Under FFTF Decommissioning Alternative 3, all aboveground structures, as well as contaminated below grade structures, equipment, and materials would be removed. As a result of the removal of all contaminated material, there would be no impacts on ecological receptors resulting from releases to groundwater.

5.2.4 Environmental Justice

Sections 5.2.1 and 5.2.2 evaluate groundwater impacts and associated potential long-term human health effects under the FFTF Decommissioning alternatives. Receptors analyzed with a potential for environmental justice concerns include a resident farmer, an American Indian resident farmer, and an American Indian hunter-gatherer. The hypothetical resident farmer, which could represent a low-income population, and American Indian resident farmer were both assumed to use only groundwater for drinking water ingestion and crop irrigation. While only a portion of the food consumed by the resident farmer was assumed to come from crops and animal products exposed to contaminated groundwater, all of the food consumed by the American Indian resident farmer was assumed to be exposed to contaminated groundwater. The American Indian hunter-gatherer was assumed to have a subsistence consumption pattern that differing from that of the American Indian resident farmer. The American Indian hunter gatherer does not cultivate crops but gathers food from indigenous plants, harvests fish from the Columbia River, and is exposed to a combination of surface water and groundwater. Given these assumptions, the two American Indian receptors would be most at risk from contaminated groundwater. These receptors were used to develop exposure scenarios at several on- and offsite locations identified in Appendix Q, Section Q.2.1. Long-term human health impacts of FFTF decommissioning actions would be greatest under FFTF Decommissioning Alternative 1. Under this alternative, none of the hypothetical receptors at any of the assessment boundaries would be exposed to radiological doses in excess of regulatory limits or to chemicals with a Hazard Index greater than 1. The greatest risk would be to the American Indian resident farmer at the FFTF boundary. During the year of peak dose, this receptor would receive a radiological dose of 3.8 millirem, compared to the regulatory limit of 100 millirem from all sources. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index less than 1. Therefore, none of the FFTF Decommissioning alternatives would pose a disproportionately high and adverse long-term human health risk to the American Indian population at offsite locations.

5.3 WASTE MANAGEMENT ALTERNATIVES

This section describes the potential long-term environmental impacts associated with the implementation of alternatives for administering ongoing solid waste management operations and proposed disposal of low-level radioactive waste (LLW) and mixed low-level radioactive waste (MLLW) from Hanford and a limited volume of offsite LLW and MLLW in an IDF located at Hanford. Specifically, this includes the management and disposal of LLW and MLLW from tank closure activities as described in Chapter 4, Section 4.1.14, as well as other non–Comprehensive Environmental Response, Compensation, and Liability Act (non-CERCLA) LLW and MLLW from Hanford, including the waste from FFTF decommissioning described in Chapter 4, Section 4.2.14, and waste from other DOE sites (i.e., offsite waste). This section analyzes the impacts of expanding Hanford's waste disposal capacity to provide space for on- and offsite waste; this section also includes an analysis of associated storage, disposal, and closure activities, as well as facility-specific construction, operations, deactivation, and closure activities.

Three Waste Management alternatives are considered and analyzed, including (1) Waste Management Alternative 1: No Action; (2) Waste Management Alternative 2: Disposal in IDF, 200-East Area Only; and (3) Waste Management Alternative 3: Disposal in IDF, 200-East and 200-West Areas.

Waste Management Alternative 1 would include storing and disposing of LLW and MLLW in trenches 31 and 34 of existing low-level radioactive waste burial ground (LLBG) 218-W-5 and storing and disposing of transuranic (TRU) waste in the Waste Isolation Project Plant (WIPP) near Carlsbad, New Mexico. No offsite waste would be received; construction/use of the IDF located in the 200-East Area (IDF-East) would be discontinued; and IDF-East would be deactivated.

Waste Management Alternative 2 would include storing LLW, MLLW, and TRU waste in the Central Waste Complex (CWC) prior to disposal and processing waste prior to disposal at new facilities or existing-facility expansions at the CWC, Waste Receiving and Processing Facility, and the T Plant. A total volume of 62,000 cubic meters (2.2 million cubic feet) of LLW and 20,000 cubic meters (706,300 cubic feet) of MLLW from other DOE sites would be received for disposal under this alternative. Waste from tank closure and treatment operations, onsite non-CERCLA sources, FFTF decommissioning, and waste management, as well as offsite waste from other DOE sites would be disposed of in IDF-East. A new RPPDF would be constructed for disposal of lightly contaminated equipment and soils as a result of tank farm clean closure activities.

Waste Management Alternative 3 would involve the same waste storage and processing provisions as Waste Management Alternative 2 and the same volume of offsite waste accepted for disposal; a new RPPDF would also be constructed. However, an additional IDF would be constructed in the 200-West Area (IDF-West). Waste from tank closure and treatment operations would be disposed of in IDF-East, while onsite non-CERCLA waste, FFTF decommissioning waste, waste management, and offsite waste from other DOE sites would be disposed of in IDF-West.

In addition, under each Waste Management action alternative (i.e., Alternatives 2 and 3), three disposal groupings are analyzed: Disposal Groups 1, 2, and 3. These disposal groupings encompass the sizing requirements and associated construction, operations, and closure requirements for the IDF(s) and RPPDF necessary to accommodate the varying waste volumes considered under each disposal configuration. These alternatives and options are described further in Chapter 2, Section 2.5, of this EIS.

These disposal groupings are further divided into subgroupings for the consideration of the different types and volumes of waste generated from the 10 Tank Closure action alternatives and the 2 FFTF Decommissioning action alternatives to analyze the long-term impacts associated with disposal of the various waste types and volumes. These subgroupings are described in Table 5–75.

Table 5–75. Waste Management Action Alternative Subgroupings

Waste Management Alternative	Disposal Group and Subgroup	Disposal Location	Tank Closure Alternative Waste	Other DOE Waste
1	N/A	LLBG, trenches 31 and 34	N/A	Non-CERCLA waste
2	Disposal Group 1, Subgroup 1-A	IDF-East	Tank Closure Alternative 2B • ILAW glass • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 2B • Closure waste (LLW and MLLW)	N/A
2	Disposal Group 1, Subgroup 1-B	IDF-East	Tank Closure Alternative 3A • ILAW glass • Bulk vitrification glass • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 3A • Closure waste (LLW and MLLW)	N/A
2	Disposal Group 1, Subgroup 1-C	IDF-East	Tank Closure Alternative 3B • ILAW glass • Cast stone waste • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 3B • Closure waste (LLW and MLLW)	N/A
2	Disposal Group 1, Subgroup 1-D	IDF-East	Tank Closure Alternative 3C • ILAW glass • Steam reforming waste • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 3C • Closure waste (LLW and MLLW)	N/A
2	Disposal Group 1, Subgroup 1-E	IDF-East	Tank Closure Alternative 4 • ILAW glass • Bulk vitrification glass • Cast stone waste • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 4 • Closure waste (LLW and MLLW)	N/A

Table 5-75. Waste Management Action Alternative Subgroupings *(continued)*

Waste Management Alternative	Disposal Group and Subgroup	Disposal Location	Tank Closure Alternative Waste	Other DOE Waste
2	Disposal Group 1, Subgroup 1-F	IDF-East	Tank Closure Alternative 5 • ILAW glass • Bulk vitrification glass • Cast stone waste • Sulfate grout • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	N/A	N/A
2	Disposal Group 1, Subgroup 1-G	IDF-East	Tank Closure Alternative 6C • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 6C • Closure waste (LLW and MLLW)	N/A
2	Disposal Group 2, Subgroup 2-A	IDF-East	Tank Closure Alternative 2A • ILAW glass • LAW melters • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	N/A	N/A
2	Disposal Group 2, Subgroup 2-B	IDF-East	Tank Closure Alternative 6B, Base and Option Cases • PPF melters • PPF glass • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 6B, Base and Option Cases • Closure waste (LLW and MLLW)	N/A
2	Disposal Group 3	IDF-East	Tank Closure Alternative 6A, Base and Option Cases • PPF melters • PPF glass • Secondary waste (LLW and MLLW)	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 6A, Base and Option Cases • Closure waste (LLW and MLLW)	N/A

Table 5-75. Waste Management Action Alternative Subgroupings *(continued)*

Waste Management Alternative	Disposal Group and Subgroup	Disposal Location	Tank Closure Alternative Waste	Other DOE Waste
3	Disposal Group 1, Subgroup 1-A	IDF-East	Tank Closure Alternative 2B • ILAW glass • LAW melters • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 2B • Closure waste (LLW and MLLW)	N/A
3	Disposal Group 1, Subgroup 1-B	IDF-East	Tank Closure Alternative 3A • ILAW glass • Bulk vitrification glass • LAW melters • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 3A • Closure waste (LLW and MLLW)	N/A
3	Disposal Group 1, Subgroup 1-C	IDF-East	Tank Closure Alternative 3B • ILAW glass • Cast stone waste • LAW melters • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 3B • Closure waste (LLW and MLLW)	N/A
3	Disposal Group 1, Subgroup 1-D	IDF-East	Tank Closure Alternative 3C • ILAW glass • Steam reforming waste • LAW melters • Secondary Waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 3C • Closure waste (LLW and MLLW)	N/A

Table 5-75. Waste Management Action Alternative Subgroupings *(continued)*

Waste Management Alternative	Disposal Group and Subgroup	Disposal Location	Tank Closure Alternative Waste	Other DOE Waste
3	Disposal Group 1, Subgroup 1-E	IDF-East	Tank Closure Alternative 4 • ILAW glass • Bulk vitrification glass • Cast stone waste • LAW melters • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 4 • Closure waste (LLW and MLLW)	N/A
3	Disposal Group 1, Subgroup 1-F	IDF-East	Tank Closure Alternative 5 • ILAW glass • Bulk vitrification glass • Cast stone waste • Sulfate grout • LAW melters • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	N/A	N/A
3	Disposal Group 1, Subgroup 1-G	IDF-East	Tank Closure Alternative 6C • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 6C • Closure waste (LLW and MLLW)	N/A
3	Disposal Group 2, Subgroup 2-A	IDF-East	Tank Closure Alternative 2A • ILAW glass • LAW melters • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	N/A	N/A

Table 5-75. Waste Management Action Alternative Subgroupings *(continued)*

Waste Management Alternative	Disposal Group and Subgroup	Disposal Location	Tank Closure Alternative Waste	Other DOE Waste
3	Disposal Group 2, Subgroup 2-B	IDF-East	Tank Closure Alternative 6B, Base and Option Cases • PPF melters • PPF glass • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 6B, Base and Option Cases • Closure waste (LLW and MLLW)	N/A
3	Disposal Group 3	IDF-East	Tank Closure Alternative 6A, Base and Option Cases • PPF melters • PPF glass • Secondary waste (LLW and MLLW)	N/A
		IDF-West	N/A	FFTF decommissioning waste Onsite secondary waste Non-CERCLA waste Offsite waste
		RPPDF	Tank Closure Alternative 6A, Base and Option Cases • Closure waste (LLW and MLLW)	N/A

Key: CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; DOE= U.S. Department of Energy; FFTF=Fast Flux Test Facility; IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; ILAW=immobilized low-activity waste; LAW=low-activity waste; LLBG=low-level radioactive waste burial ground; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; N/A=not applicable; PPF=Preprocessing Facility; RPPDF=River Protection Project Disposal Facility.

5.3.1 Groundwater

5.3.1.1 Waste Management Alternative 1: No Action

This section describes the groundwater analysis results for Waste Management Alternative 1, including long-term groundwater impacts of contaminant sources within the Trenches 31 and 34 Barrier. Impacts of sources remaining within the tank farm barriers are presented in Section 5.1, which discusses tank closure impacts. Impacts of sources remaining within the FFTF Barrier are presented in Section 5.2, which discusses FFTF decommissioning impacts.

5.3.1.1.1 Actions and Timeframes Influencing Groundwater Impacts

Summaries of the proposed actions and timelines for Waste Management Alternative 1 are provided in Chapter 2, Section 2.5. For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 1, as follows:

- The disposal period was assumed to start with the onset of disposal operations in LLBG 218-W-5, trenches 31 and 34, in CY 2008 and continue through CY 2035, when the trenches would be operationally closed. During this time, these trenches have accepted, and would continue to

accept, onsite non-CERCLA LLW and MLLW. During the disposal period, the materials in this permitted, operational facility would not be available for release to the environment.

- The post-disposal period was assumed to start in CY 2036 and continue through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in the trenches become available for release to the environment. Waste Management Alternative 1 does not include construction of barriers over trenches 31 and 34. However, the surrounding LLBG 218-W-5, which is included in the cumulative impact analysis, would have a barrier emplaced consistent with the cumulative impact analysis end-state methodology (see Appendix S). For the purpose of analyzing long-term groundwater impacts under Waste Management Alternative 1, trenches 31 and 34 are assumed to be covered by a barrier that limits infiltration for the first 500 years of the post-disposal period.

5.3.1.1.2 COPC Drivers

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

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

The COPC drivers for Waste Management Alternative 1 were selected by evaluating the risk or hazard associated with all 40 COPCs in 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 1.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, 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.

5.3.1.1.3 Analysis of Release and Mass Balance

This section presents the impacts of Waste Management Alternative 1 in terms of the 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 5–345 through 5–350). Two subtotals are plotted representing releases from trenches 31 and 34. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over three orders of magnitude.

Figure 5–345 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–346, the chemical hazard drivers. For both 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). Trenches 31 and 34 are equal sources for all COPCs.

Figure 5–347 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–348, 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 COPCs act as conservative tracers, and essentially all of the release to the vadose zone reached groundwater in the analysis.

Figure 5–349 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–350, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. In all cases, nearly 100 percent of the amount released to groundwater reached the Columbia River in the analysis.

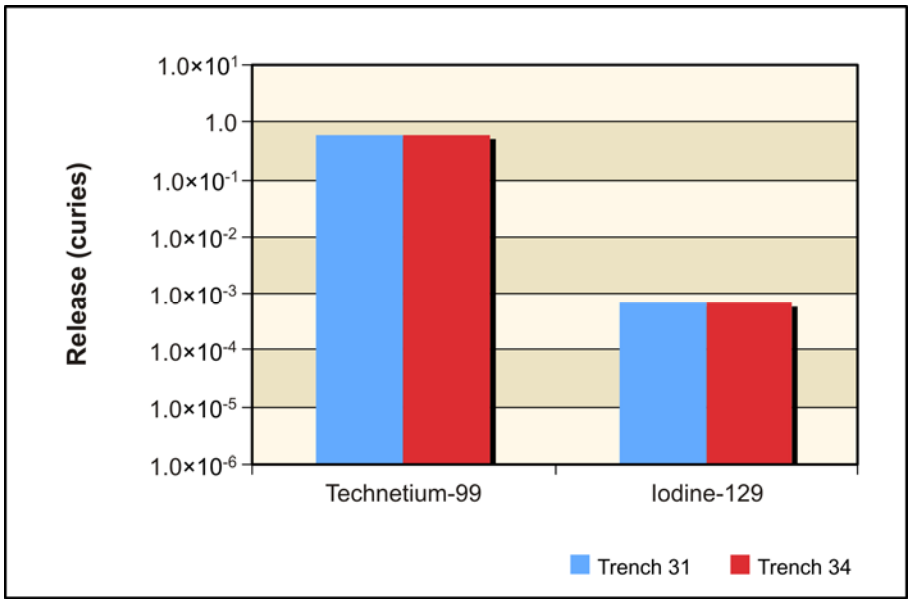


Figure 5–345. Waste Management Alternative 1, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

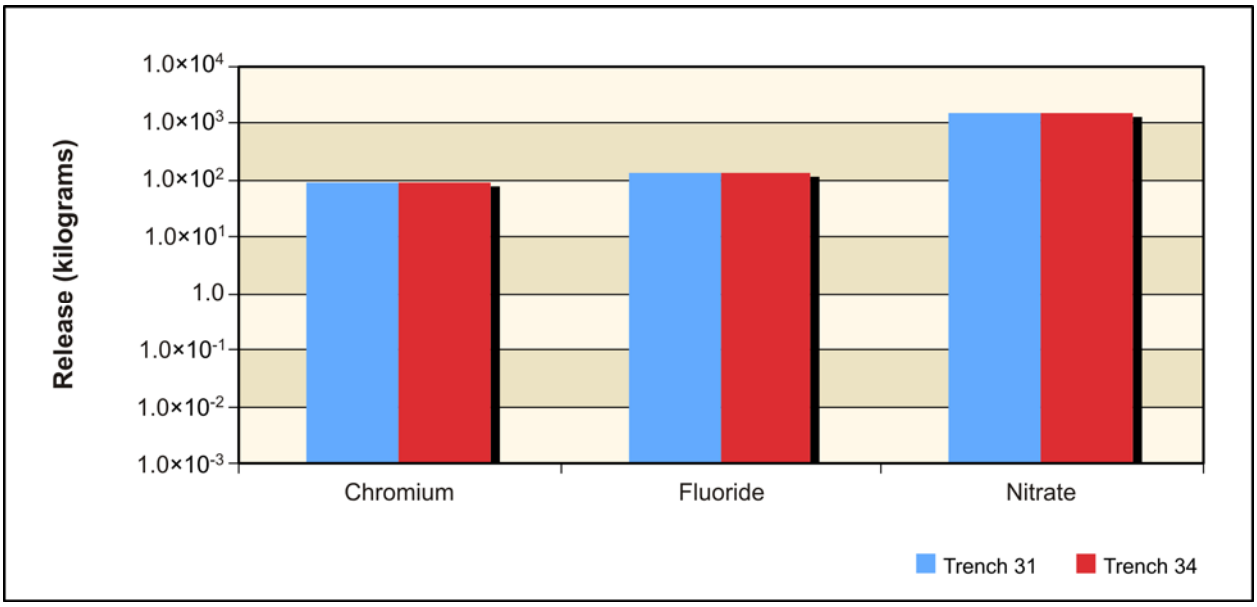


Figure 5–346. Waste Management Alternative 1, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

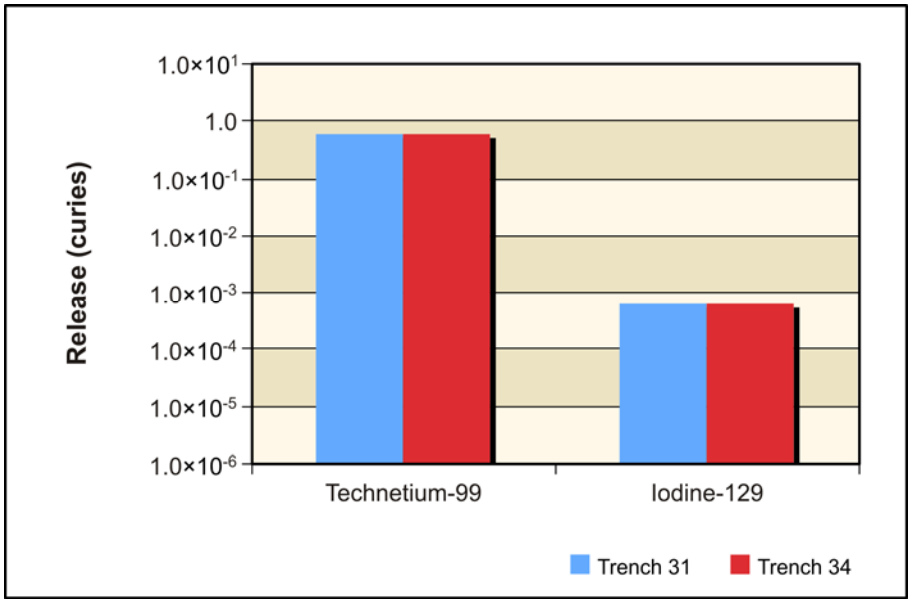


Figure 5–347. Waste Management Alternative 1, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

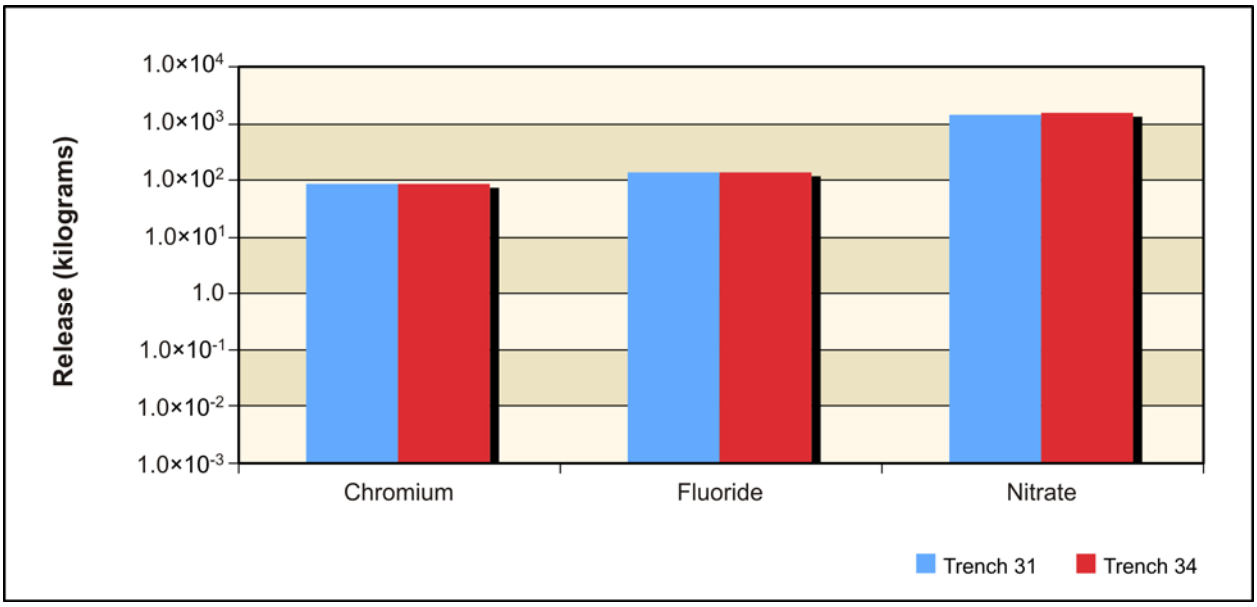


Figure 5–348. Waste Management Alternative 1, Chemical Releases at 200-East Area Integrated Disposal Facility Groundwater

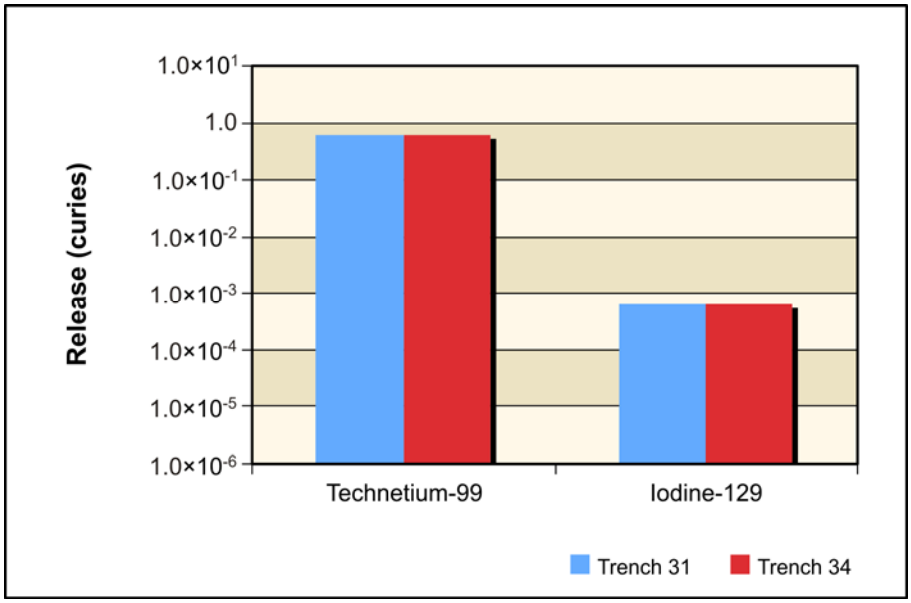


Figure 5–349. Waste Management Alternative 1, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

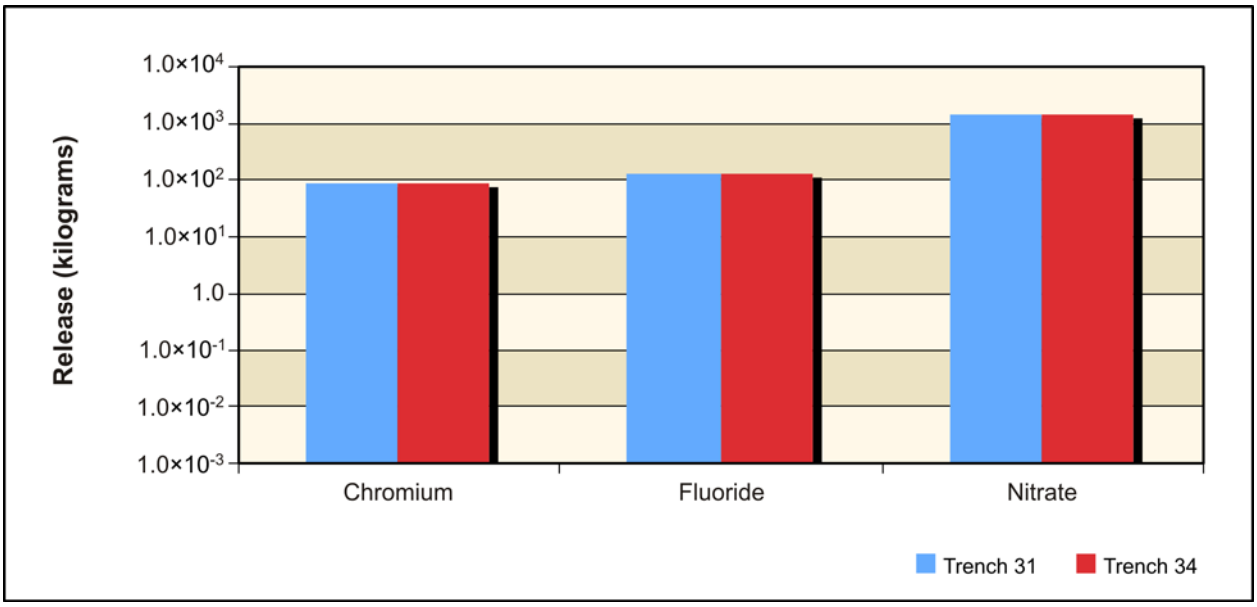


Figure 5–350. Waste Management Alternative 1, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

5.3.1.1.4 Analysis of Concentration Versus Time

This section presents the analysis of Waste Management Alternative 1 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 (see Figures 5–351 through 5–356). The benchmark concentration for each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude. Table 5–76 lists the maximum concentrations of the COPCs in the peak year at trenches 31 and 34 and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–351 through 5–354 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). For technetium-99, concentrations at the Core Zone Boundary rise early in the simulation, reaching a peak of about two orders of magnitude below the benchmark between CYs 2940 and 3940. After the peak, concentrations decline for the remainder of the simulation. Iodine-129, chromium, and nitrate all follow similar patterns, although the peak concentration for nitrate at the Core Zone Boundary is over three orders of magnitude below the benchmark.

Figures 5–355 and 5–356 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 over four 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.

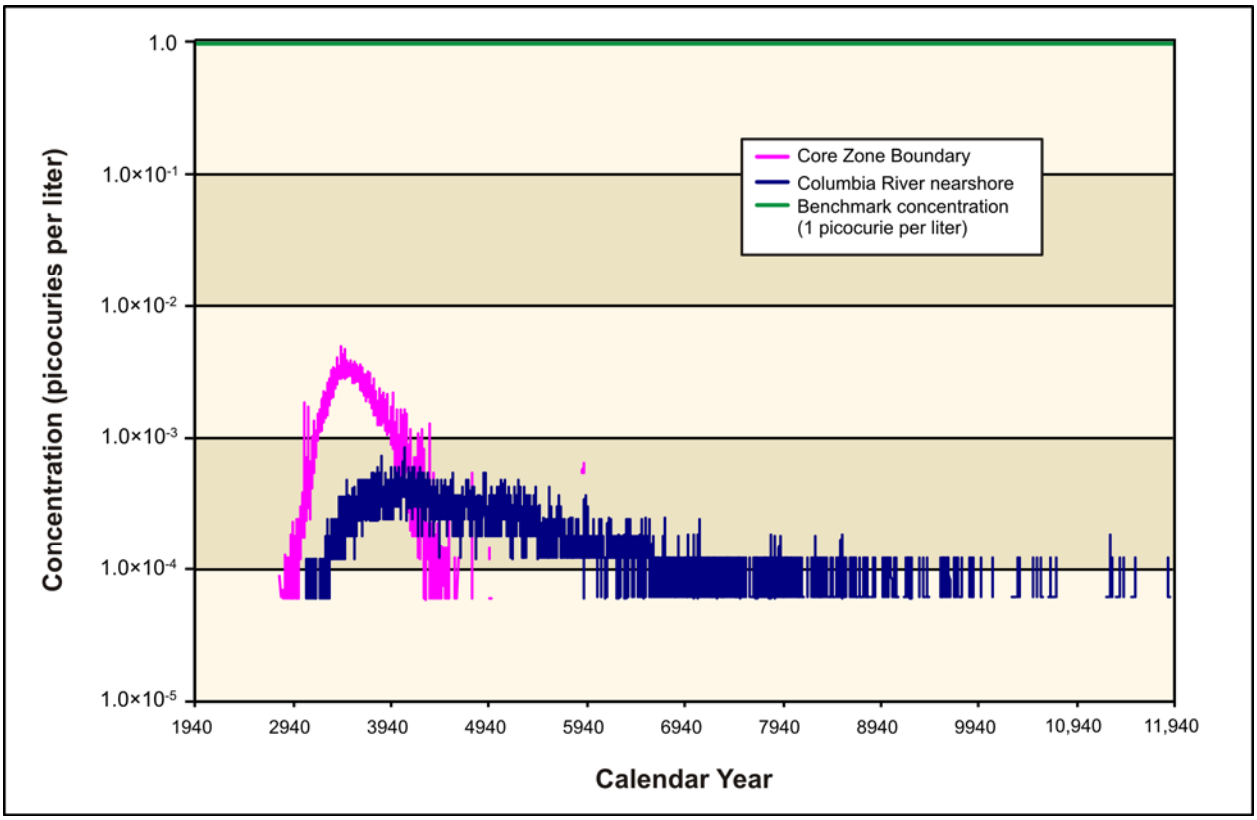


Figure 5–351. Waste Management Alternative 1, Iodine-129 Concentration Versus Time

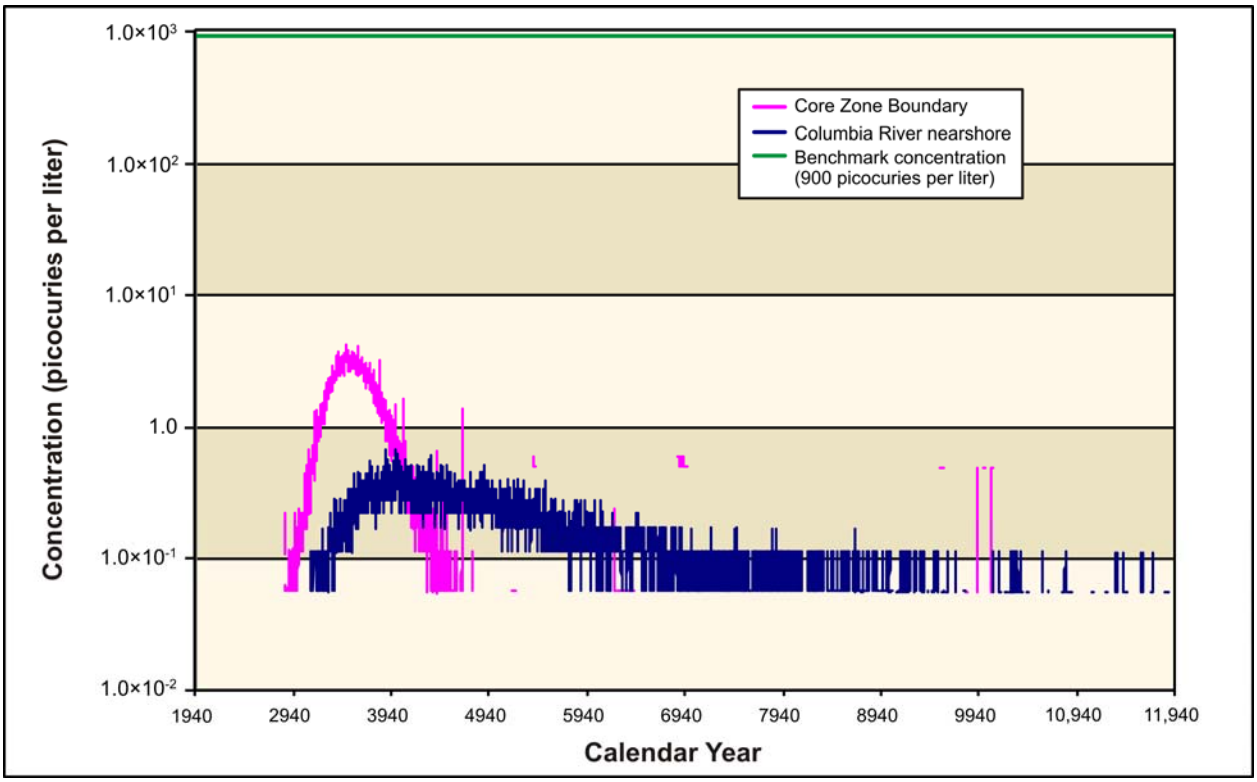


Figure 5–352. Waste Management Alternative 1, Technetium-99 Concentration Versus Time

