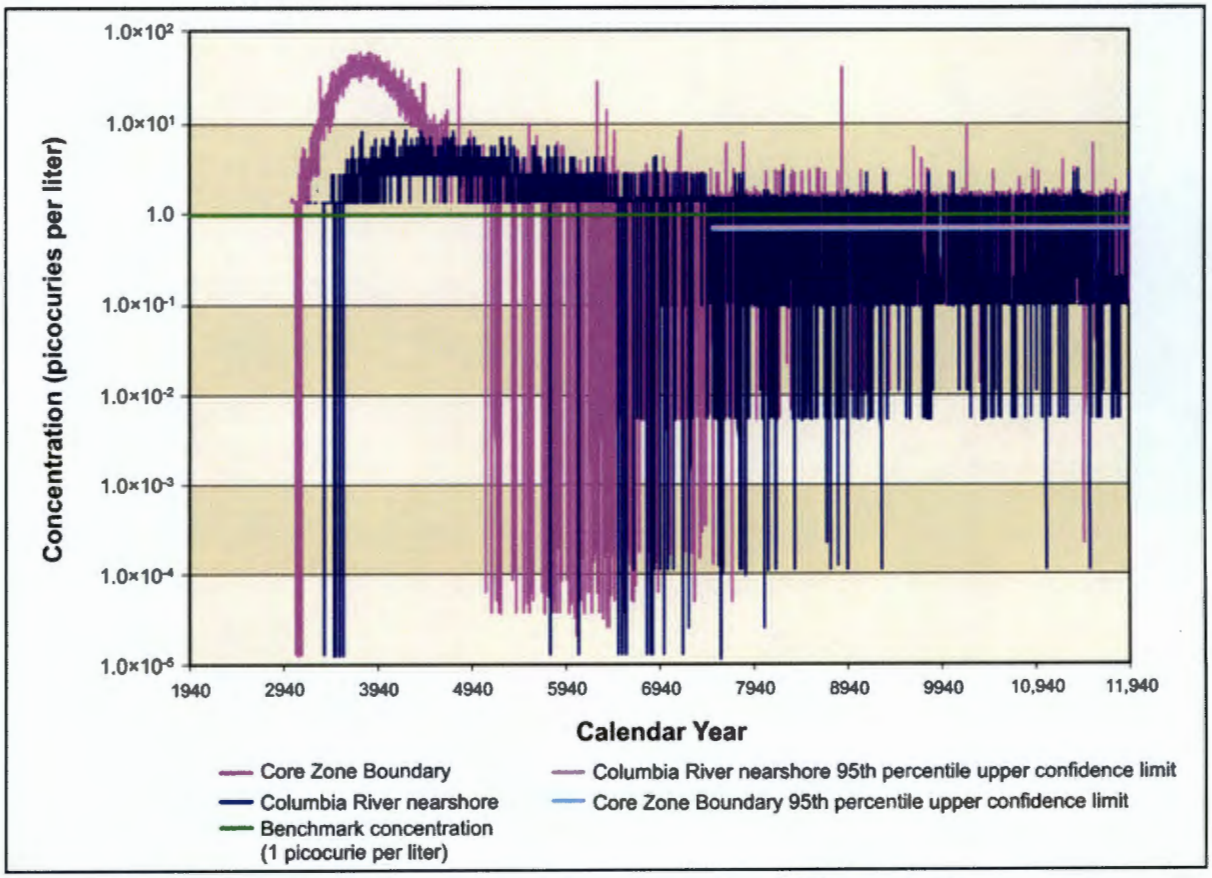


Figure 5–972. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Iodine-129 Concentration Versus Time

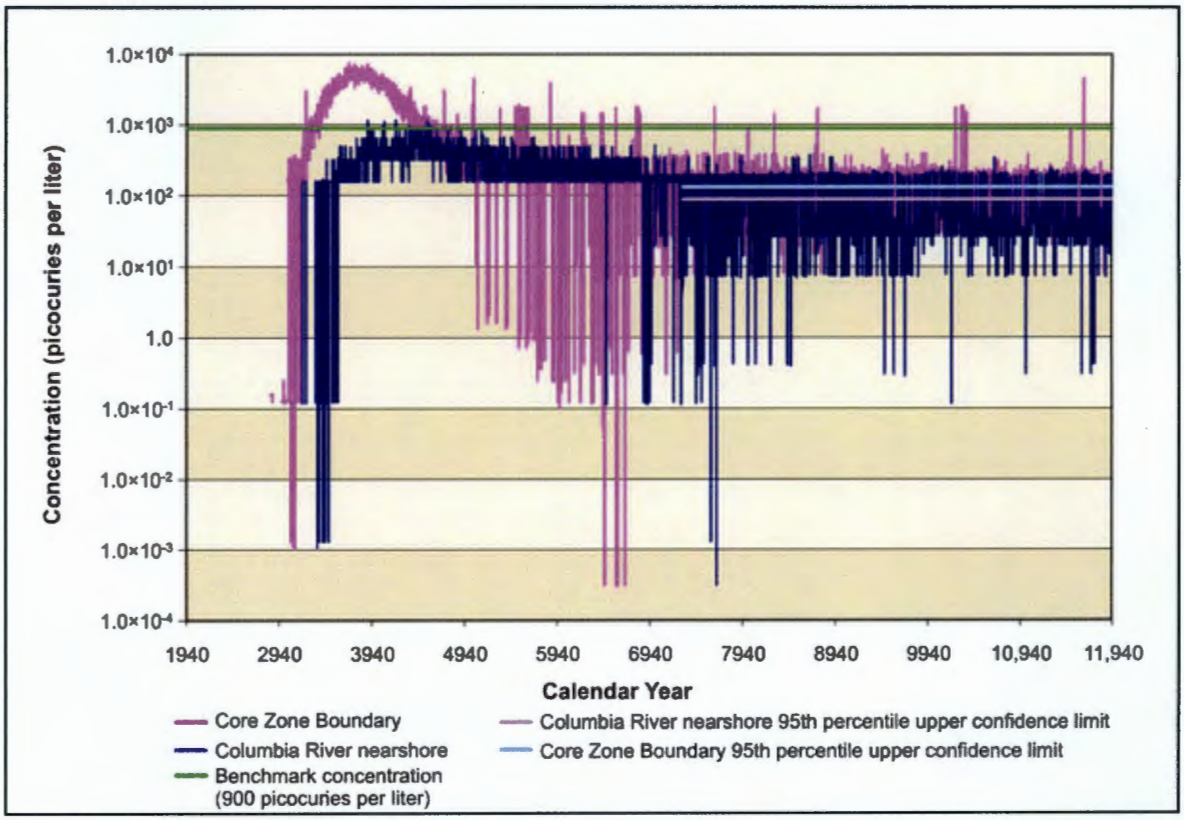


Figure 5–973. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Technetium-99 Concentration Versus Time

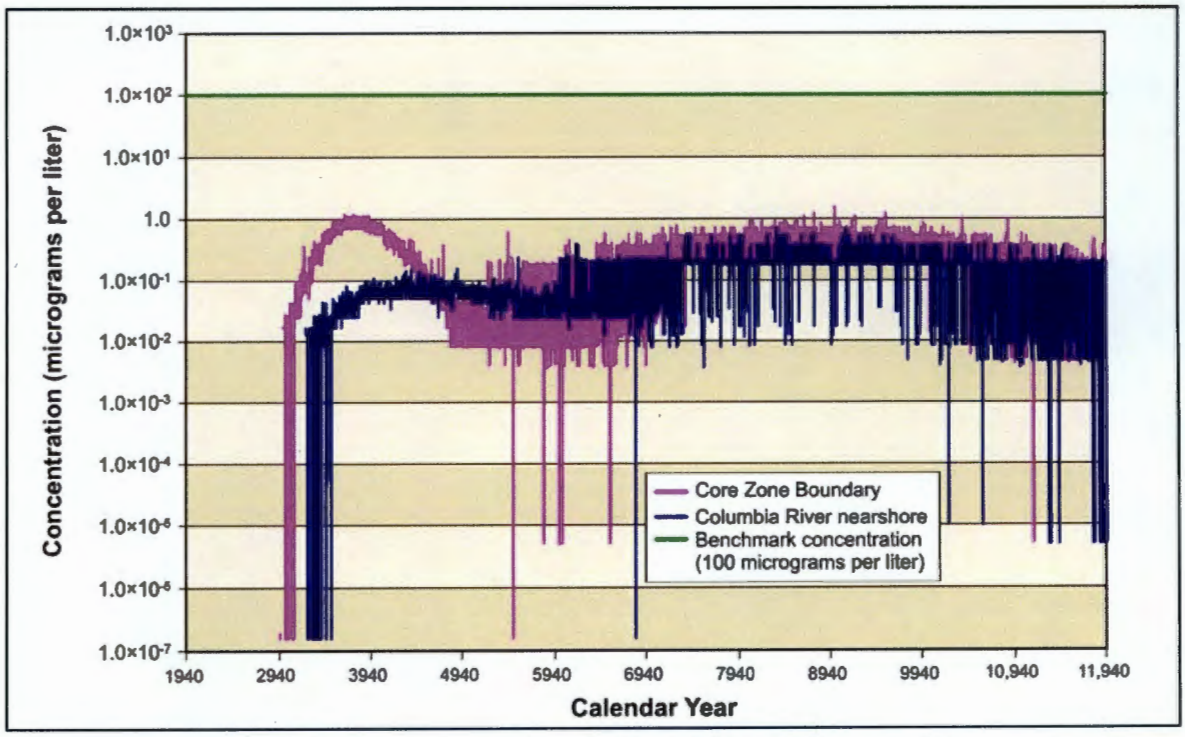


Figure 5–974. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Chromium Concentration Versus Time

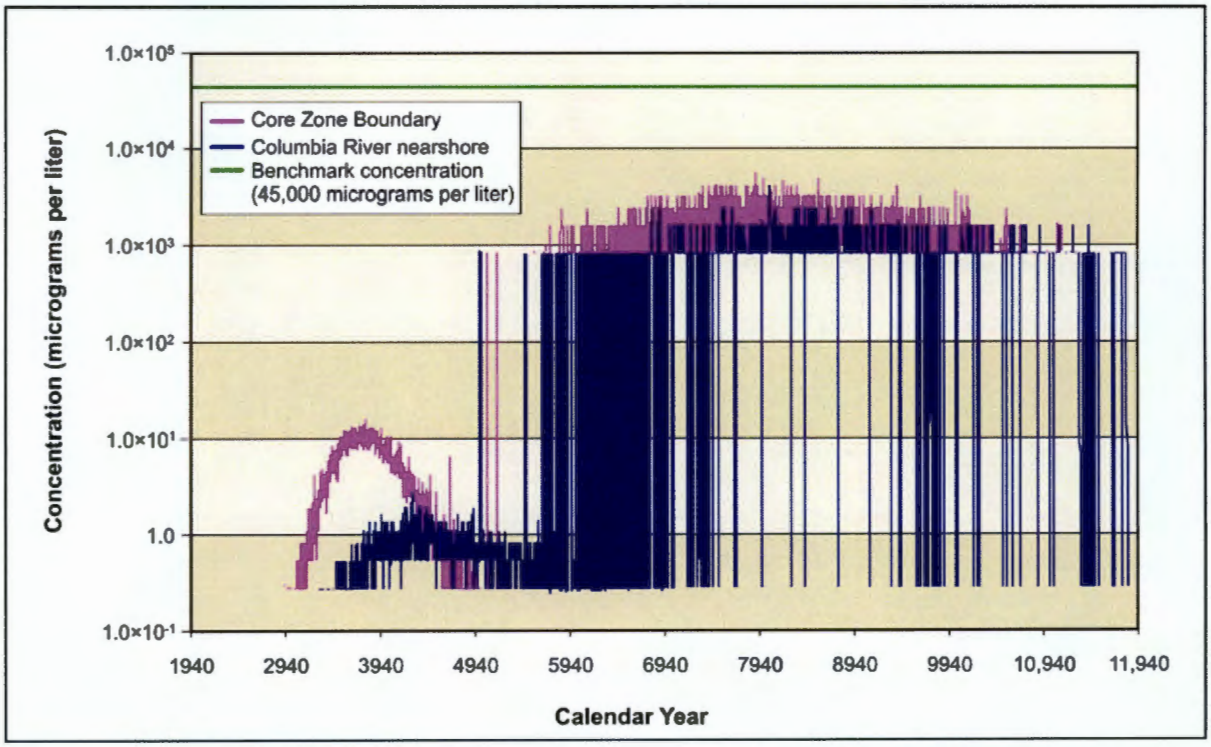


Figure 5–975. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Nitrate Concentration Versus Time

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.

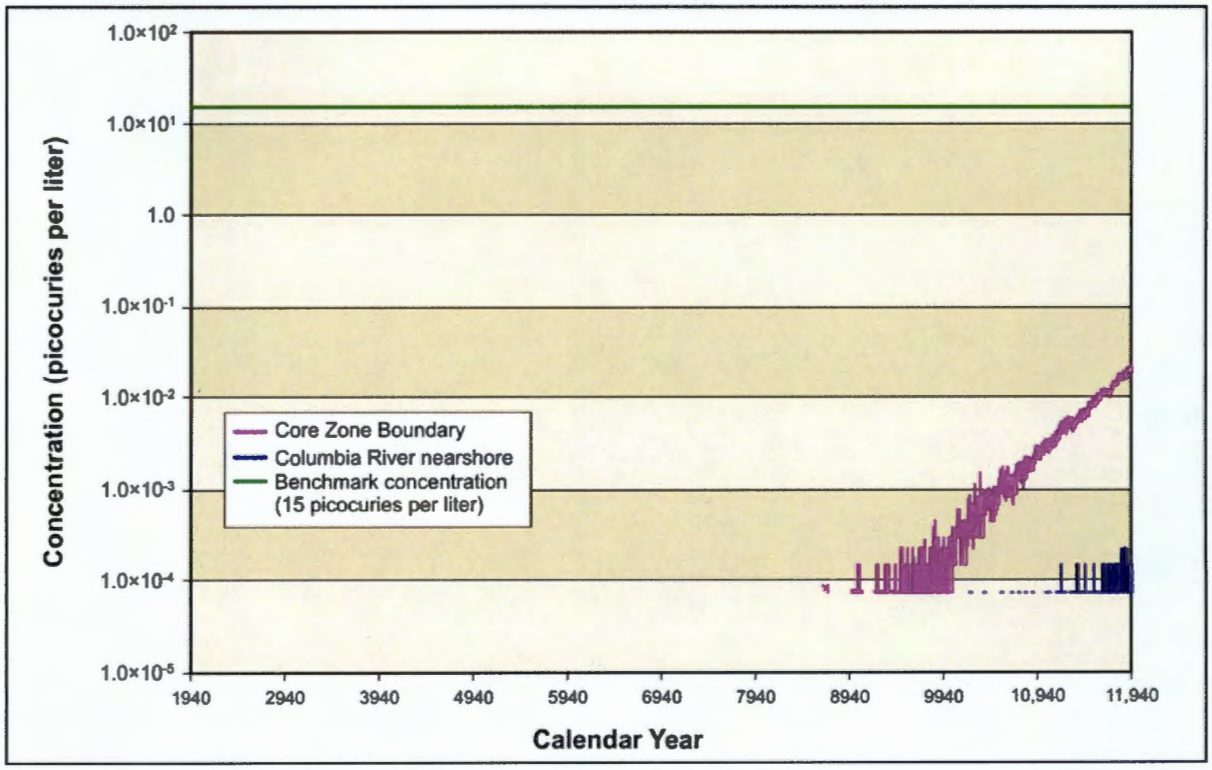
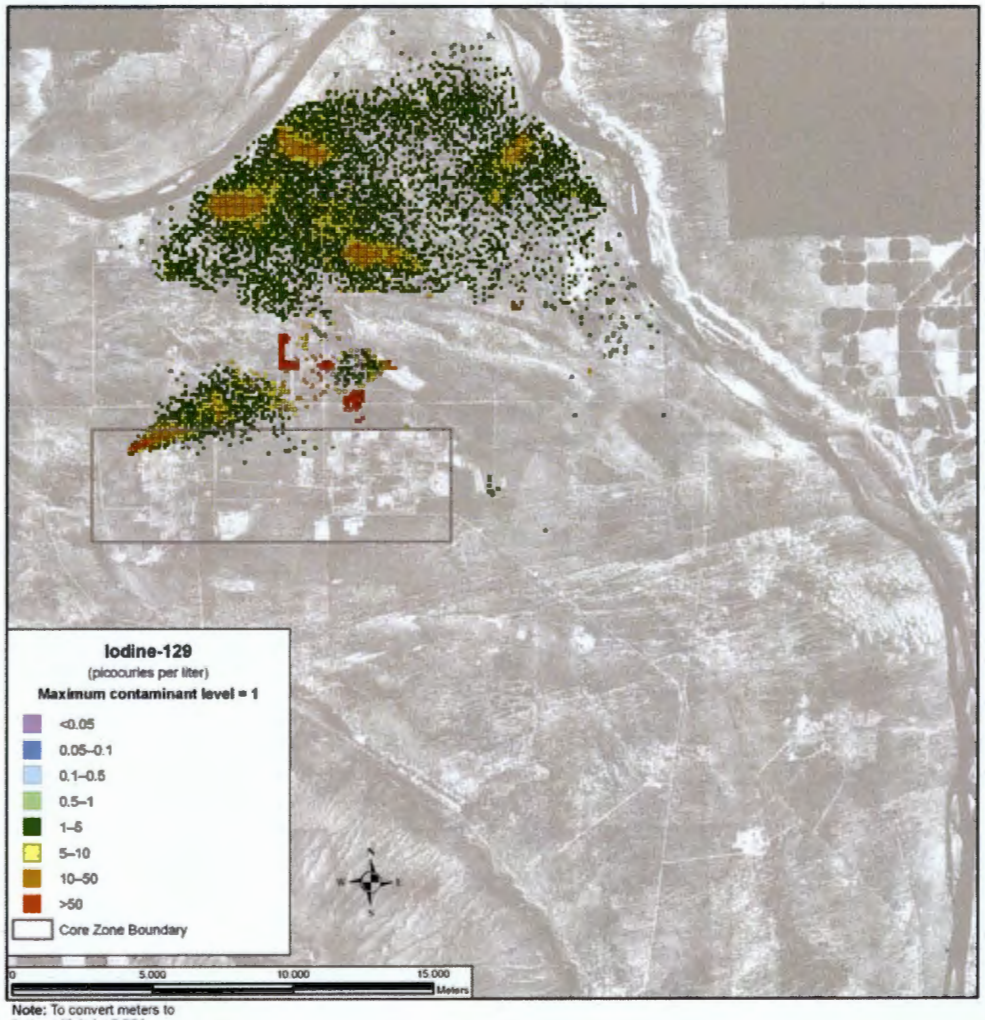