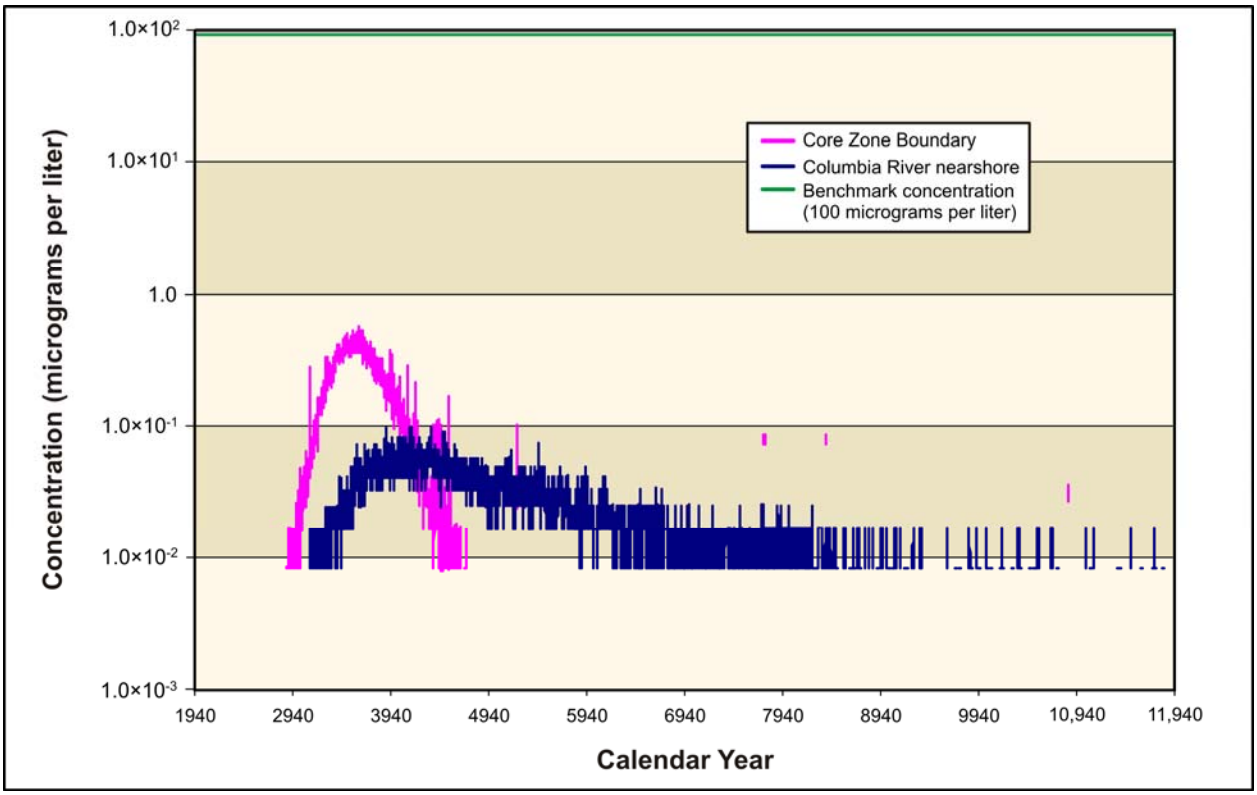


Figure 5–353. Waste Management Alternative 1, Chromium Concentration Versus Time

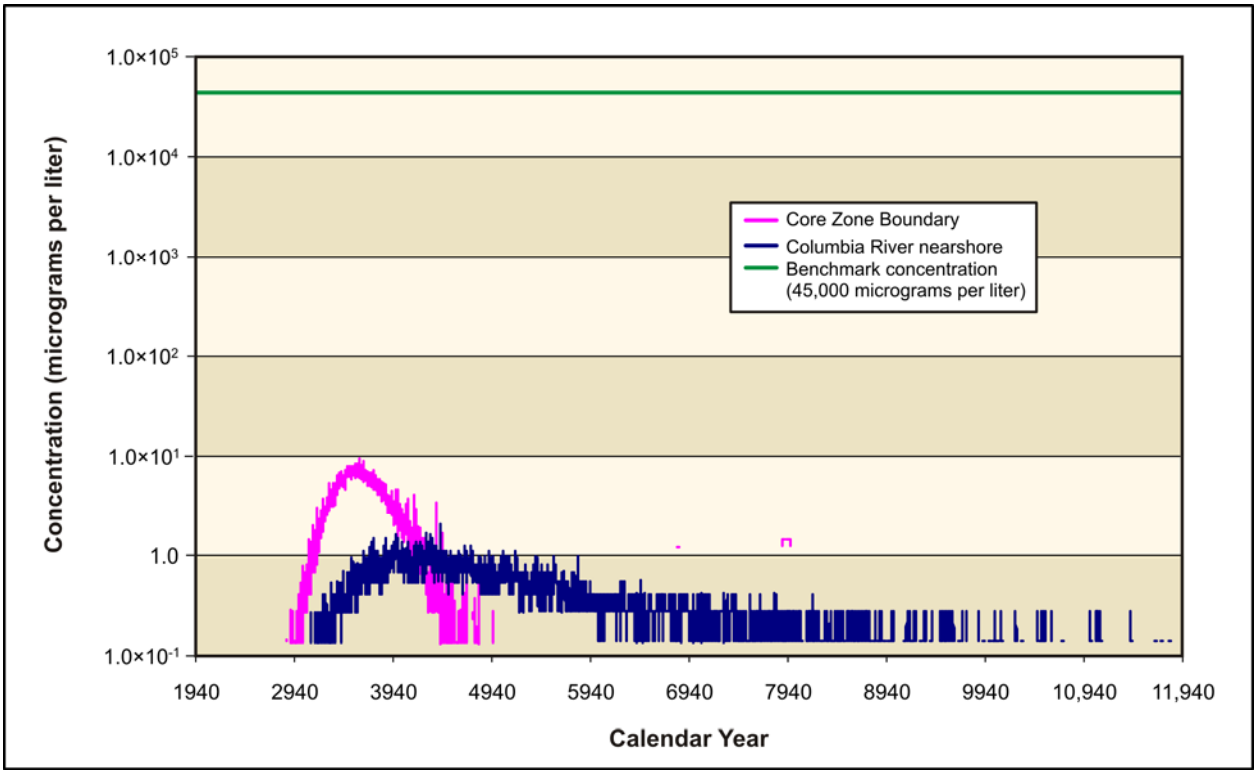


Figure 5–354. Waste Management Alternative 1, Nitrate Concentration Versus Time

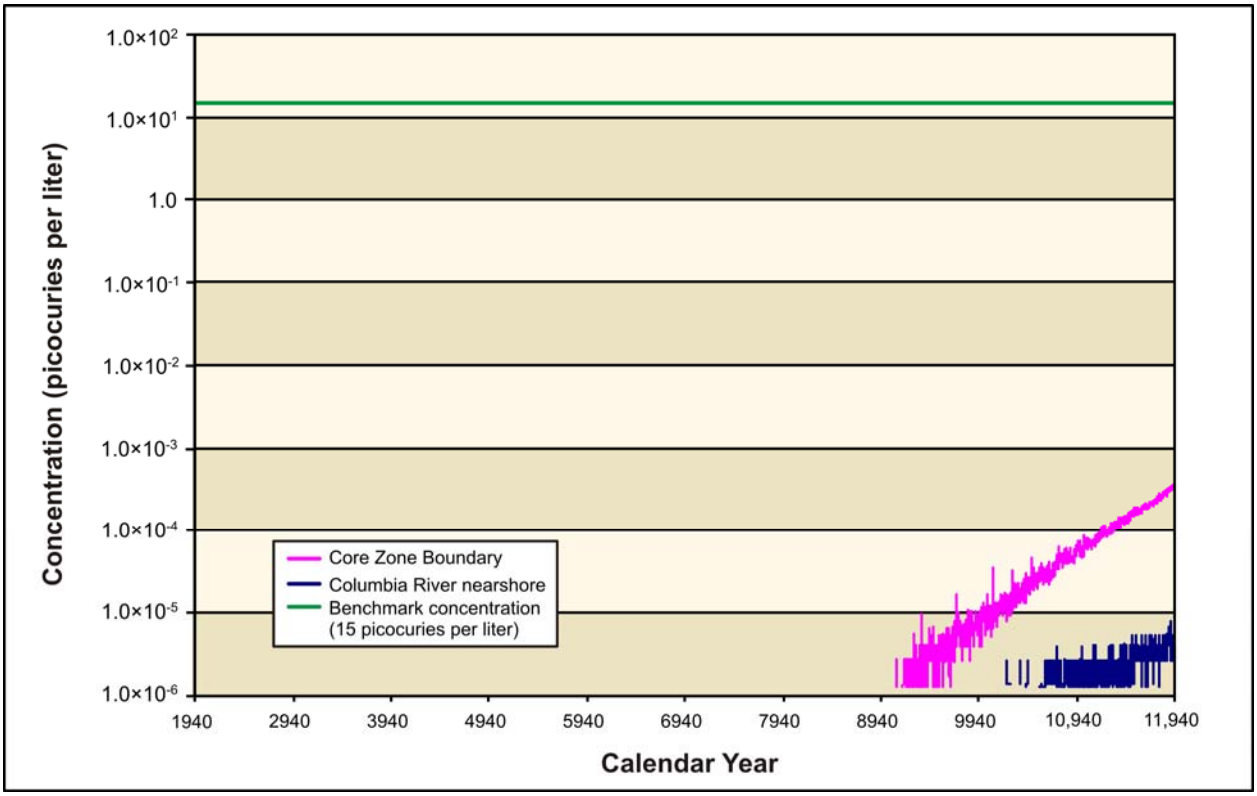


Figure 5–355. Waste Management Alternative 1, Uranium-238 Concentration Versus Time

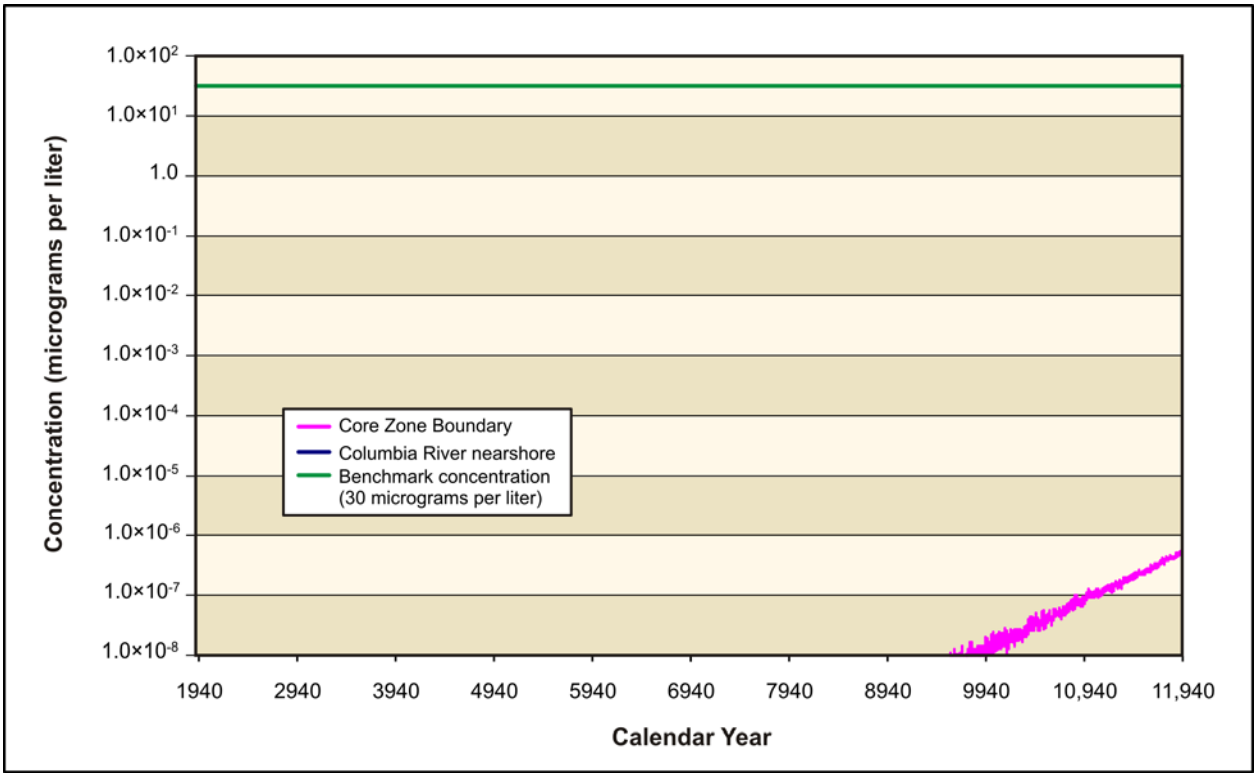


Figure 5–356. Waste Management Alternative 1, Total Uranium Concentration Versus Time

Table 5–76. Waste Management Alternative 1 Maximum COPC Concentrations in the Peak Year at Trenches 31 and 34, and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	Trenches 31 and 34	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	22 (3499)	N/A	4 (3474)	1 (3974)	900
Chemical in micrograms per liter					
Chromium	3 (3526)	N/A	1 (3615)	0 (4353)	100
Fluoride	4 (3545)	N/A	1 (3661)	0 (4592)	4,000
Nitrate	47 (3534)	N/A	9 (3600)	2 (4417)	45,000

Note: Corresponding calendar year shown in parentheses.
Key: COPC=constituent of potential concern; N/A=not applicable; RPPDF=River Protection Project Disposal Facility.

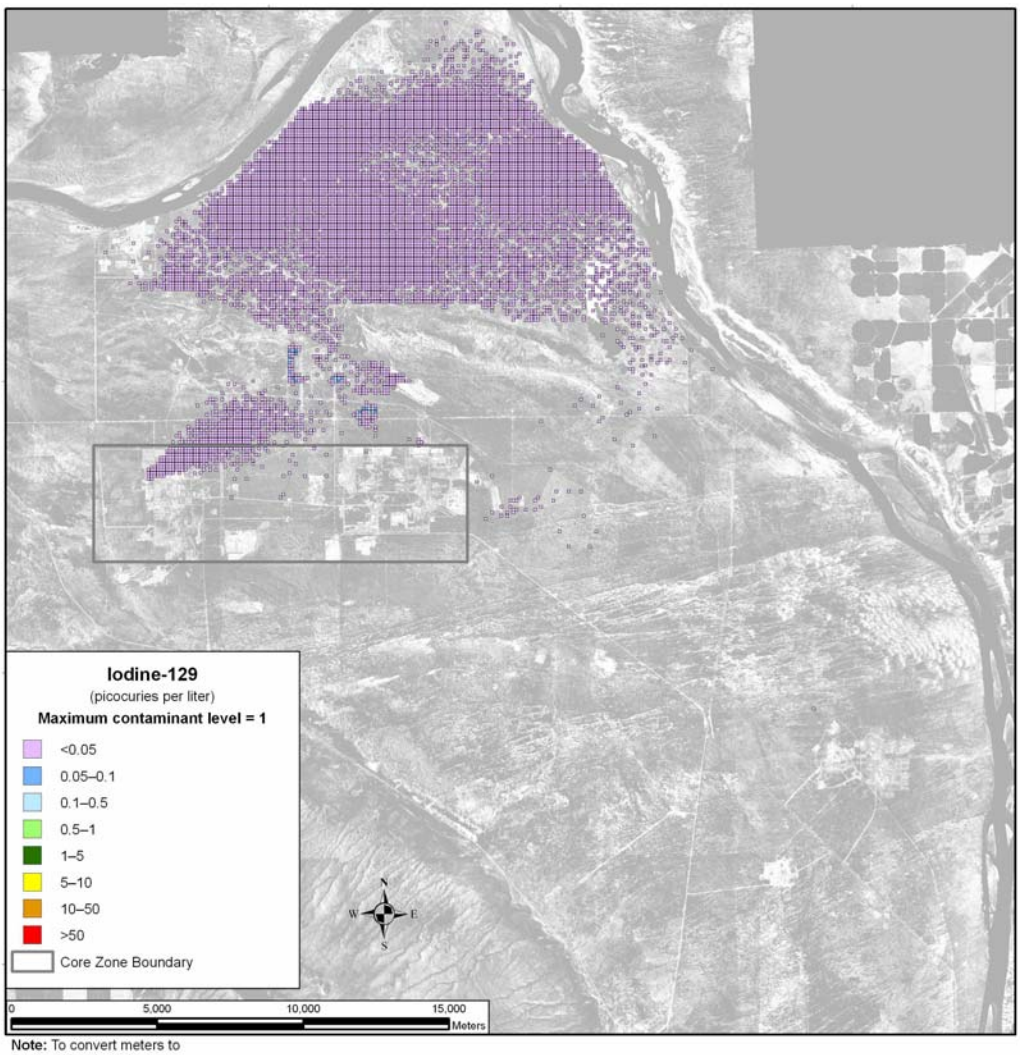
5.3.1.1.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of Waste Management Alternative 1 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 (see Figures 5–357 through 5–366). 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.

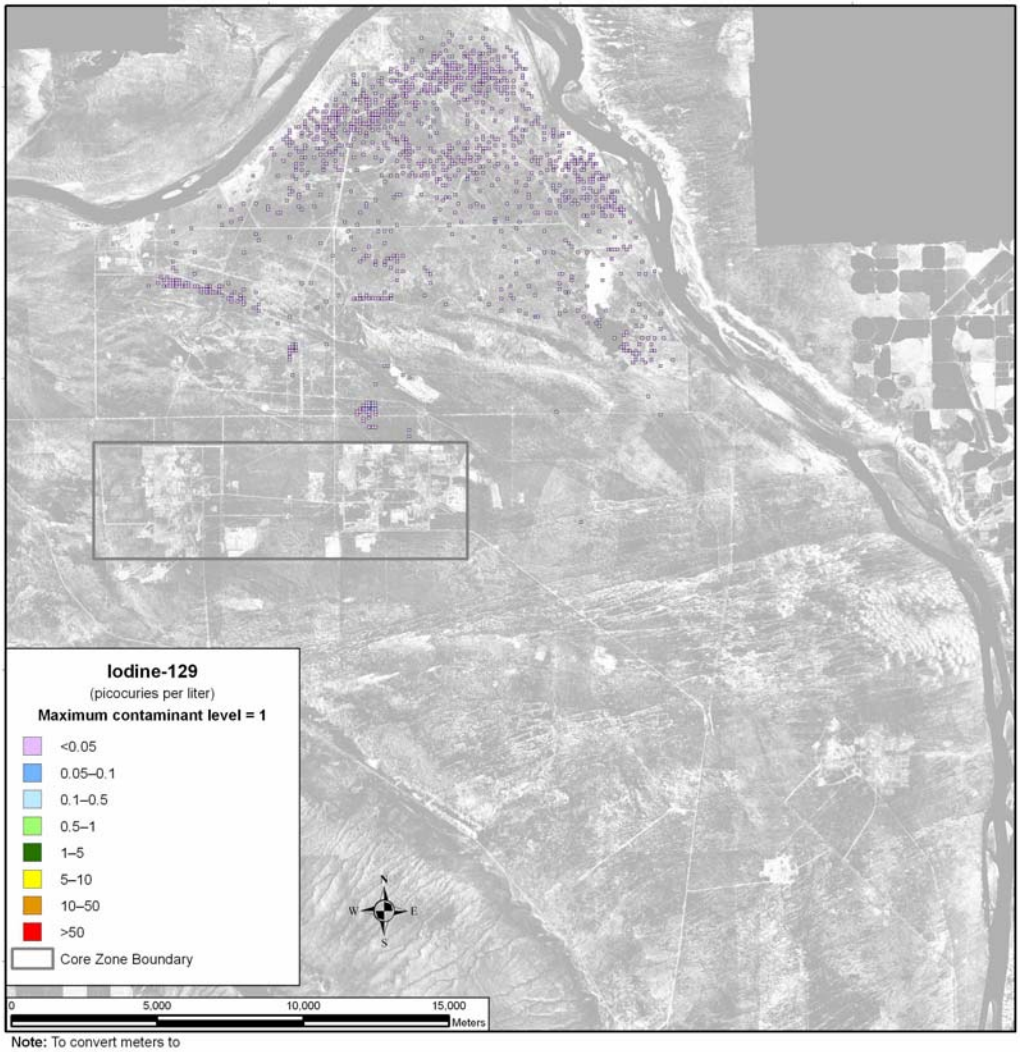
At CY 3890 (see Figure 5–357), there is a very low-concentration plume of iodine-129 stretching northeast of trenches 31 and 34 and through Gable Gap. By CY 7140 (Figure 5–358), the plume has almost completely dissipated. Technetium-99 (see Figures 5–359 and 5–360), nitrate (see Figures 5–361 and 5–362), and chromium (see Figures 5–363 and 5–364) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

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 are total uranium and uranium-238 plumes (see Figures 5–365 and 5–366, respectively) extending through Gable Gap from trenches 31 and 34. Concentrations in all areas of the plumes remain below one-twentieth of the benchmark.



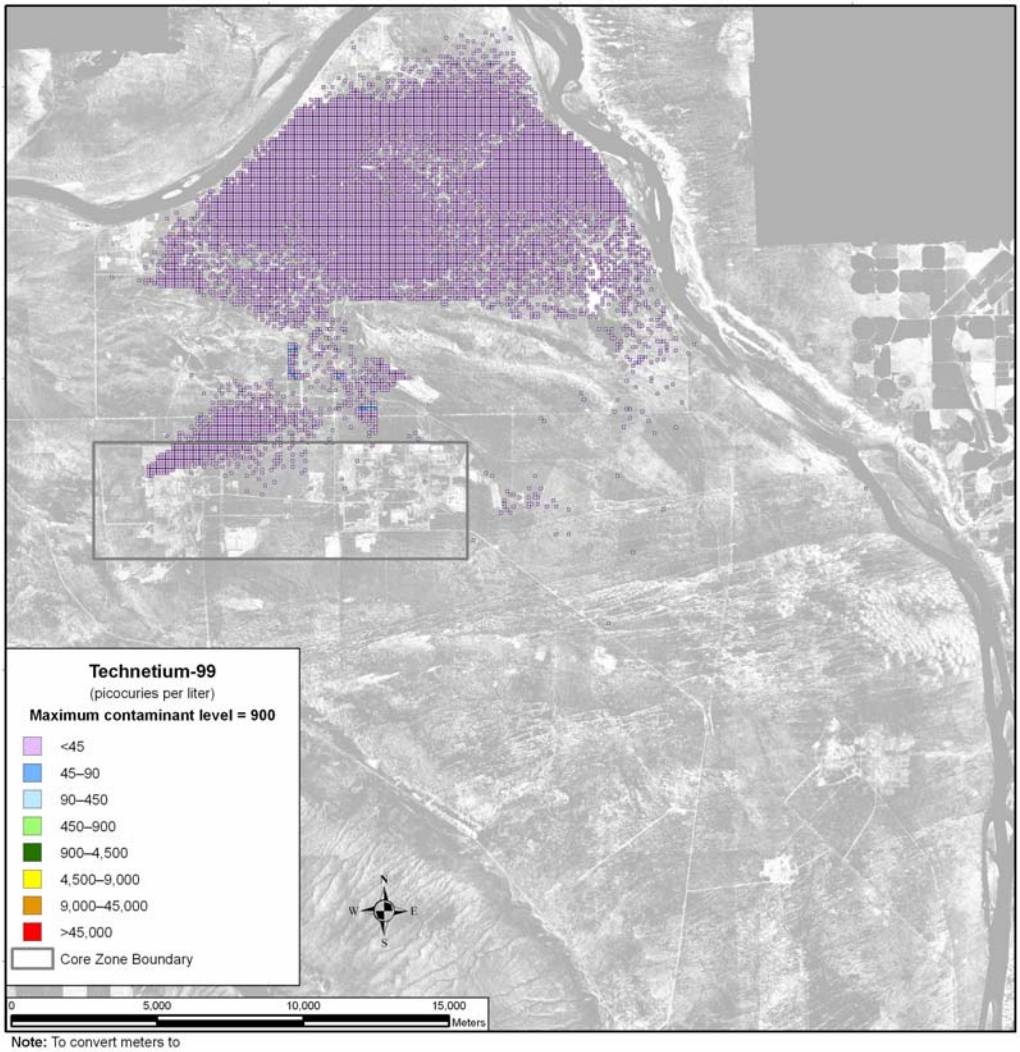
Note: To convert meters to feet, multiply by 3.281

Figure 5–357. Waste Management Alternative 1, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



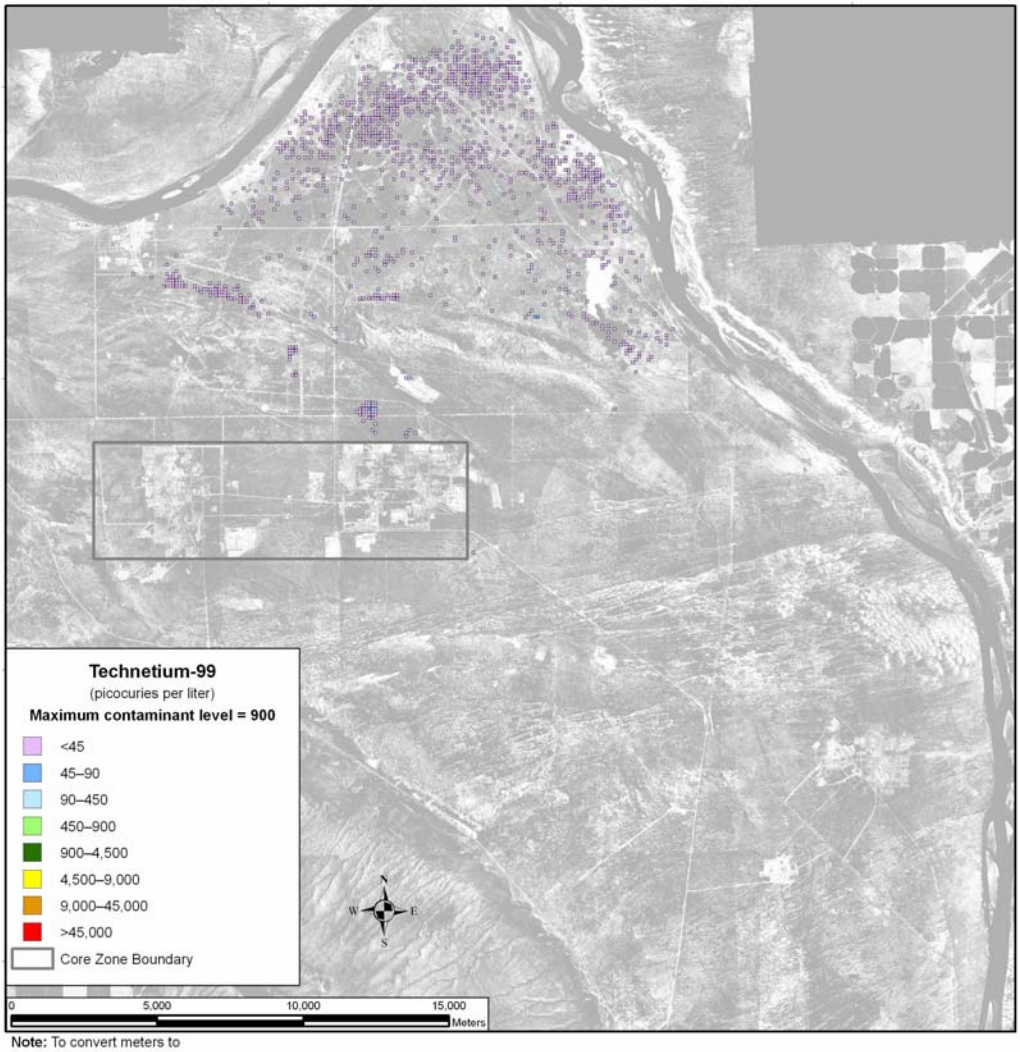
Note: To convert meters to feet, multiply by 3.281

Figure 5–358. Waste Management Alternative 1, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



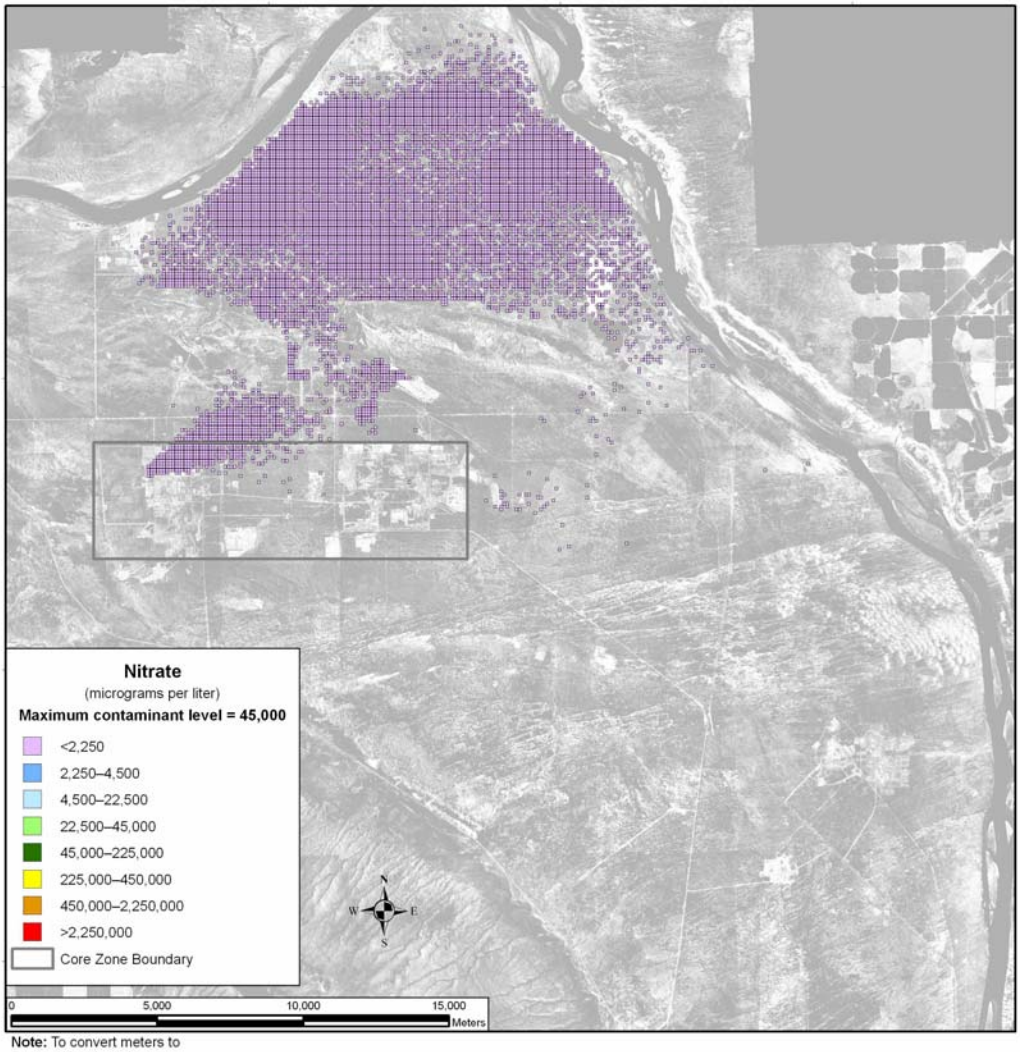
Note: To convert meters to feet, multiply by 3.281

Figure 5–359. Waste Management Alternative 1, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



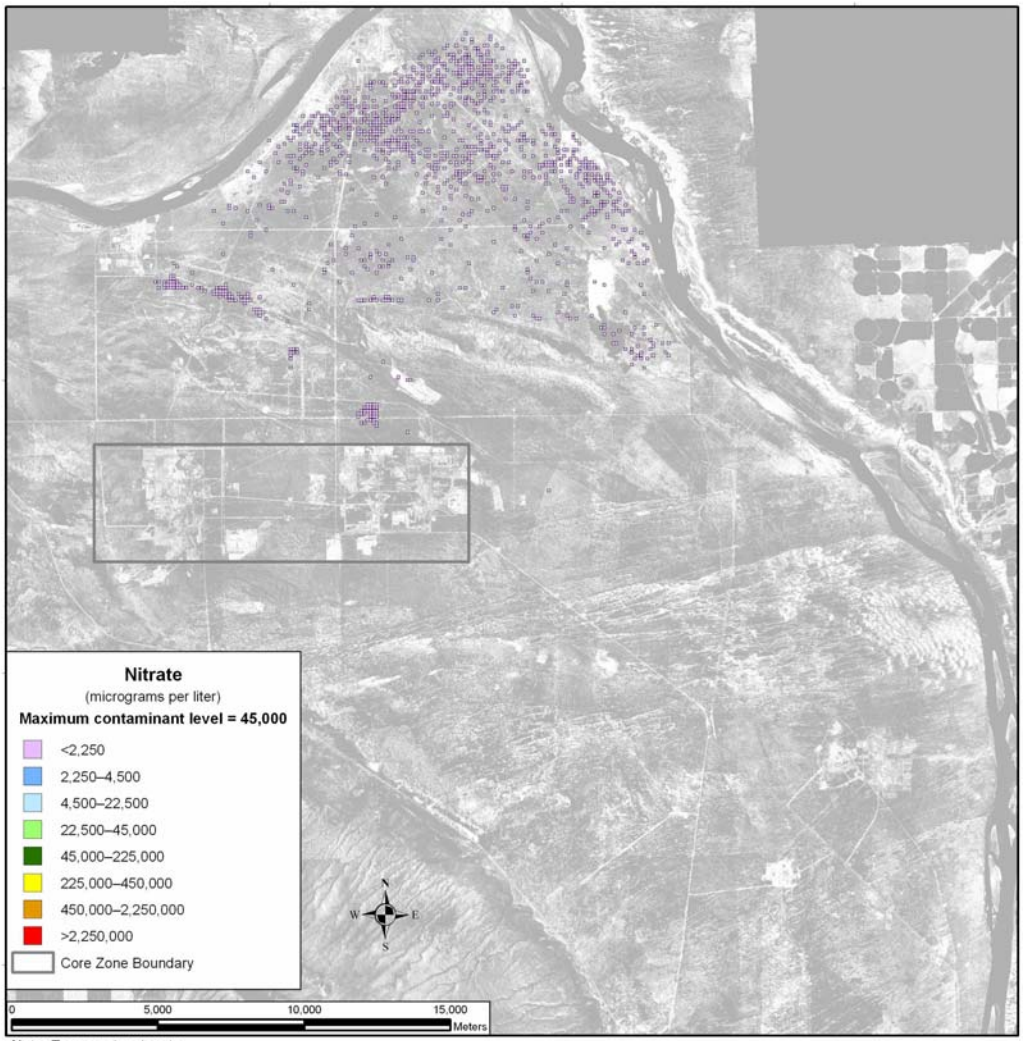
Note: To convert meters to feet, multiply by 3.281

Figure 5–360. Waste Management Alternative 1, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



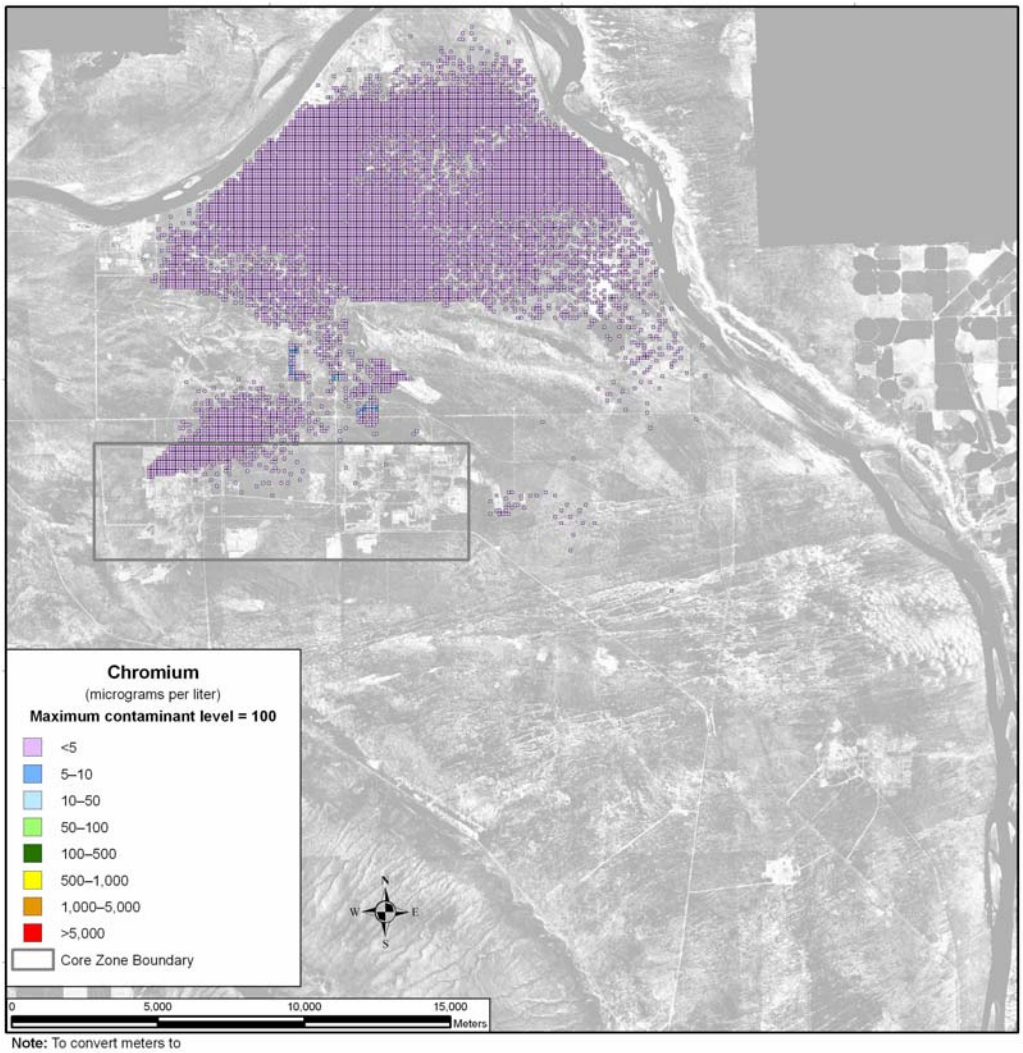
Note: To convert meters to feet, multiply by 3.281

Figure 5–361. Waste Management Alternative 1, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



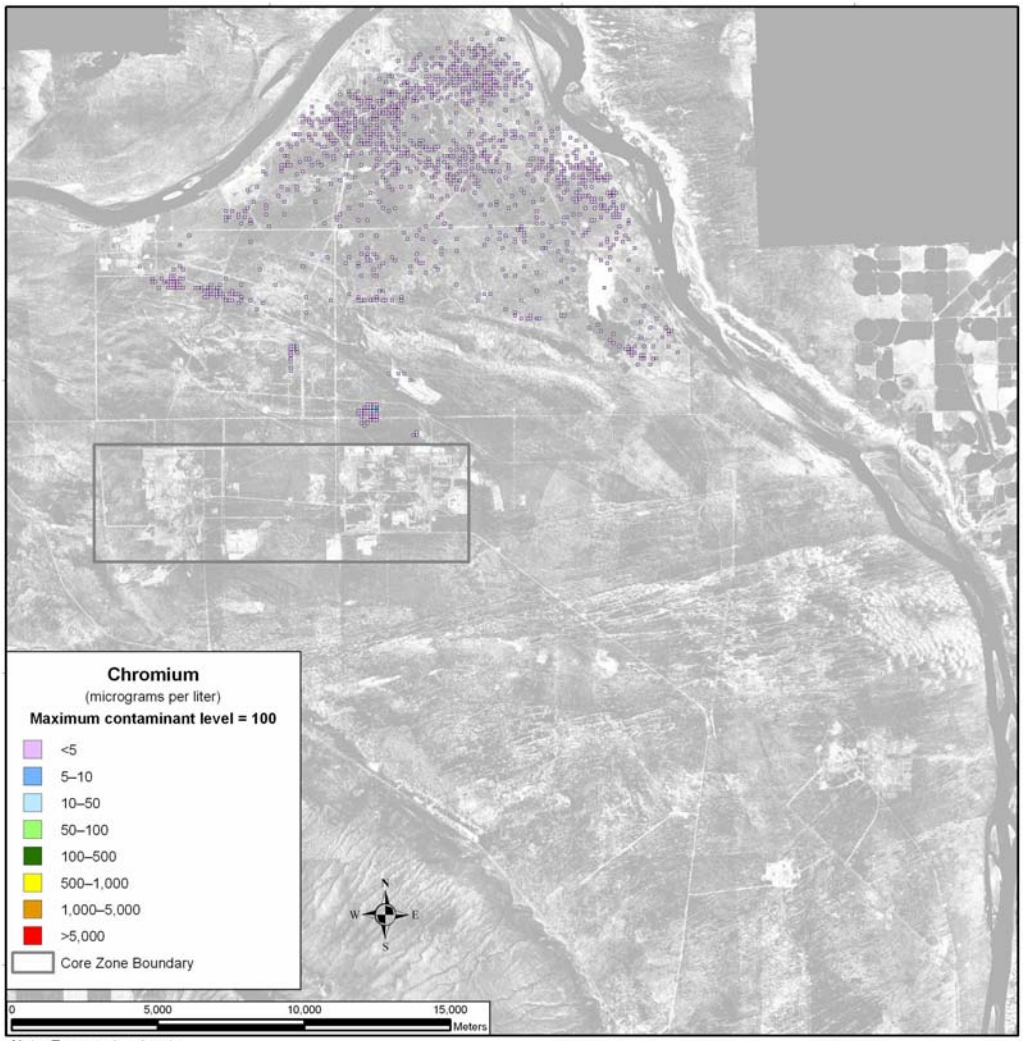
Note: To convert meters to feet, multiply by 3.281

Figure 5–362. Waste Management Alternative 1, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