Figure 5–976. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Uranium-238 Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

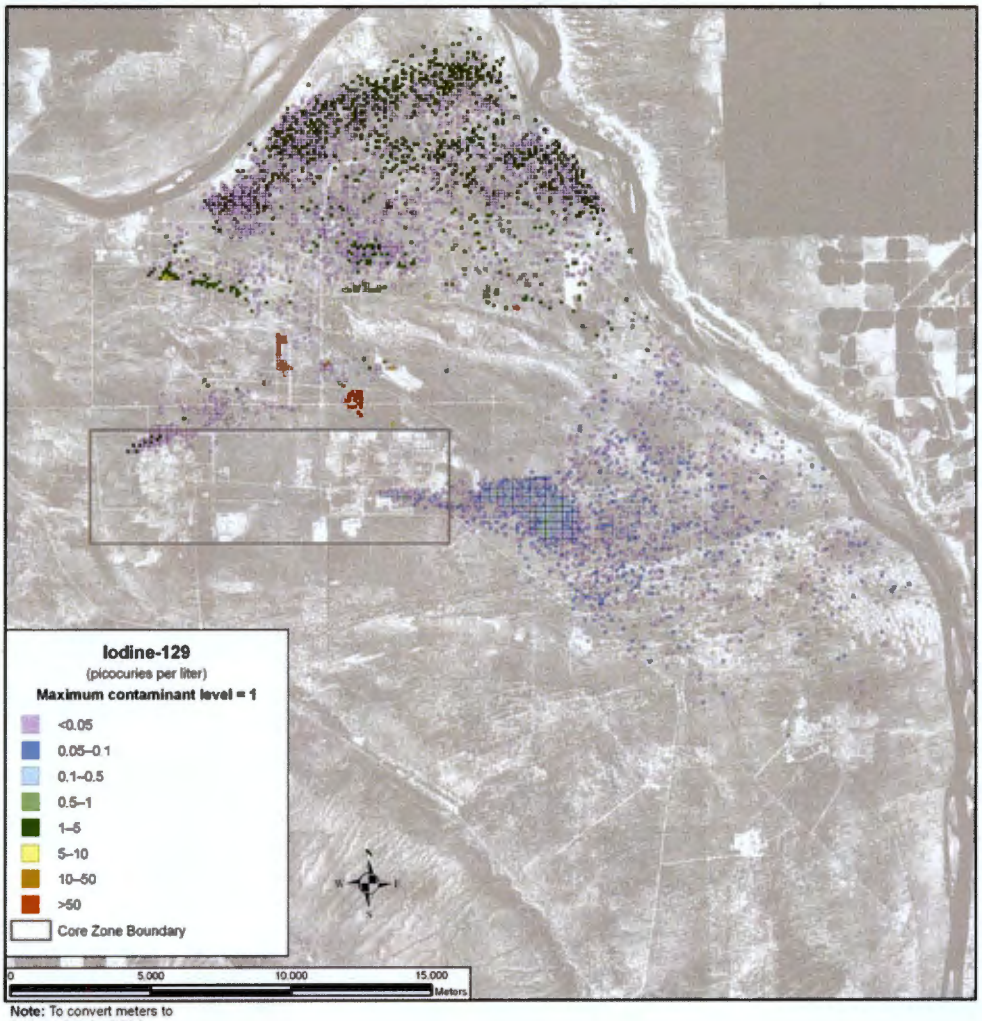
This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations of 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).



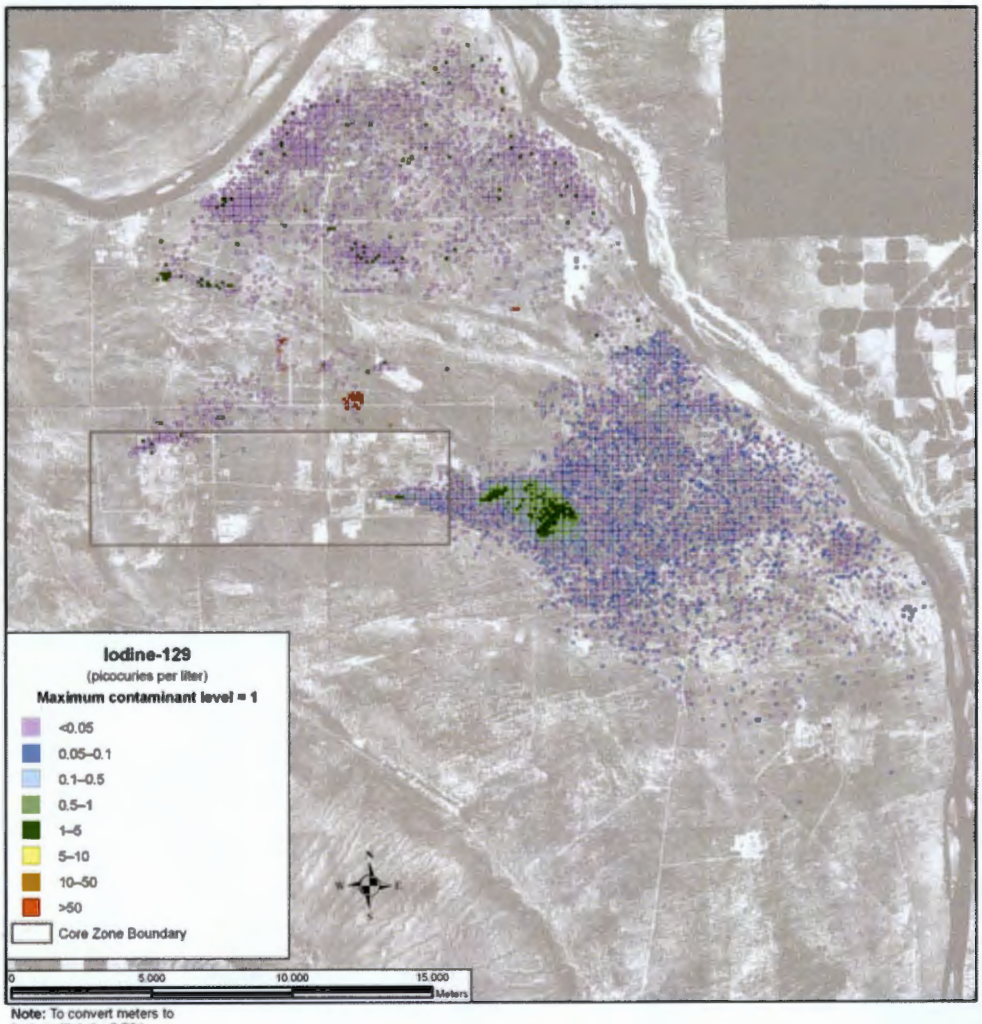
Note: To convert meters to feet, multiply by 3.281

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



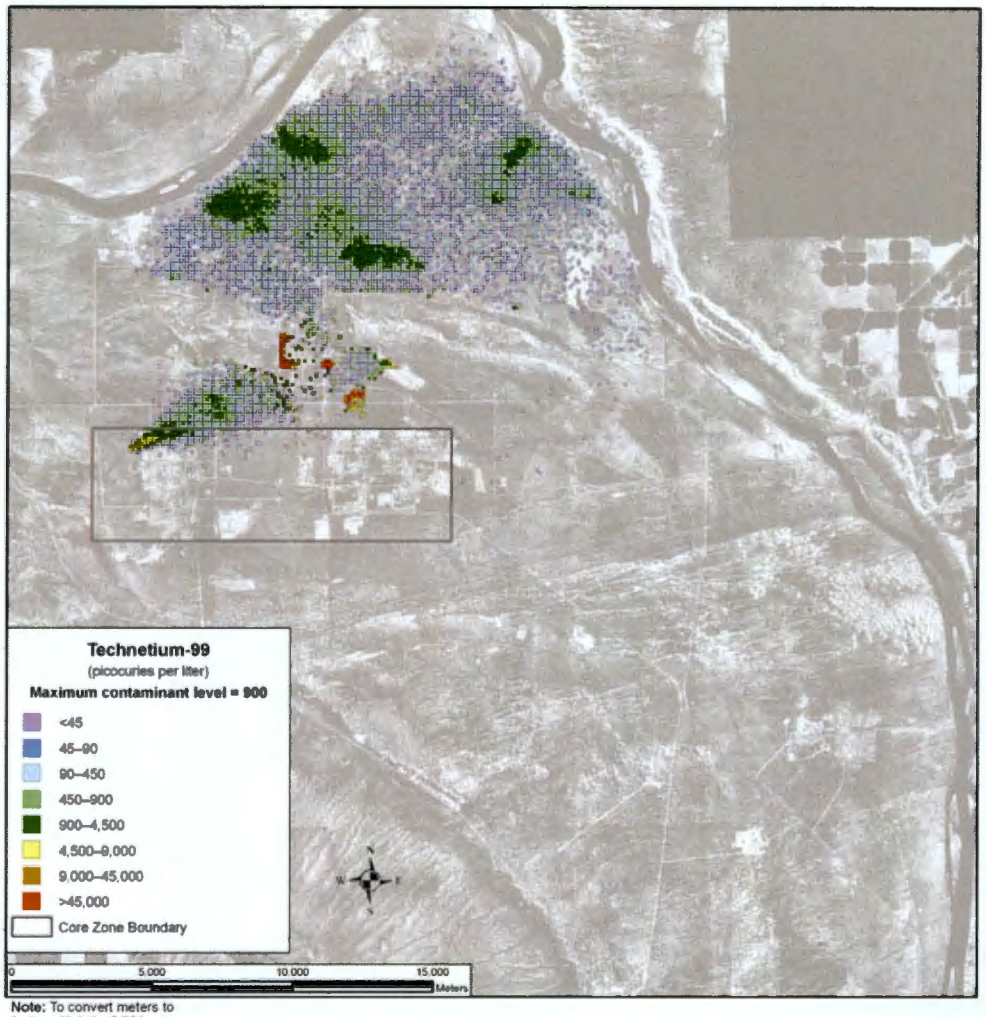
Note: To convert meters to feet, multiply by 3.281

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



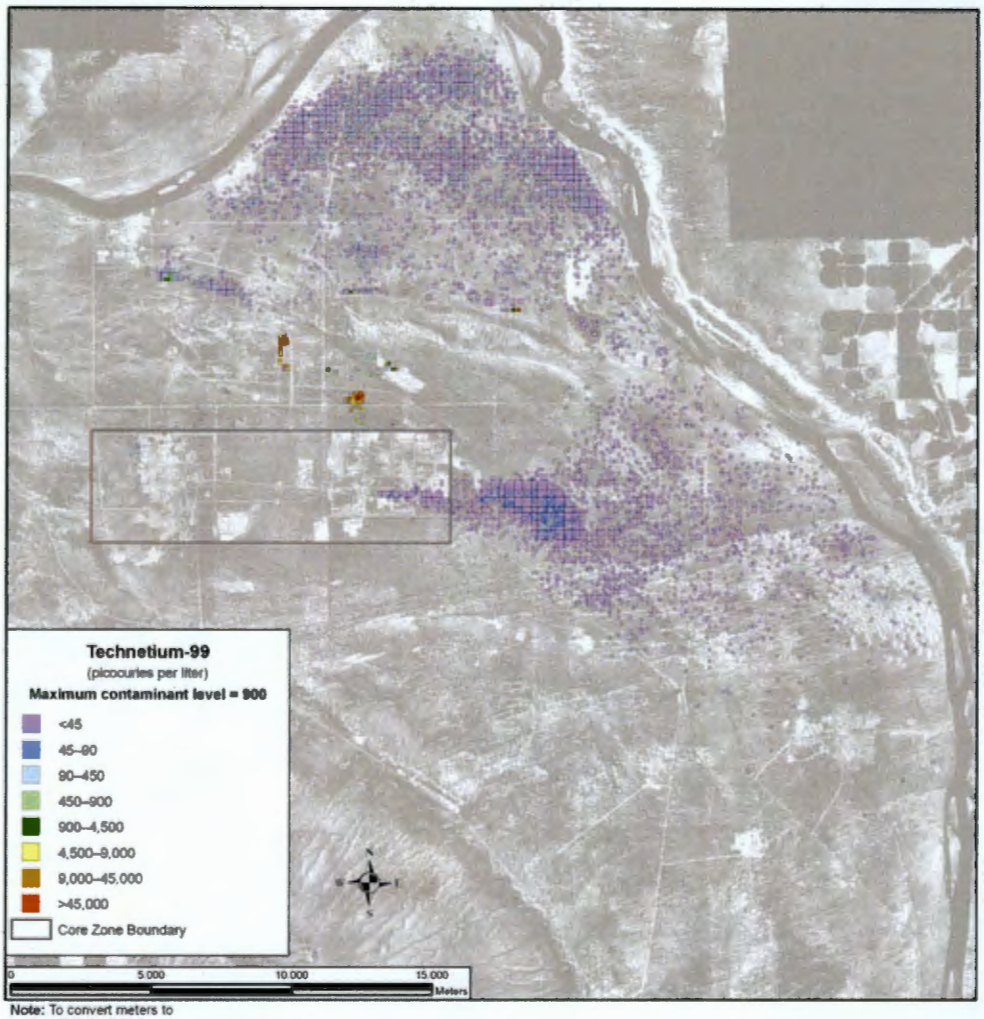
Note: To convert meters to feet, multiply by 3.281

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



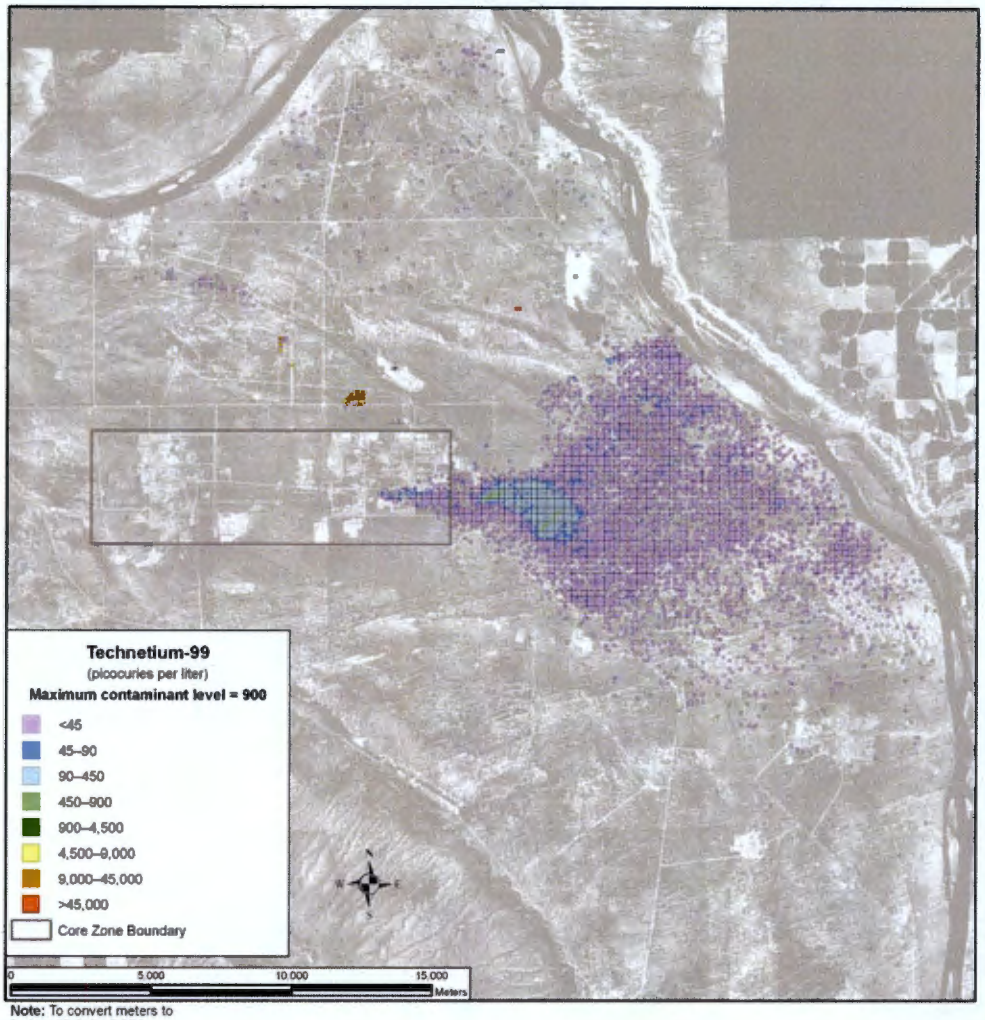
Note: To convert meters to feet, multiply by 3.281

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



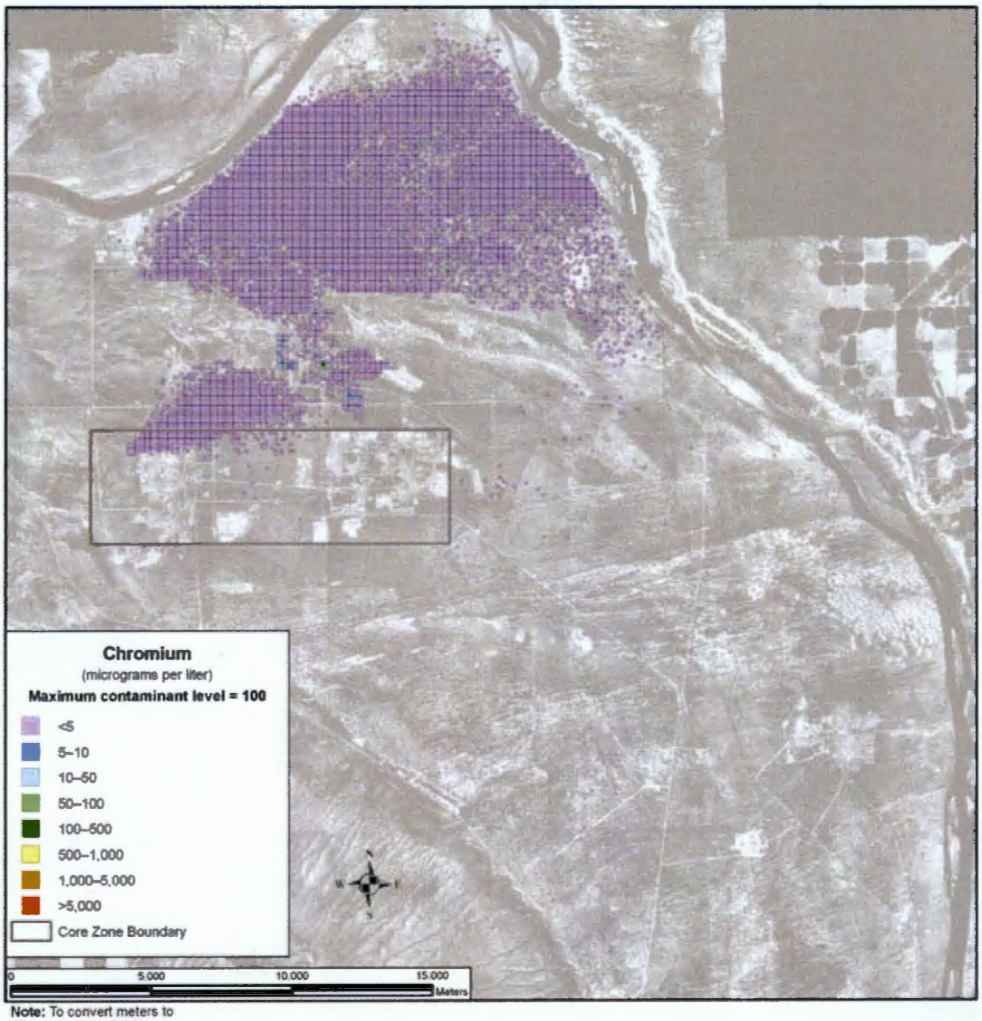
Note: To convert meters to feet, multiply by 3.281

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



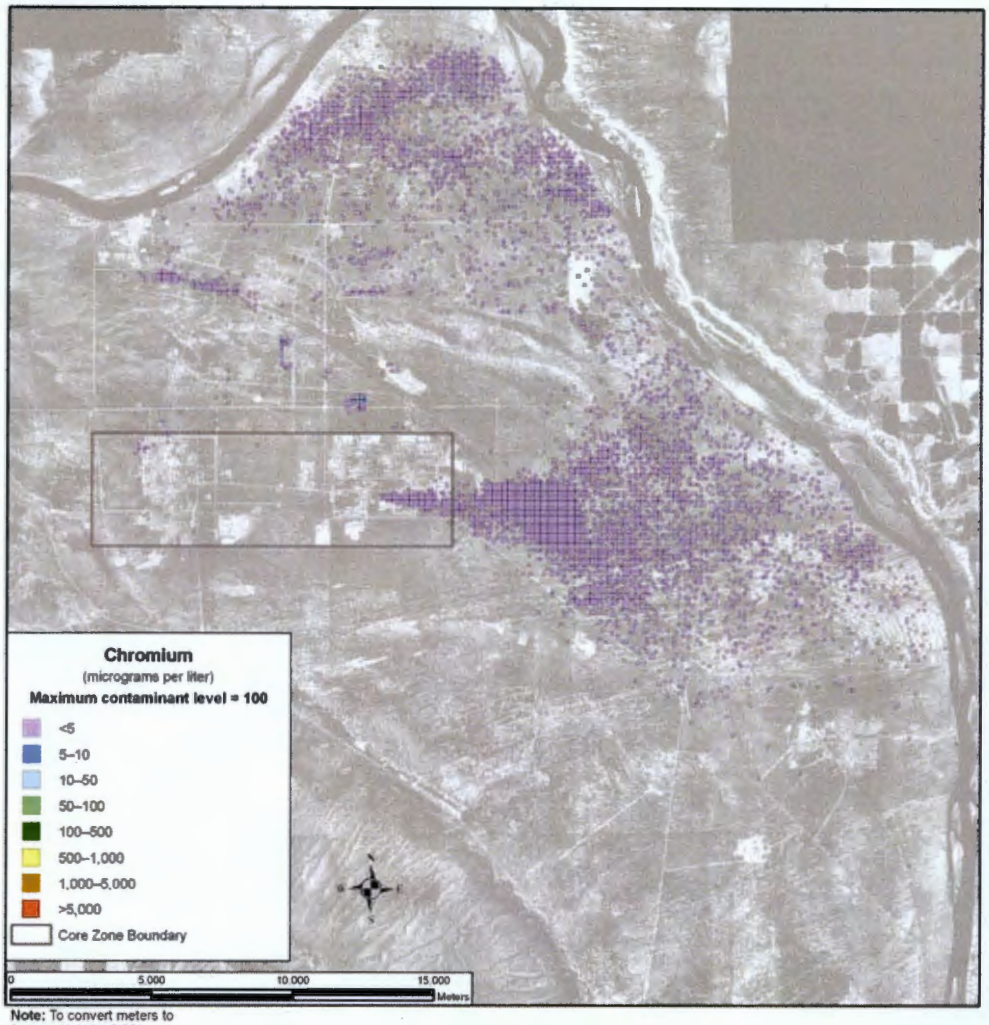
Note: To convert meters to feet, multiply by 3.281

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



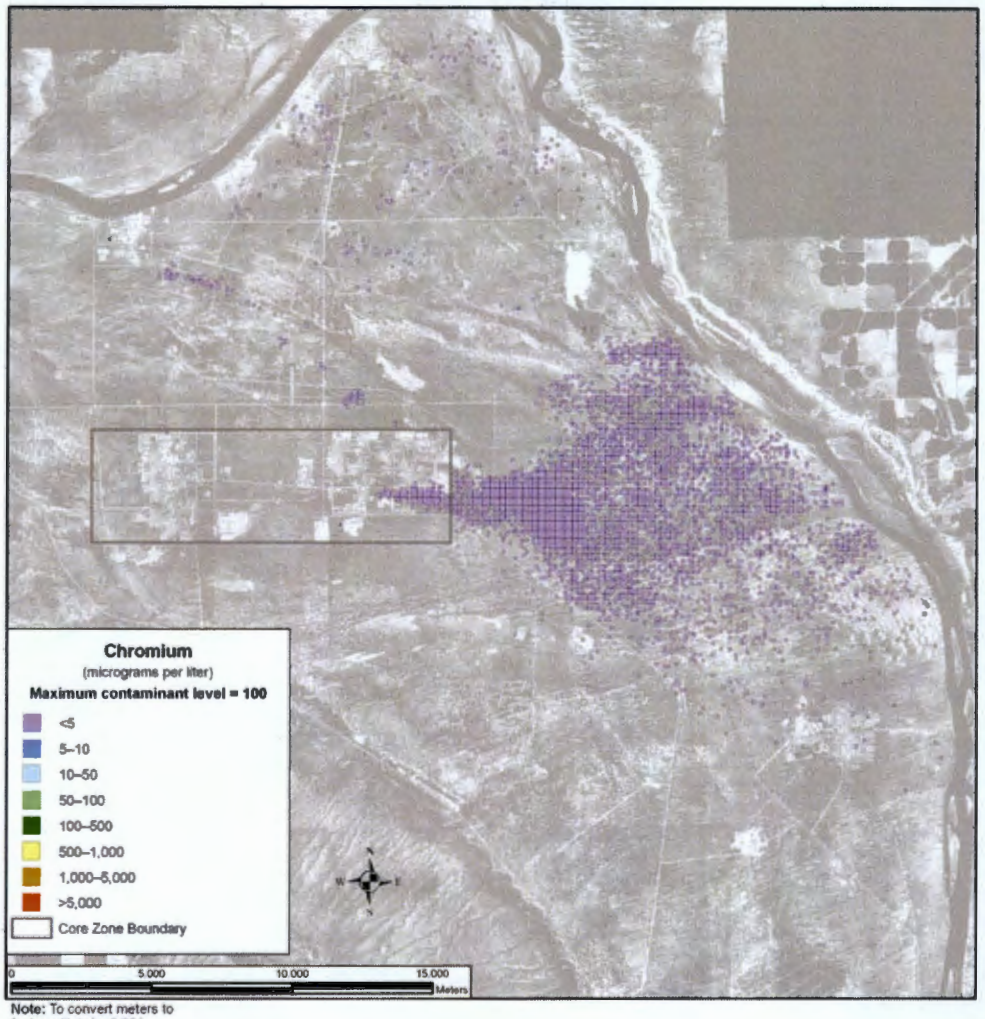
Note: To convert meters to feet, multiply by 3.281

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



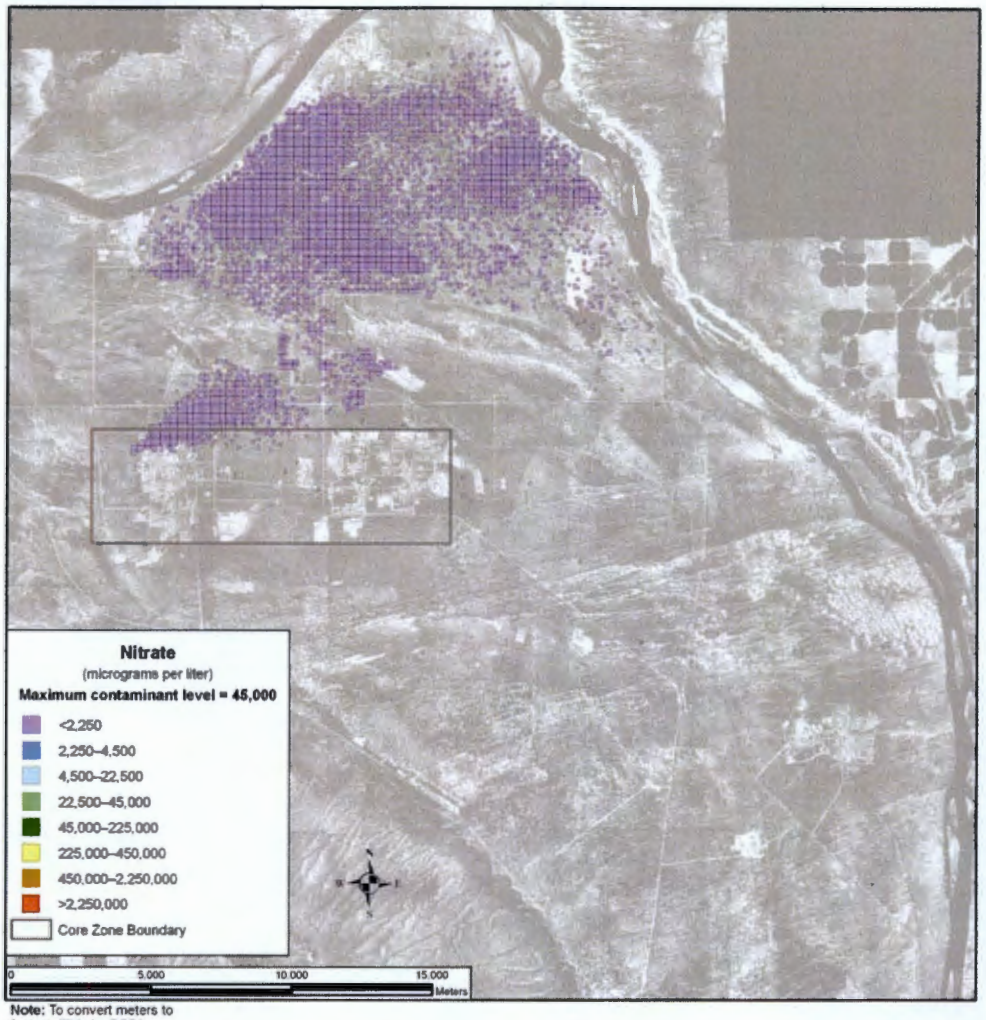
Note: To convert meters to feet, multiply by 3.281

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



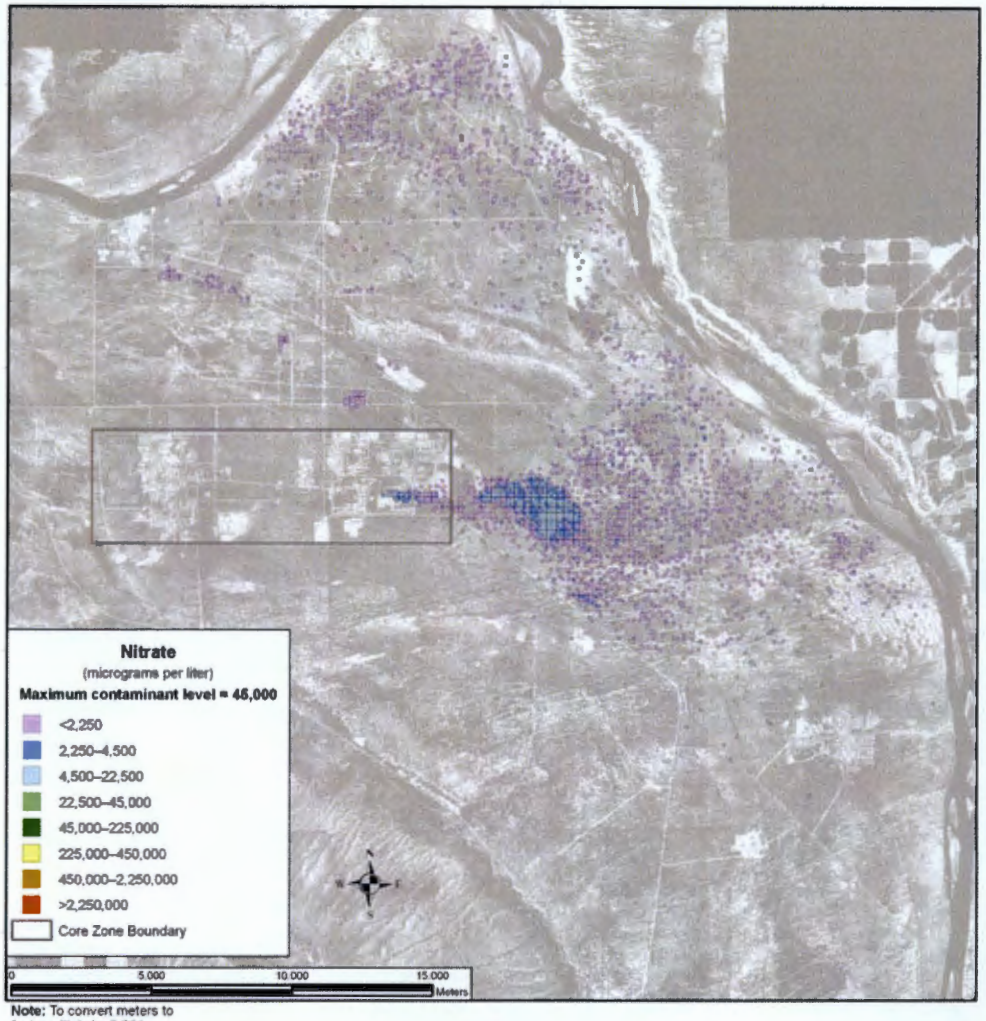
Note: To convert meters to feet, multiply by 3.281

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



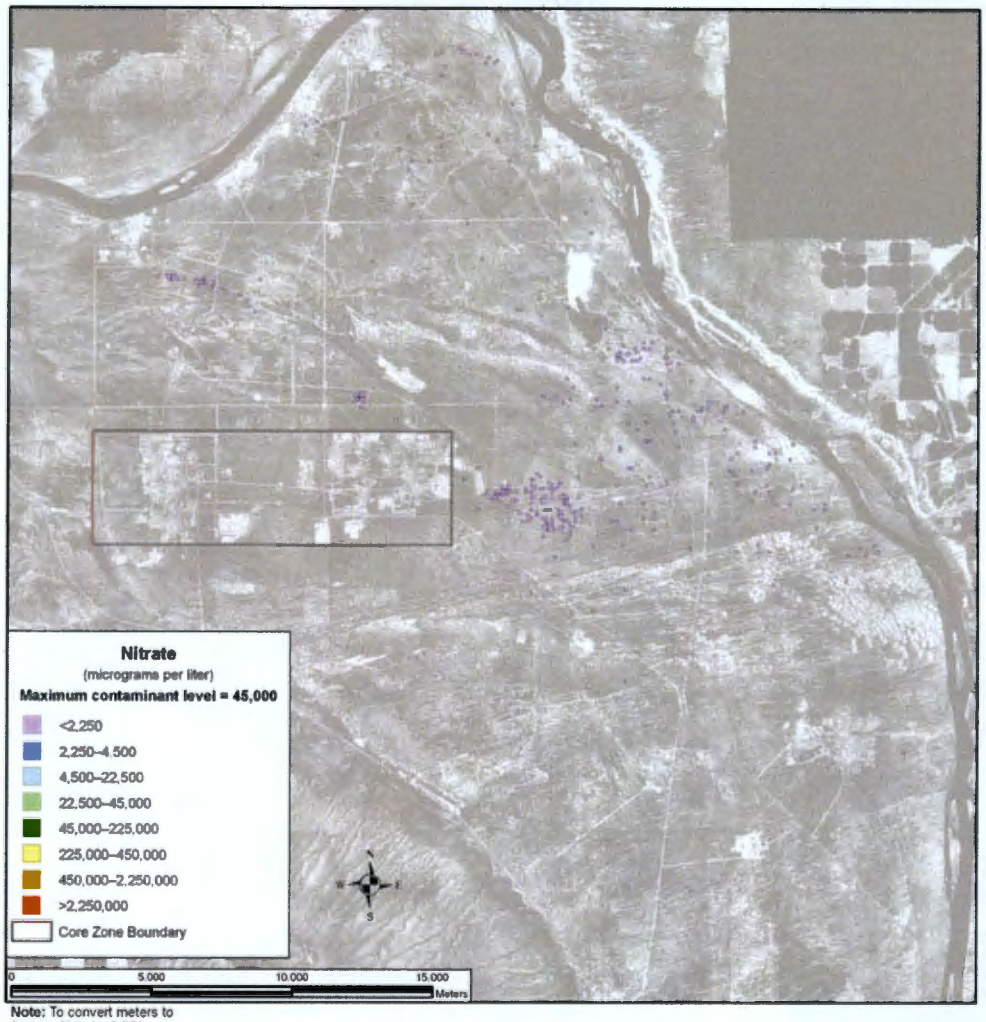
Note: To convert meters to feet, multiply by 3.281