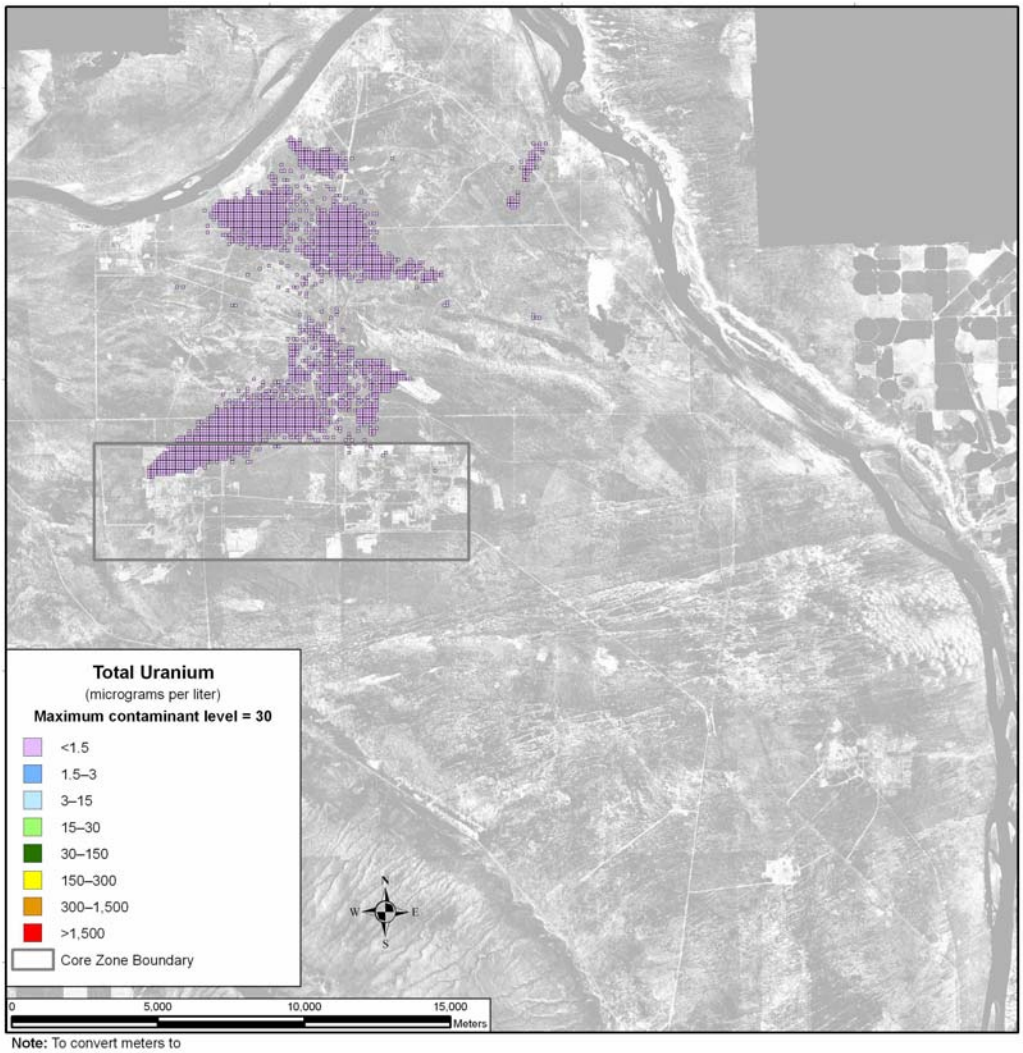
Note: To convert meters to feet, multiply by 3.281

Figure 5–363. Waste Management Alternative 1, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



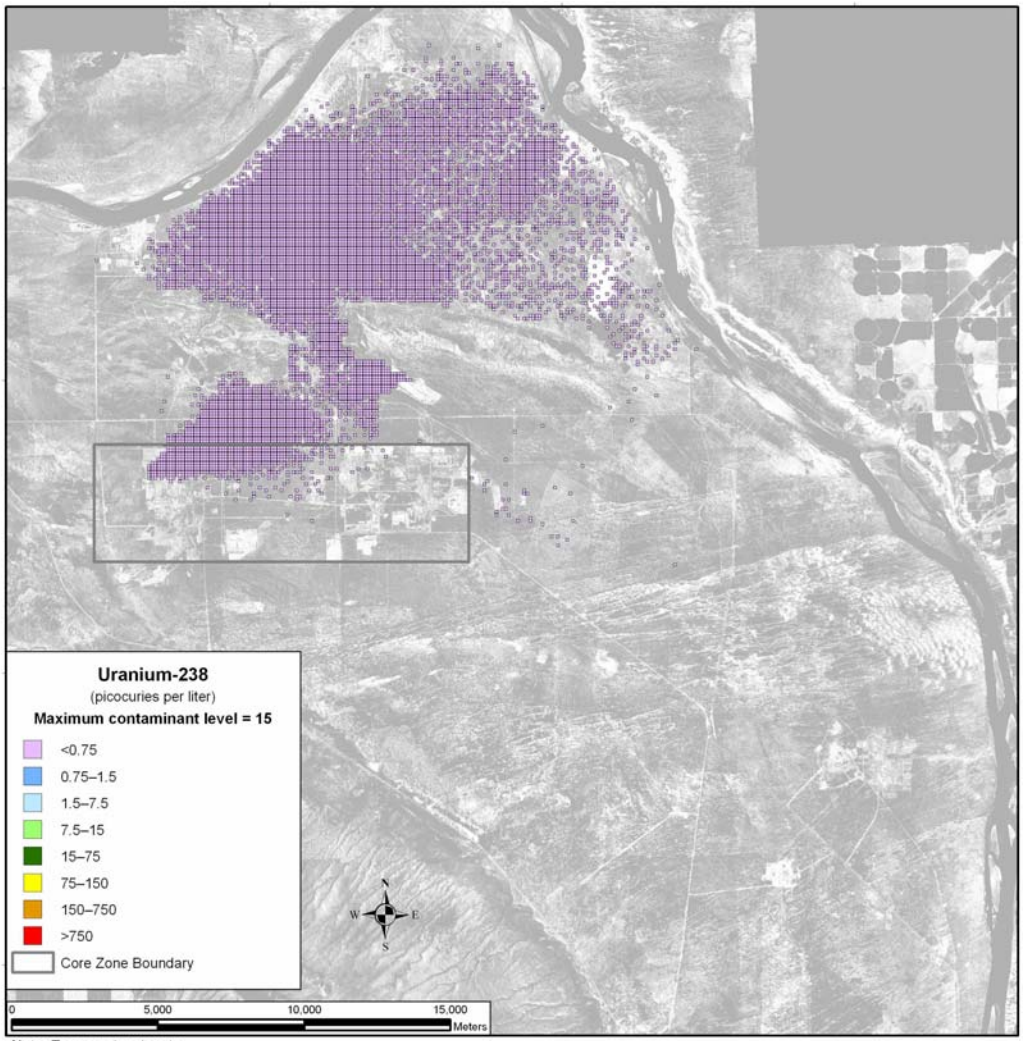
Note: To convert meters to feet, multiply by 3.281

Figure 5–364. Waste Management Alternative 1, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–365. Waste Management Alternative 1, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–366. Waste Management Alternative 1, Spatial Distribution of Groundwater Uranium-238 Concentration During Calendar Year 11,885

5.3.1.1.6 Summary of Impacts

Under Waste Management Alternative 1, all discharges originate in trenches 31 and 34.

No COPCs reached a concentration exceeding the benchmark concentration at the Core Zone Boundary or Columbia River during the course of the simulation.

5.3.1.2 Waste Management Alternative 2: Disposal in IDF, 200-East Area Only

This section describes the groundwater analysis results for Waste Management Alternative 2, including long-term groundwater impacts of contaminant sources within the IDF-East and RPPDF Barriers. Impacts of sources remaining within the tank farm barriers are presented in Section 5.1, which discusses tank closure impacts. Impacts of sources remaining within the FFTF Barrier are presented in Section 5.2, which discusses FFTF decommissioning impacts.

Summaries of the proposed actions and timelines for Waste Management Alternative 2 are provided in Chapter 2, Section 2.5. There are three disposal facilities, as follows:

- LLBG 218-W-5 trenches 31 and 34, which receive LLW and MLLW. For the purposes of this analysis, the waste inventories associated with these trenches are included with the IDF-East inventory.

- IDF-East, located in the south-central part of the 200-East Area, which receives tank waste, FFTF decommissioning waste, onsite-generated non-CERCLA waste, and offsite-received LLW and MLLW. The LLW and MLLW inventories for trenches 31 and 34 are also included at IDF-East in this analysis.

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

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

5.3.1.2.1 Disposal Group 1

Disposal Group 1 is characterized by an operational completion date of CY 2050 for both IDF-East and the RPPDF. Under Disposal Group 1, IDF-East has a large capacity (1,200,000 cubic meters [1,570,000 cubic yards]) and the RPPDF has a smaller capacity (1,030,000 cubic meters [1,350,000 cubic yards]). These capacities were designed to meet the waste generation volumes associated with Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, and 6C; either FFTF Decommissioning Alternative 2 or 3; and waste management activities.

5.3.1.2.1.1 Disposal Group 1, Subgroup 1-A

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

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

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and the RPPDF in CY 2008 and continue through CY 2050, when these 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 the facilities become available for release to the environment, and modified RCRA Subtitle C barriers would be emplaced over IDF-East and the RPPDF to limit infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A (Tank Closure Alternative 2B, FFTF Decommissioning Alternative 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: boron, chromium, fluoride, and nitrate

The COPC drivers for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-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 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 2, Disposal Group 1, Subgroup 1-A.

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 2, Disposal Group 1, Subgroup 1-A, in terms of the 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 5–367 through 5–378). Three subtotals are plotted, representing releases from the RPPDF and IDF-East, which include ILAW glass, Effluent Treatment Facility (ETF)-generated secondary waste, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste. 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.

Figure 5–367 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers representing the individual waste form release and Figure 5–368, 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 in the analysis). For the radiological COPCs (technetium-99 and iodine-129), the releases range over seven orders of magnitude, depending on the source. The chemical COPCs (boron, chromium, fluoride, and nitrate) in IDF-East all have releases associated with waste management secondary waste and onsite-generated waste. Other sources include 99 percent of the nitrate release from ETF-generated secondary waste and 81 percent of the chromium release from tank closure secondary waste; the other chromium releases are dispersed in the other waste forms.

Figure 5–369 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–370, 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, boron, chromium, fluoride, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone. The exception to this is the release associated with retired melters, which decreases at groundwater for both technetium-99 and iodine-129 by more than 40 percent. These results suggest that melters as a source do not continue to release after the initial exposure.

Figure 5–371 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–372, 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. The exception to this is the *de minimis* release associated with the retired melters.

Figure 5–373 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–374, the chemical hazard drivers. The release of technetium-99 is more than two orders of magnitude greater than the release of iodine-129 at the RPPDF. The chemical constituents show nitrate as the predominant COPC, about two orders of magnitude greater than the release of chromium at the RPPDF.

Figure 5–375 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–376, the chemical hazard drivers. 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 5–377 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–378, the chemical hazard drivers. Both figures show trends similar to those discussed in the previous paragraph for the release to the Columbia River for all COPC drivers at the RPPDF.

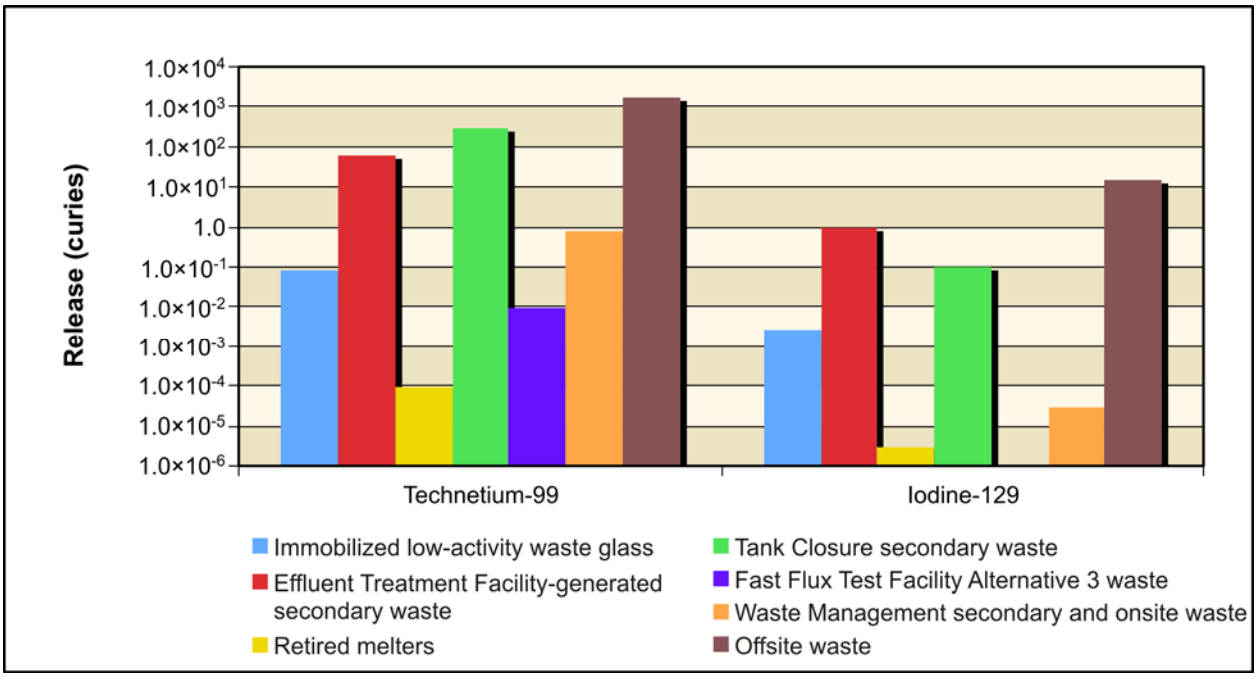


Figure 5–367. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

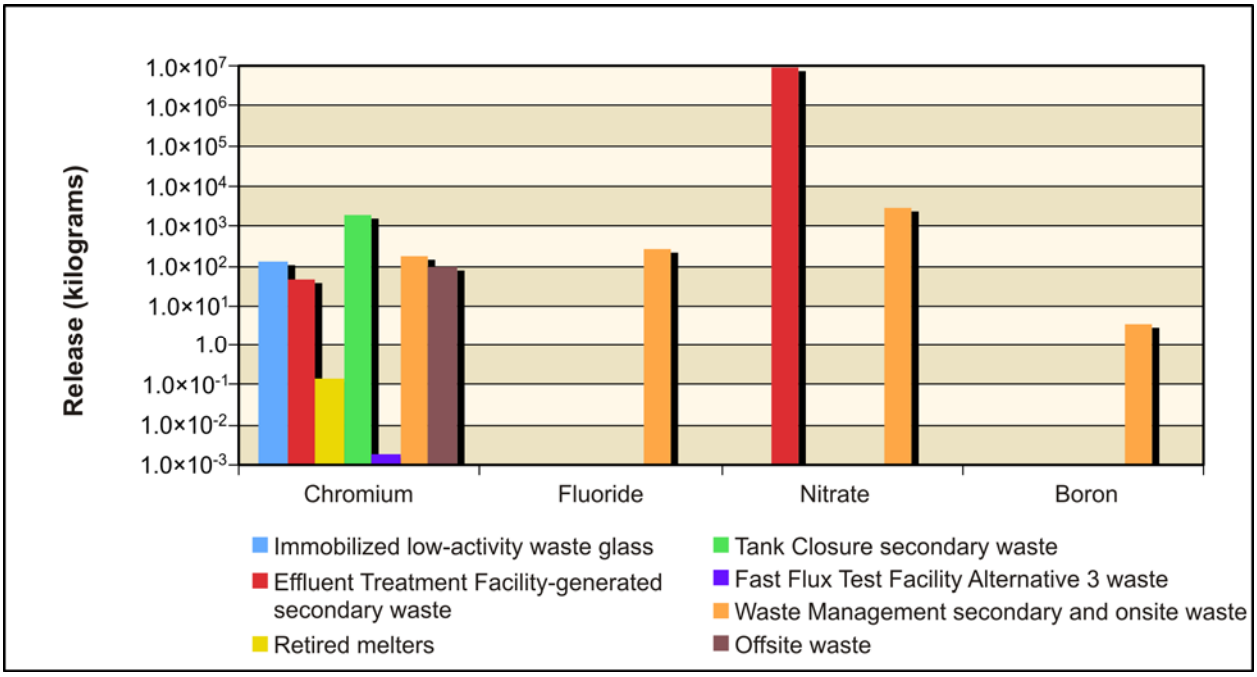


Figure 5–368. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

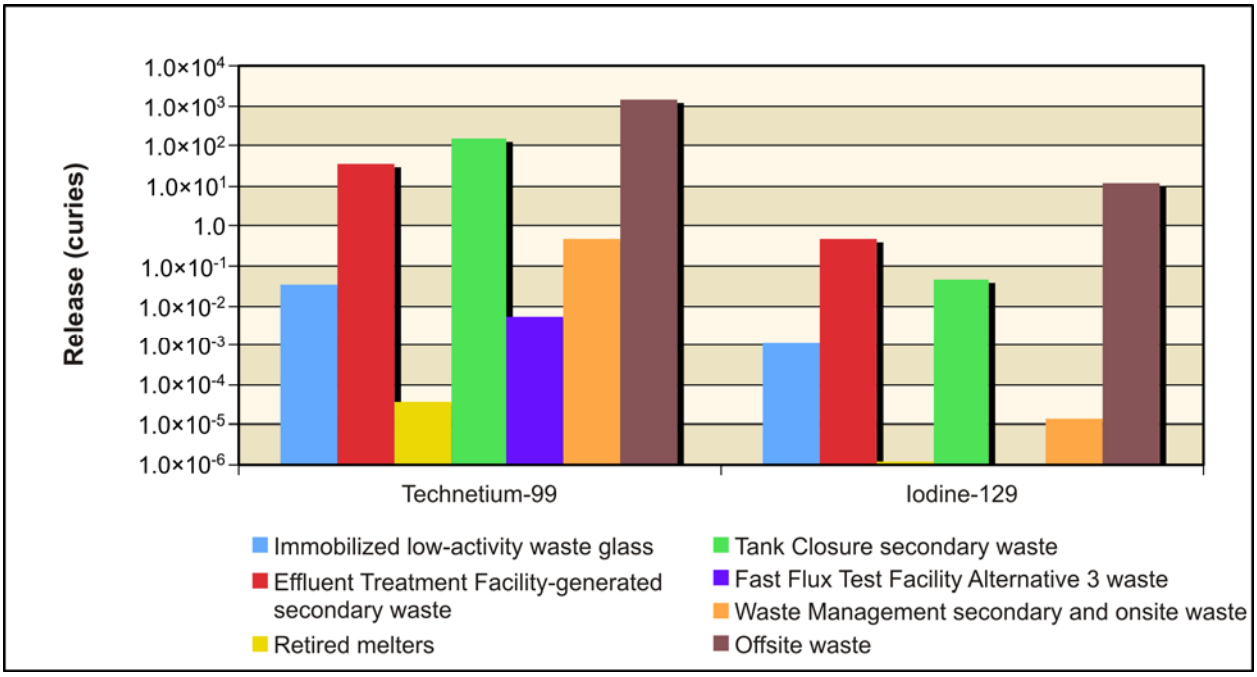


Figure 5–369. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

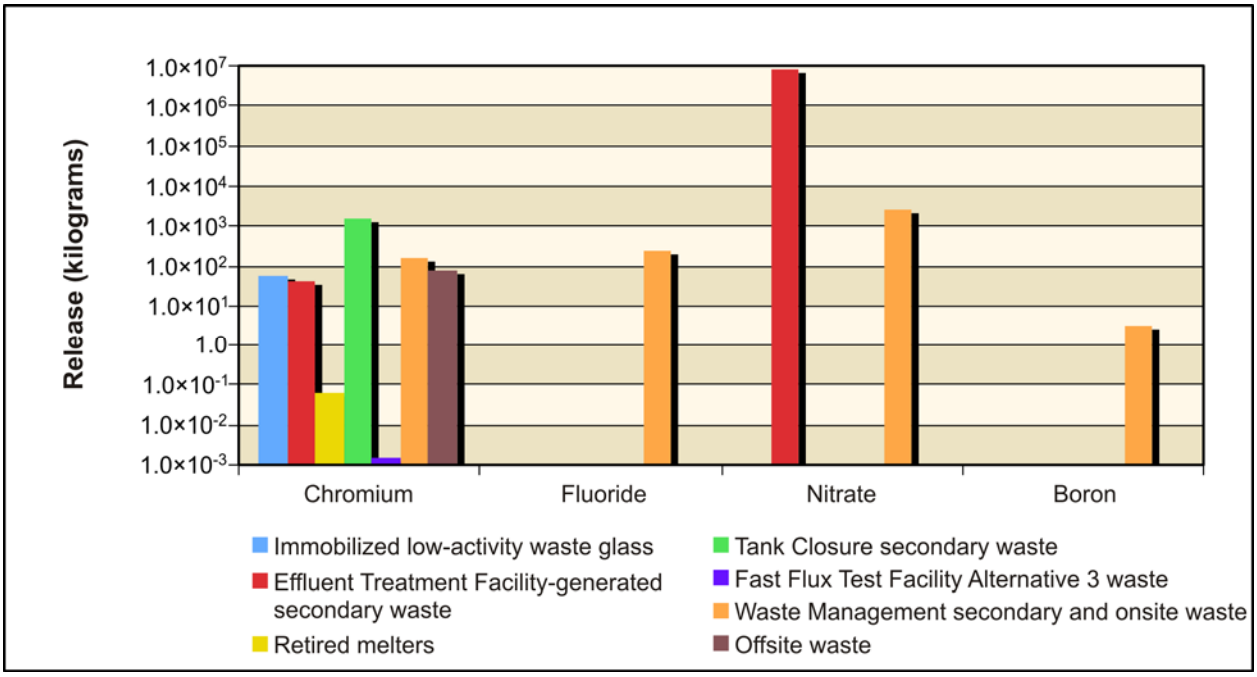


Figure 5–370. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

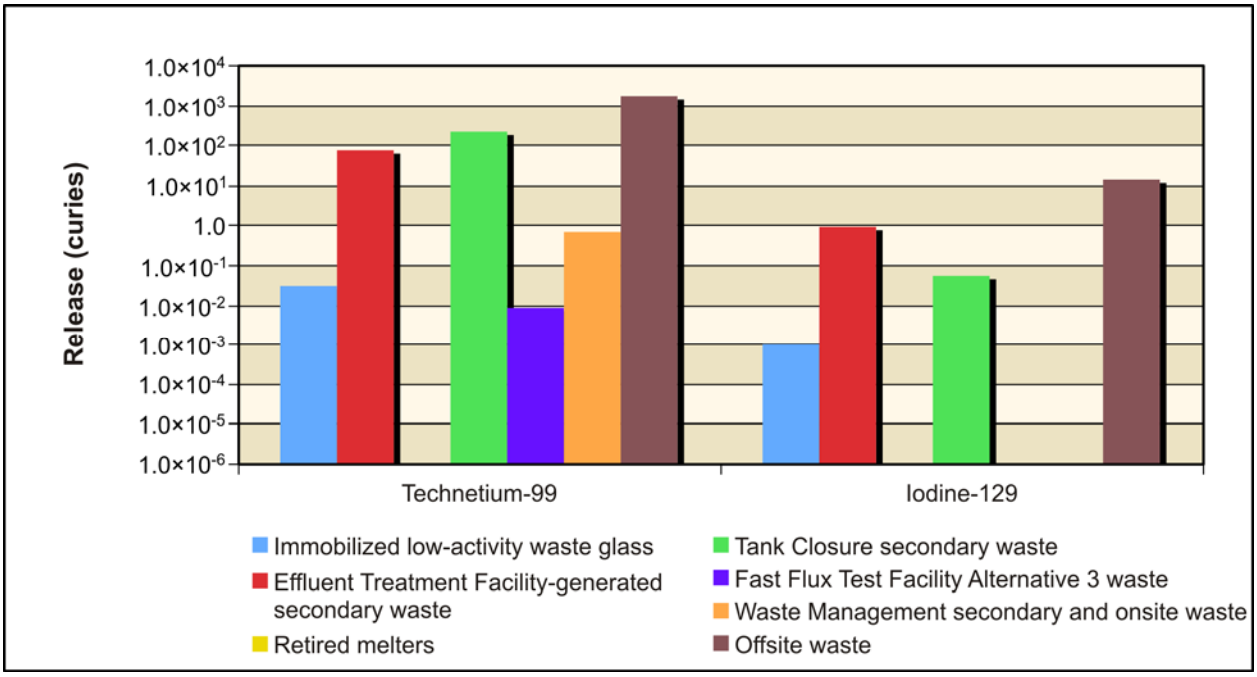


Figure 5–371. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

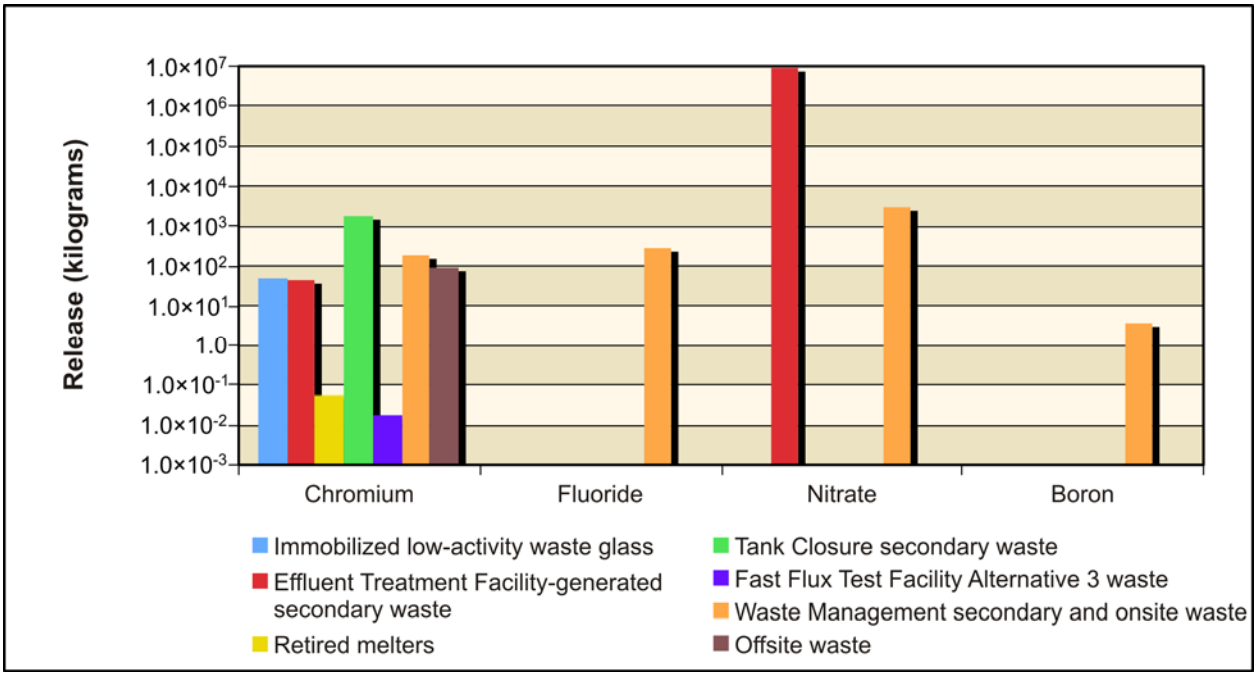


Figure 5–372. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

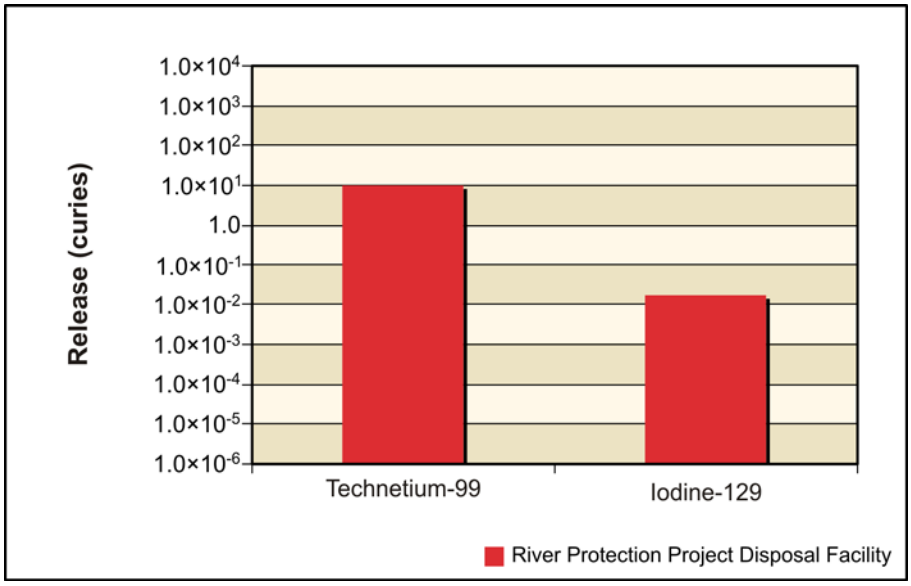


Figure 5–373. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

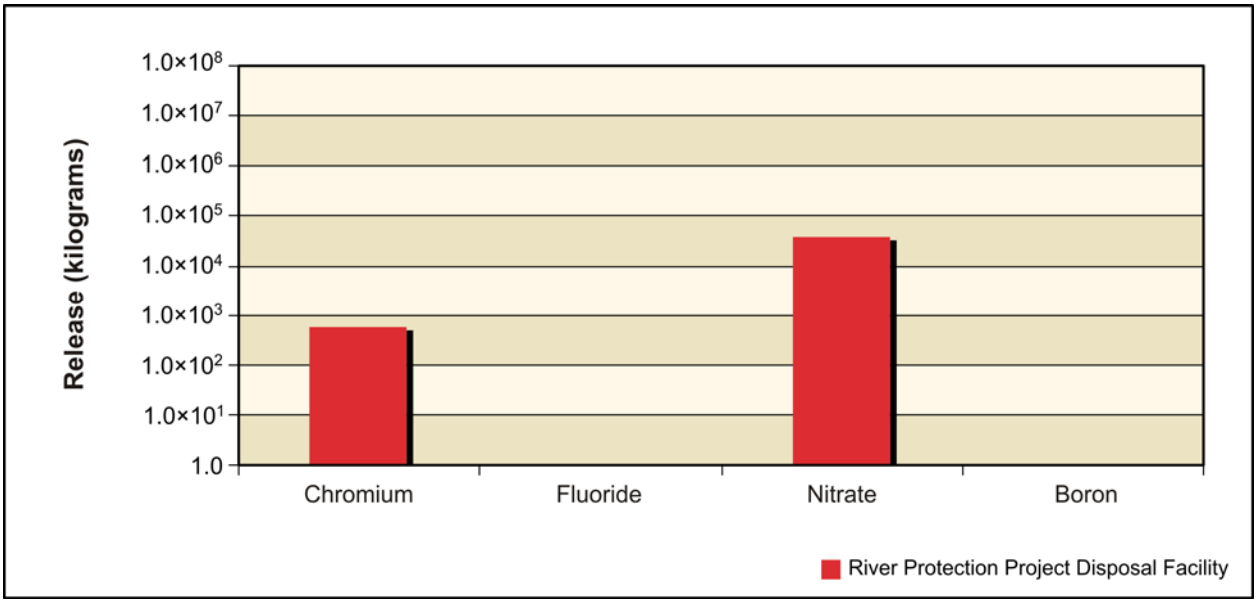


Figure 5–374. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

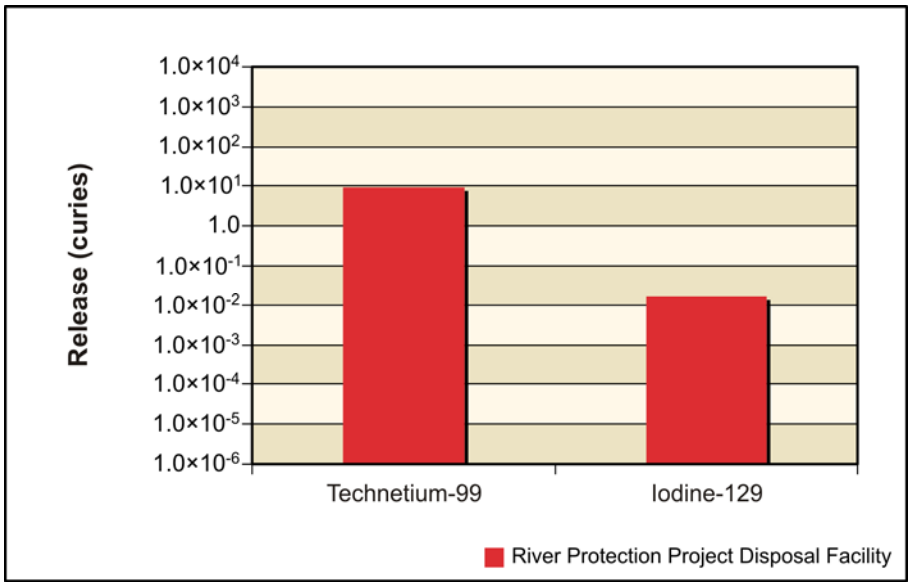


Figure 5–375. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Radiological Releases at River Protection Project Disposal Facility to Groundwater

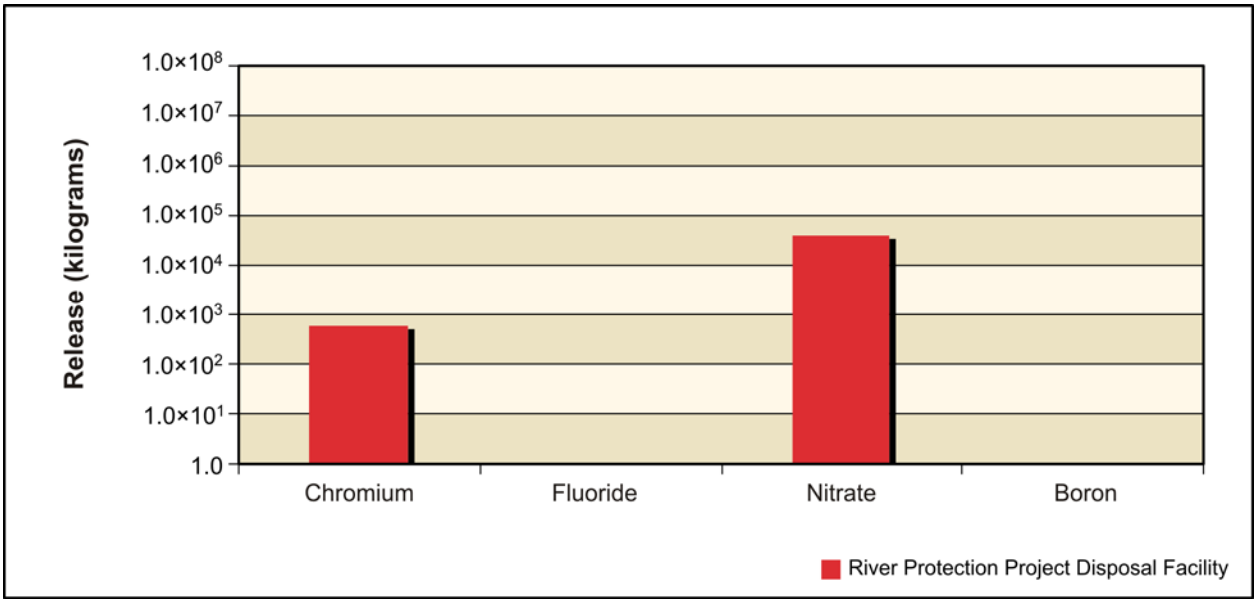


Figure 5–376. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chemical Releases at River Protection Project Disposal Facility to Groundwater

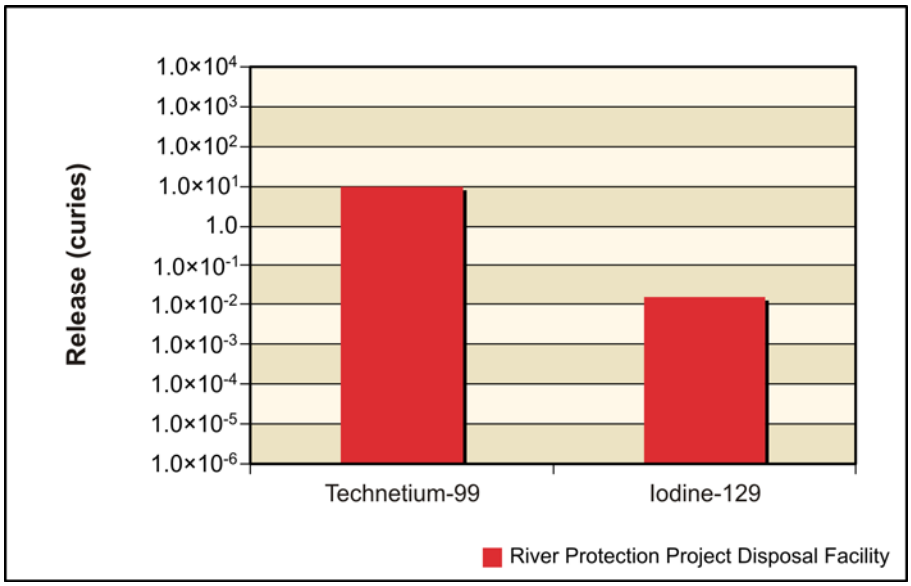


Figure 5–377. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Radiological Releases at River Protection Project Disposal Facility to Columbia River

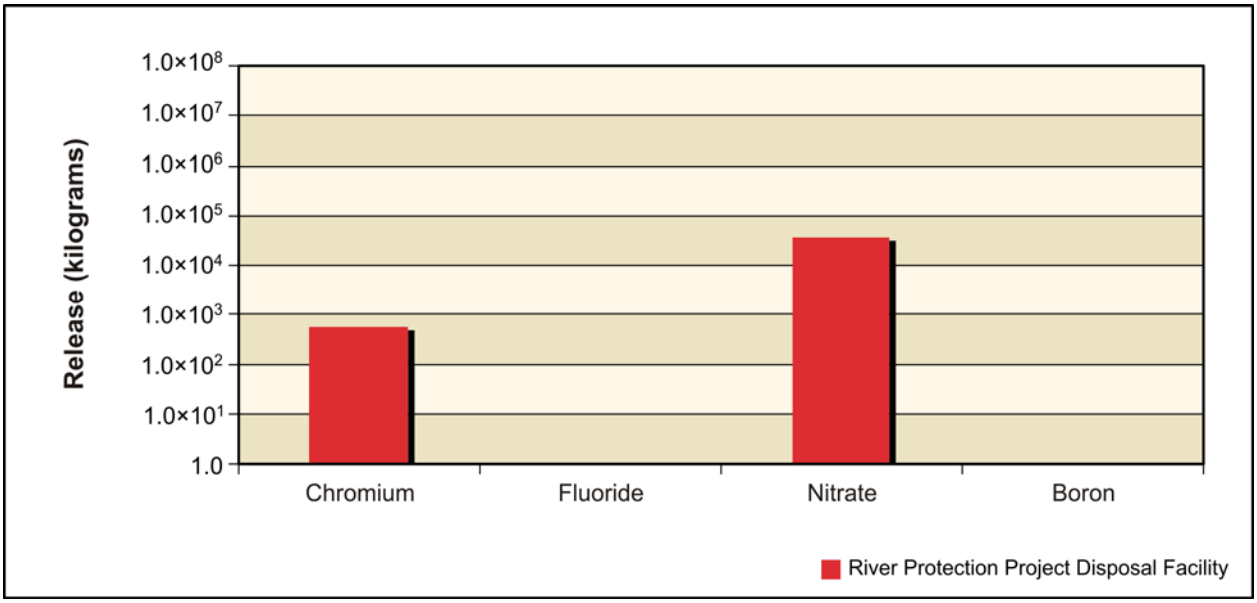


Figure 5–378. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Disposal Group 1, Subgroup 1-A, 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 (see Figures 5–379 through 5–383). 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 a few 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 5–77 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–379 through 5–382 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Releases from IDF-East and the RPPDF at the Core Zone Boundary cause groundwater concentrations to exceed the benchmark concentration for iodine-129 in CY 5500; using the confidence interval, the concentrations appear slightly below the benchmark for both the Core Zone Boundary and the Columbia River nearshore. The same trend is applicable to technetium-99 concentrations 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, showing a trend similar to iodine-129 and technetium-99.