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

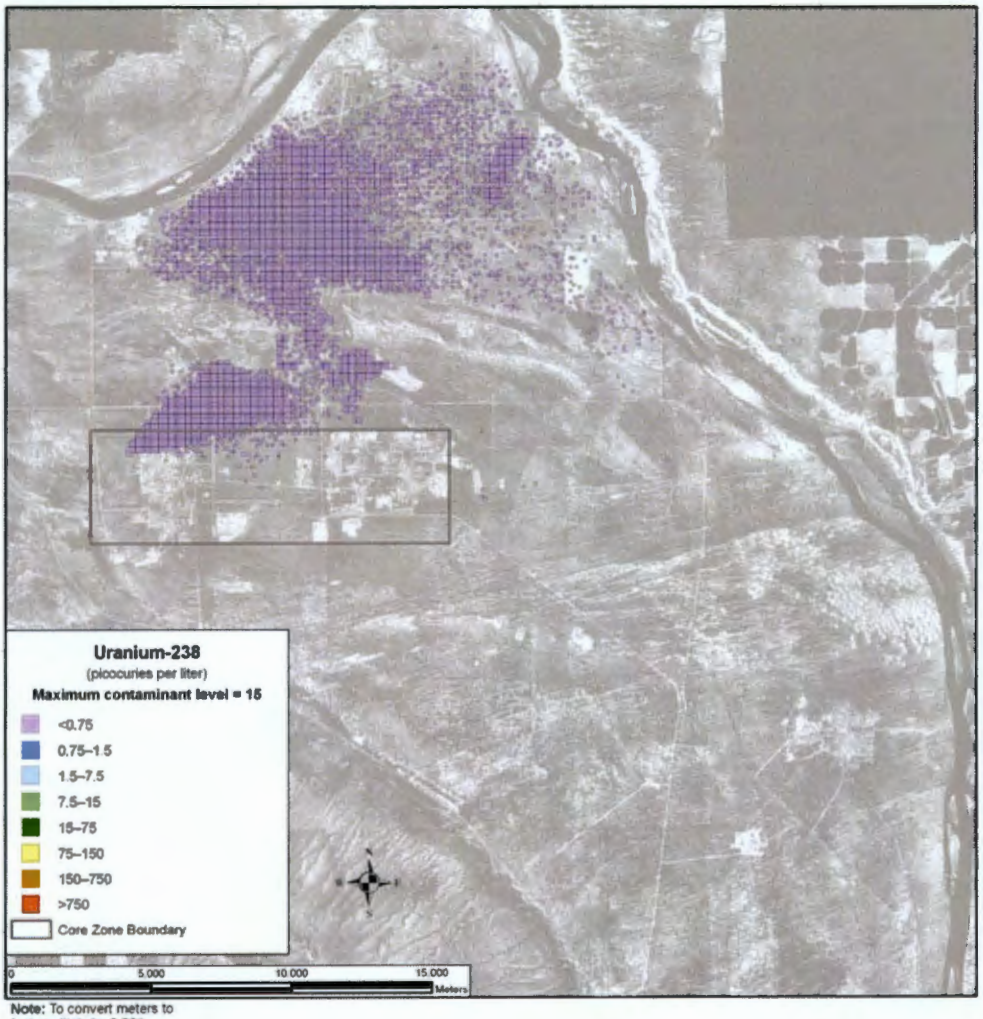
Figure 5–987. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



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.

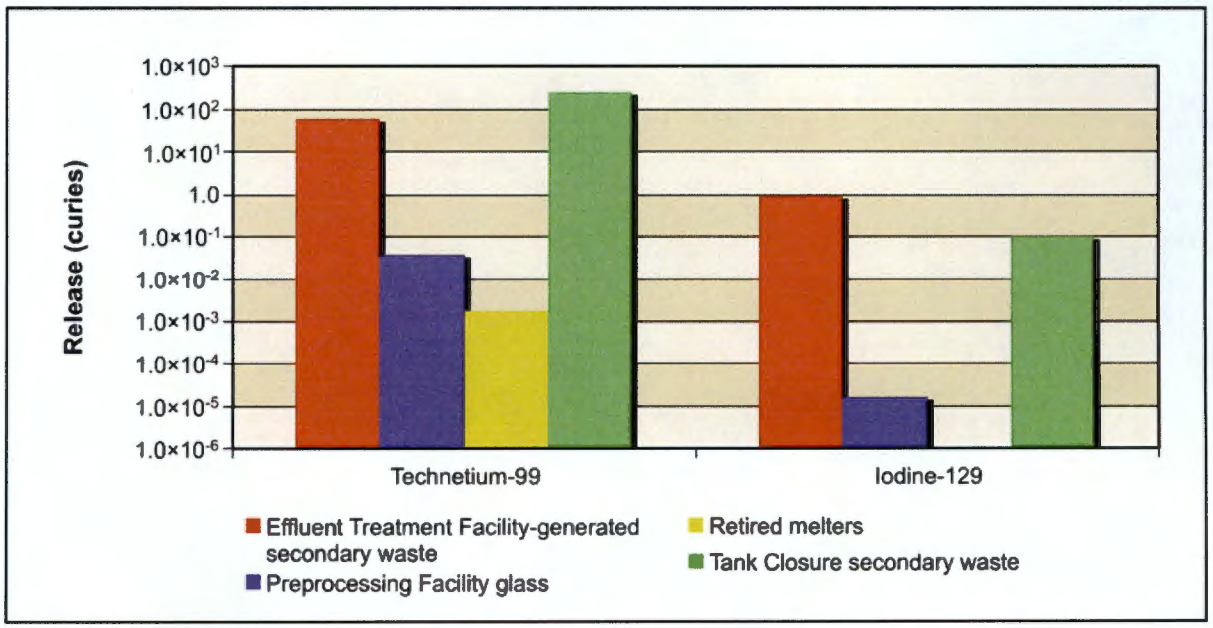


Figure 5–990. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

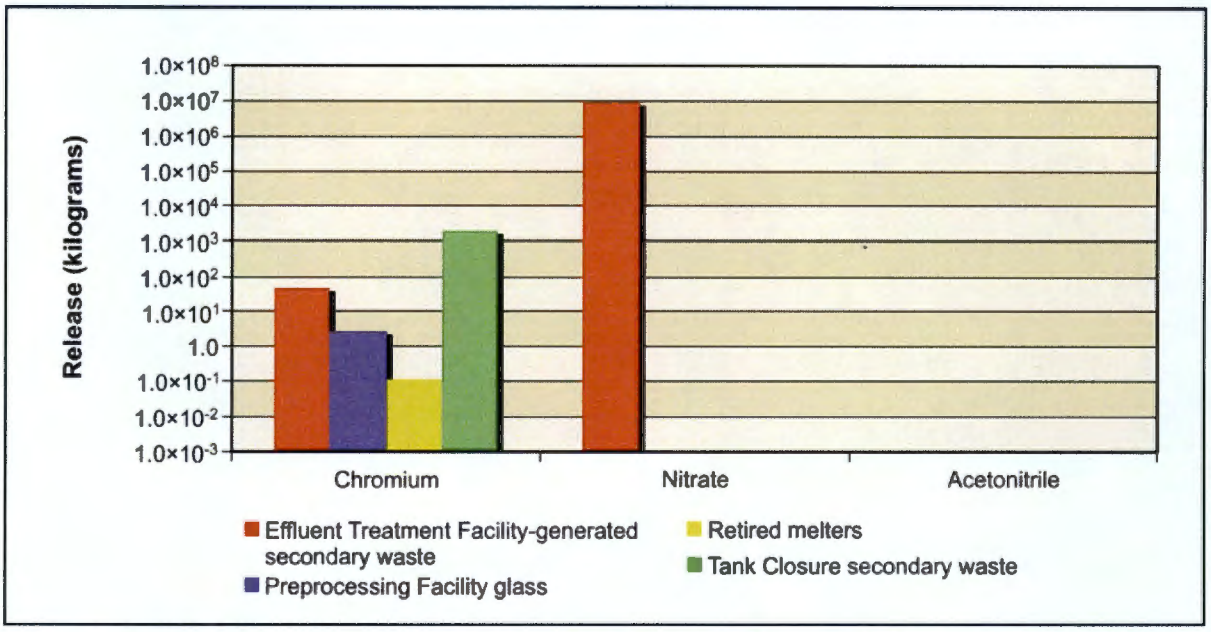


Figure 5–991. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

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.

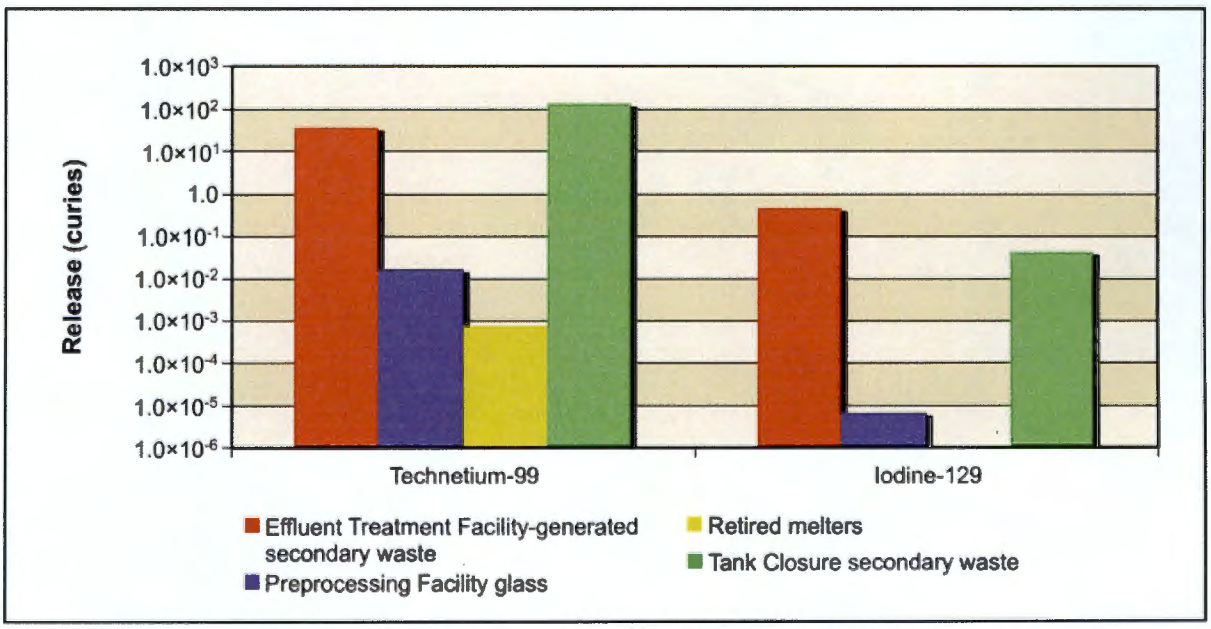


Figure 5–992. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

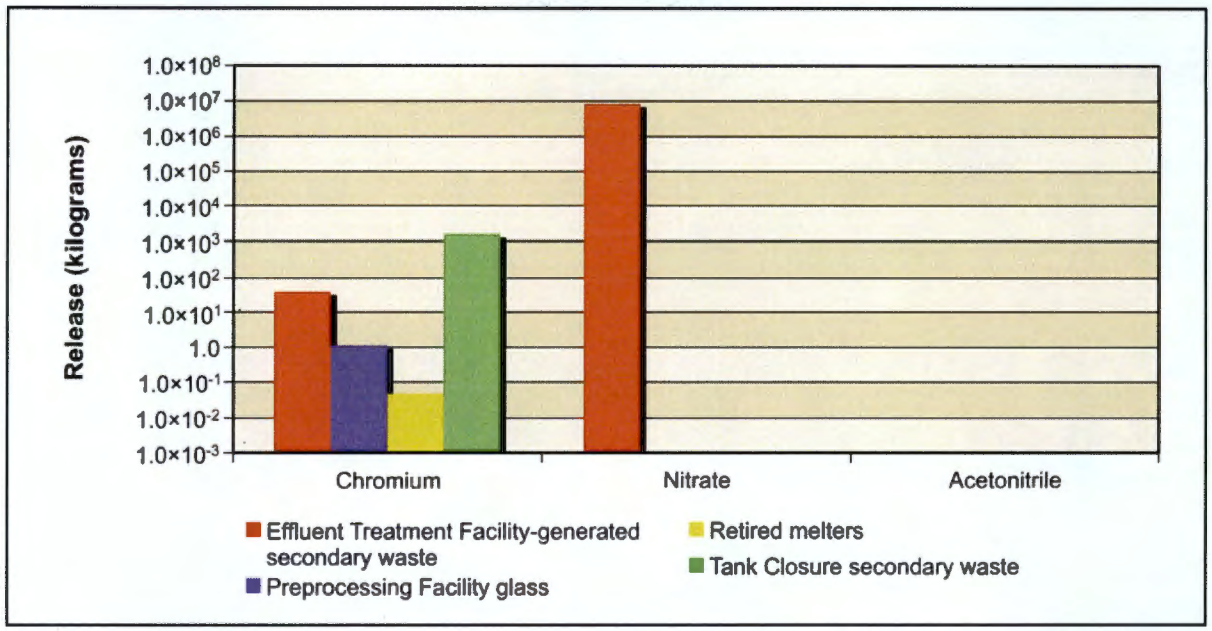


Figure 5–993. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

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.

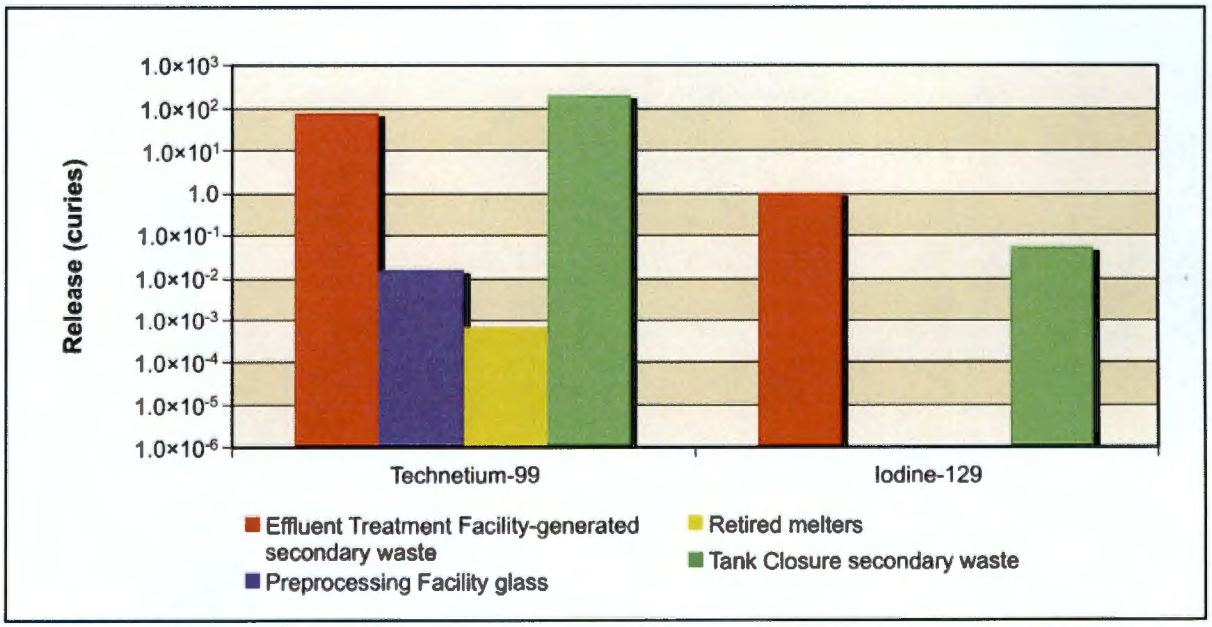


Figure 5–994. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

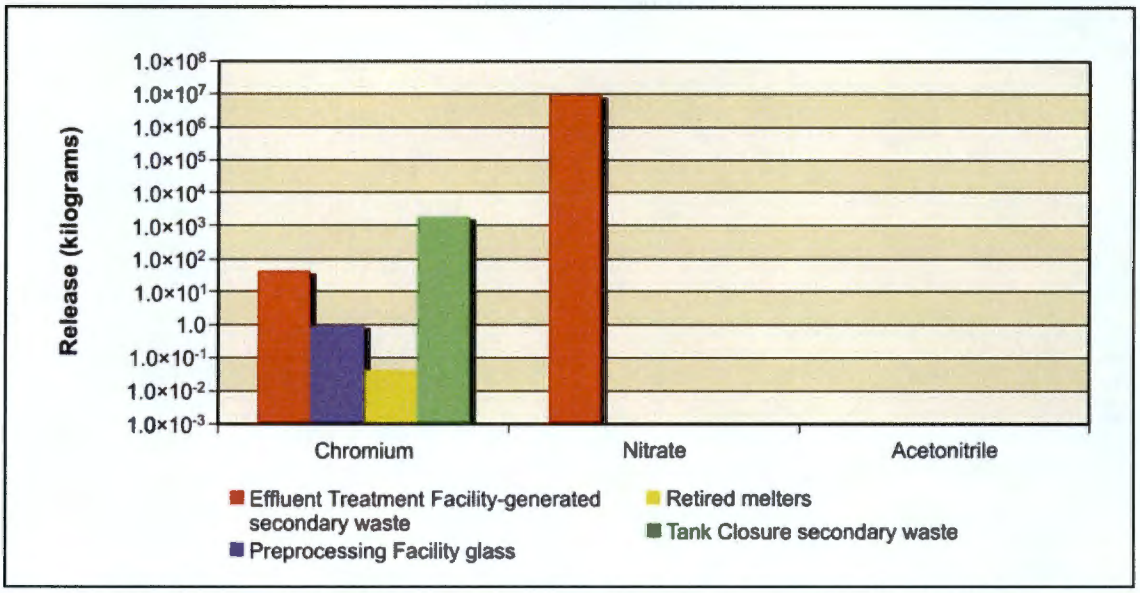


Figure 5–995. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

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.