Figure 5–383 shows concentration versus time for total uranium. Because of the high retardation of uranium, no contamination appears until CY 9800, when total uranium concentrations at the Core Zone Boundary first surpass 1.0×10^{-8} micrograms per liter. Uranium-238 does not surpass 1.0×10^{-8} picocuries per liter during the simulation, but total uranium continues to rise near the end of the

10,000-year period of analysis, still well below the benchmark for both the Core Zone Boundary and Columbia River nearshore by eight to nine orders of magnitude at the end of the period of analysis.

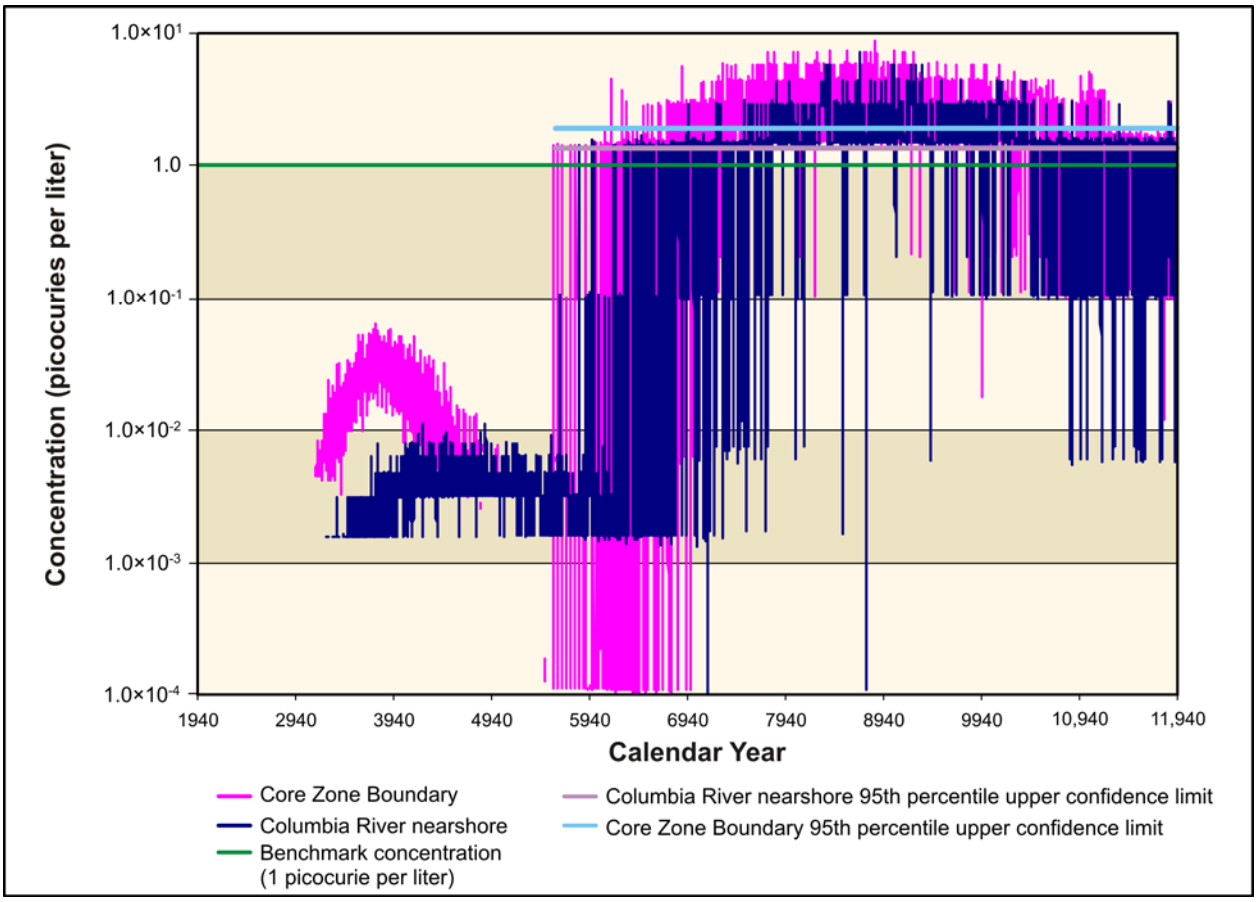


Figure 5–379. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Iodine-129 Concentration Versus Time

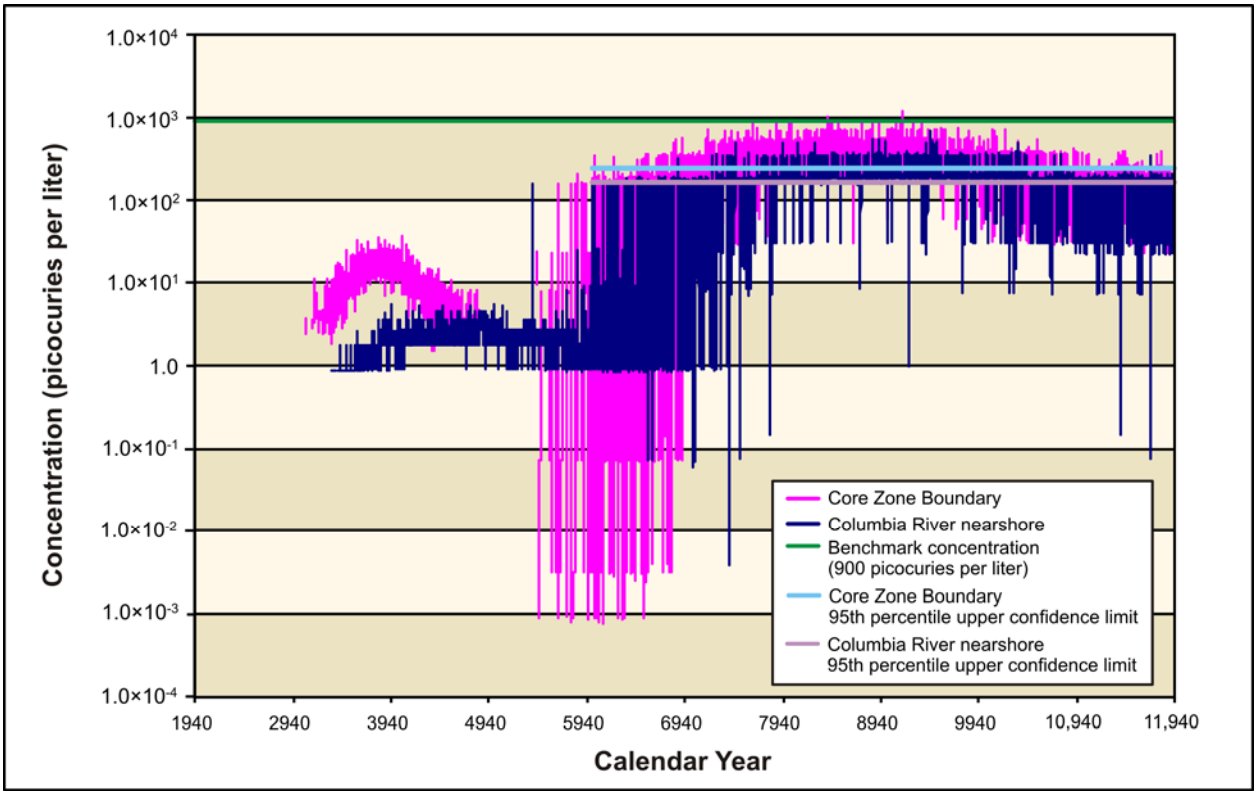


Figure 5–380. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Technetium-99 Concentration Versus Time

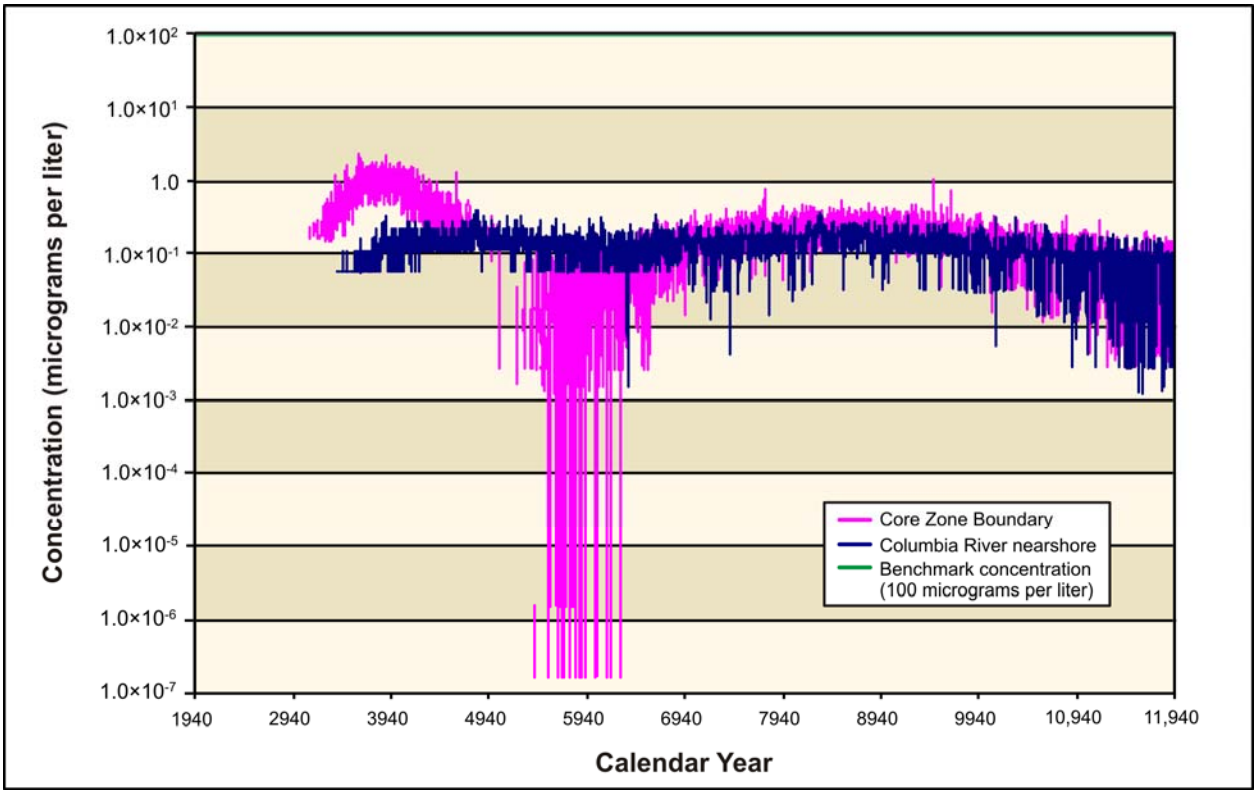


Figure 5–381. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Chromium Concentration Versus Time

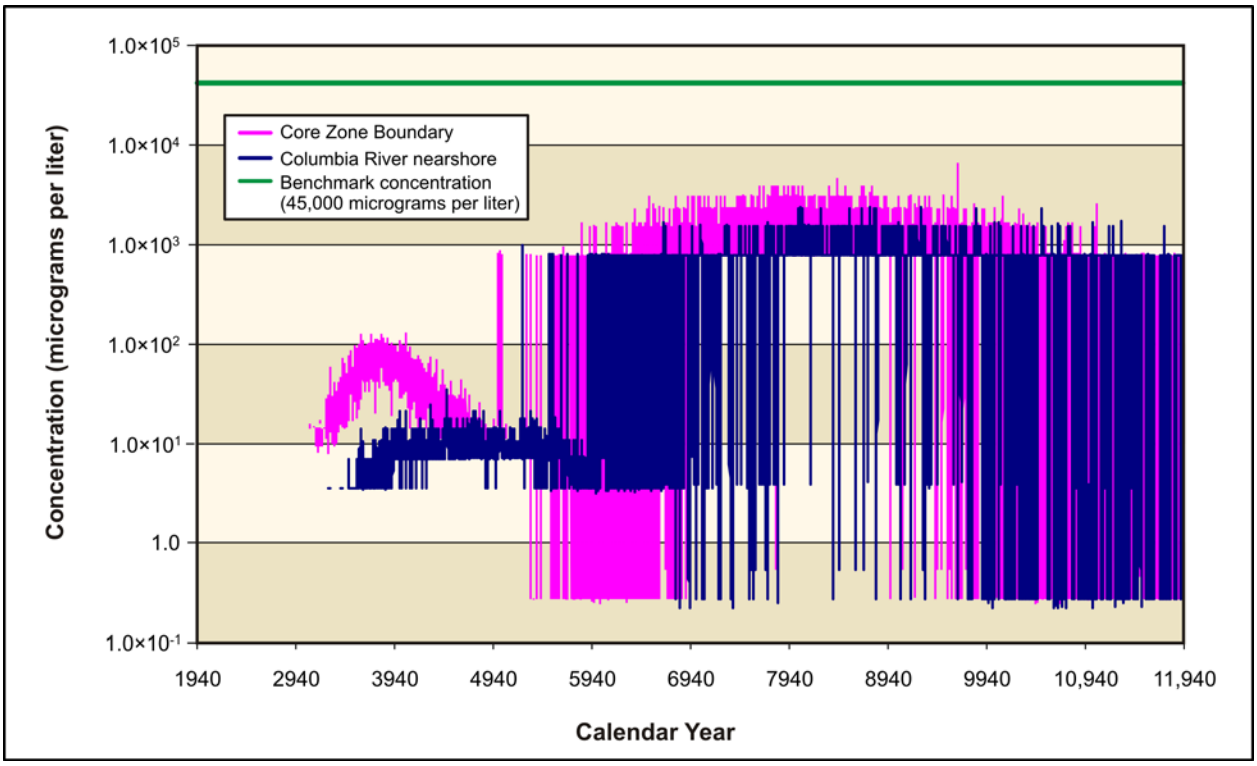


Figure 5–382. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Nitrate Concentration Versus Time

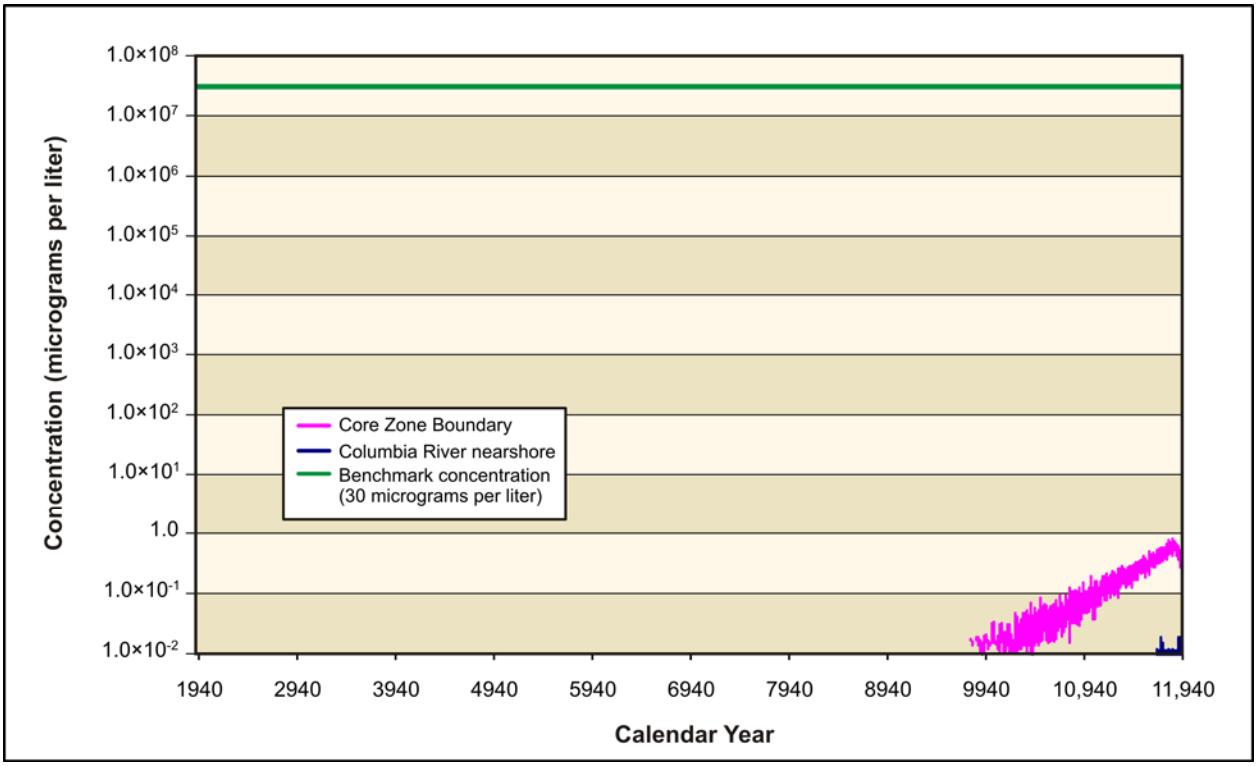


Figure 5–383. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Total Uranium Concentration Versus Time

Table 5–77. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**2,040**	33	**1,180**	675	900
	(9004)	(3825)	(9155)	(9451)	
Iodine-129	**19**	0.1	**9**	**7**	1
	(8739)	(3772)	(8858)	(8700)	
Chemical in micrograms per liter					
Chromium	4	2	2	1	100
	(8511)	(3856)	(3889)	(8898)	
Fluoride	0	0	1	0	4,000
	(8035)	(1940)	(7258)	(8913)	
Nitrate	14,200	149	5,630	2,440	45,000
	(8522)	(3811)	(9653)	(8827)	

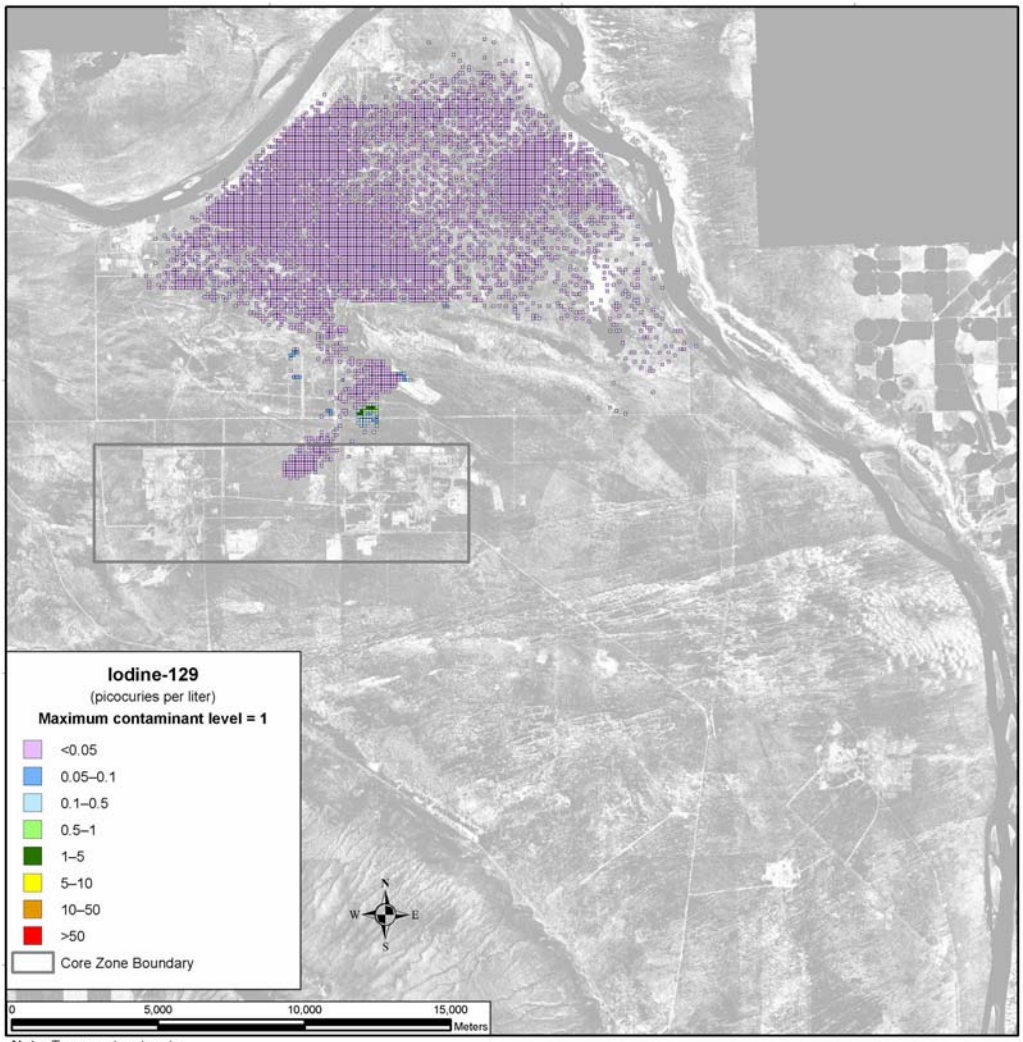
Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

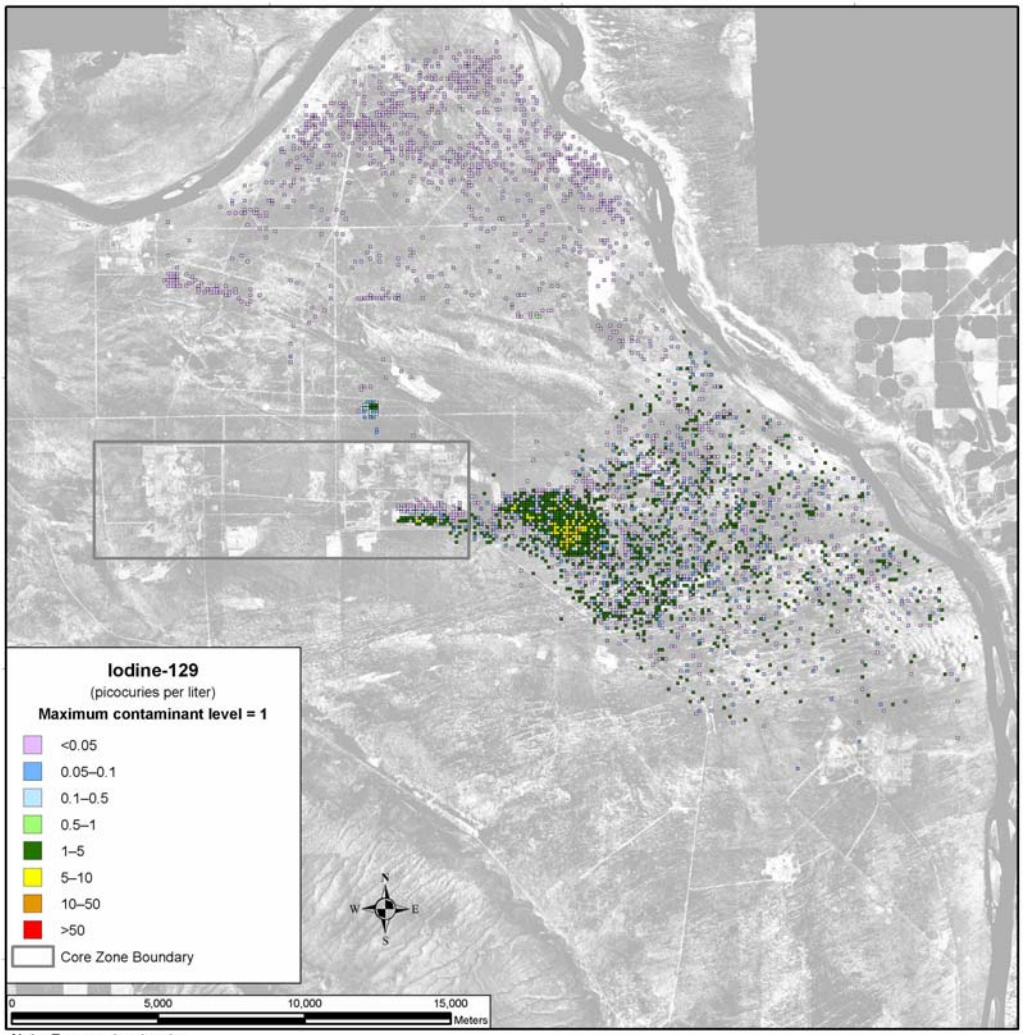
This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, in terms of the spatial distribution of groundwater concentration at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–384 through 5–396). 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.

Figures 5–384 through 5–386 show the spatial distribution of groundwater concentration for iodine-129. During CY 3890, there is a low-concentration plume that stretches north from the RPPDF and through Gable Gap. By CY 7140, the plume from the RPPDF is gone, but a new plume has formed, traveling east from IDF-East. The peak concentrations in this plume are greater than the benchmark. By CY 11,885, the plume continues to spread toward the river and the concentrations within remain relatively the same. Technetium-99 (see Figures 5–387 through 5–389), chromium (see Figures 5–390 through 5–392), and nitrate (see Figures 5–393 through 5–395) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).



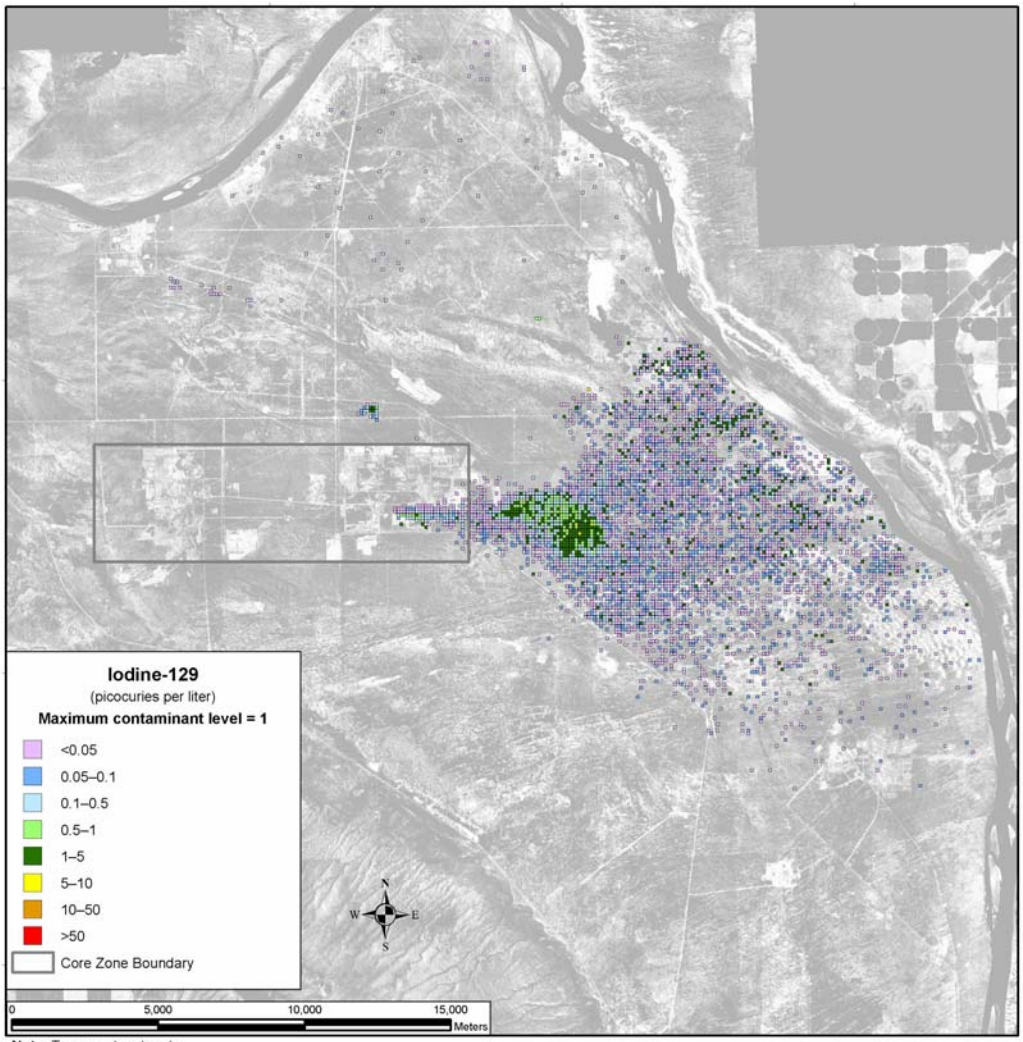
Note: To convert meters to feet, multiply by 3.281

Figure 5–384. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



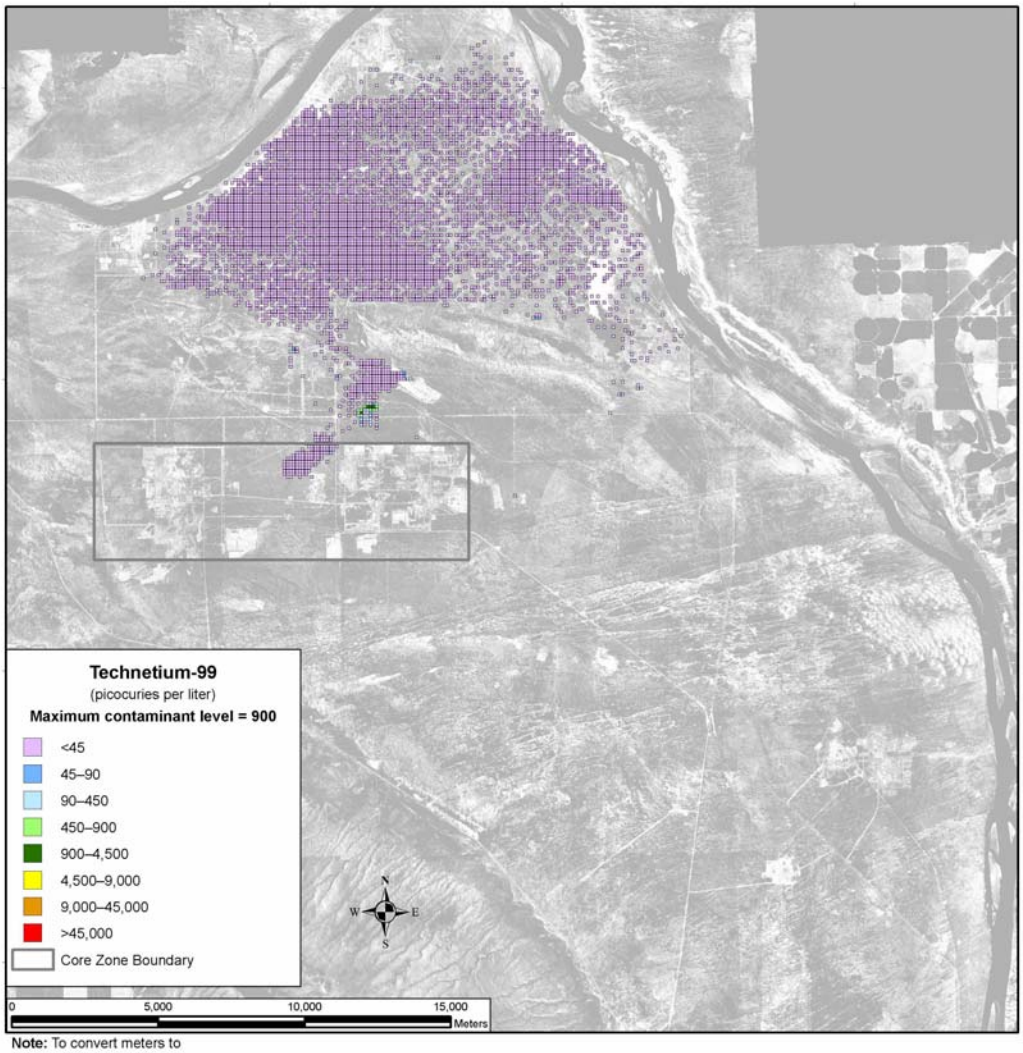
Note: To convert meters to feet, multiply by 3.281

Figure 5–385. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



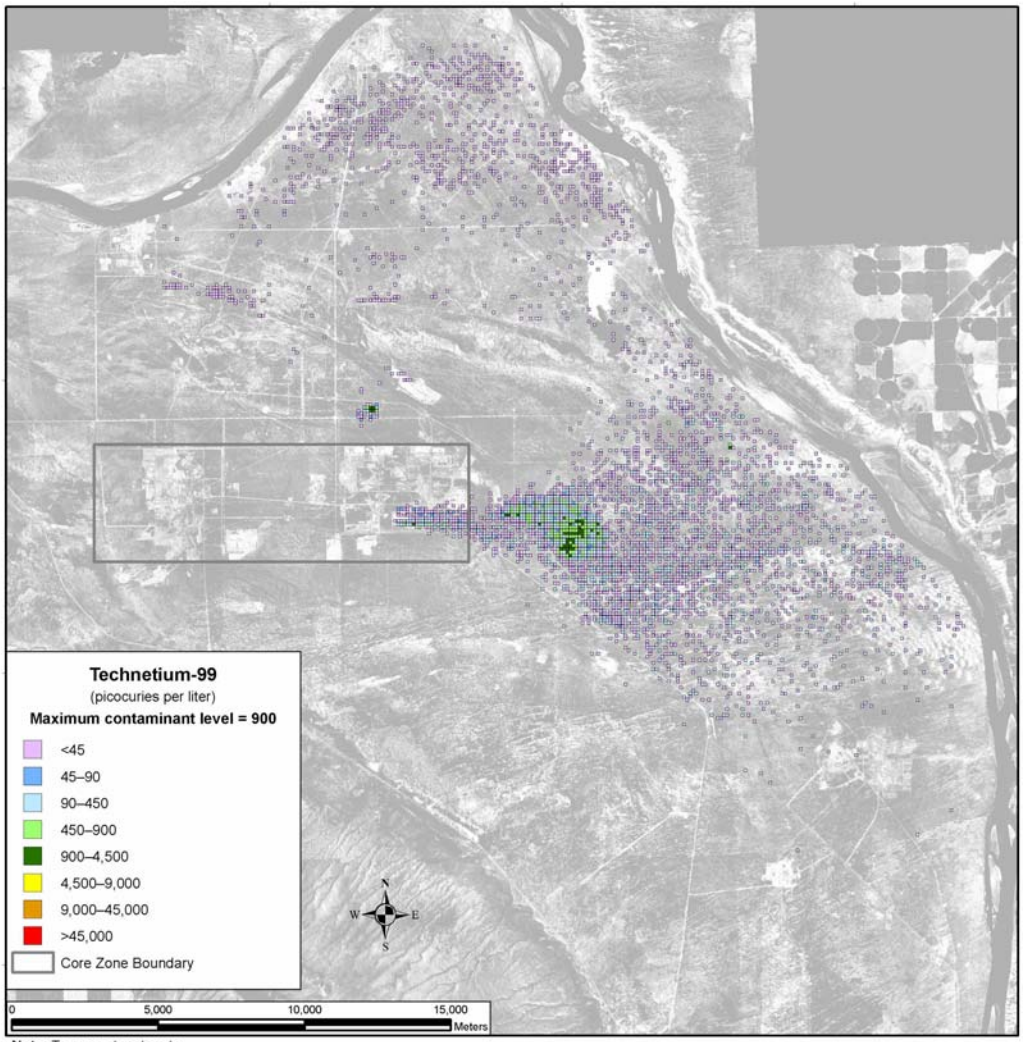
Note: To convert meters to feet, multiply by 3.281