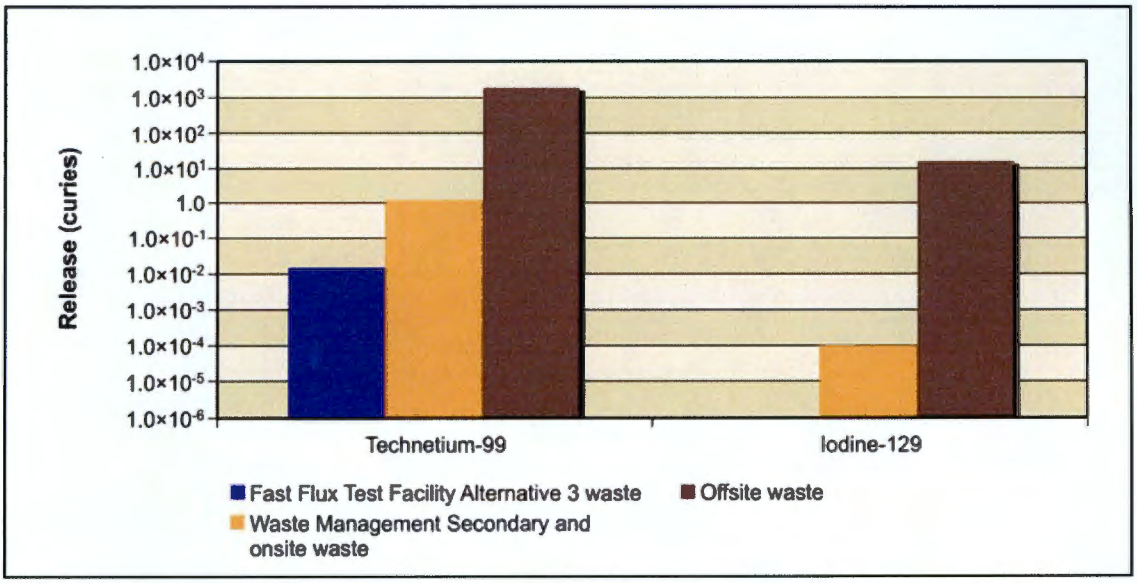


Figure 5–996. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

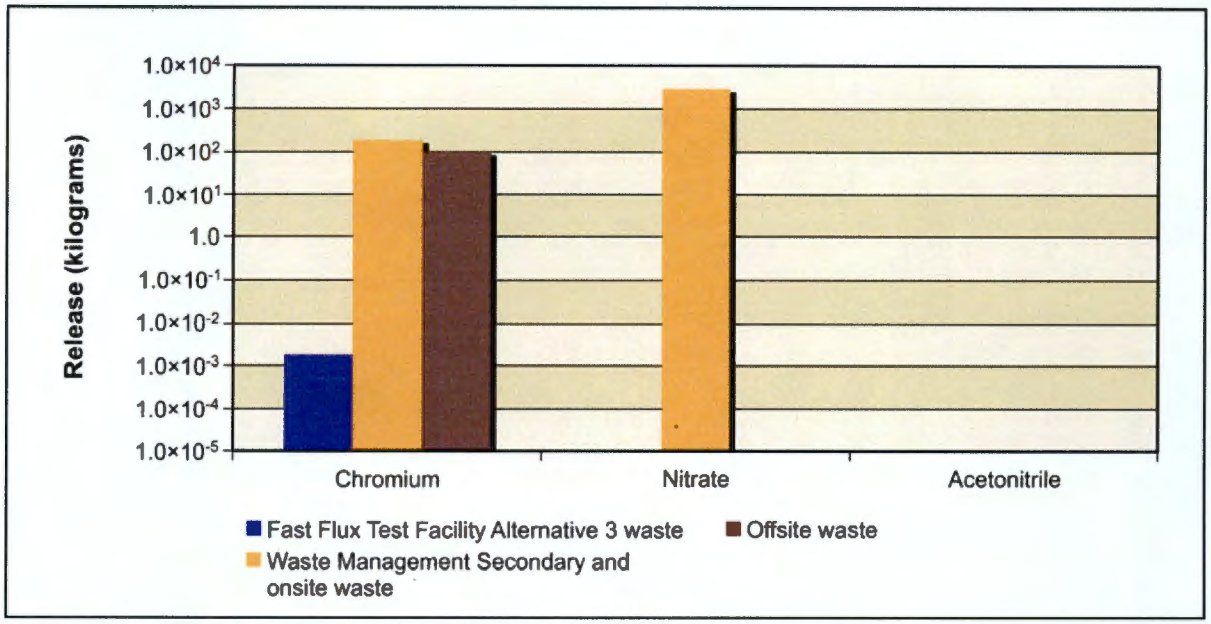


Figure 5–997. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Vadose Zone

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.

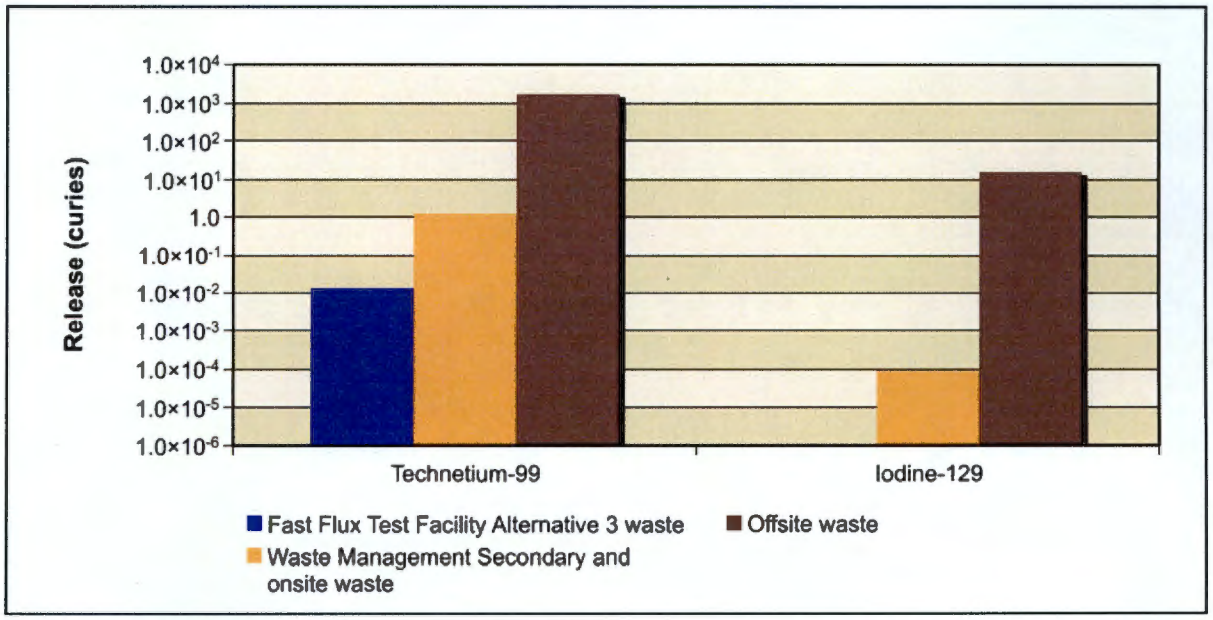


Figure 5–998. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Groundwater

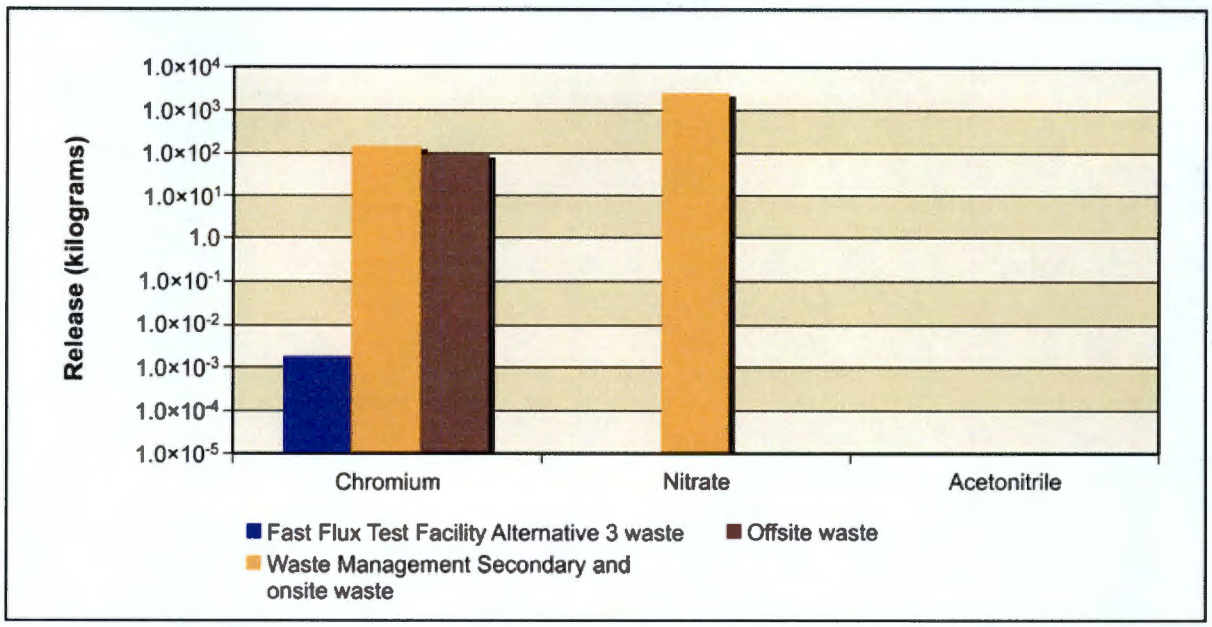


Figure 5–999. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Groundwater

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.

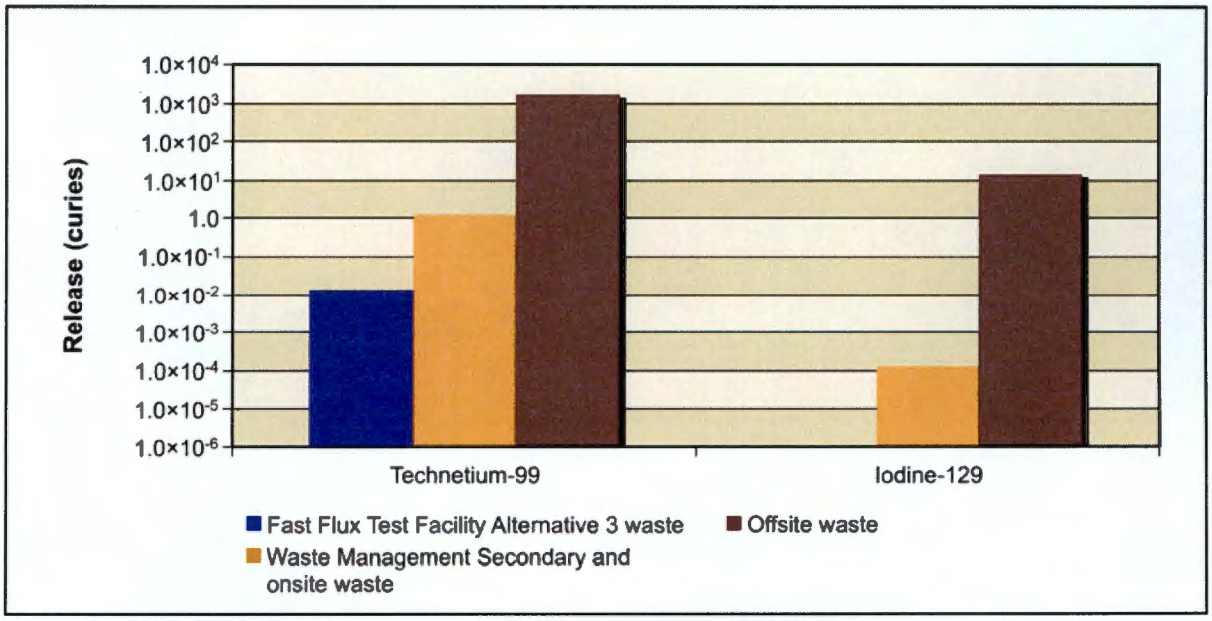


Figure 5–1000. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-West Area Integrated Disposal Facility to Columbia River

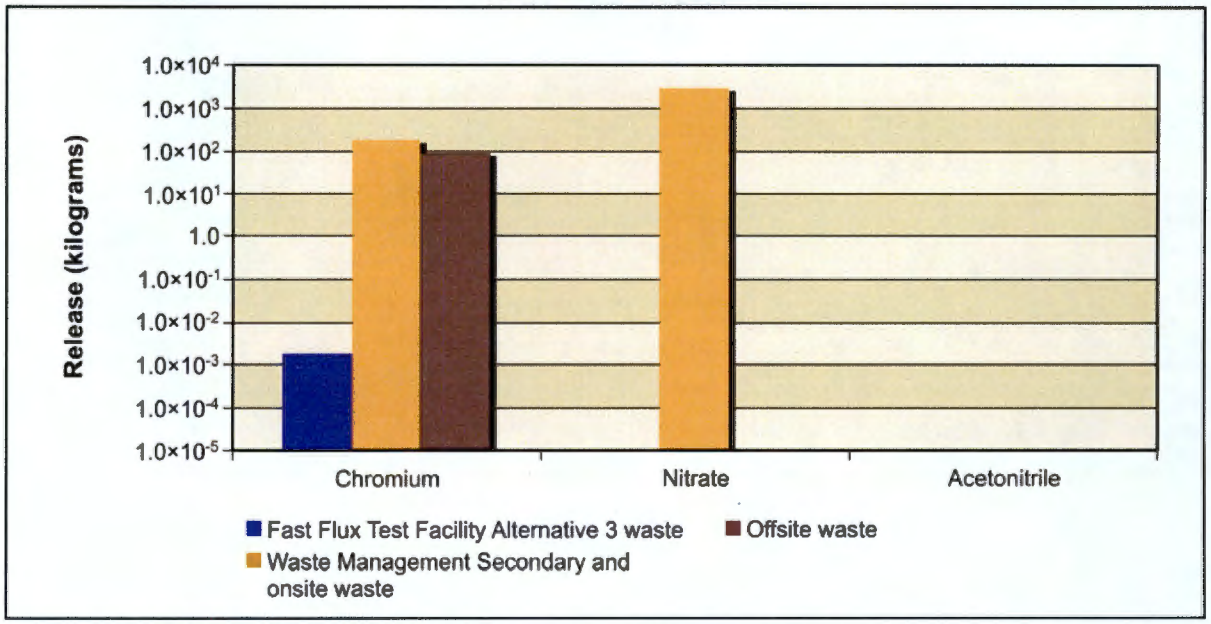


Figure 5–1001. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-West Area Integrated Disposal Facility to Columbia River

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.

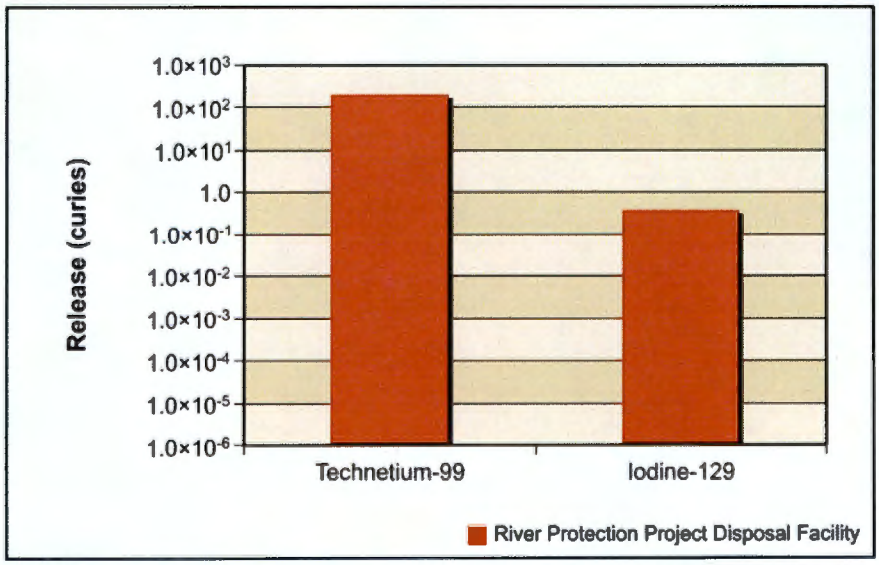


Figure 5–1002. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

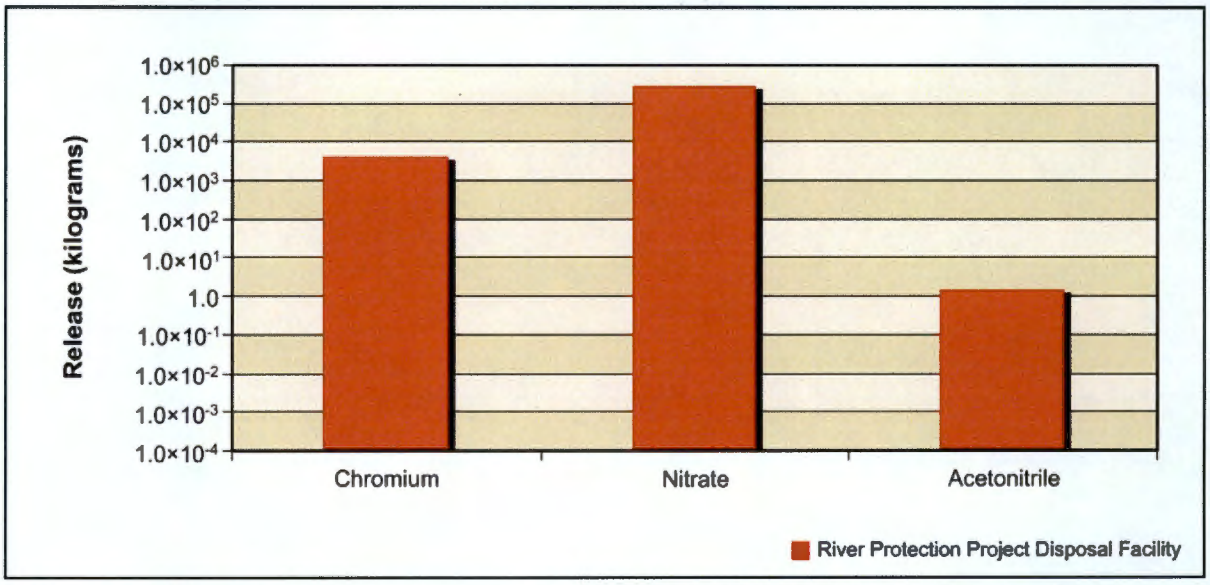


Figure 5–1003. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

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.