Figure 5–386. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



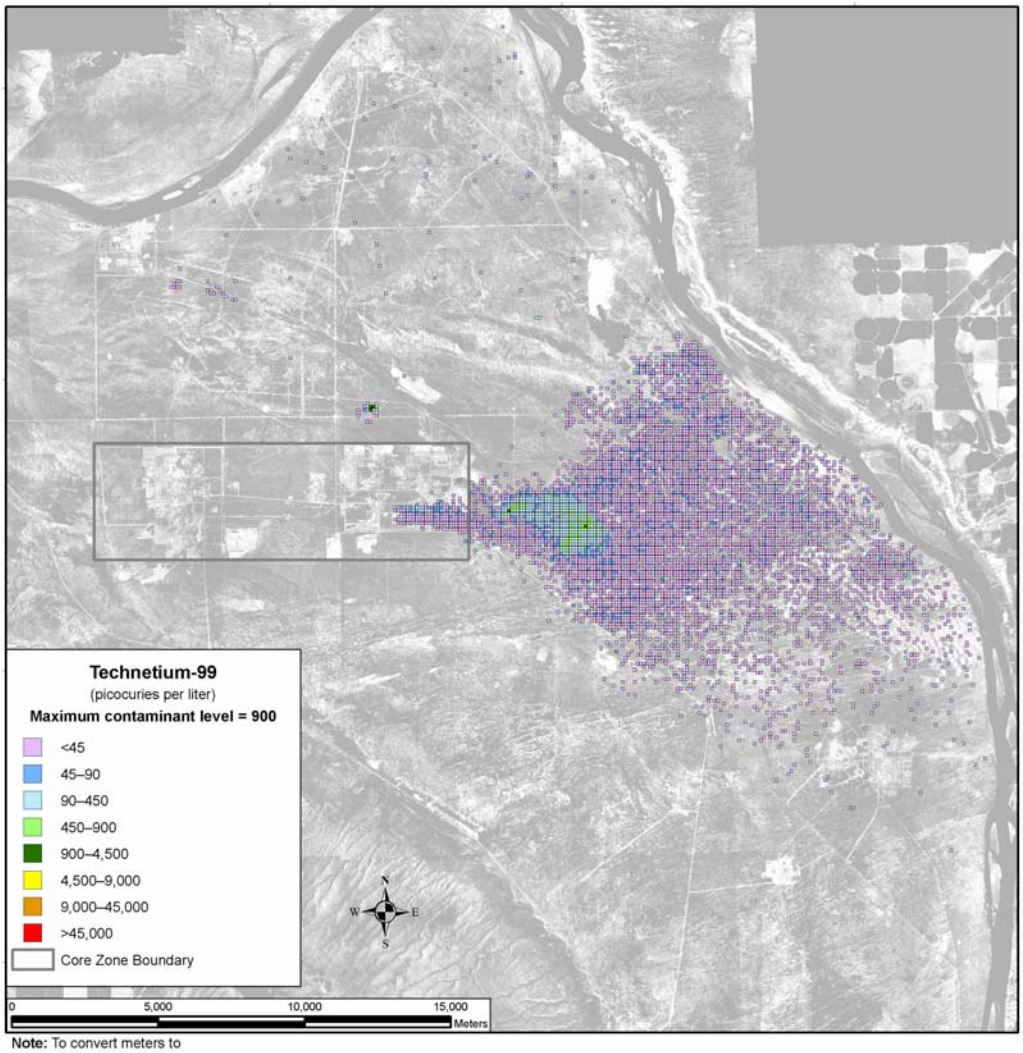
Note: To convert meters to feet, multiply by 3.281

Figure 5–387. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



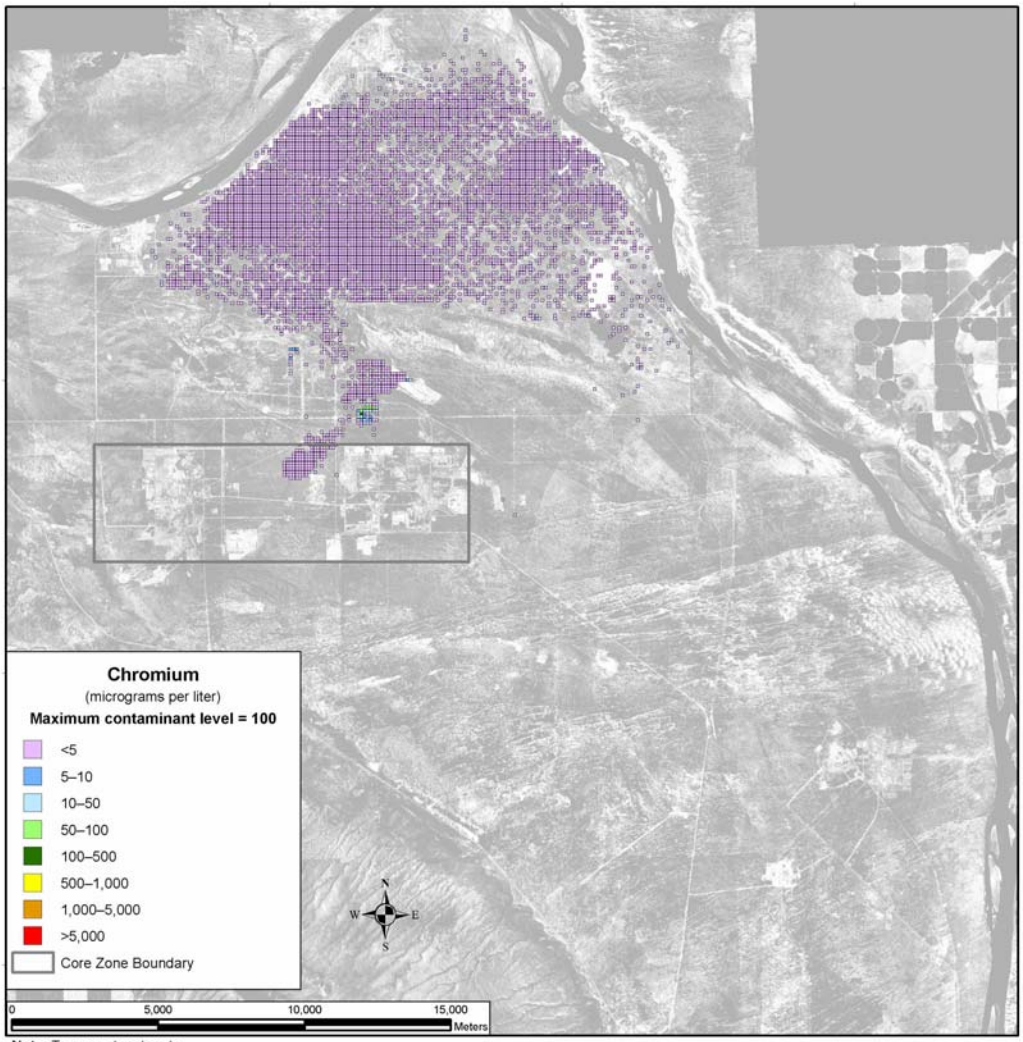
Note: To convert meters to feet, multiply by 3.281

Figure 5–388. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



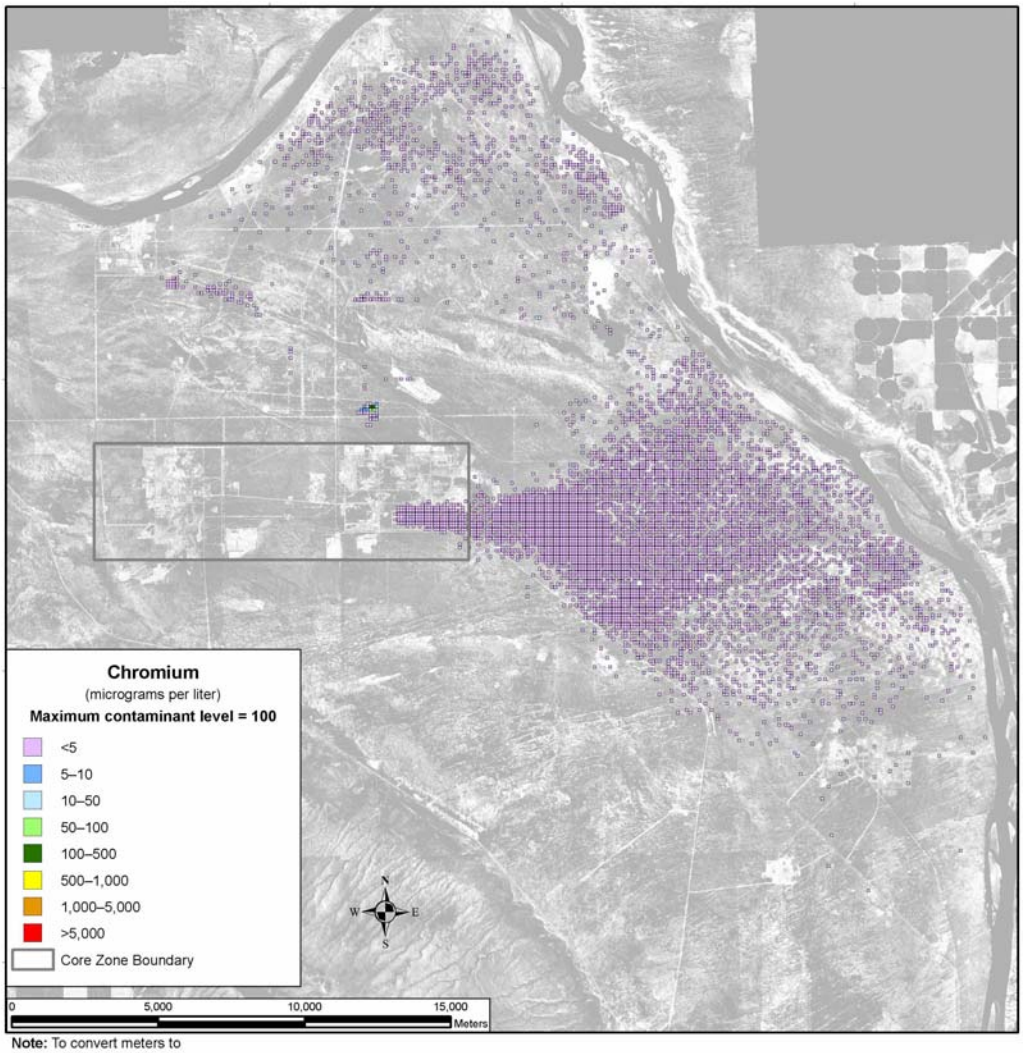
Note: To convert meters to feet, multiply by 3.281

Figure 5–389. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



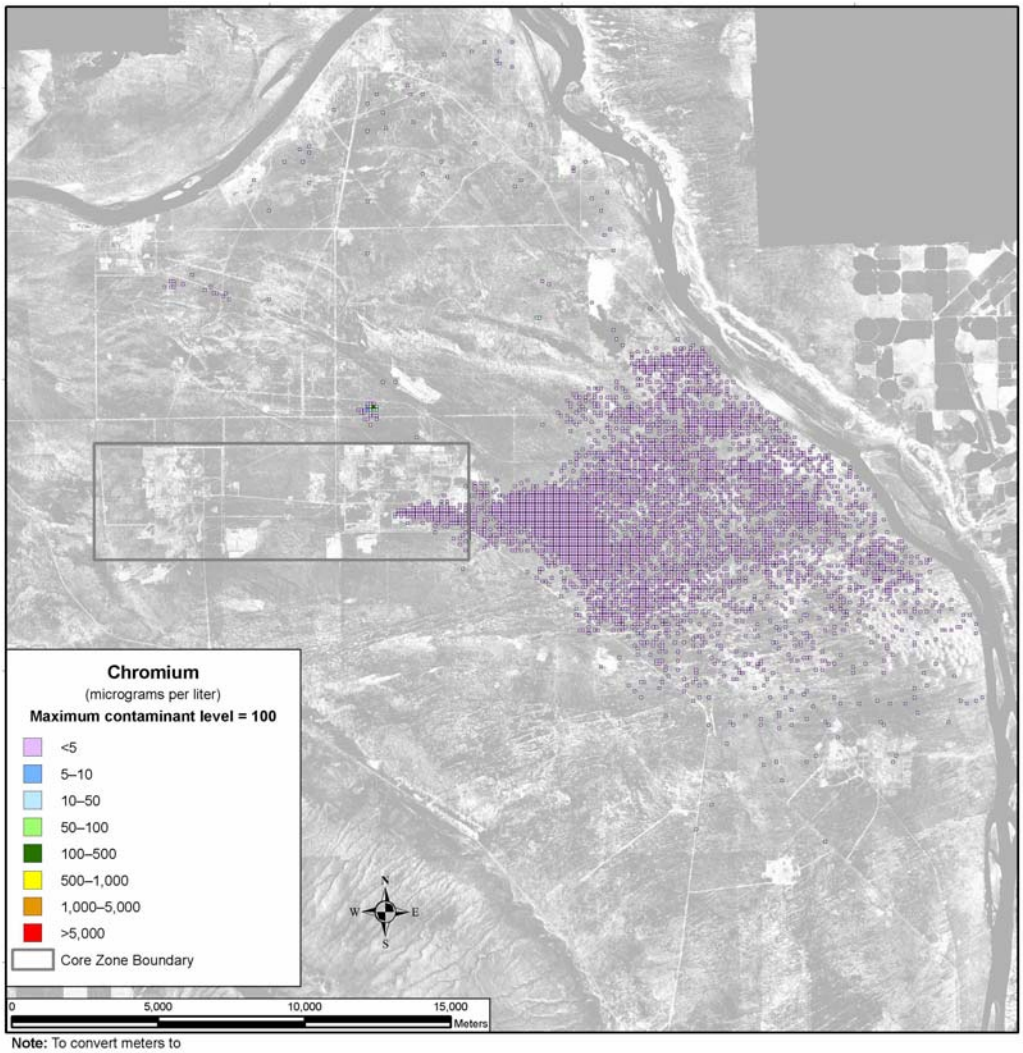
Note: To convert meters to feet, multiply by 3.281

Figure 5–390. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



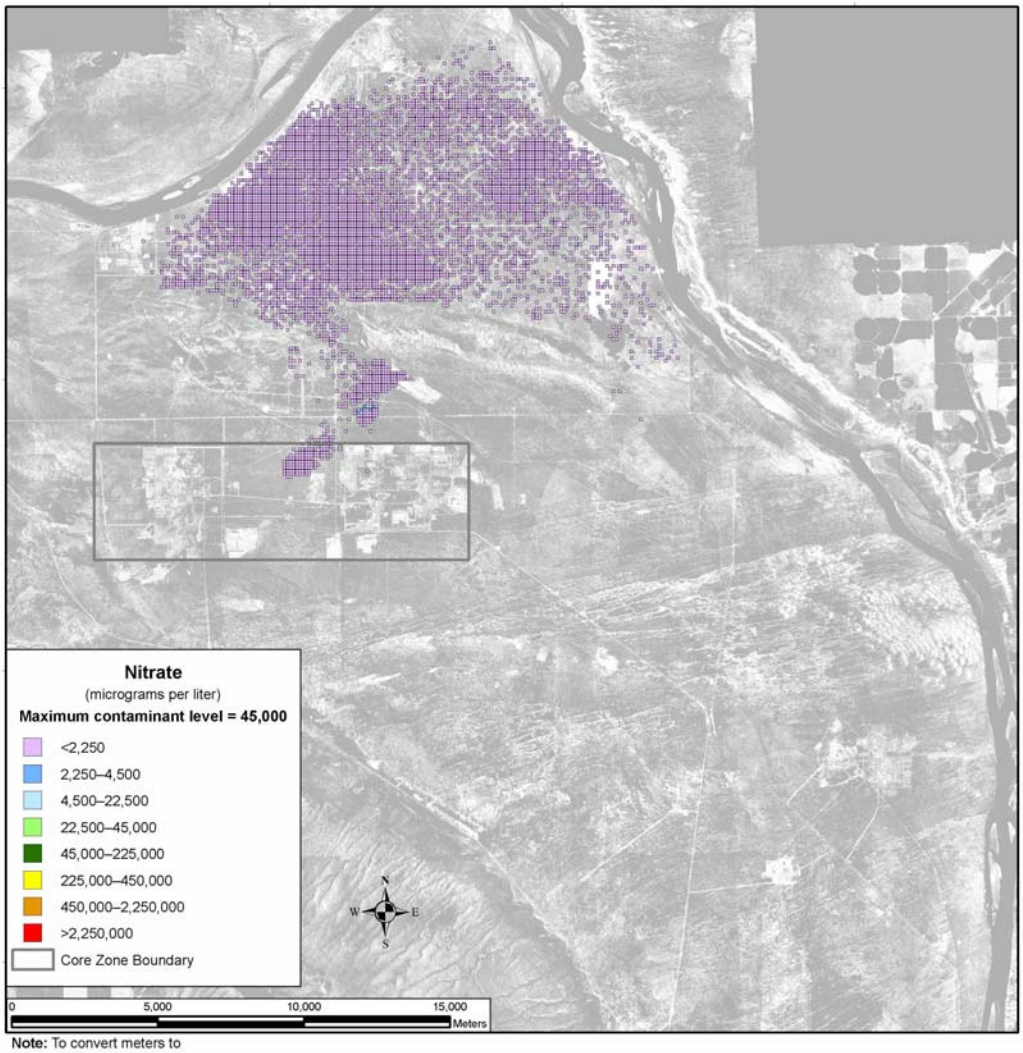
Note: To convert meters to feet, multiply by 3.281

Figure 5–391. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



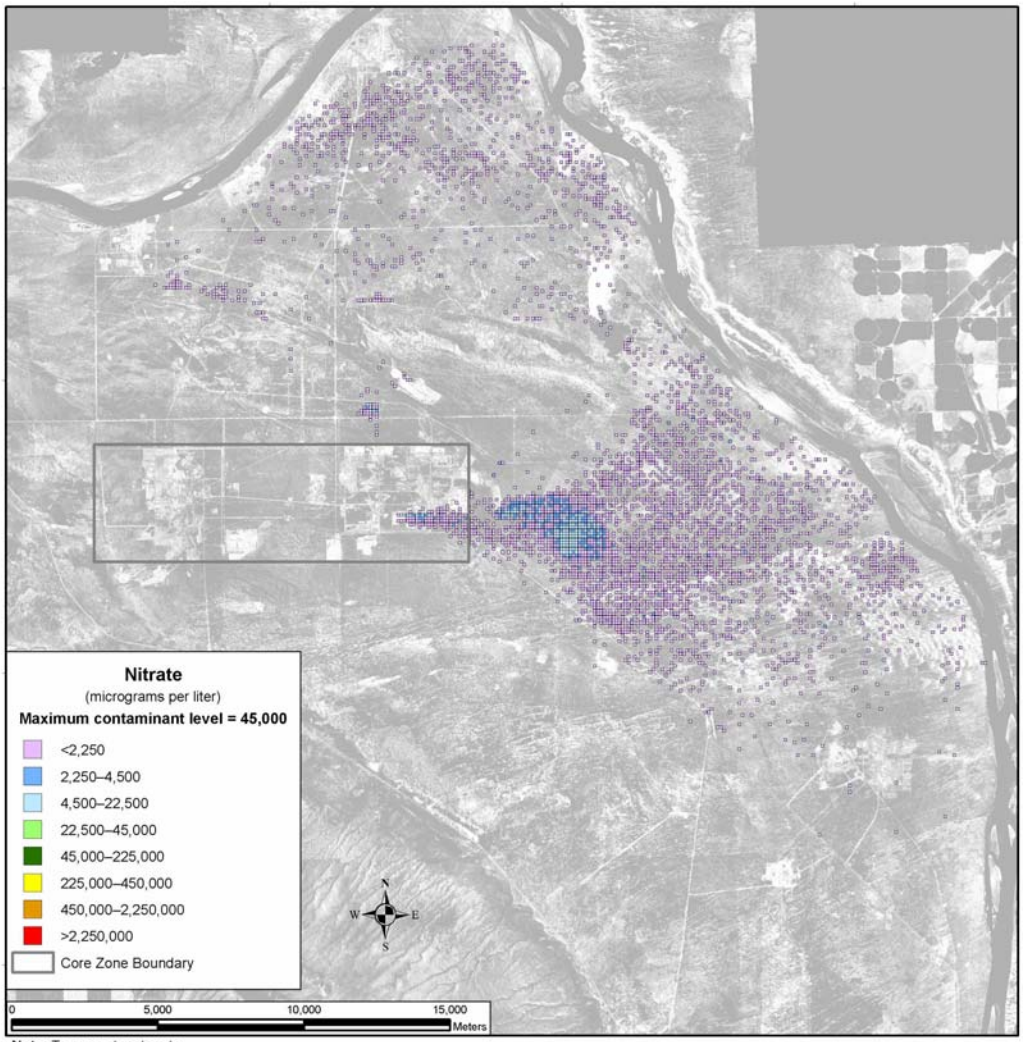
Note: To convert meters to feet, multiply by 3.281

Figure 5–392. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



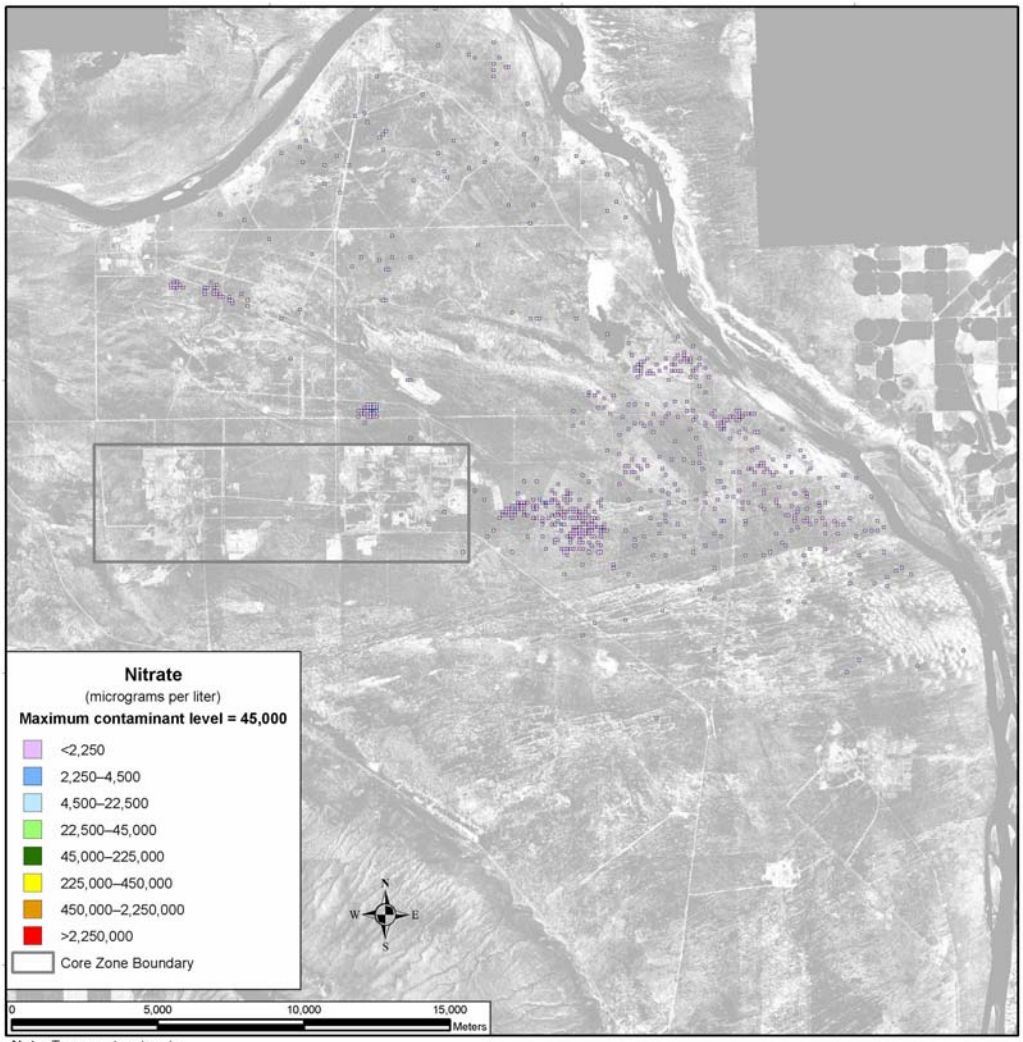
Note: To convert meters to feet, multiply by 3.281

Figure 5–393. Waste Management Alternative 2, 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

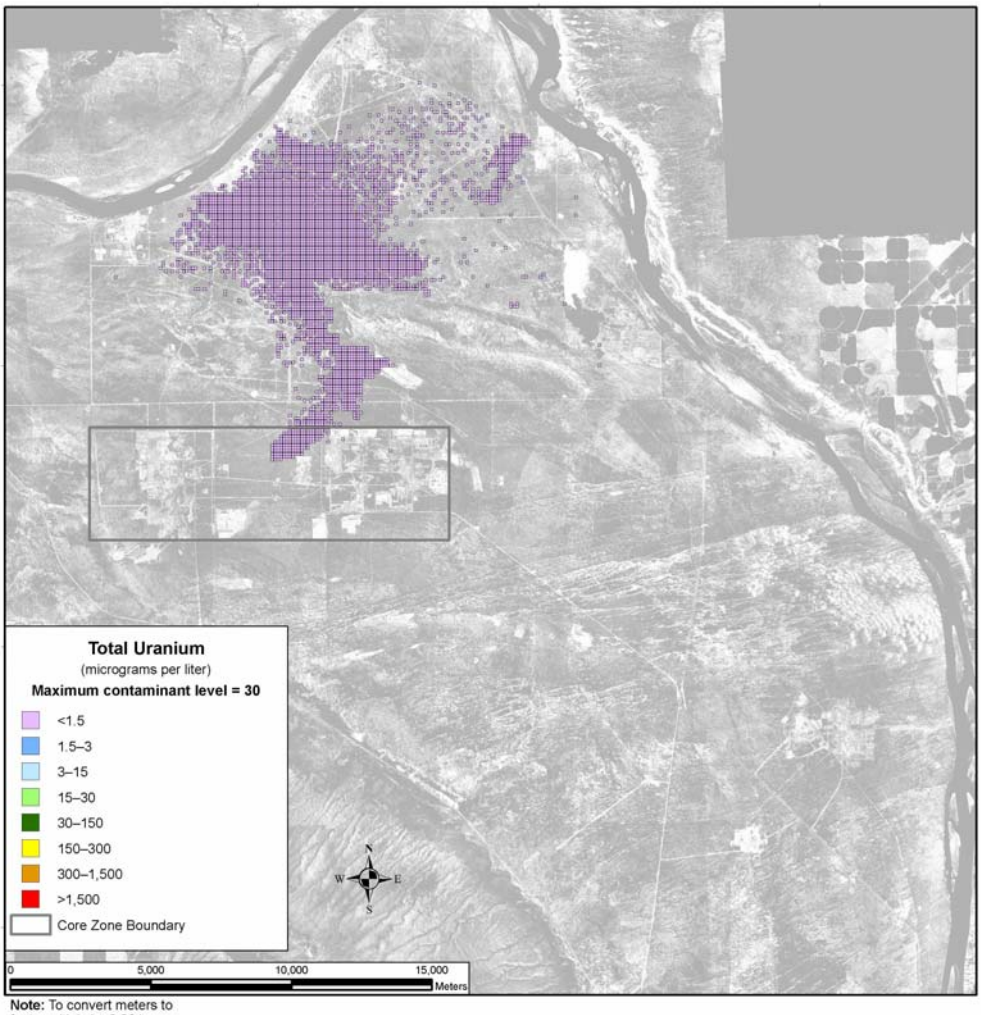
Figure 5–394. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–395. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

Total uranium shows a different spatial distribution over time. This COPC is not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–396 shows the distribution of total uranium at CY 11,885. There is a low-concentration plume that stretches north from the RPPDF and Gable Gap. Concentrations in all areas of the plume remain below one-tenth of the benchmark.



Note: To convert meters to feet, multiply by 3.281

Figure 5–396. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, in general, the inventory remaining in IDF-East, available for release to the environment at the start of the post-disposal period, is the predominant contributor. The inventory available for release from the RPPDF during the post-disposal period is a secondary contributor.

For the conservative tracers, concentrations at the Core Zone Boundary approach or exceed benchmark standards by less than one order of magnitude during most of the period of analysis. Concentrations at the Columbia River nearshore are similar to or slightly lower than the concentrations at the Core Zone Boundary. The intensities and areas of these groundwater plumes peak between CYs 8000 and 9000.

For total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species are increasing, but are well below the benchmark at the Core Zone Boundary beyond CY 9940, and remain eight orders of magnitude below the benchmark at the Columbia River after CY 11,940. The peak intensity and area of the contamination plume are largest near the end of the period of analysis.

5.3.1.2.1.2 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 FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Waste would be converted to IHLW, ILAW glass, and bulk vitrification glass. IHLW would be stored on site, while ILAW glass and bulk vitrification glass would be disposed of at IDF-East.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, 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 the RPPDF in CY 2009 and continue through CY 2050, when these 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 the facilities become available for release to the environment, and modified RCRA Subtitle C barriers would be emplaced over IDF-East and the RPPDF to limit infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2. Complete results for all 40 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2, 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 2 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 2.

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 2, Disposal Group 1, Subgroup 1-B, in terms of the 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 5–397 through 5–408). Three subtotals are plotted representing releases from ILAW glass, bulk vitrification glass, ETF-generated secondary waste, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over eight orders of magnitude.

Figure 5–397 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–398, 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 sources of technetium-99 are bulk vitrification glass and offsite-generated waste; of iodine-129 is offsite-generated waste; and of boron is waste management secondary waste. The predominant sources for chromium are tank closure secondary waste, waste management secondary waste, and onsite- and offsite-generated waste. The predominant sources for fluoride are waste management secondary waste and onsite-generated waste. The predominant source for nitrate is ETF-generated secondary waste.

Figure 5–399 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–400, 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. Nearly all of the technetium-99 and iodine-129 released to the vadose zone reached groundwater in the analysis, as well as nearly all of the chromium, fluoride, nitrate, and boron.

Figure 5–401 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–402, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99 and iodine-129, about 90 percent of the total amounts released from the vadose zone reached the Columbia River in the analysis; for chromium, about 93 percent; and for fluoride, nitrate, and boron, about 98 percent.

Figure 5–403 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–404, 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 in the analysis (fluoride and boron are not).

Figure 5–405 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–406, 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 5–407 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–408, 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, approximately 100 percent of the total amounts released to the vadose zone at the RPPDF reached the Columbia River in the analysis.