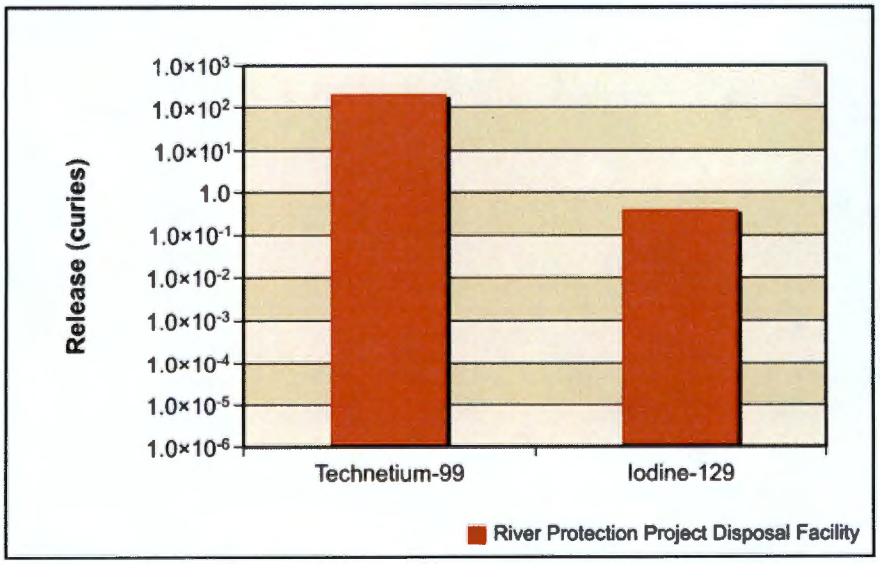


Figure 5–1004. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

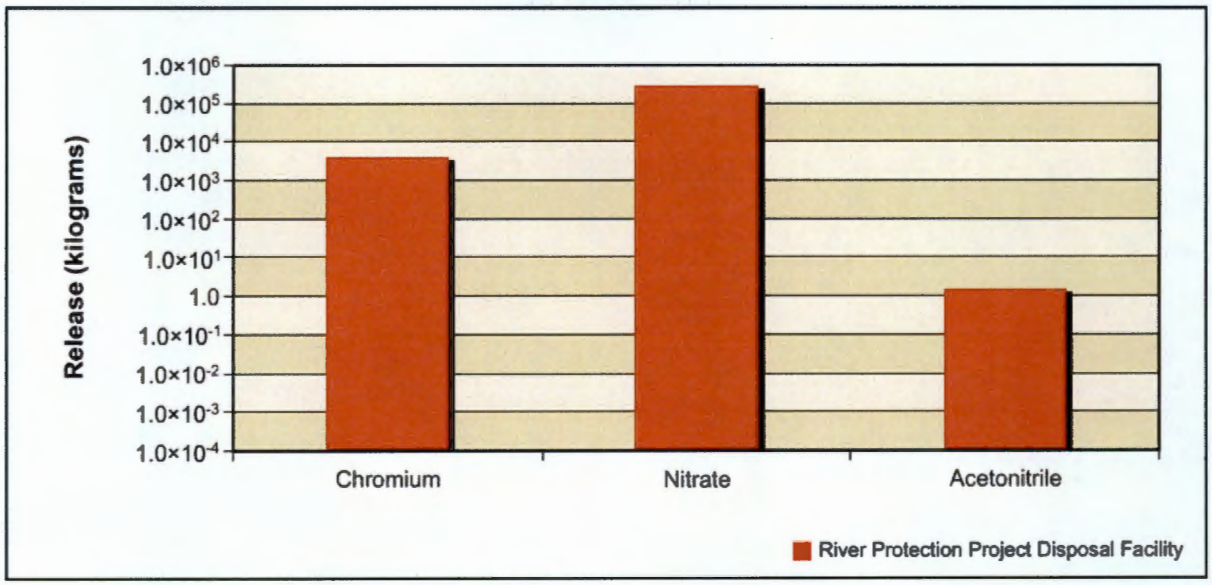


Figure 5–1005. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

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.

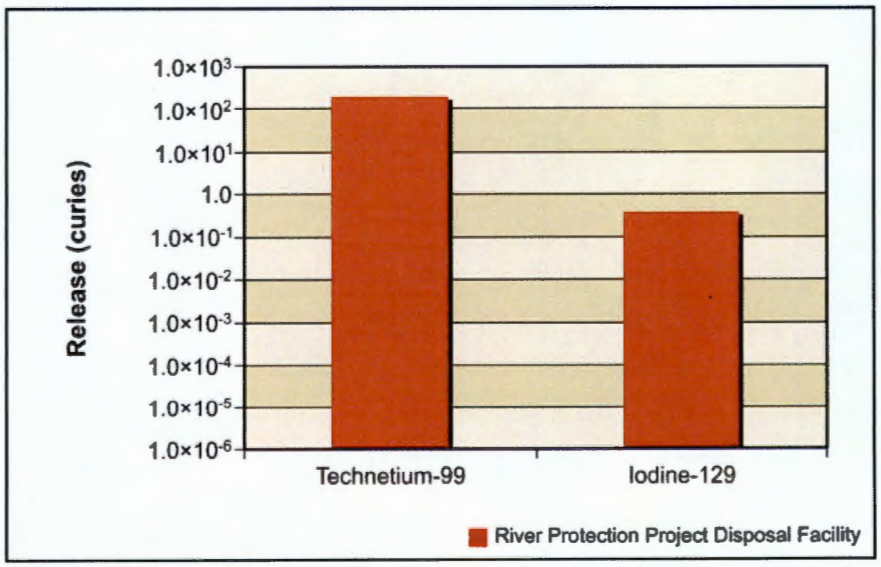


Figure 5–1006. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

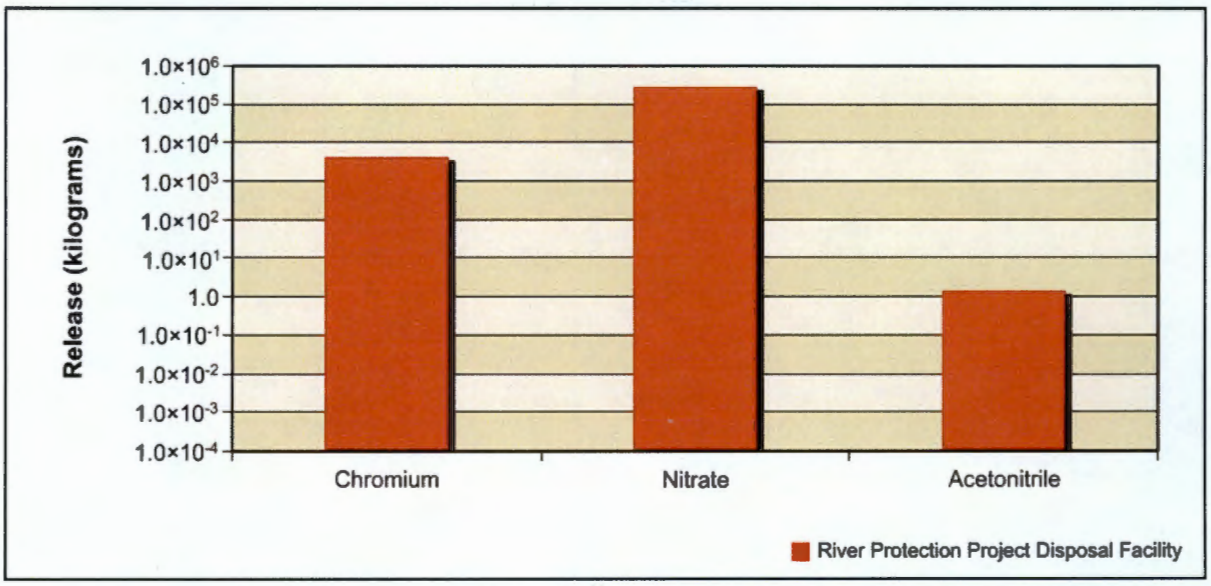


Figure 5–1007. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

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.

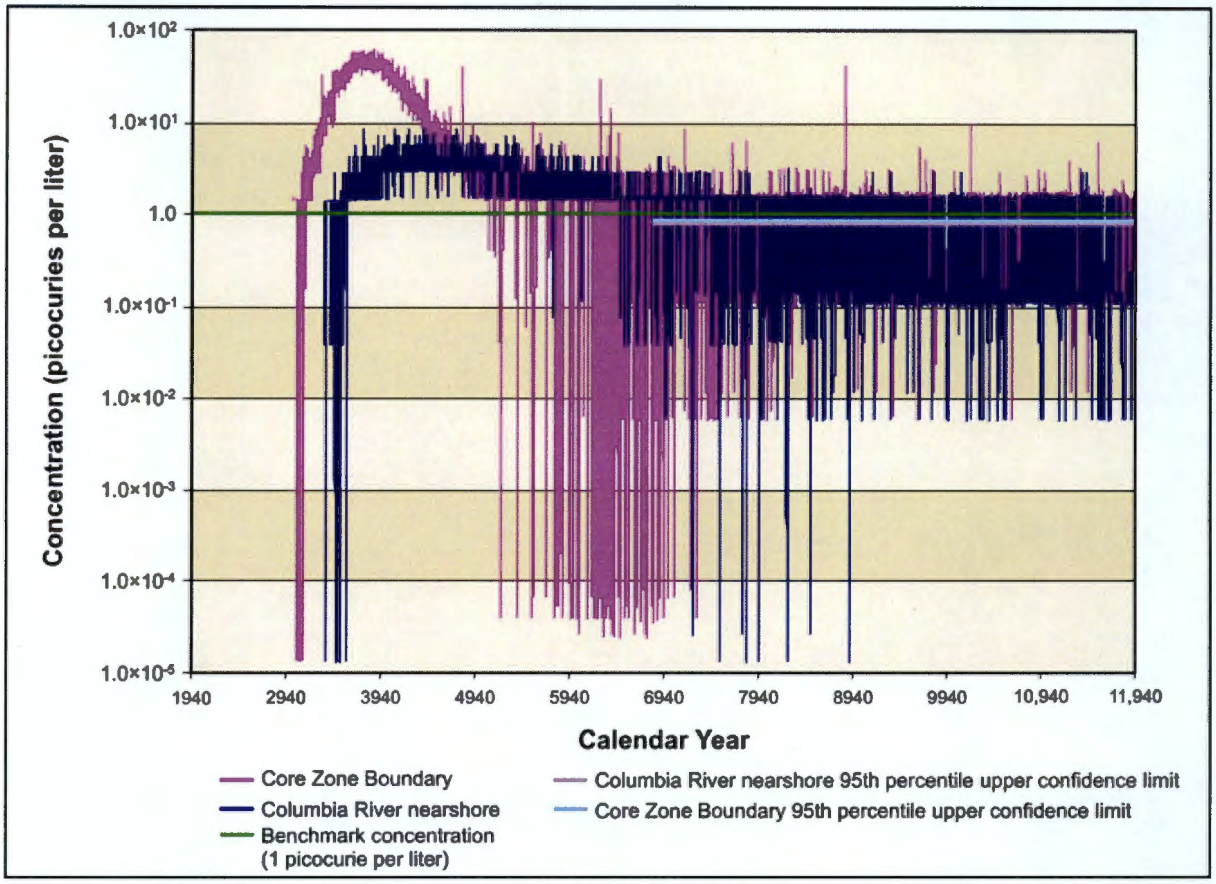


Figure 5–1008. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Iodine-129 Concentration Versus Time

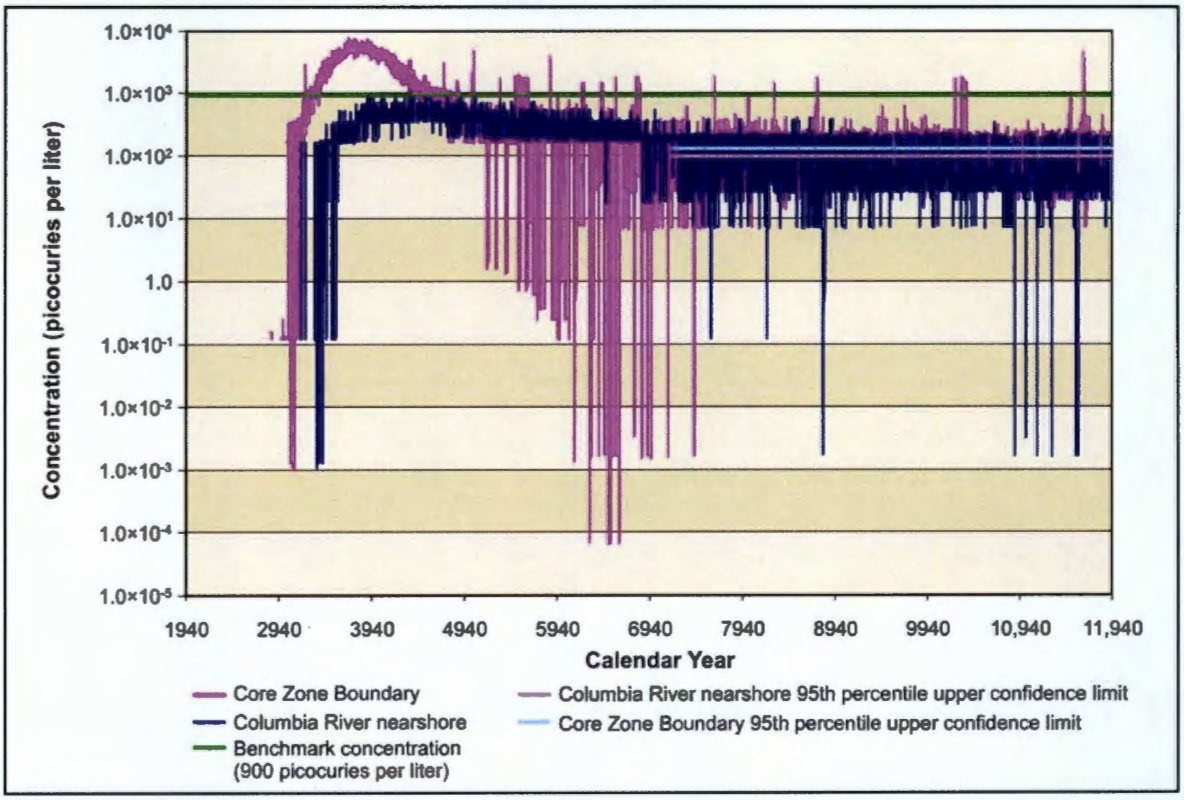


Figure 5–1009. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Technetium-99 Concentration Versus Time

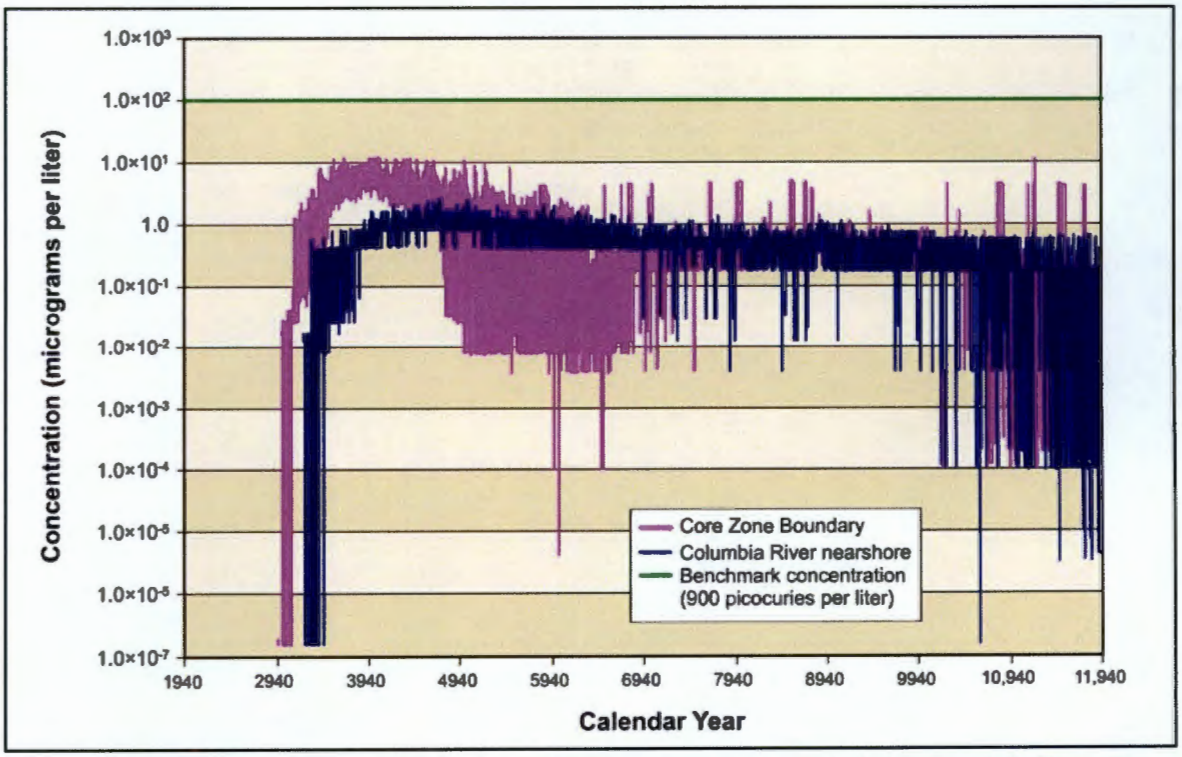


Figure 5–1010. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Chromium Concentration Versus Time

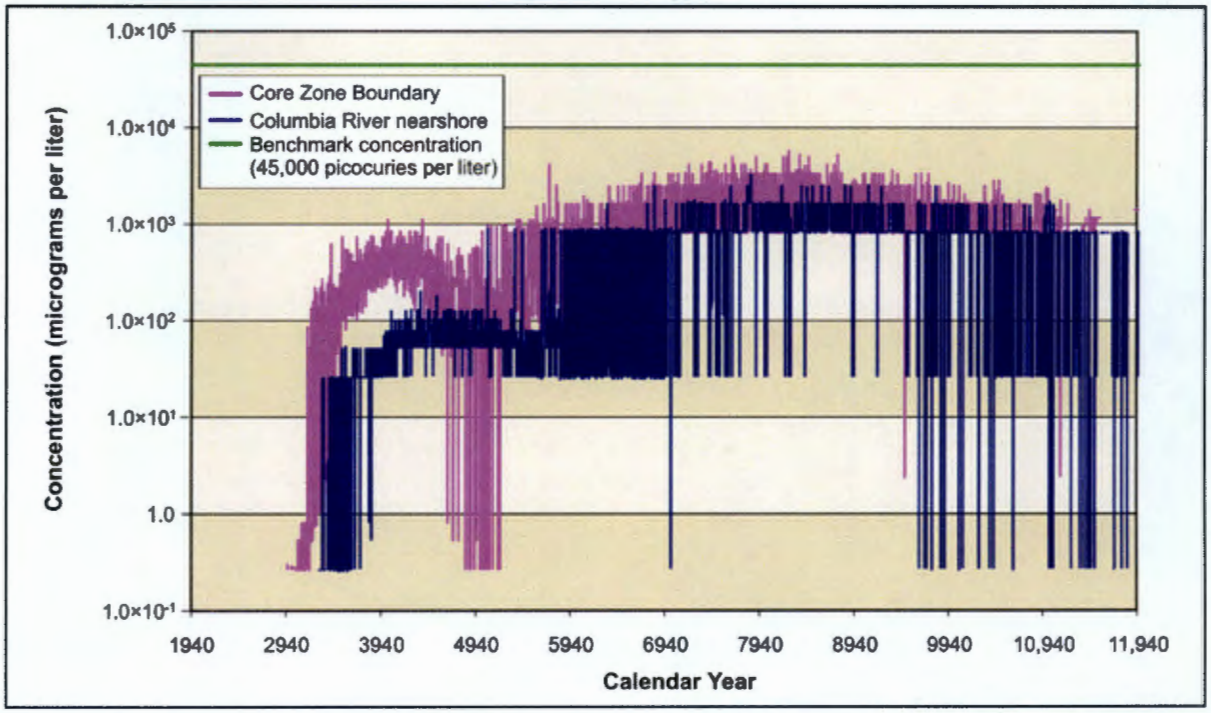


Figure 5–1011. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Nitrate Concentration Versus Time

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.

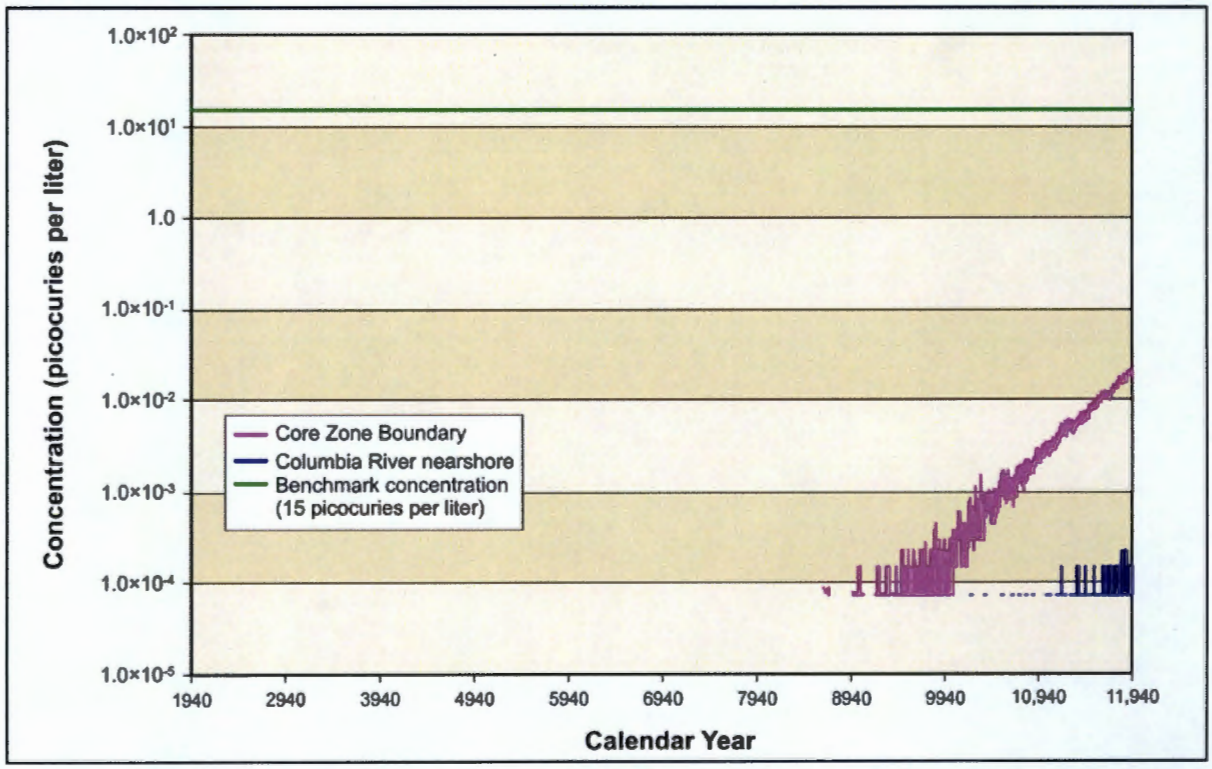


Figure 5–1012. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Uranium-238 Concentration Versus Time

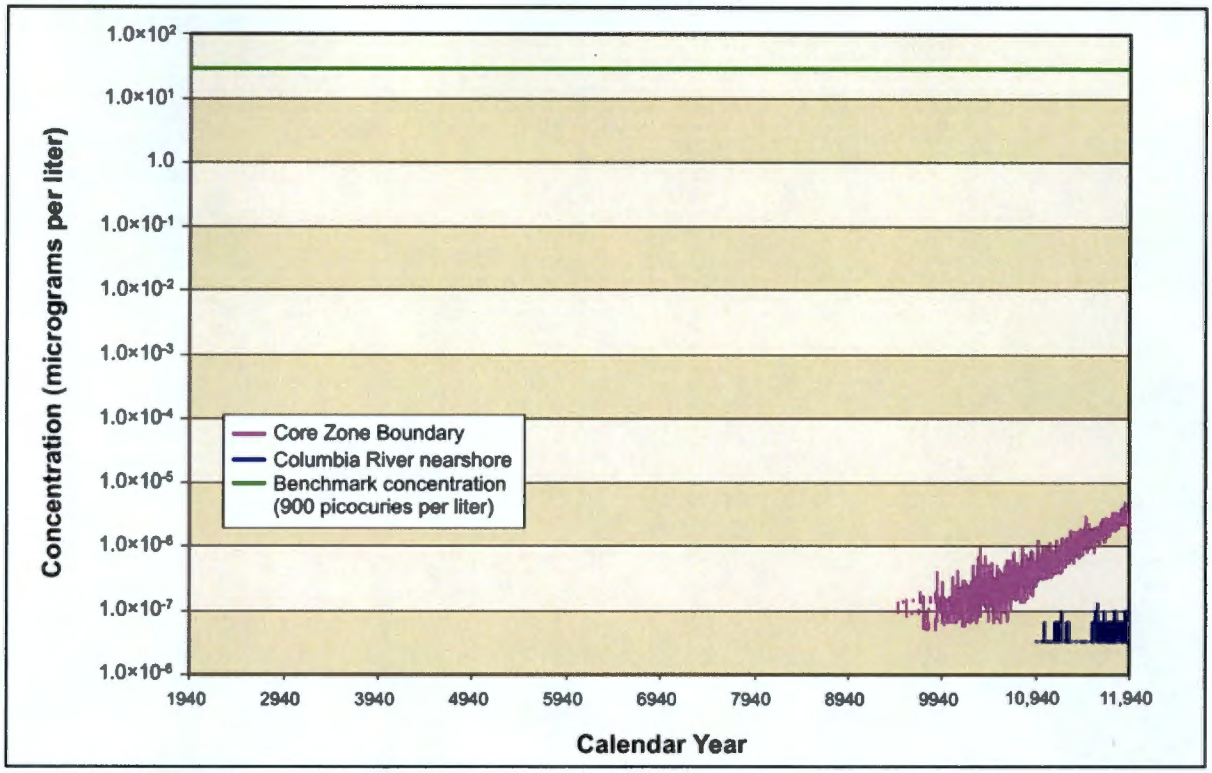
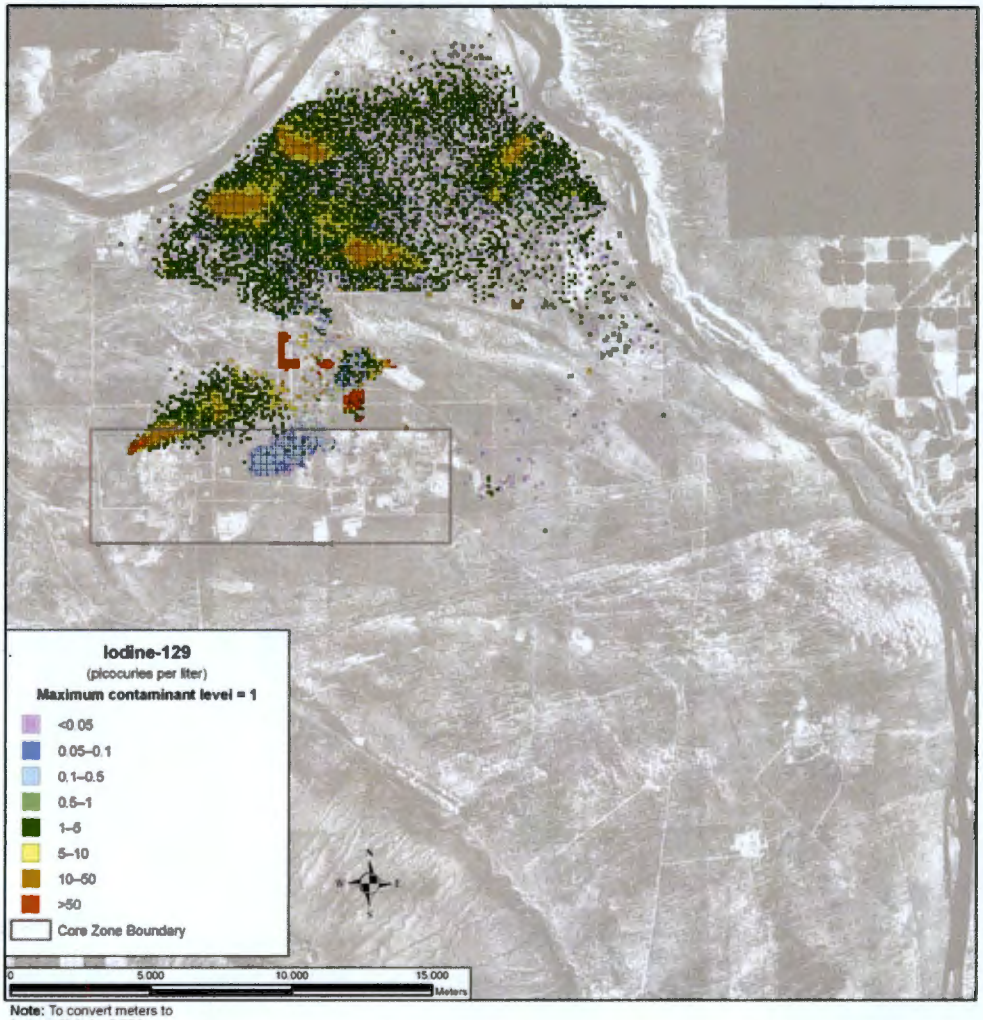


Figure 5–1013. Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, Total Uranium Concentration Versus

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

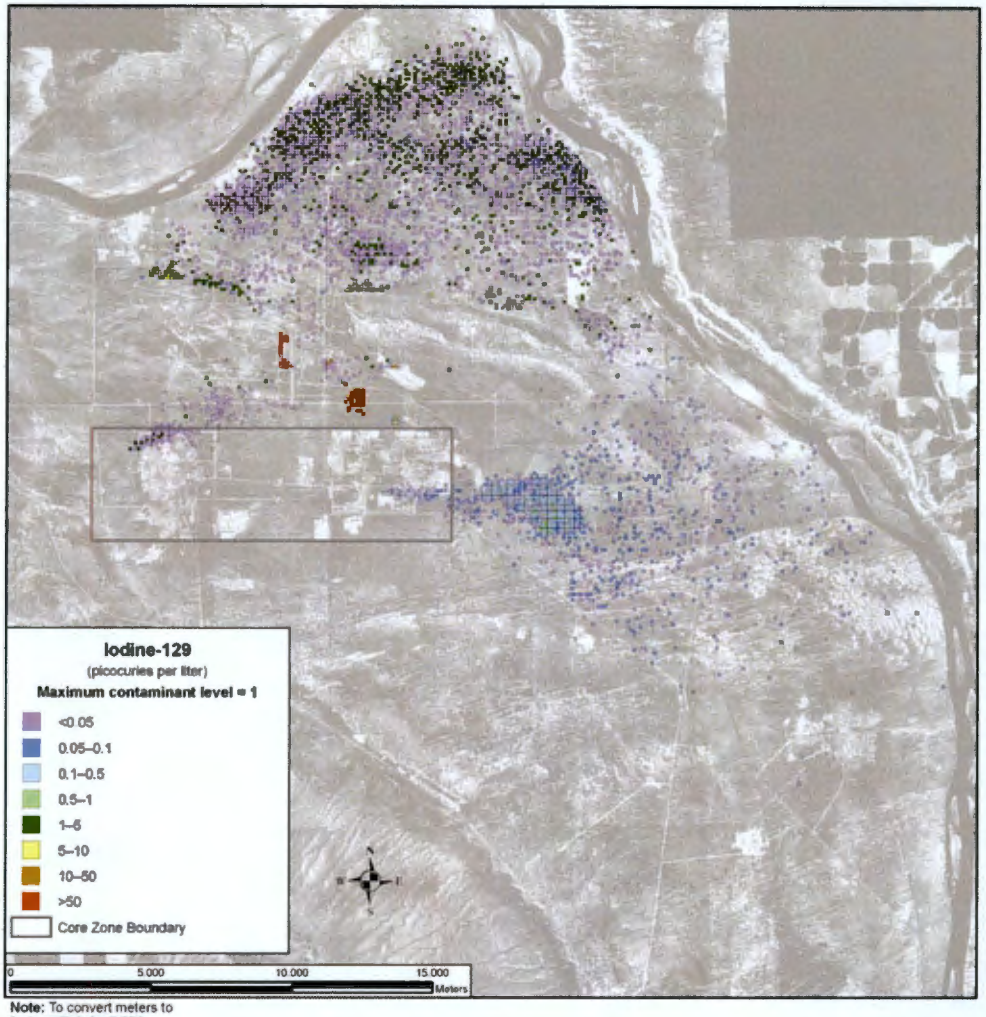
This section presents the impacts of Waste Management Alternative 3, Disposal Group 2, Subgroup 2-B, Base Case, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. Concentrations 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).



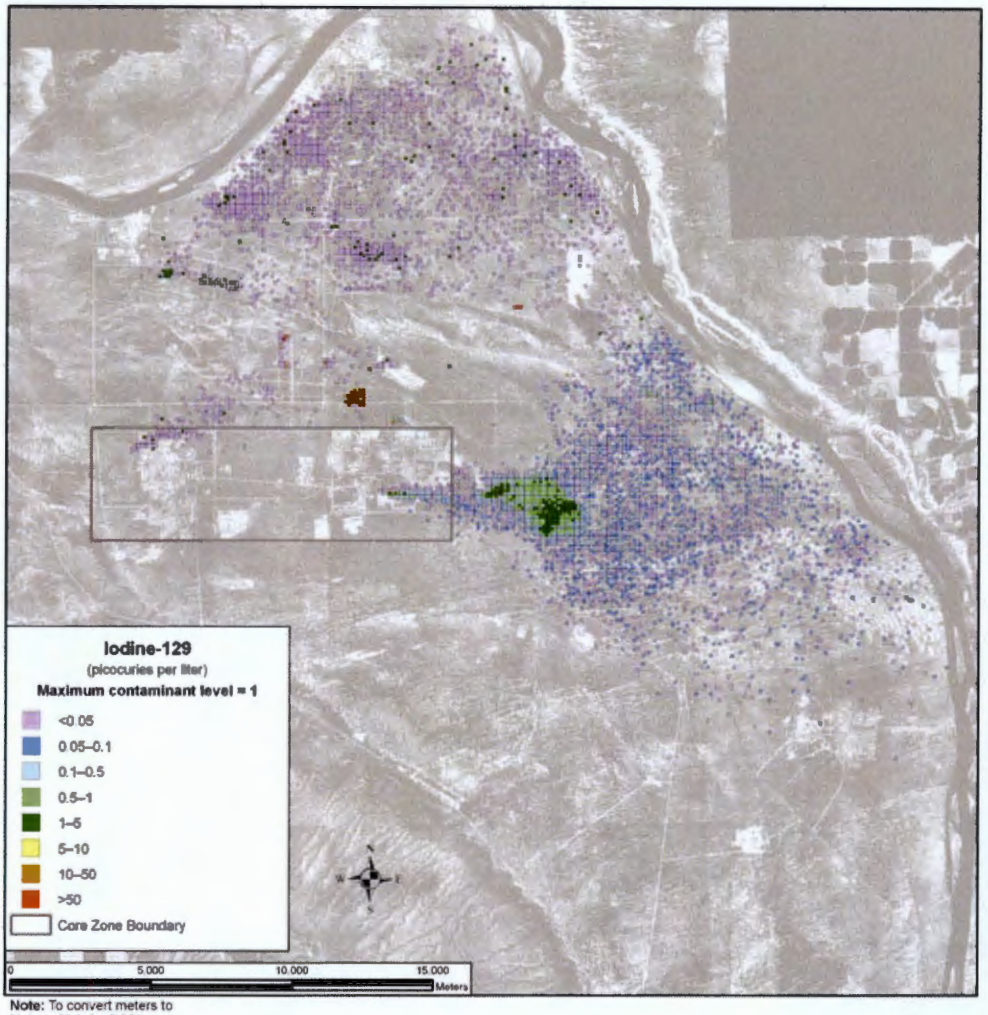
Note: To convert meters to feet, multiply by 3.281