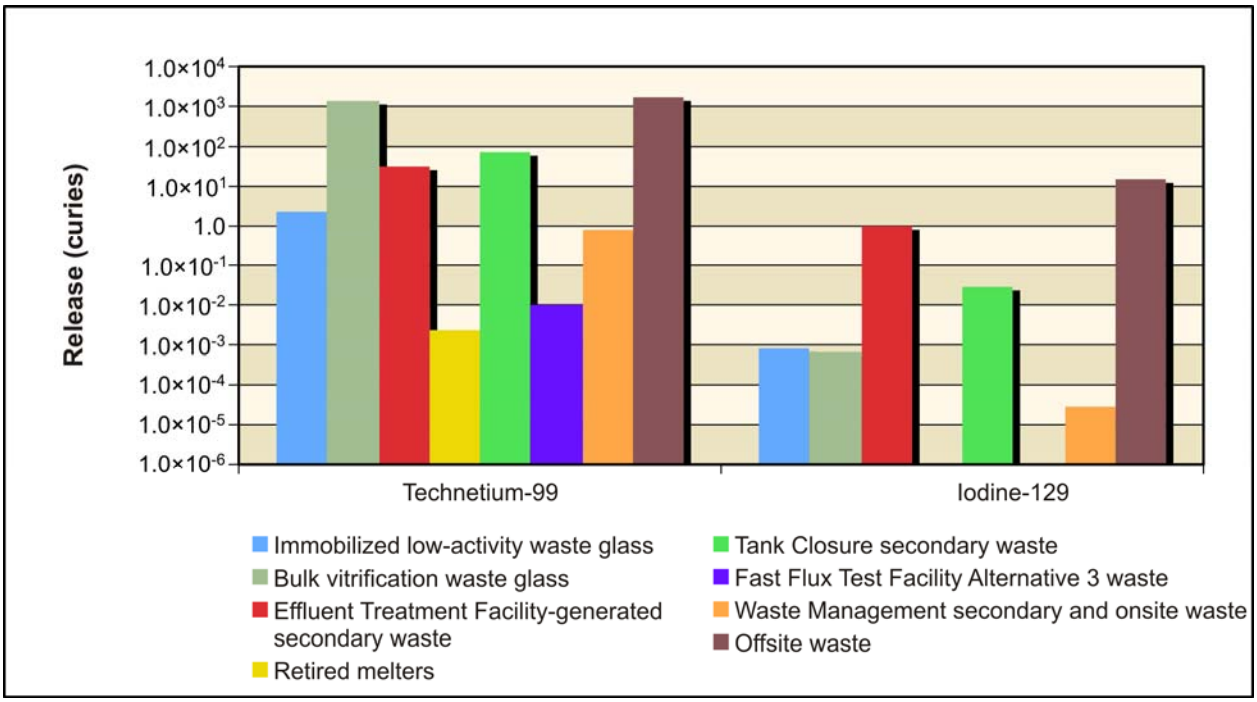


Figure 5–397. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

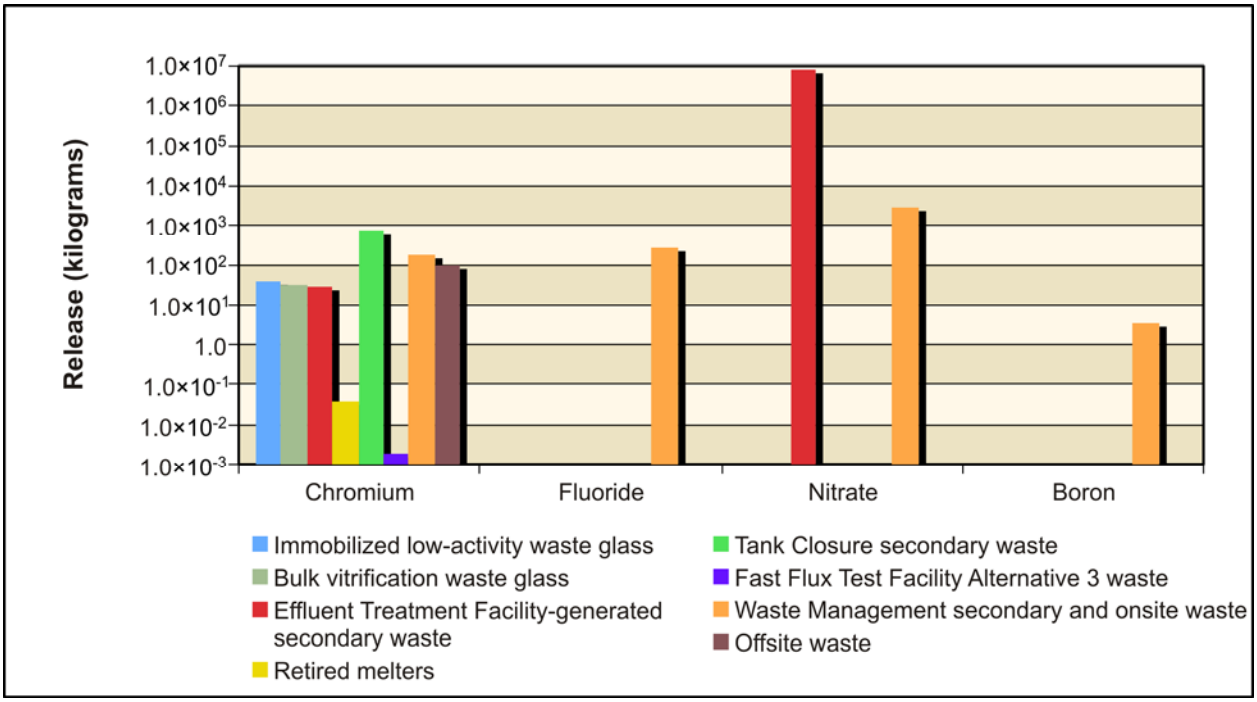


Figure 5–398. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

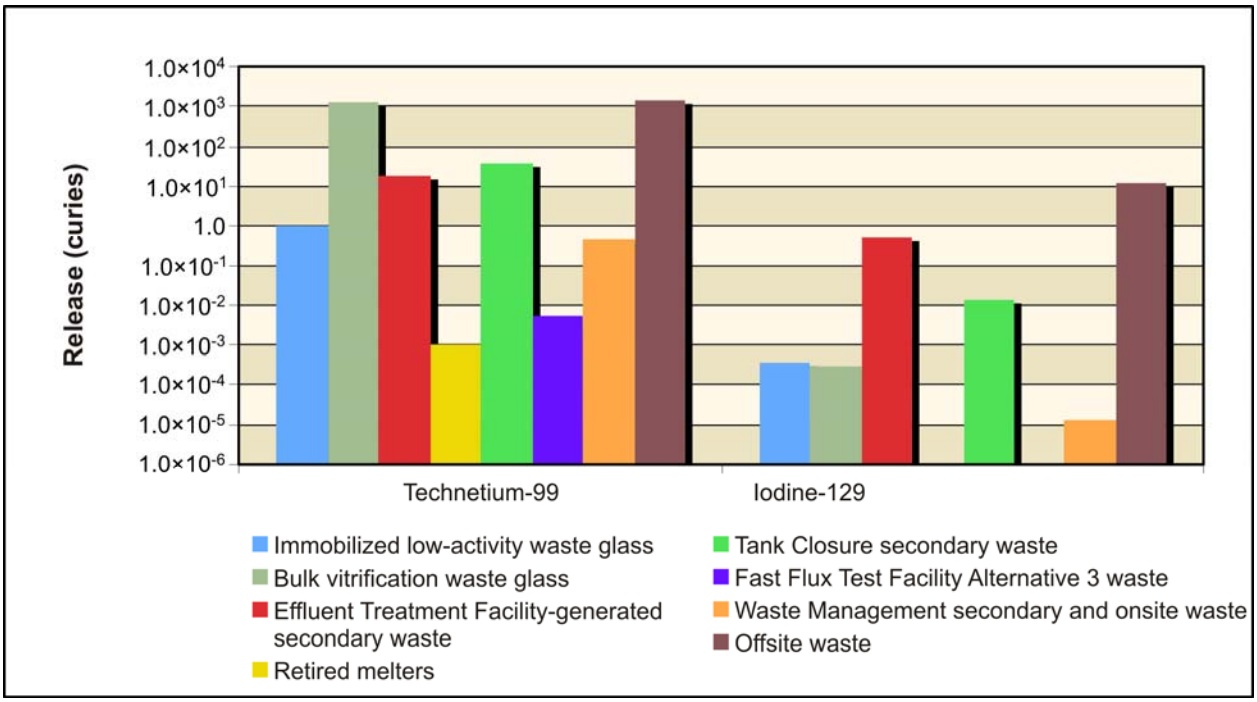


Figure 5–399. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

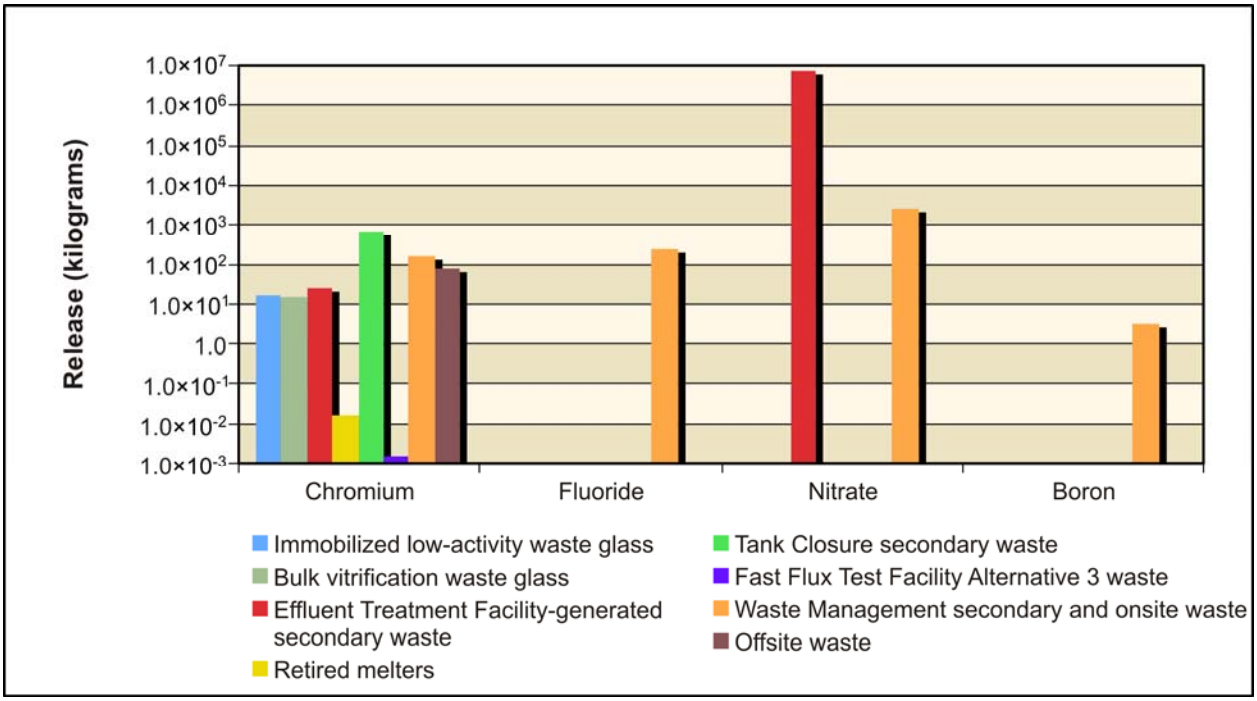


Figure 5–400. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

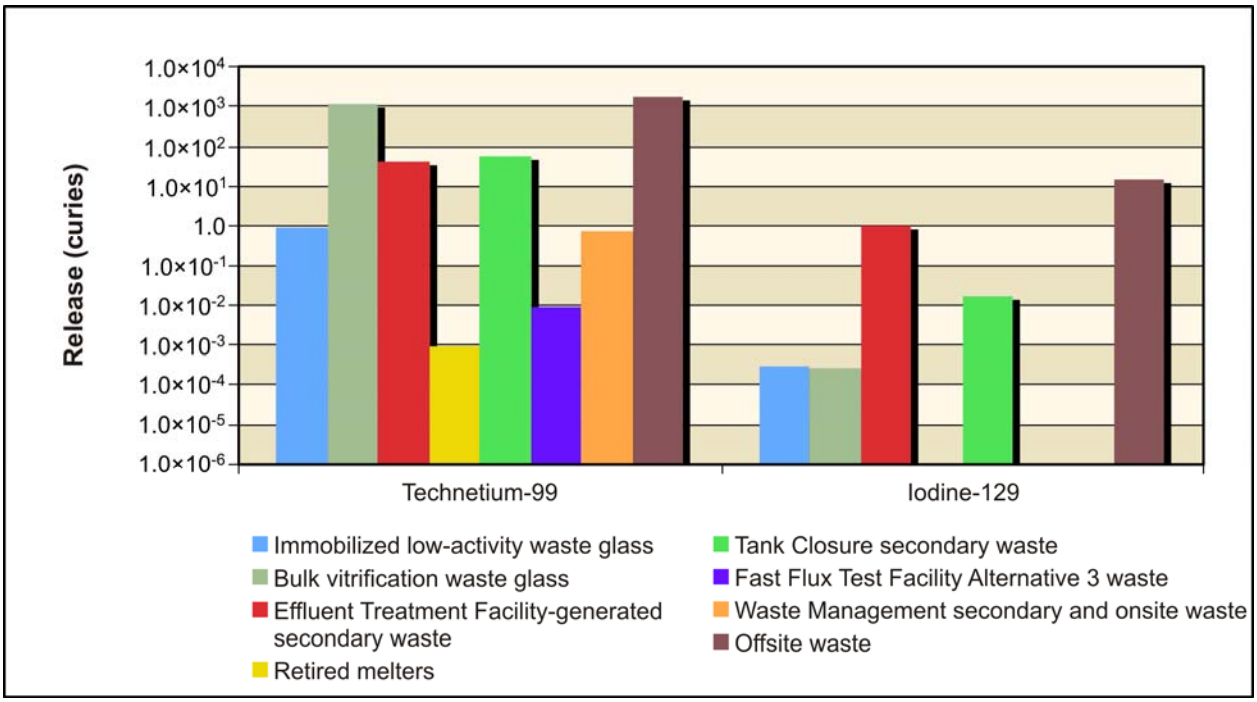


Figure 5–401. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

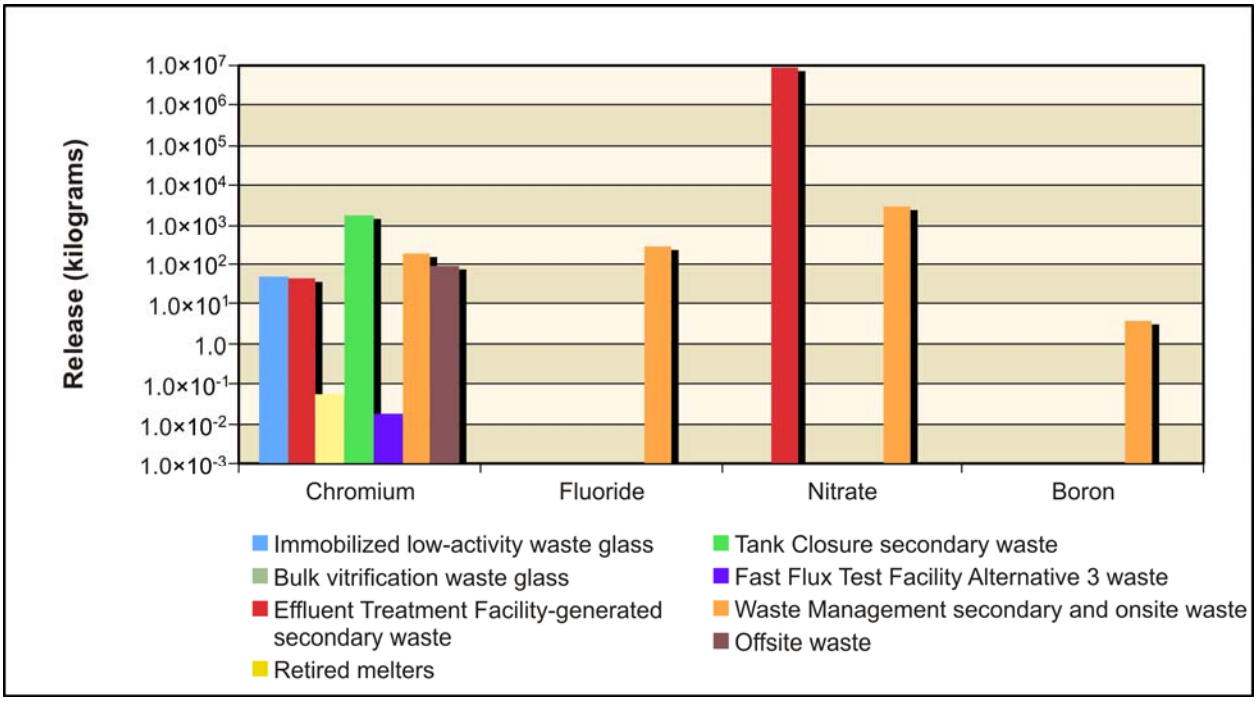


Figure 5–402. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

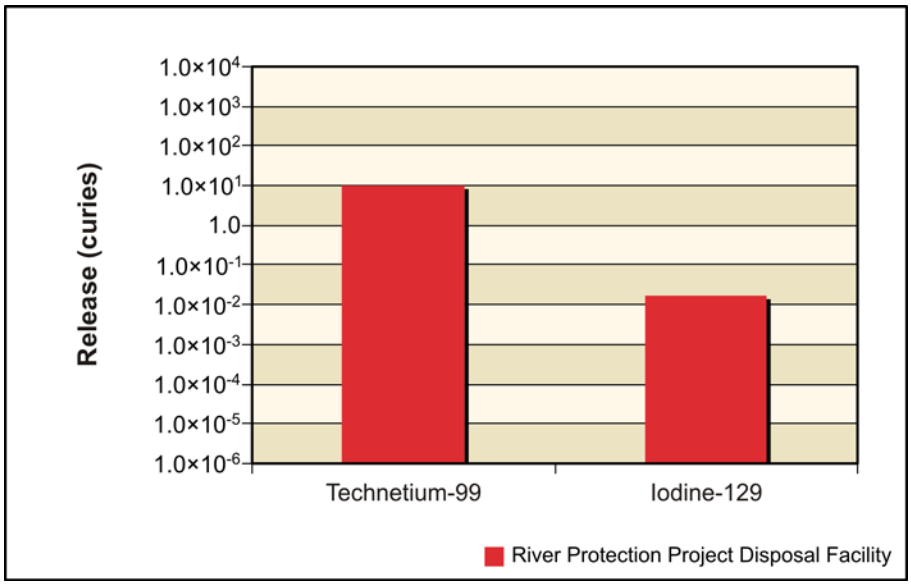


Figure 5–403. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

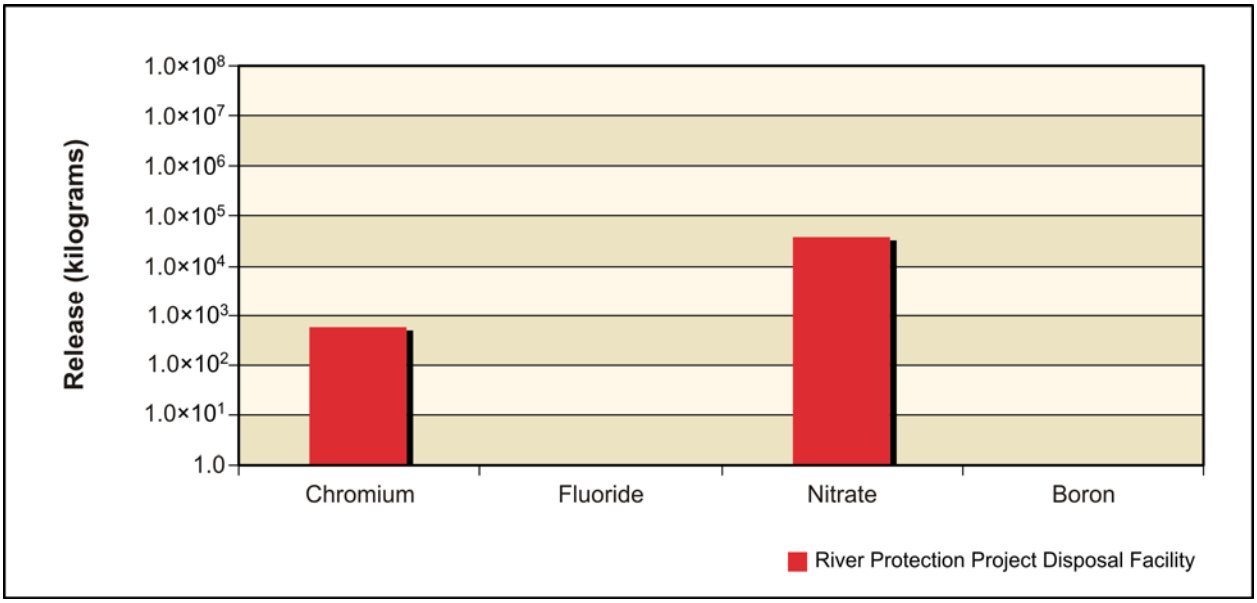


Figure 5–404. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

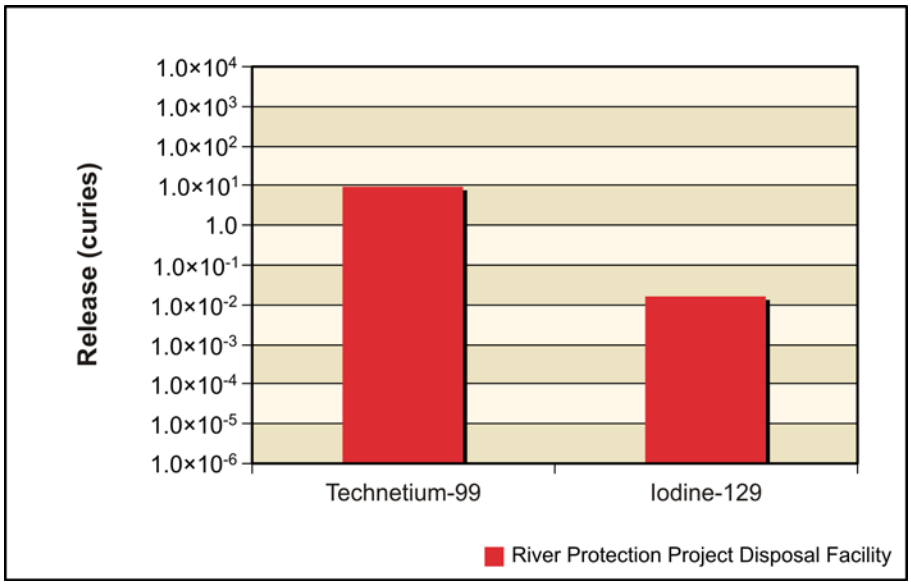


Figure 5–405. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Groundwater

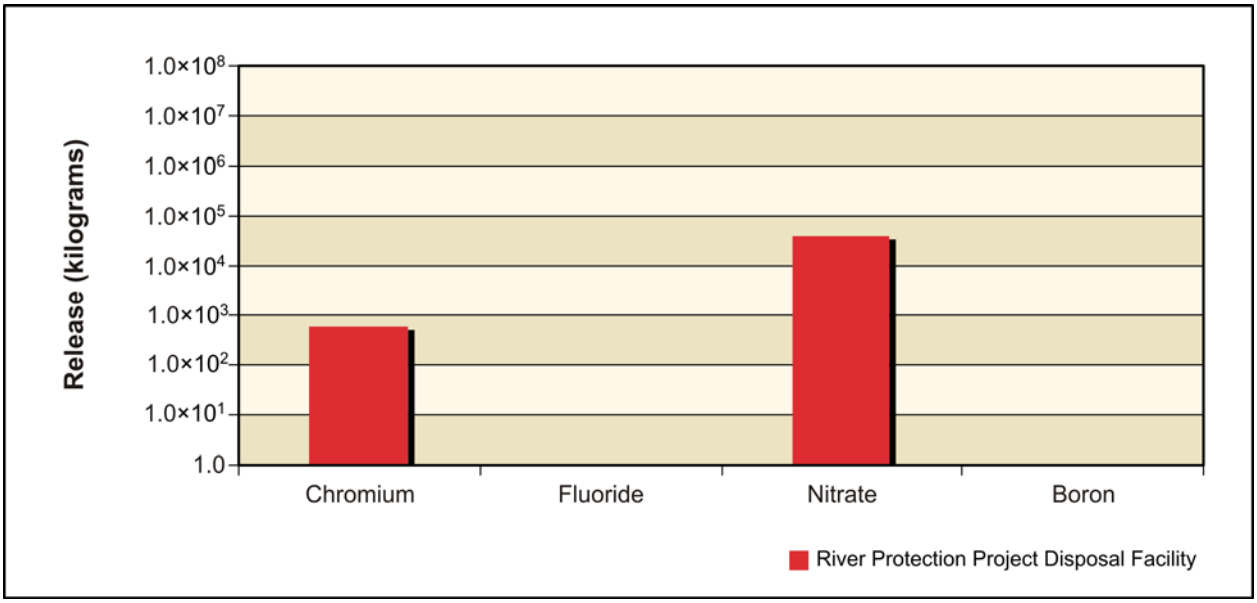


Figure 5–406. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Groundwater

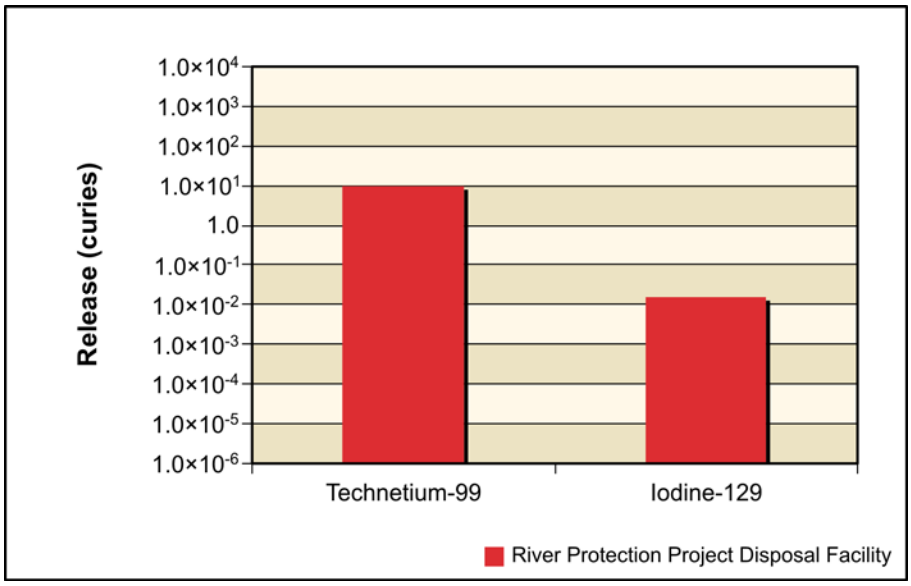


Figure 5–407. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Radiological Releases at River Protection Project Disposal Facility to Columbia River

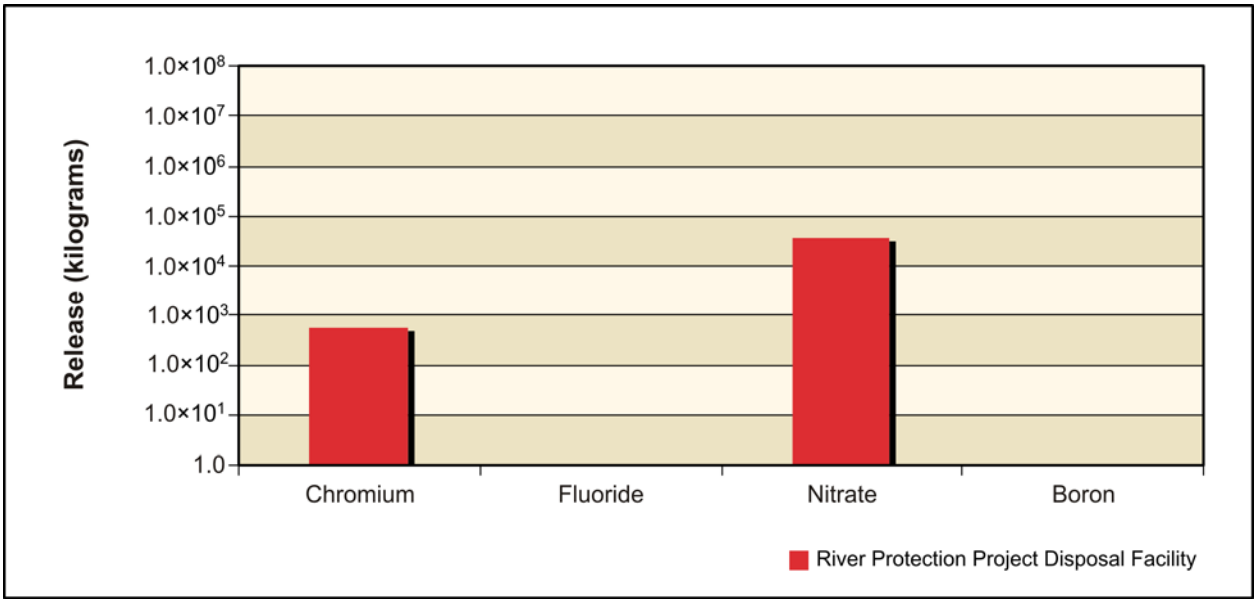


Figure 5–408. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, 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 (see Figures 5–409 through 5–413). 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 5–78 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–409 through 5–412 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). For technetium-99, a small rise in concentration is evident in the early years, peaking around CY 3940, but remaining over an order of magnitude below the benchmark concentration. Beginning in CY 5400, concentrations at the Core Zone Boundary begin climbing again, reaching a level just below the benchmark concentration at CY 7940. Iodine-129 follows a similar pattern, reaching a concentration slightly above the benchmark, while chromium and nitrate peak over an order of magnitude below the benchmark.

Figure 5–413 shows concentration versus time for total uranium. Because of the high retardation of uranium, no contamination appears until CY 9940, when total uranium concentrations at the Core Zone Boundary first surpass 1.0×10^{-8} micrograms per liter. Total uranium remains over seven orders of magnitude below the benchmark concentration at the Core Zone Boundary throughout the simulation. Uranium-238 does not surpass 1.0×10^{-8} picocuries per liter during the simulation.

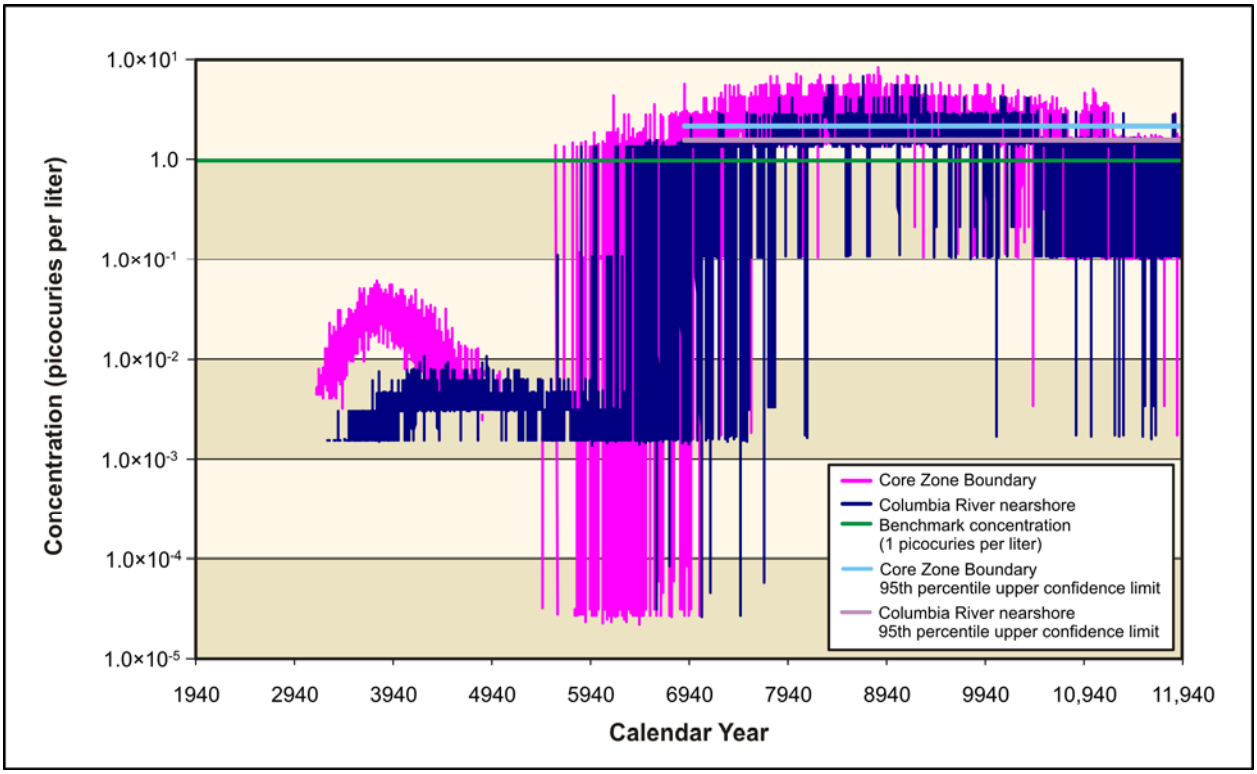


Figure 5–409. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Iodine-129 Concentration Versus Time

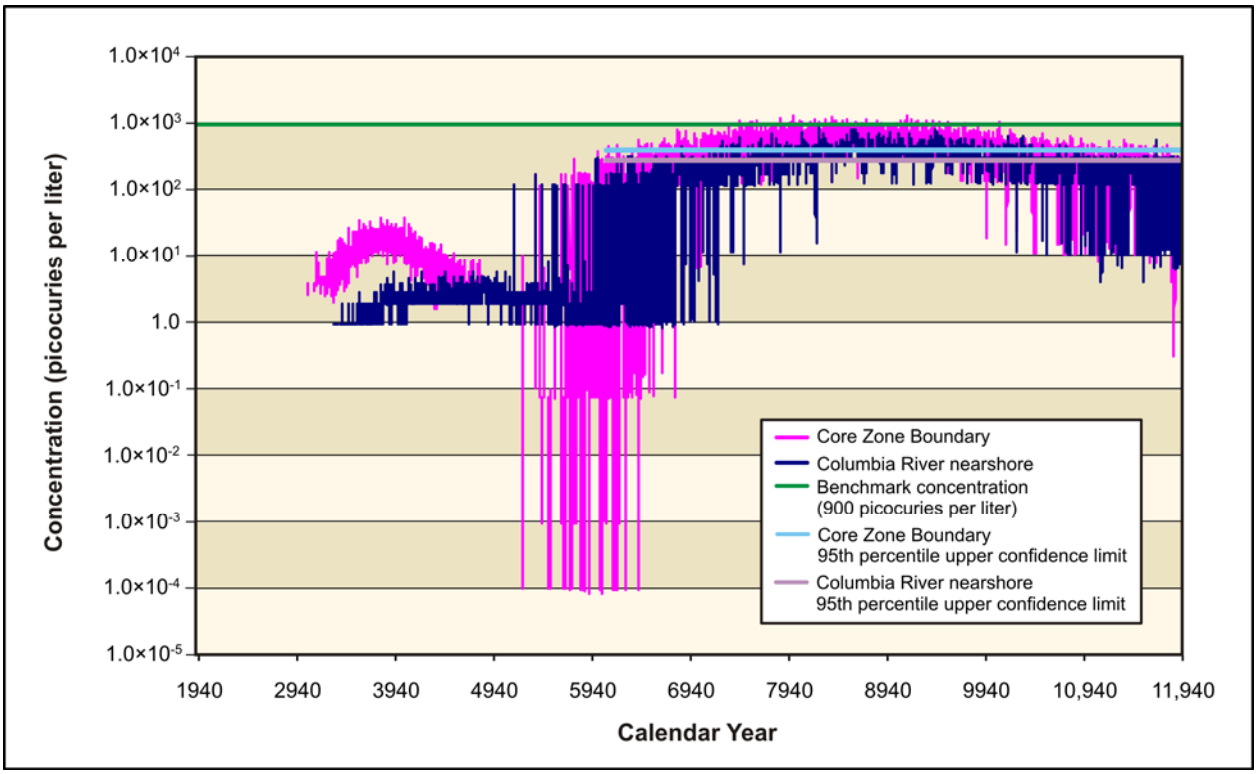


Figure 5–410. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Technetium-99 Concentration Versus Time

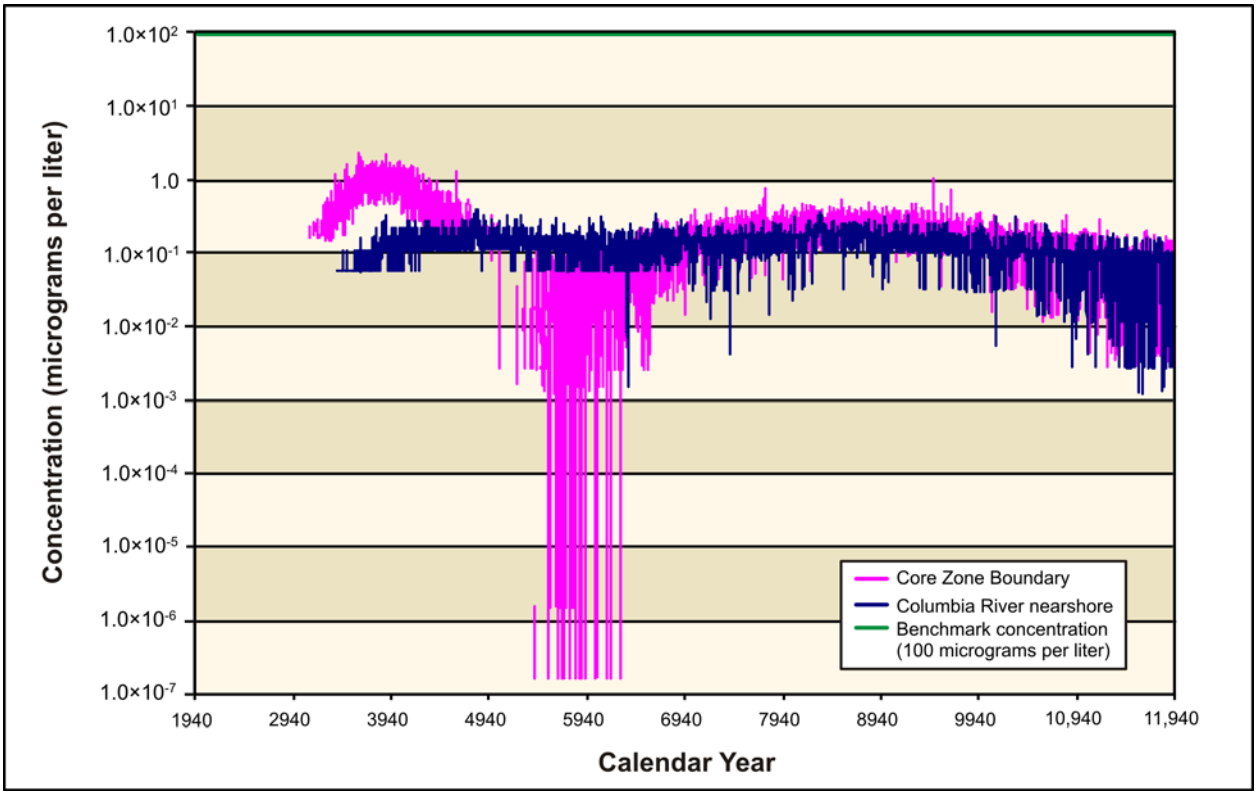


Figure 5–411. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Chromium Concentration Versus Time

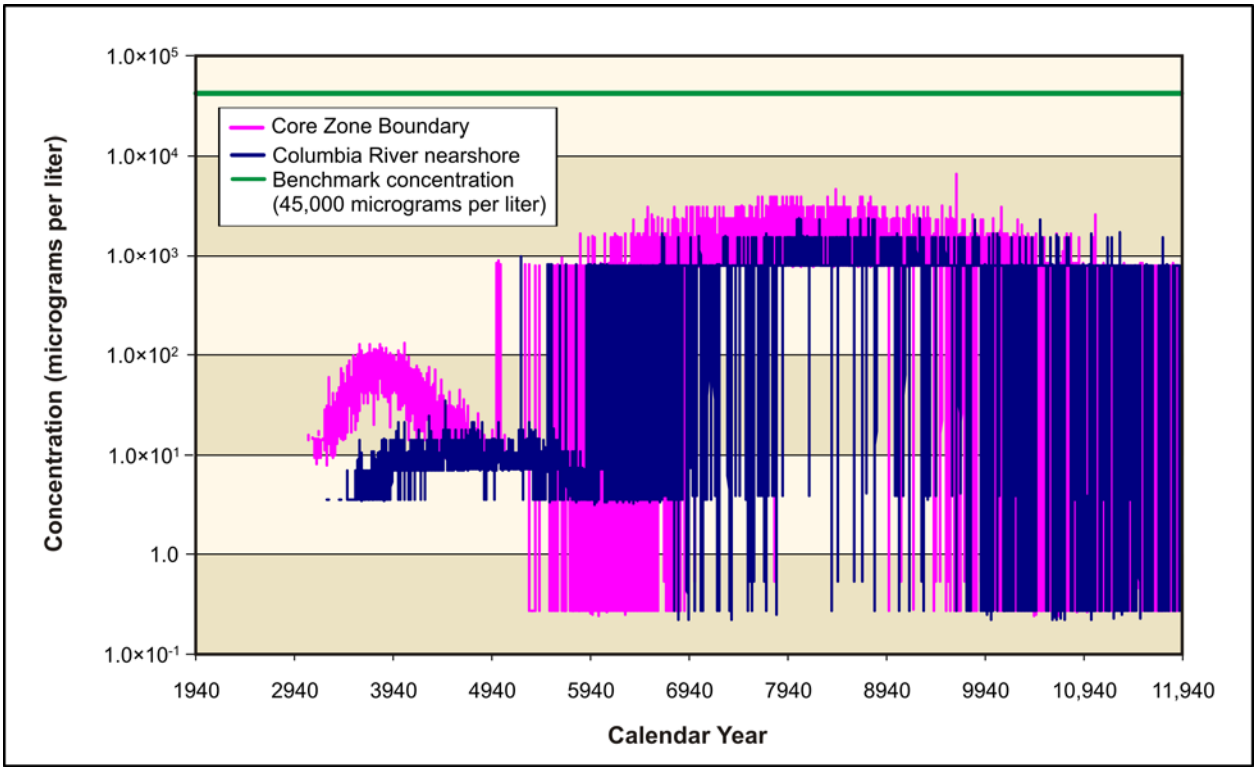


Figure 5–412. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Nitrate Concentration Versus Time

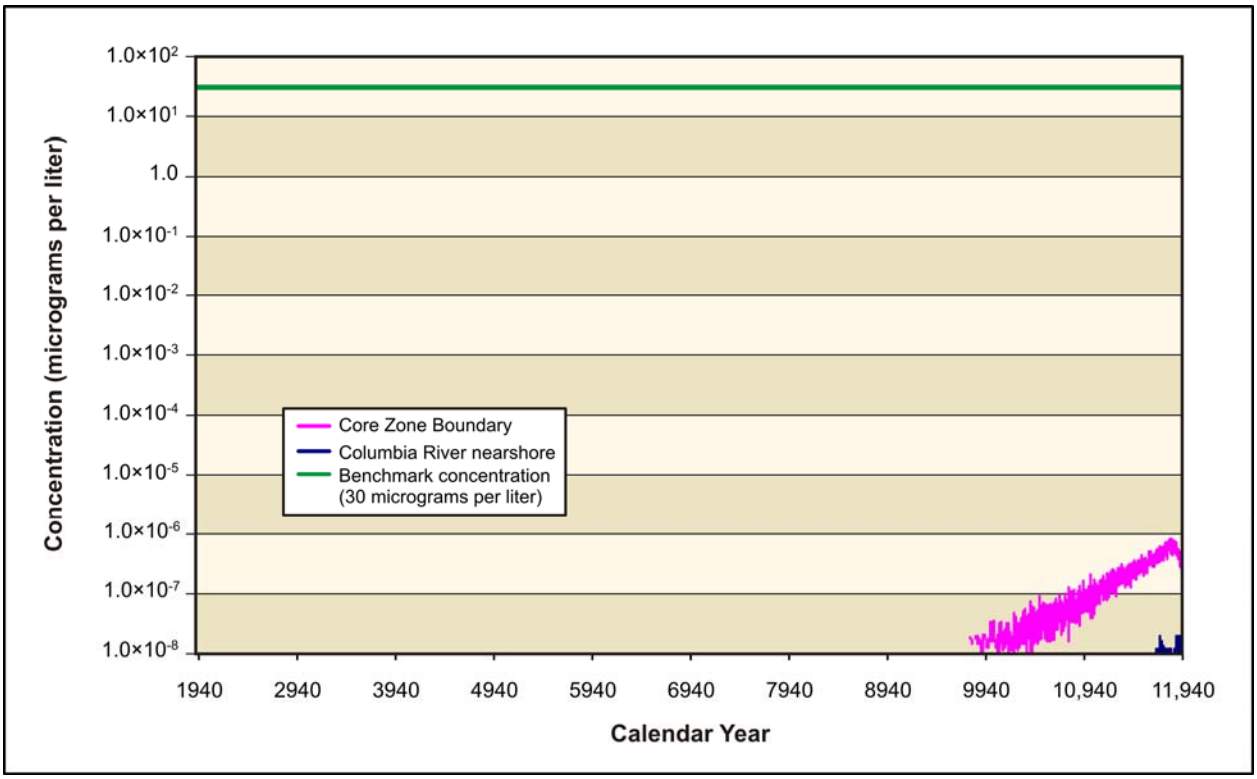


Figure 5–413. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Total Uranium Concentration Versus Time

Table 5–78. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**2,880**	33	**1,250**	815	900
	(8486)	(3825)	(7998)	(8273)	
Iodine-129	**18**	0.1	**8**	**7**	1
	(8195)	(3772)	(8858)	(8700)	
Chemical in micrograms per liter					
Chromium	2	2	2	0	100
	(8278)	(3856)	(3889)	(4826)	
Fluoride	0	0	1	0	4,000
	(8035)	(1940)	(7258)	(8913)	
Nitrate	14,400	149	5,860	3,680	45,000
	(7821)	(3811)	(8905)	(8144)	

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

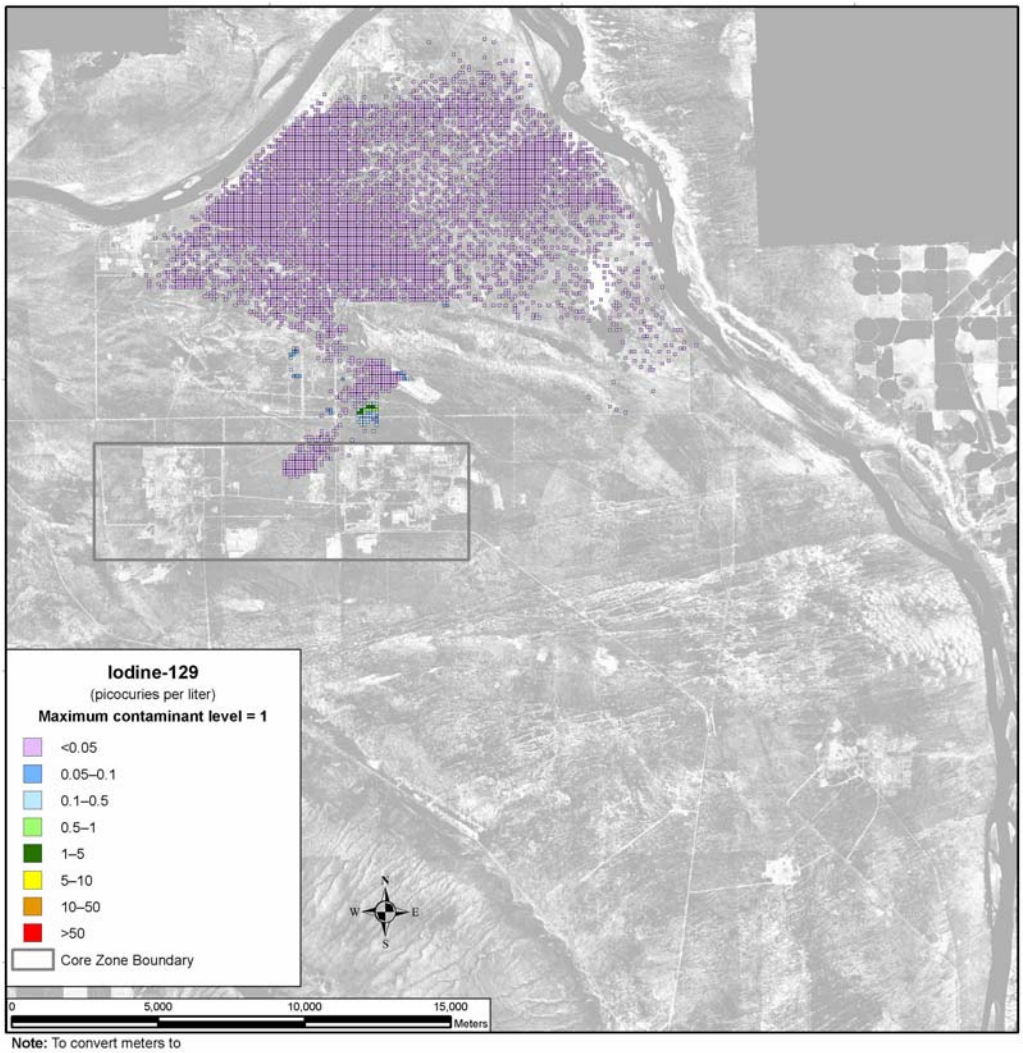
Key: COPC=constituent of potential concern; IDF-East=an Integrated Disposal Facility in the 200-East Area of Hanford; RPPDF=River Protection Project Disposal Facility.

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, 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 5–414 through 5–426). 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.

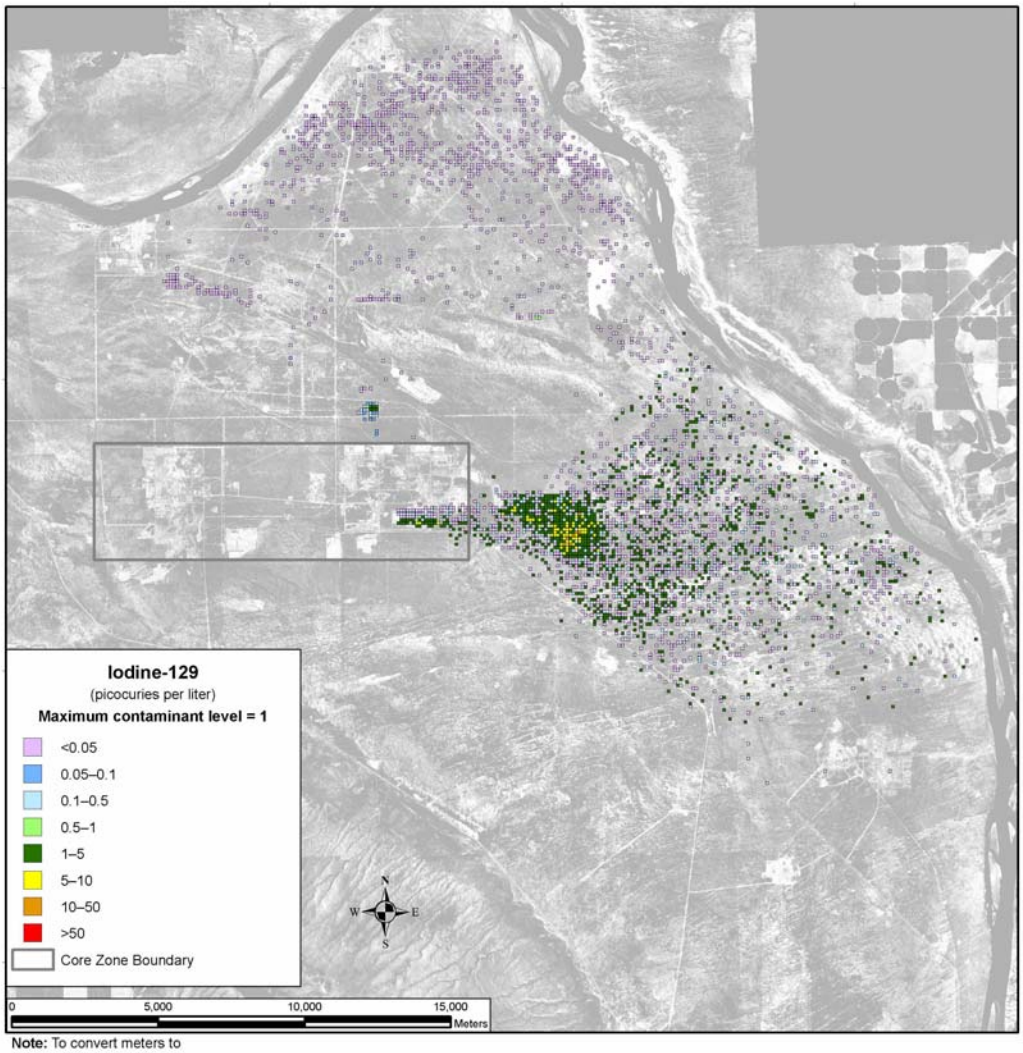
At CY 3890 (see Figure 5–414), there is a low-concentration plume of iodine-129 that stretches north from the RPPDF and through Gable Gap. By CY 7140 (see Figure 5–415), the plume from the RPPDF is gone, but a new plume has formed, traveling east from IDF-East. Concentrations in this plume reach a level over an order of magnitude above the benchmark. Figure 5–416 shows the iodine-129 concentration for CY 11,885. Technetium-99 (see Figures 5–417 through 5–419), chromium (see Figures 5–420 through 5–422), and nitrate (see Figures 5–423 through 5–425) show similar spatial distributions, with lower concentrations at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

Total uranium shows a different spatial distribution over time. It is 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 plume extending through Gable Gap from the RPPDF (see Figure 5–426). Concentrations in all areas of the plume remain below one-twentieth of the benchmark.



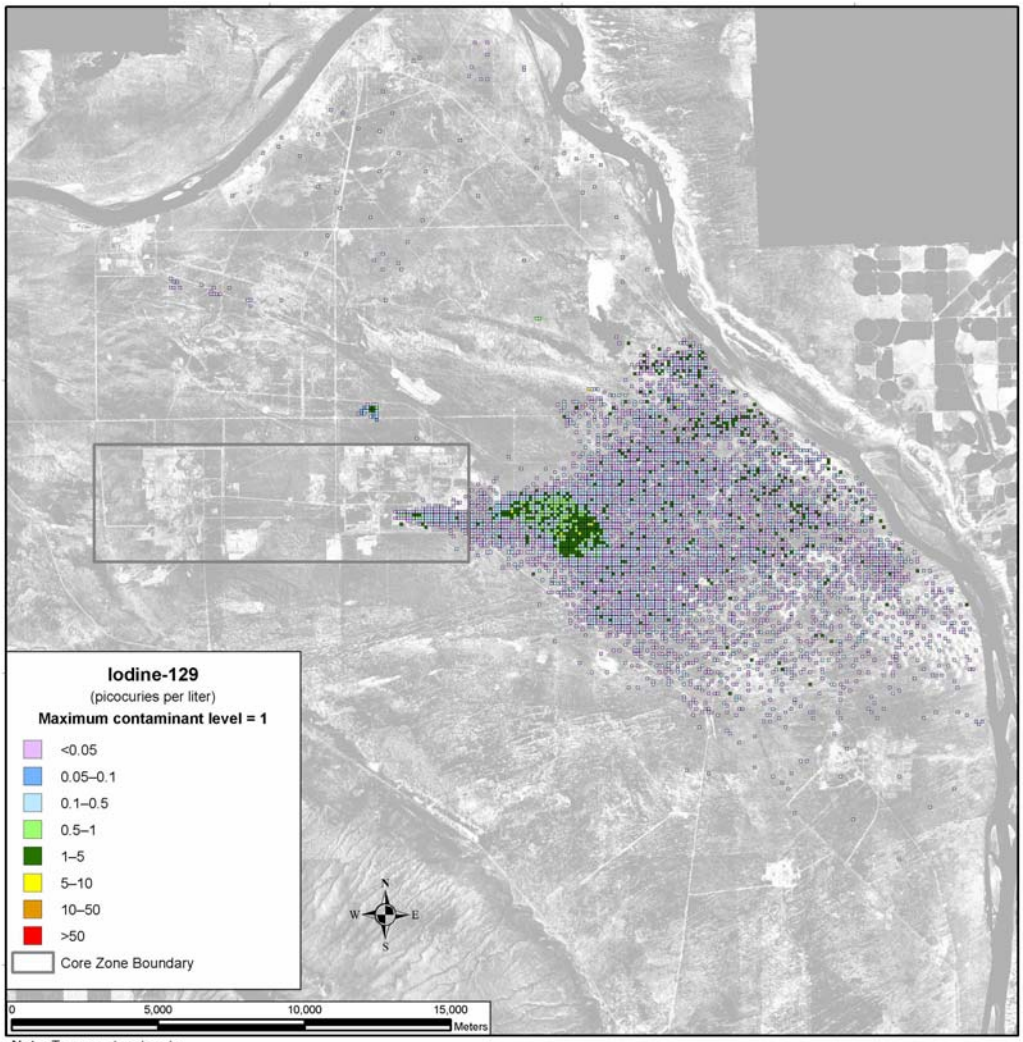
Note: To convert meters to feet, multiply by 3.281

Figure 5–414. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



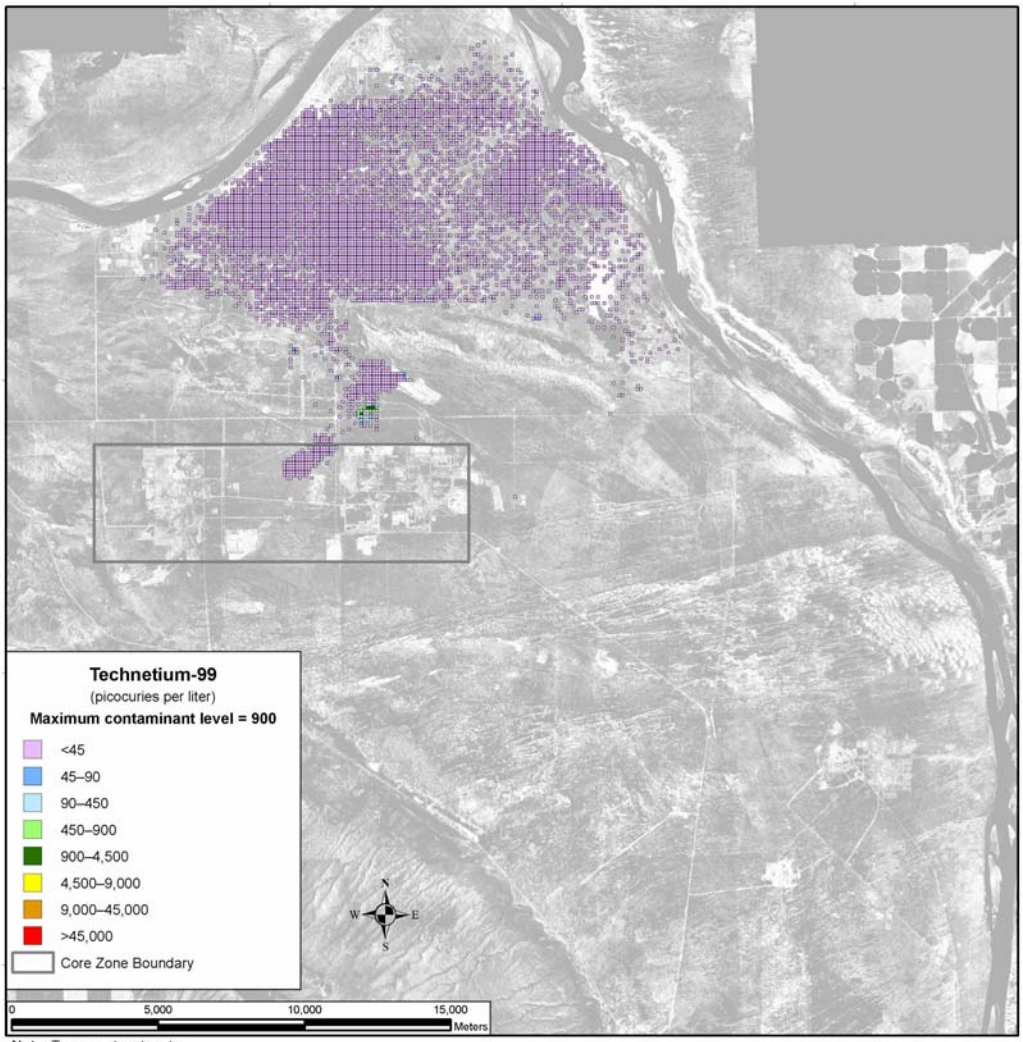
Note: To convert meters to feet, multiply by 3.281

Figure 5–415. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



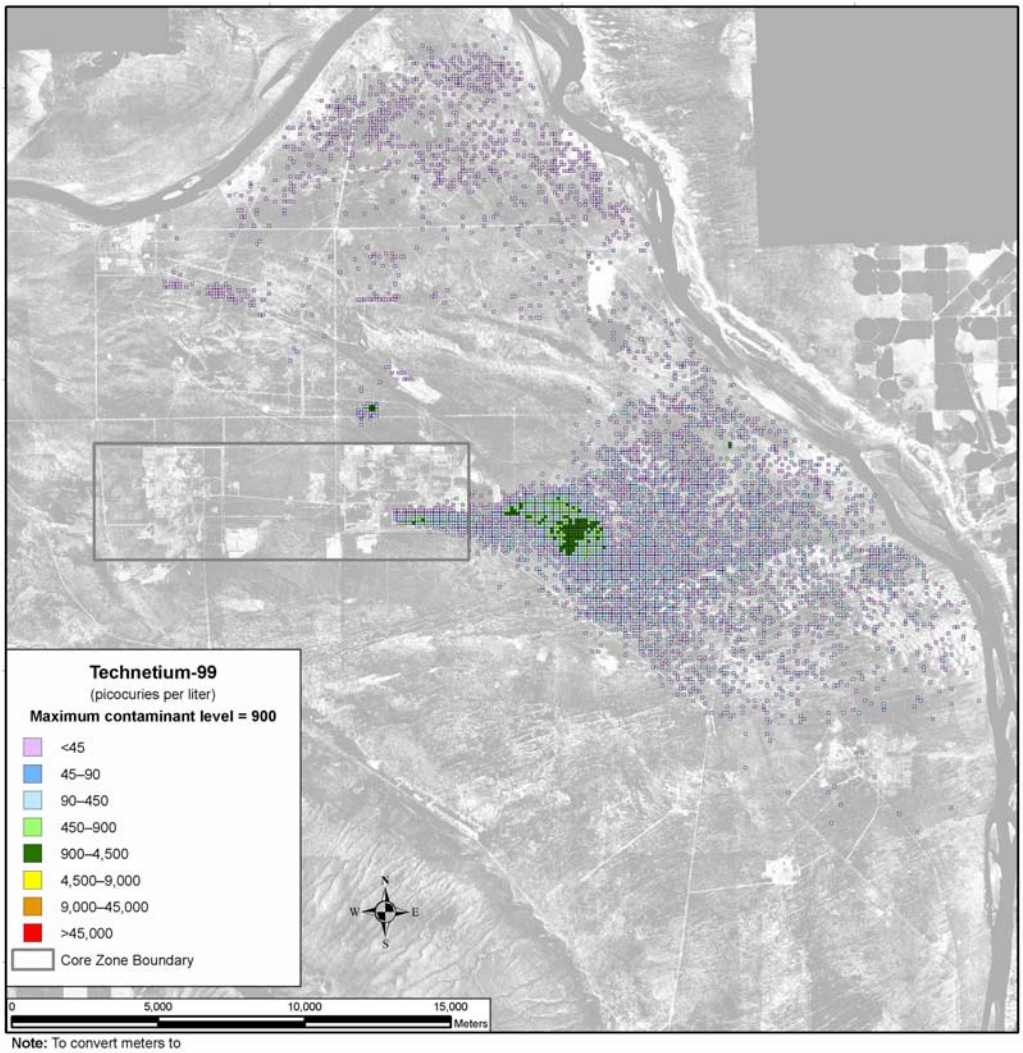
Note: To convert meters to feet, multiply by 3.281

Figure 5–416. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



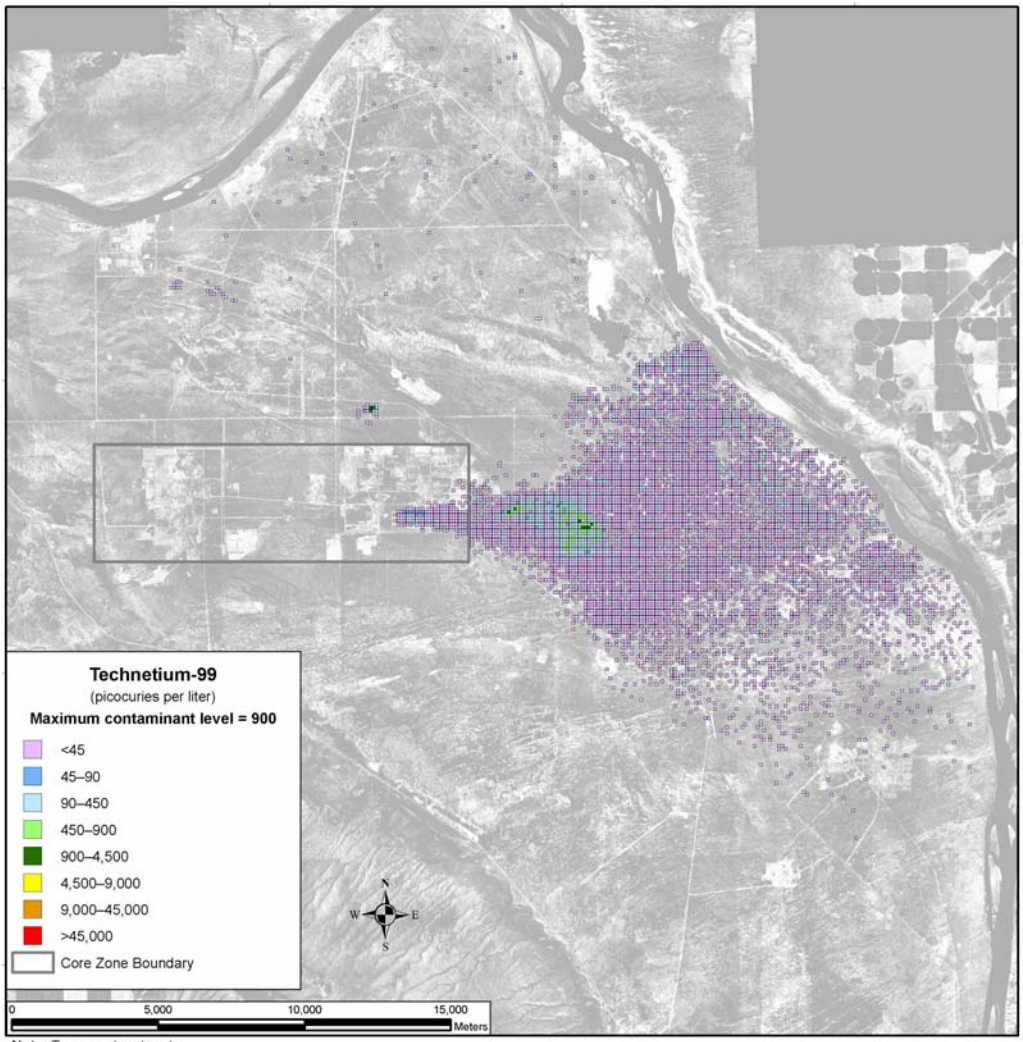
Note: To convert meters to feet, multiply by 3.281

Figure 5–417. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



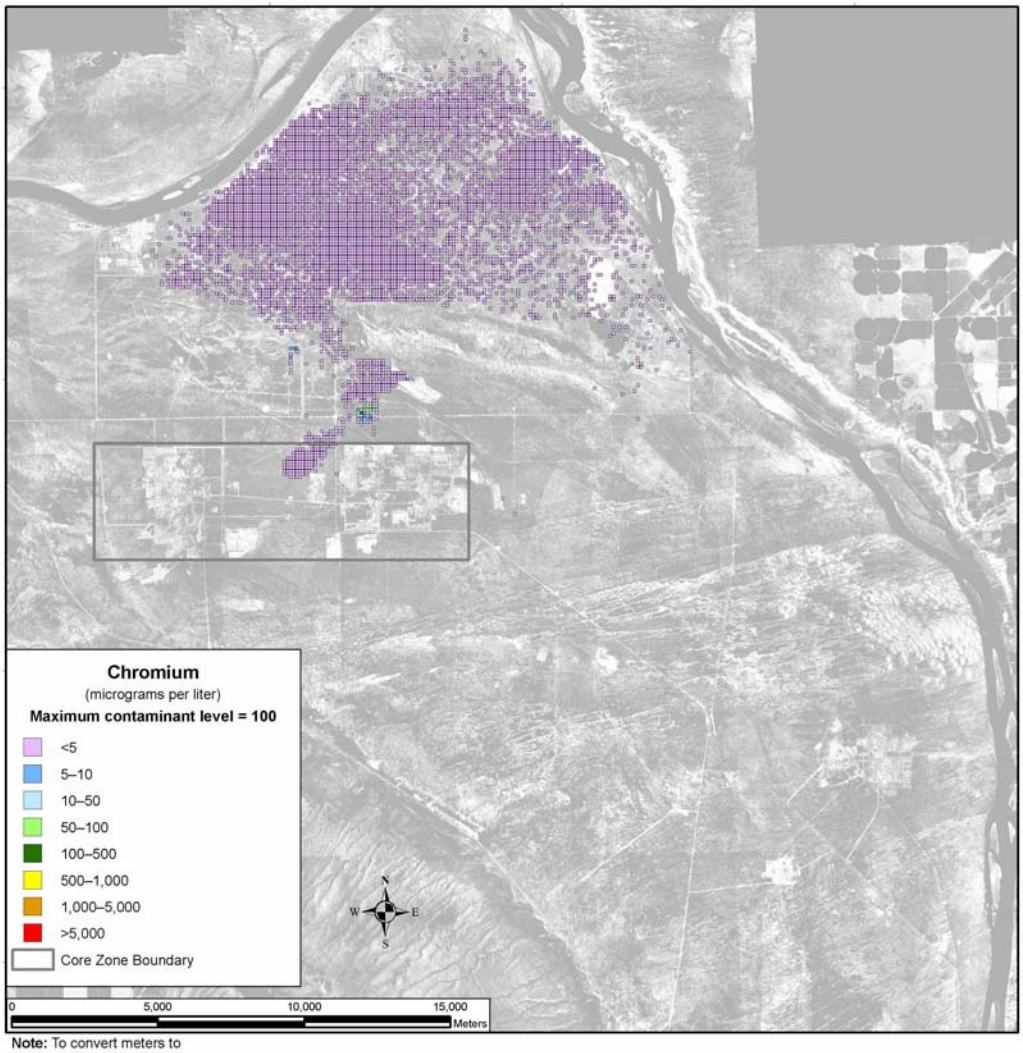
Note: To convert meters to feet, multiply by 3.281

Figure 5–418. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



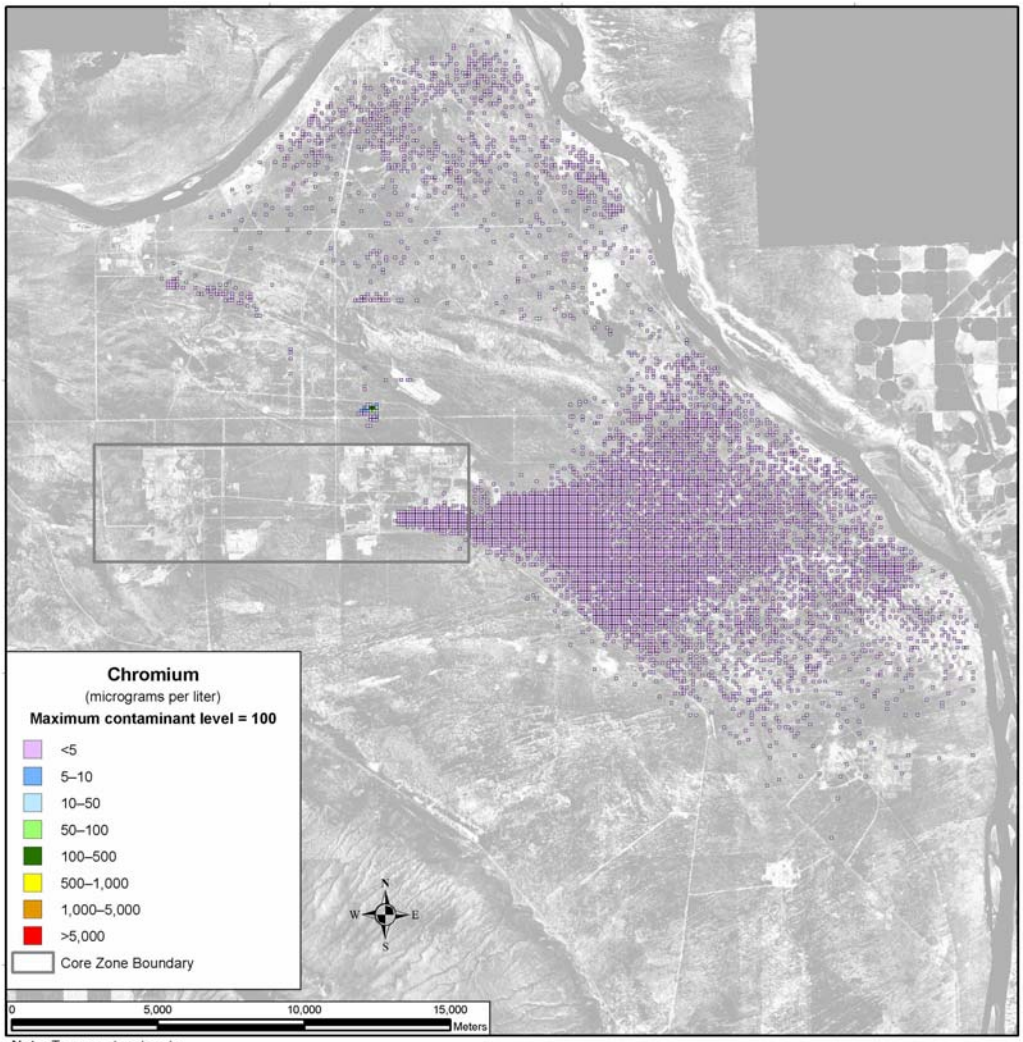
Note: To convert meters to feet, multiply by 3.281

Figure 5–419. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



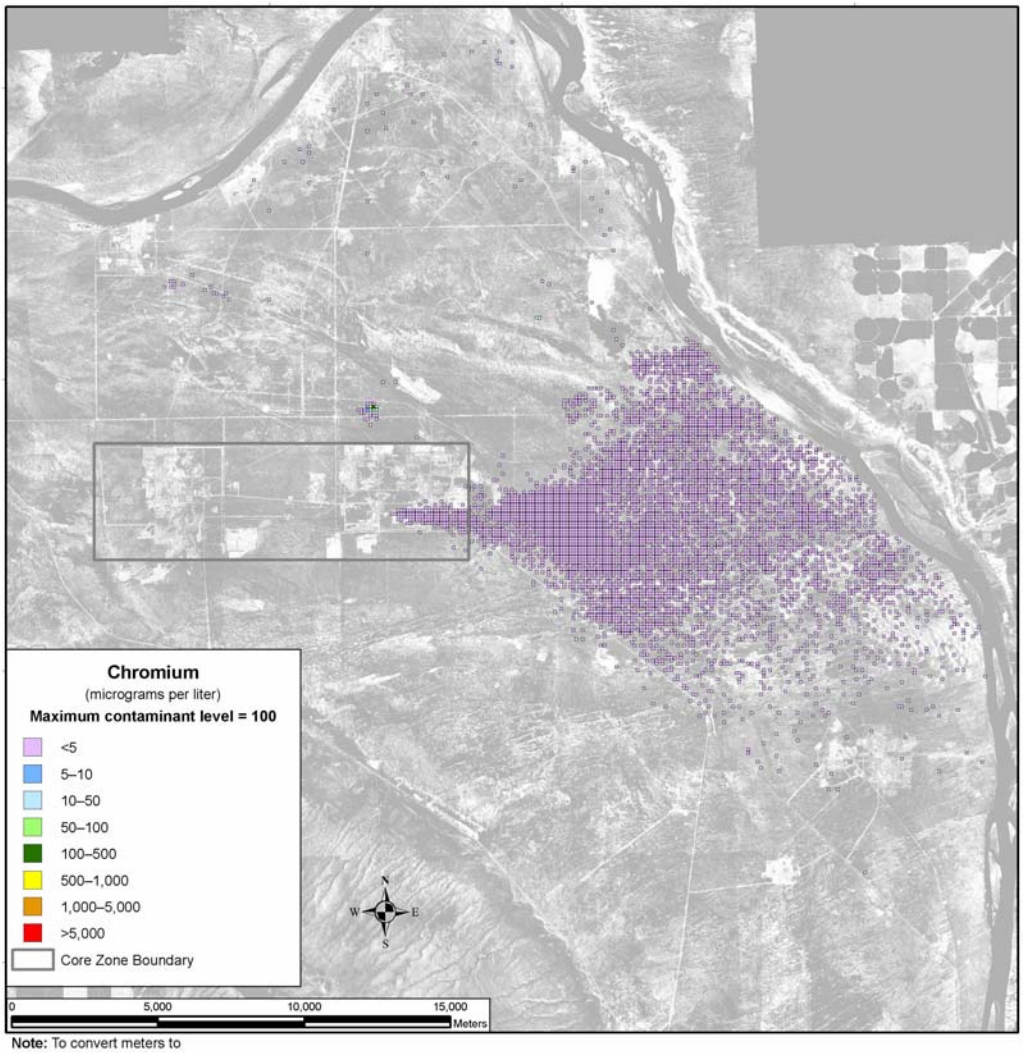
Note: To convert meters to feet, multiply by 3.281

Figure 5–420. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



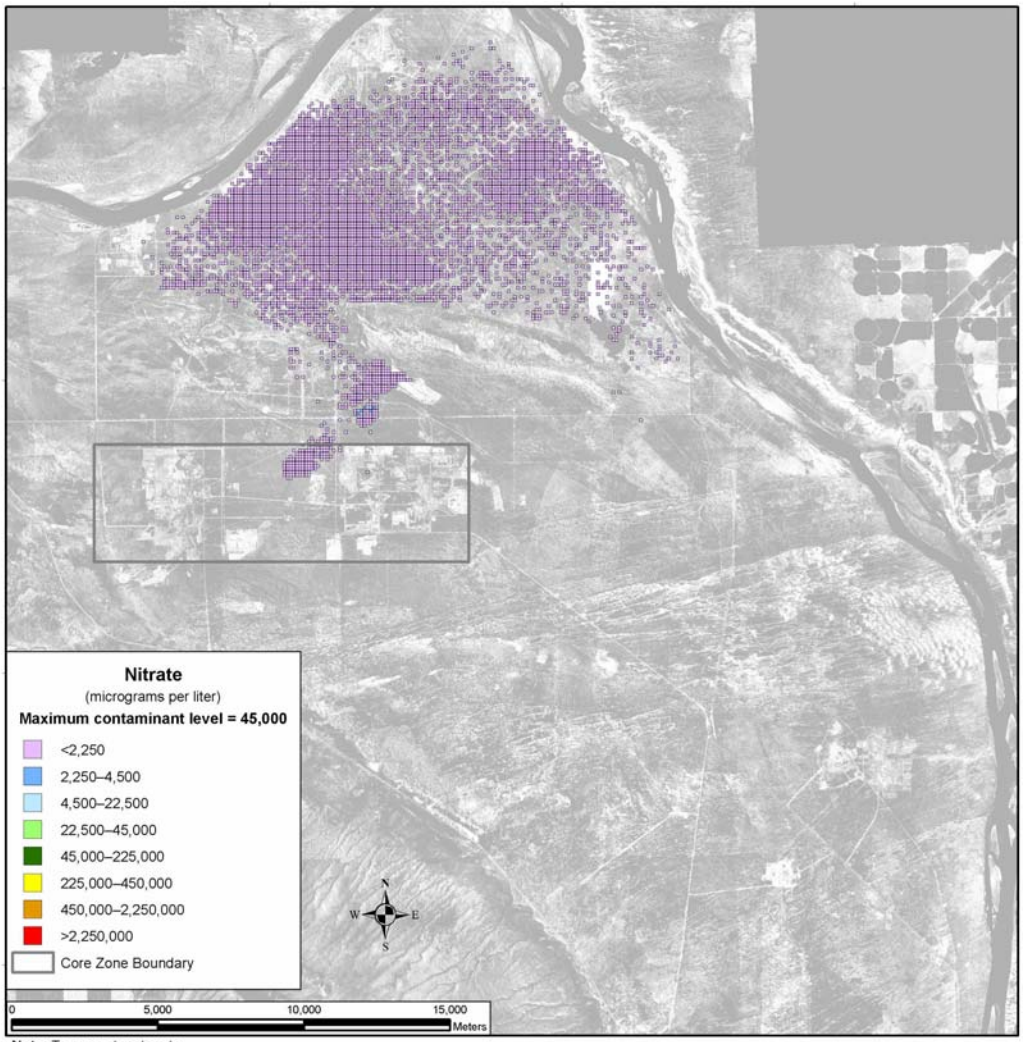
Note: To convert meters to feet, multiply by 3.281