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



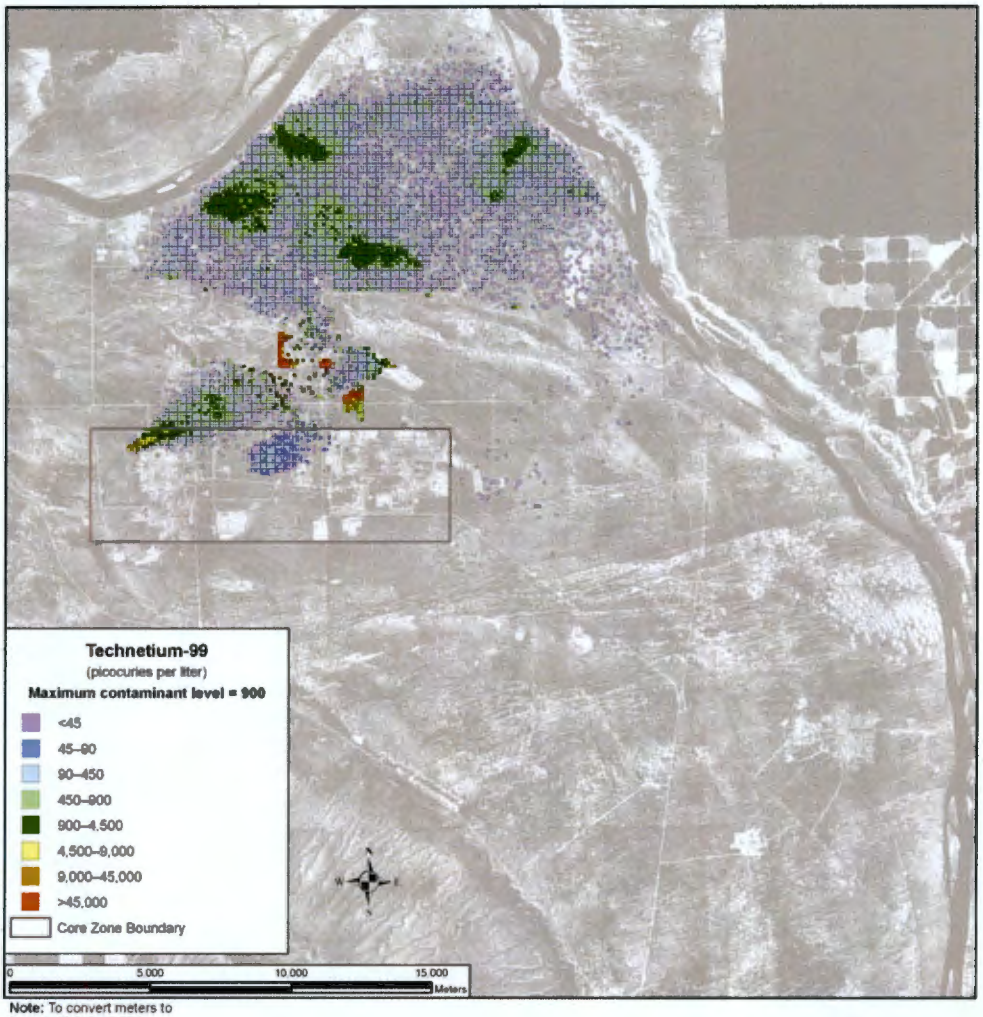
Note: To convert meters to feet, multiply by 3.281

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



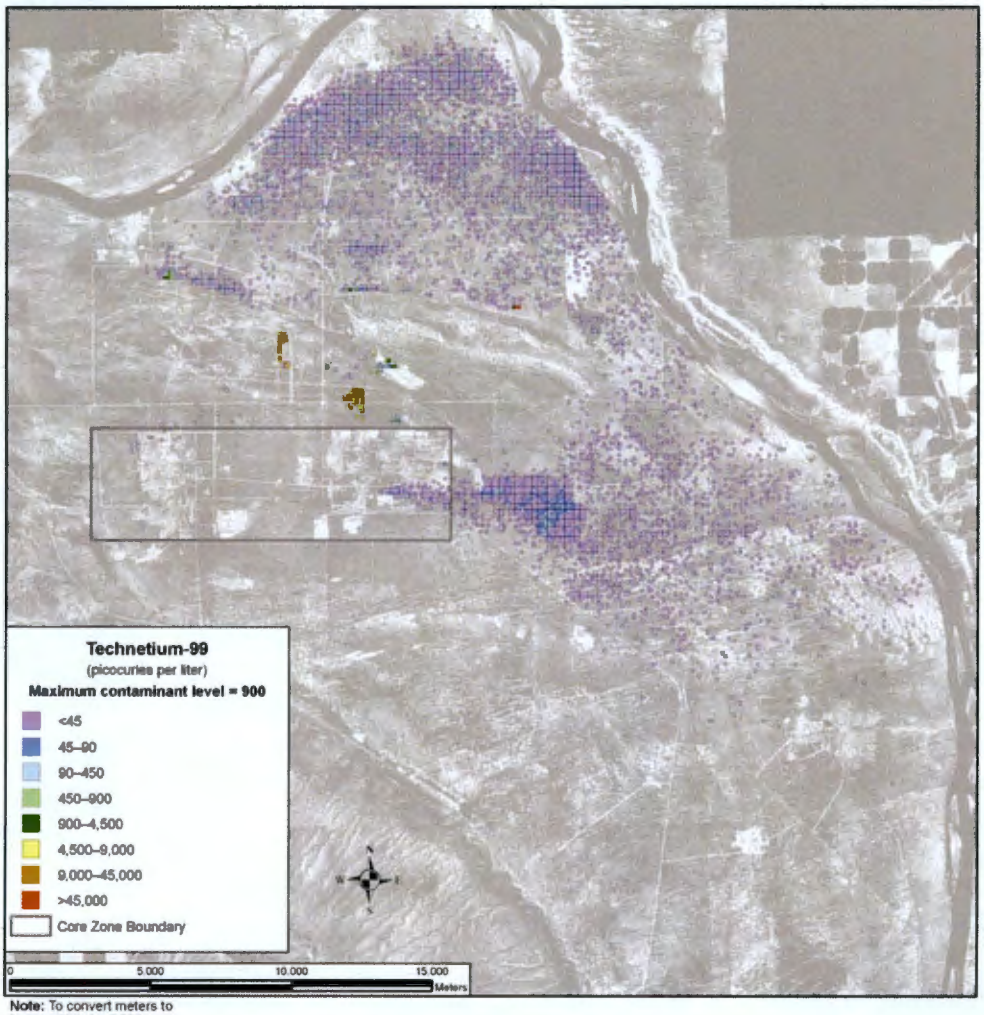
Note: To convert meters to feet, multiply by 3.281

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



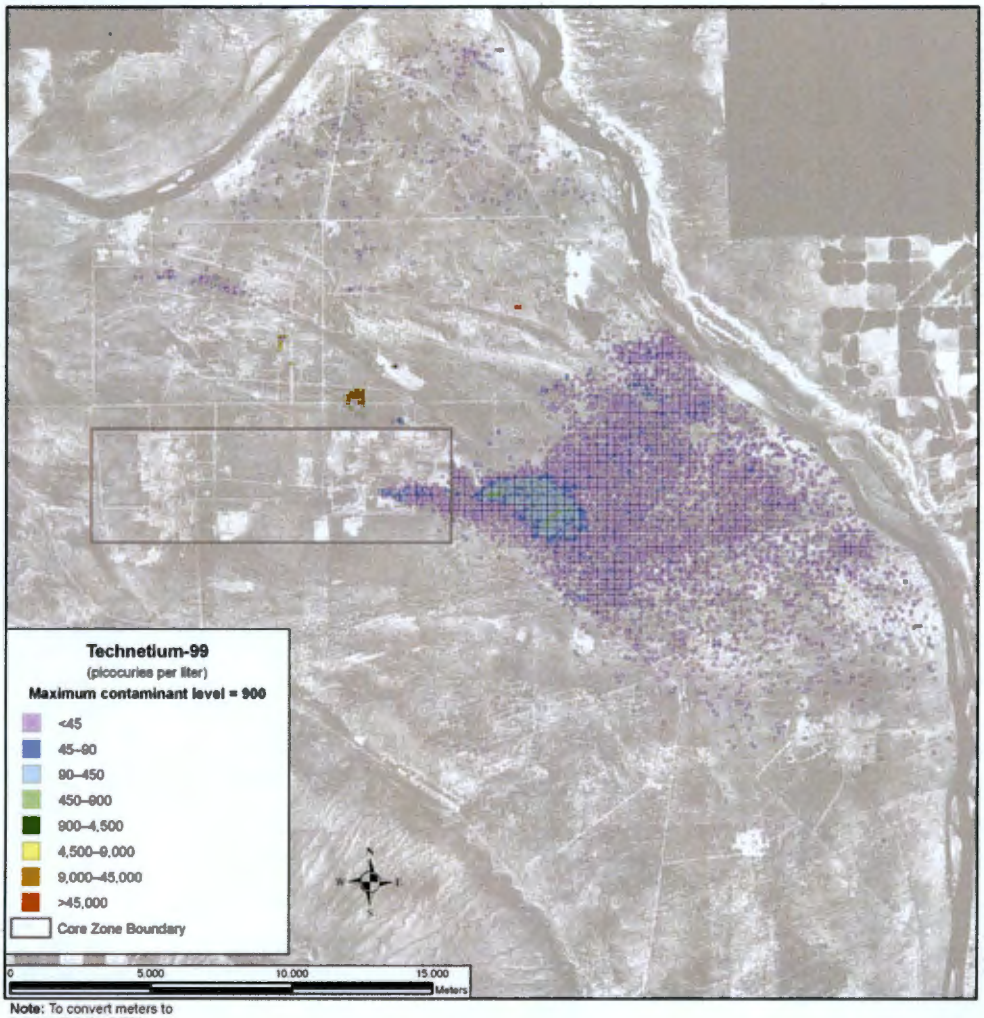
Note: To convert meters to feet, multiply by 3.281

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



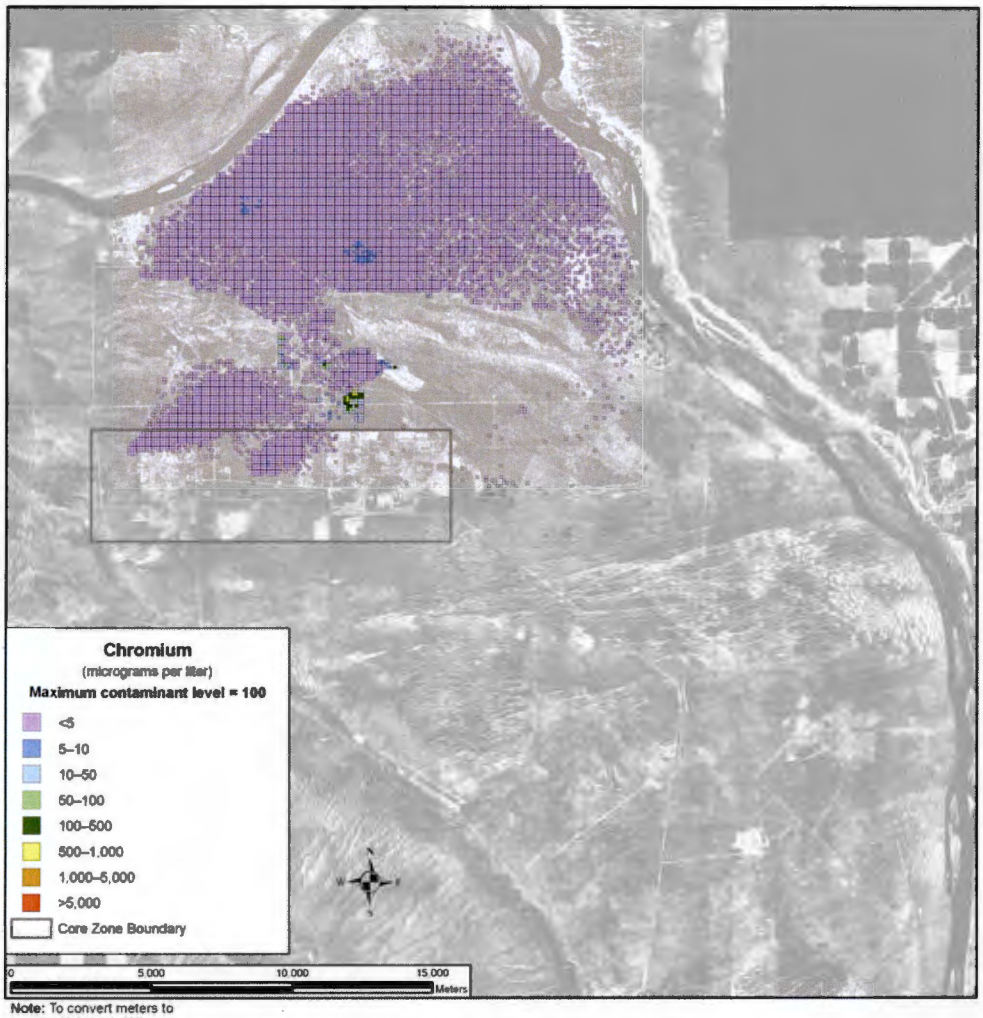
Note: To convert meters to feet, multiply by 3.281

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



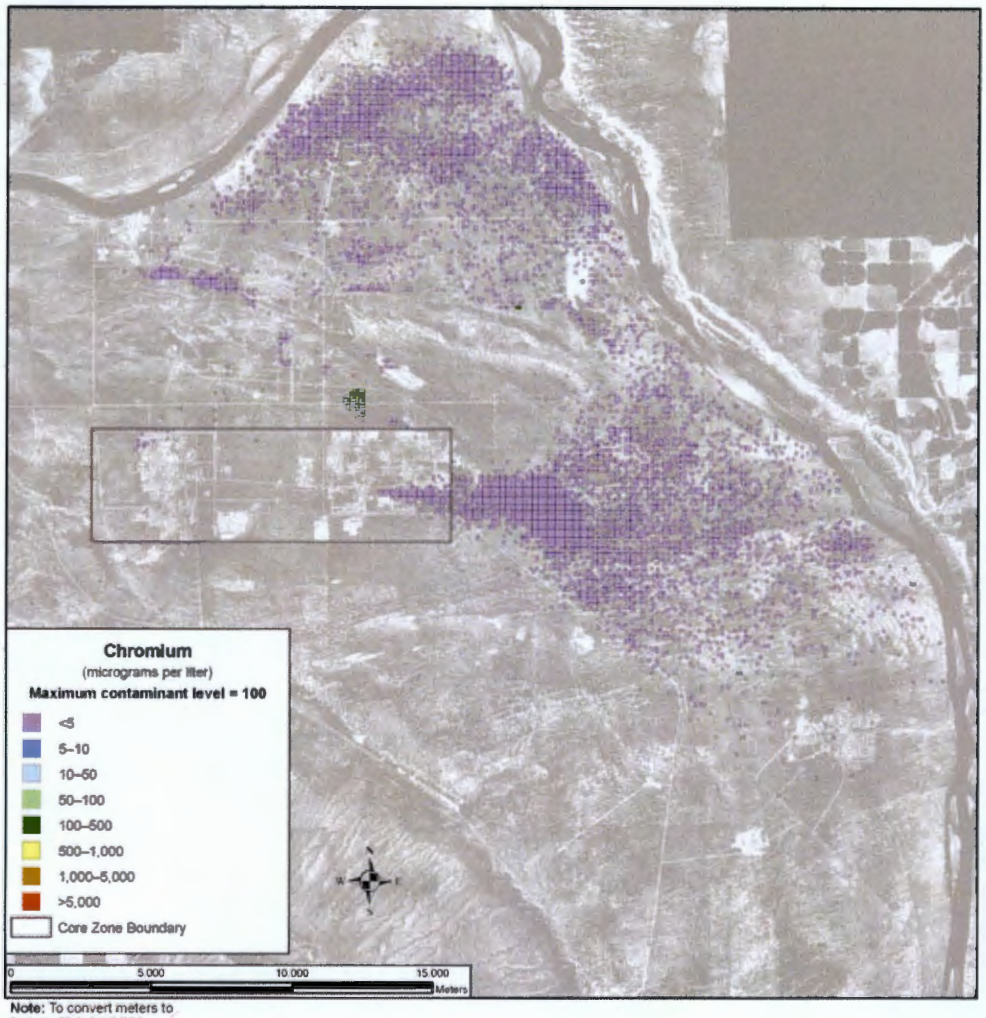
Note: To convert meters to feet, multiply by 3.281

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



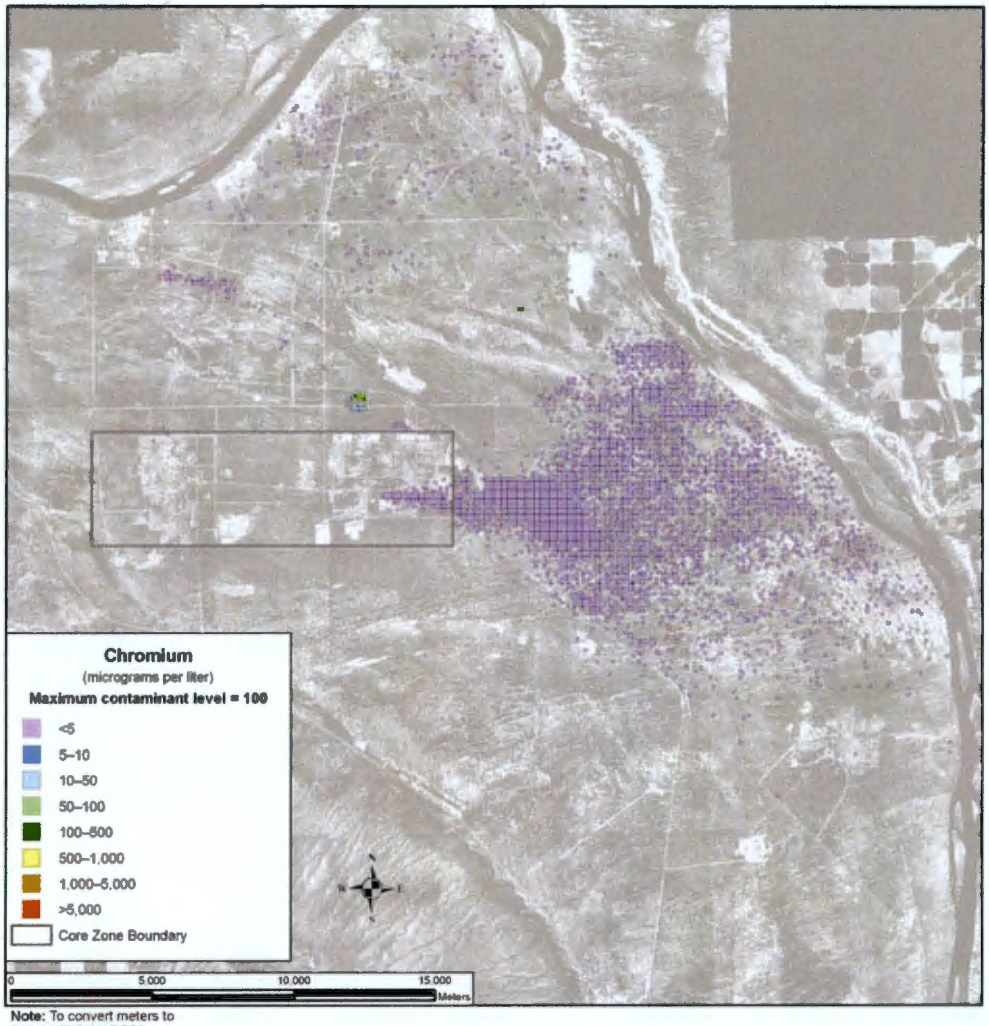
Note: To convert meters to feet, multiply by 3.281

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