Figure 5–421. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



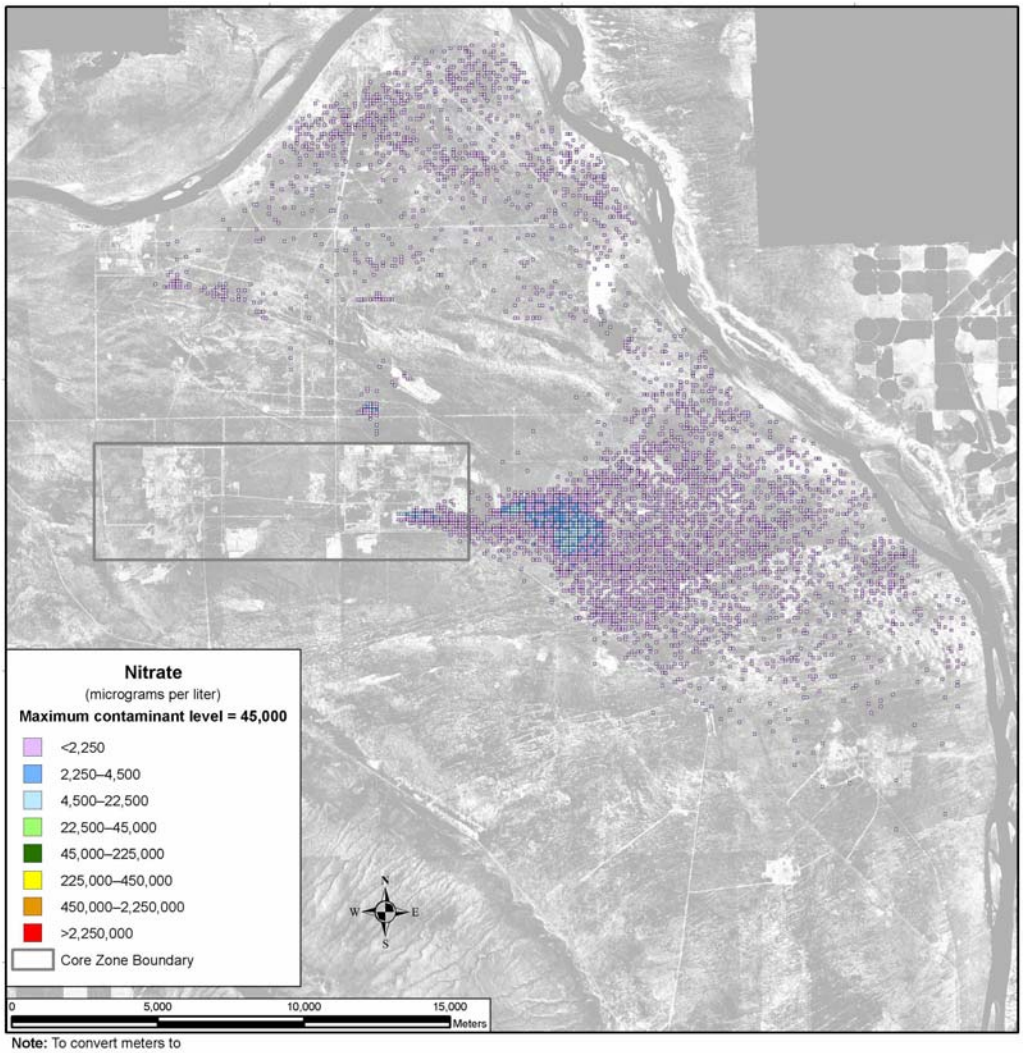
Note: To convert meters to feet, multiply by 3.281

Figure 5–422. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



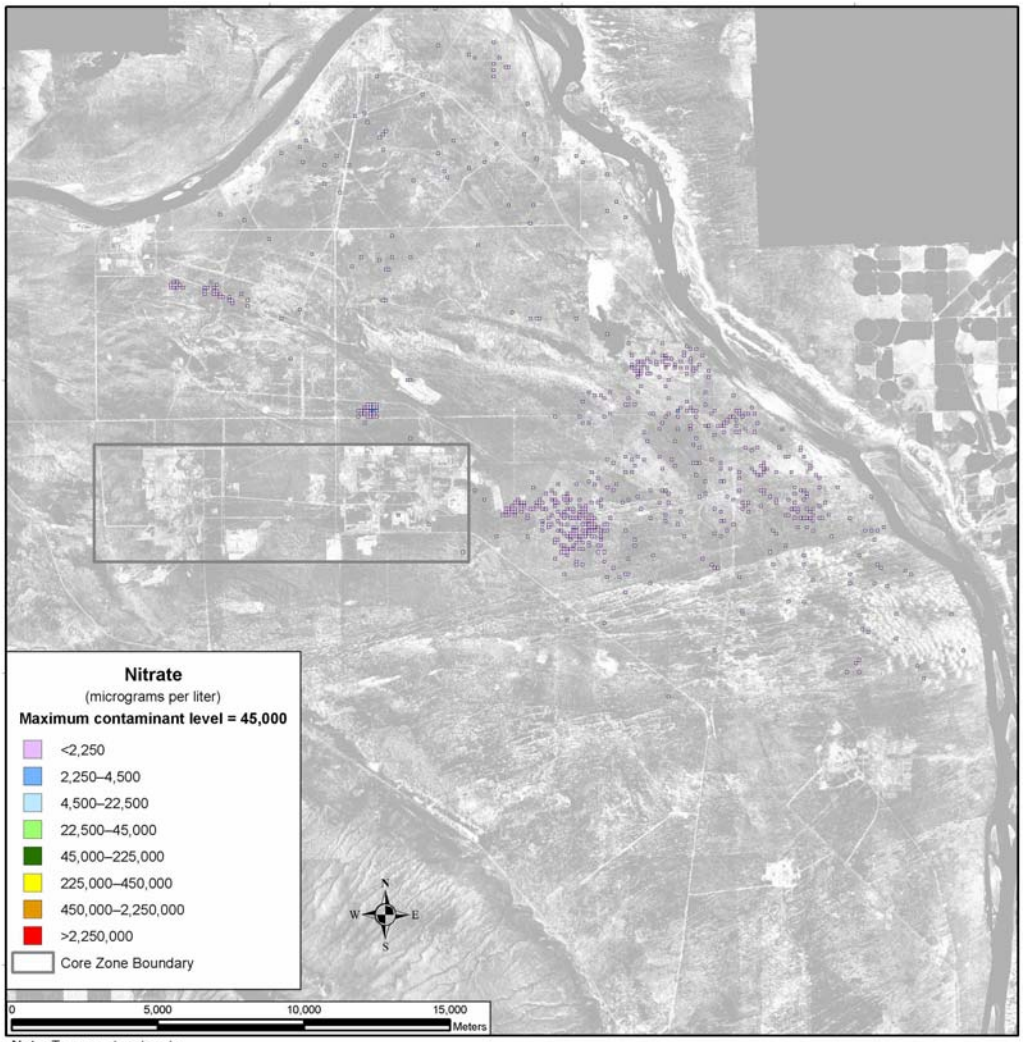
Note: To convert meters to feet, multiply by 3.281

Figure 5–423. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



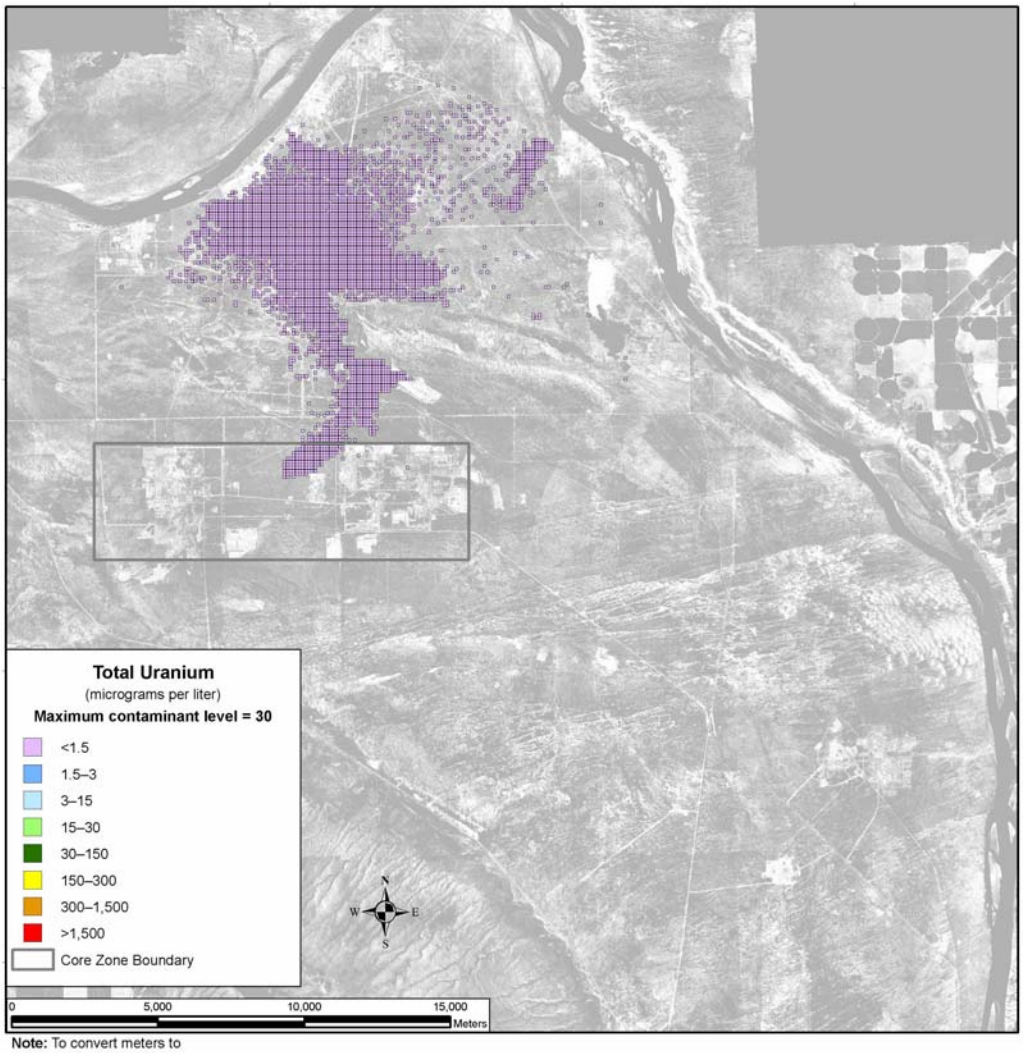
Note: To convert meters to feet, multiply by 3.281

Figure 5–424. Waste Management Alternative 2, 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 5–425. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-B, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–426. Waste Management Alternative 2, 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 2, Disposal Group 1, Subgroup 1-B, in general, discharges from IDF-East are the predominant contributors. The RPPDF is a secondary contributor.

For the conservative tracers, with the exception of chromium, 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 are slightly lower, but within an order of magnitude of the concentrations at the Core Zone Boundary. Chromium concentrations remain over two orders of magnitude below the benchmark at the Core Zone Boundary and the Columbia River.

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 throughout the simulation. The peak intensity and area of the contamination plume are near the end of the period of analysis.

5.3.1.2.1.3 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 and FFTF Decommissioning Alternative 2 or 3 as well as 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 IDF-East.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, 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 the RPPDF in CY 2009 and continue through CY 2050, when these 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 the facilities become available for release to the environment, and modified RCRA Subtitle C barriers would be emplaced over IDF-East and the RPPDF to limit infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C. Complete results for all 40 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2, 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, boron, chromium, fluoride, nitrate, and total uranium

The COPC drivers for Waste Management Alternative 2, 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 2, 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, boron, 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 2, Disposal Group 1, Subgroup 1-C, in terms of the 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 5–427 through 5–438). Eight 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, onsite- and offsite-generated waste, and RPPDF waste. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over eight orders of magnitude.

Figure 5–427 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–428, 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, and technetium-99 is the cast stone waste; of iodine-129 is offsite-generated waste. Other sources of contamination include ILAW glass, ETF-generated secondary waste, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite-generated waste.

Figure 5–429 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–430, 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 offsite-generated waste, of which nearly all that was 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 reaches groundwater. For nitrate, fluoride, boron, and acetonitrile, nearly everything released to the vadose zone reaches groundwater.

Figure 5–431 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–432, 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 exceptions to this trend are the retired melters for both technetium-99 and iodine-129 and waste management secondary and onsite-generated waste for iodine-129. In these cases, nothing released to groundwater reached the Columbia River.

Figure 5–433 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–434, 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 5–435 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–436, 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 5–437 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–438, 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 in the analysis for all COPC drivers present.

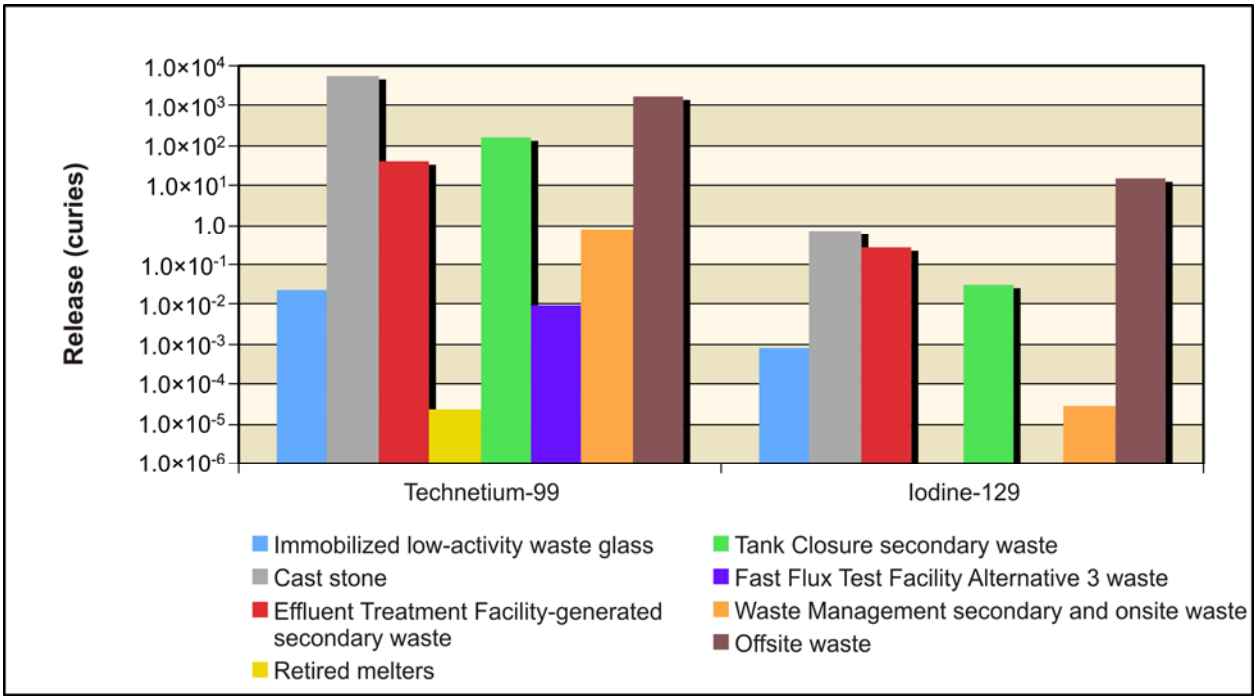


Figure 5–427. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

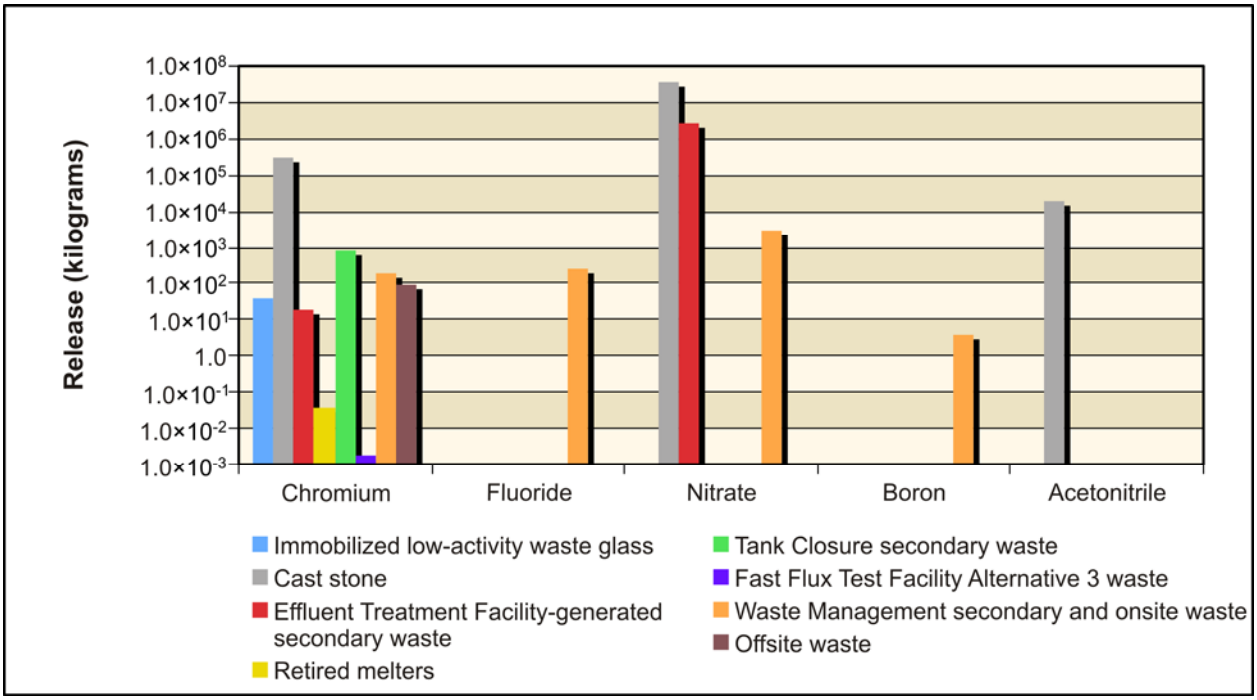


Figure 5–428. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

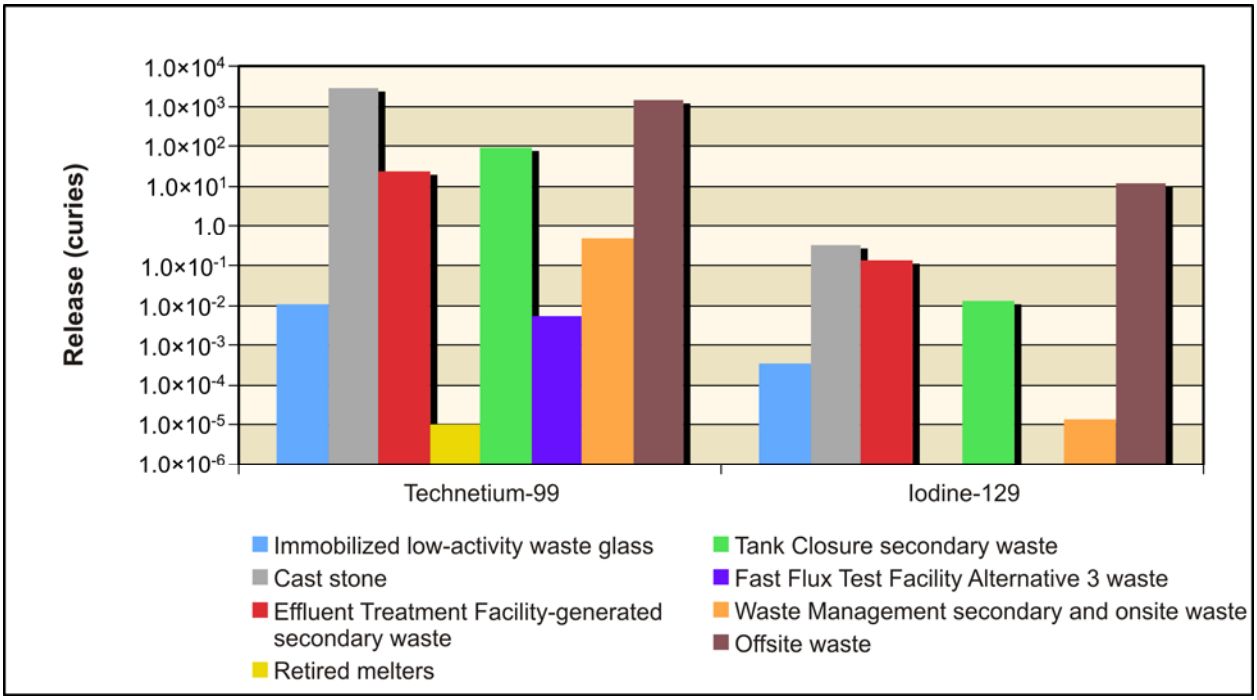


Figure 5–429. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

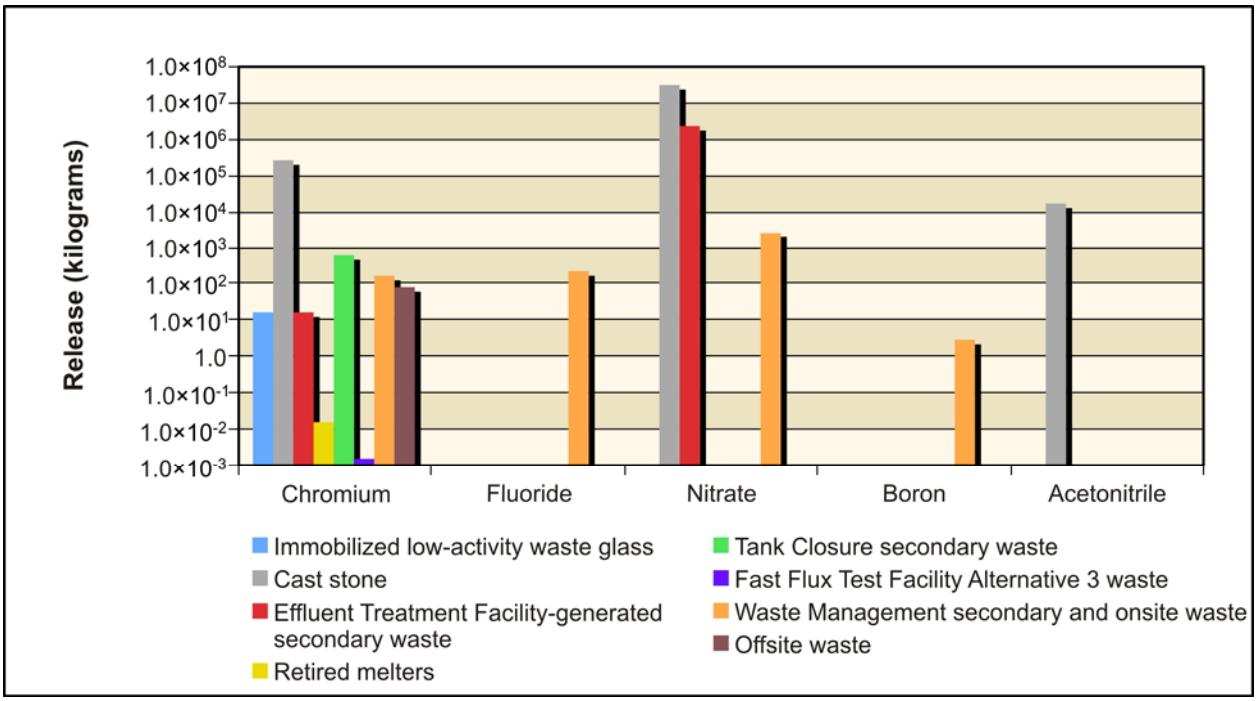


Figure 5–430. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

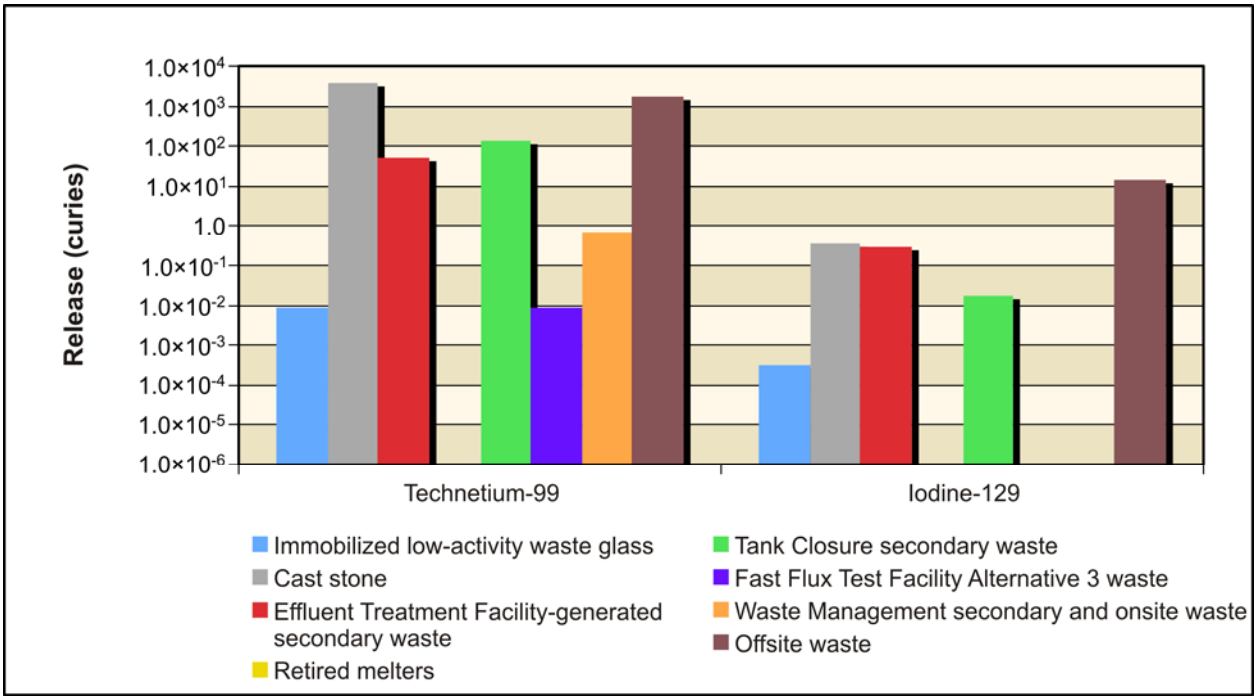


Figure 5–431. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

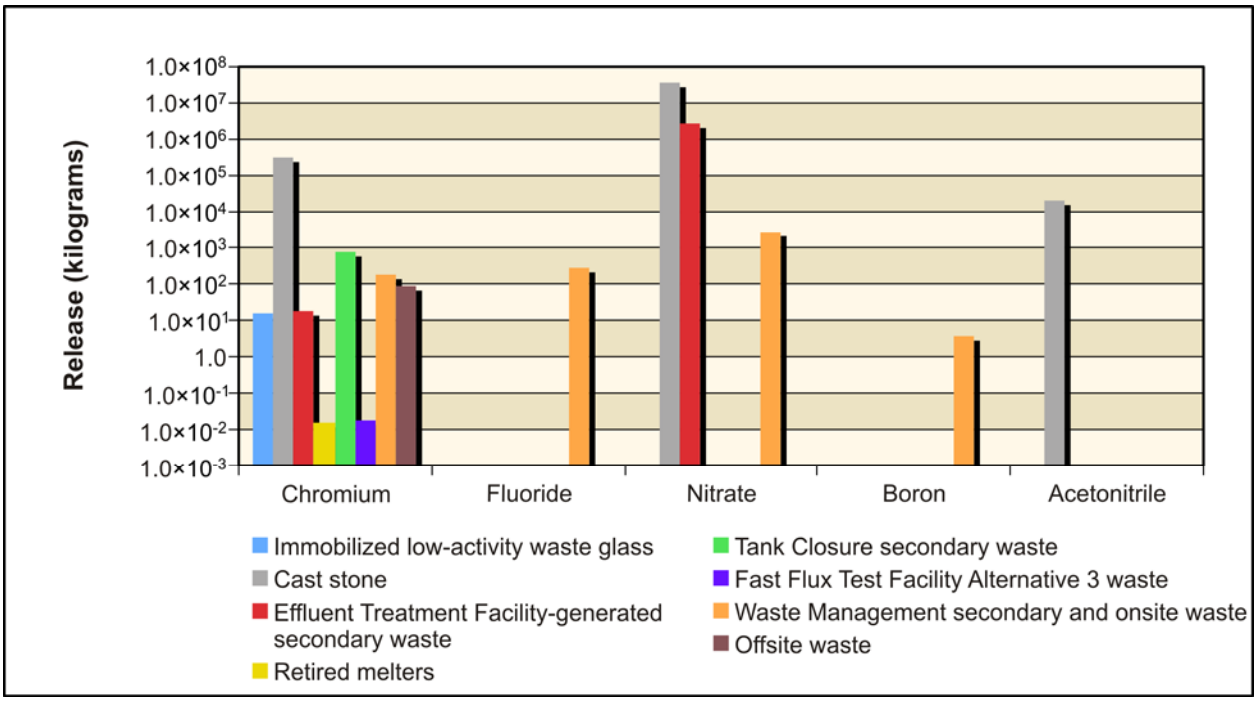


Figure 5–432. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

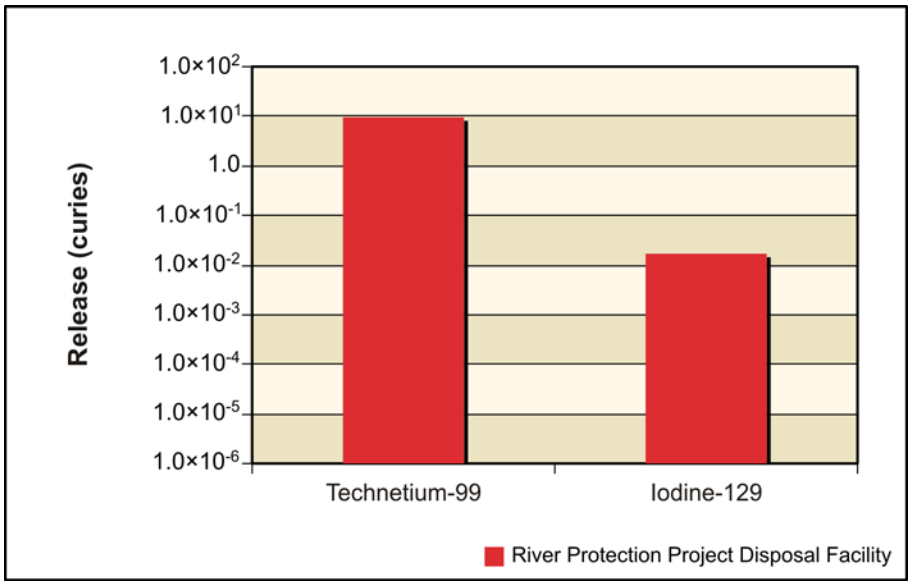


Figure 5–433. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

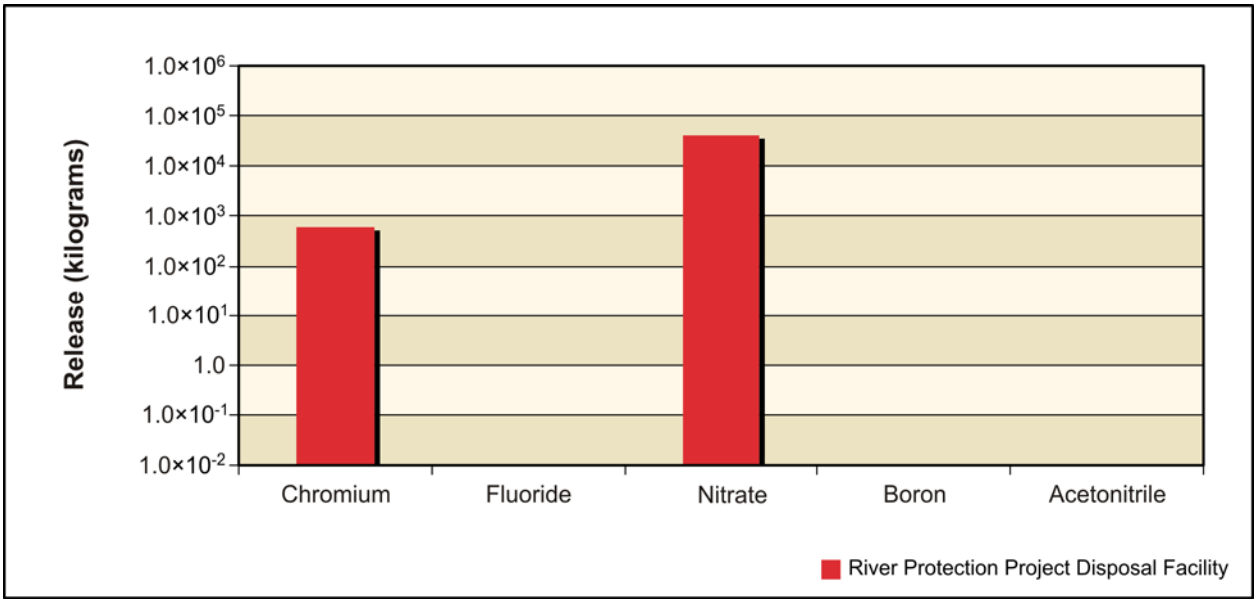


Figure 5–434. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

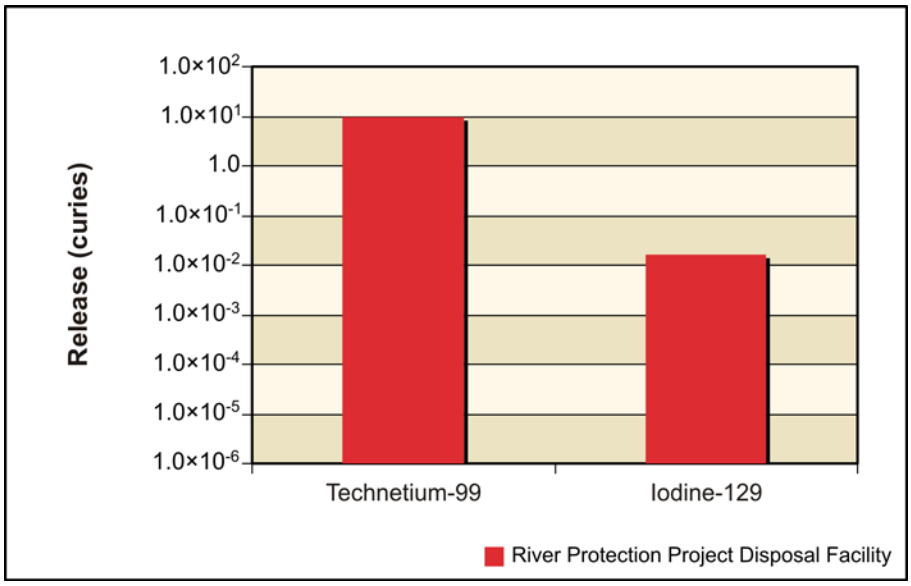


Figure 5–435. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Facility to Groundwater

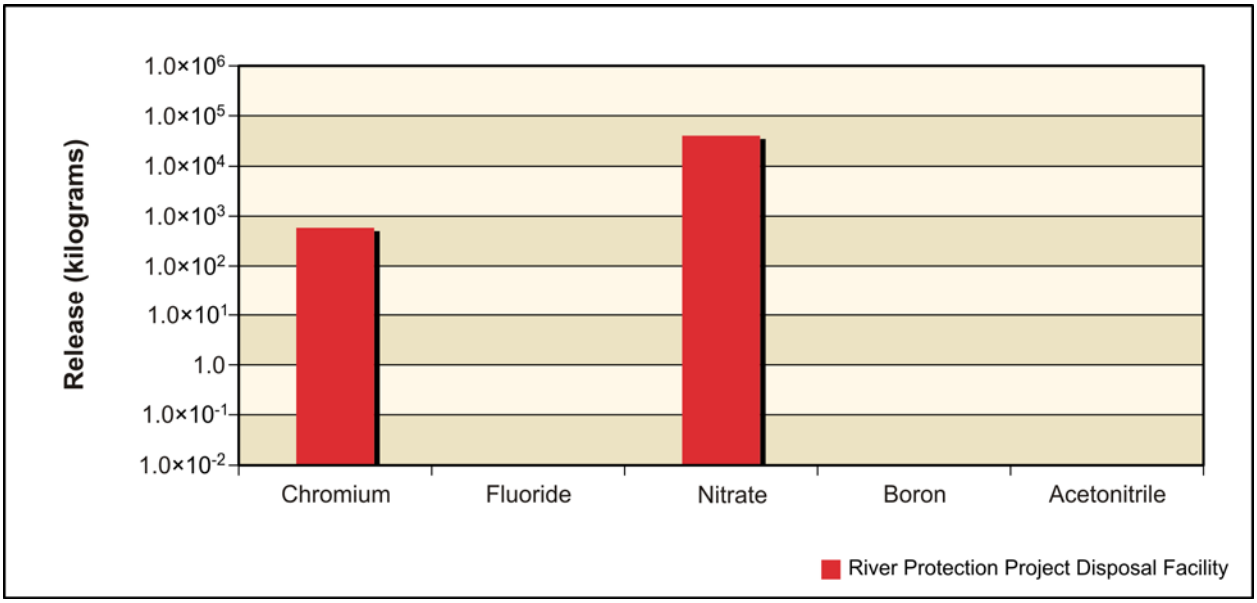


Figure 5–436. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Facility to Groundwater

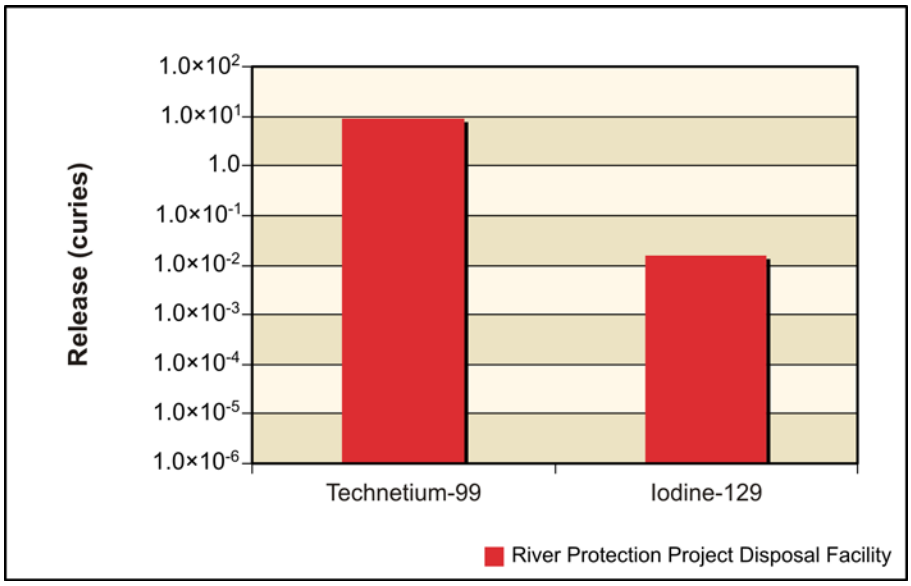


Figure 5–437. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Radiological Releases at River Protection Project Disposal Facility to Columbia River

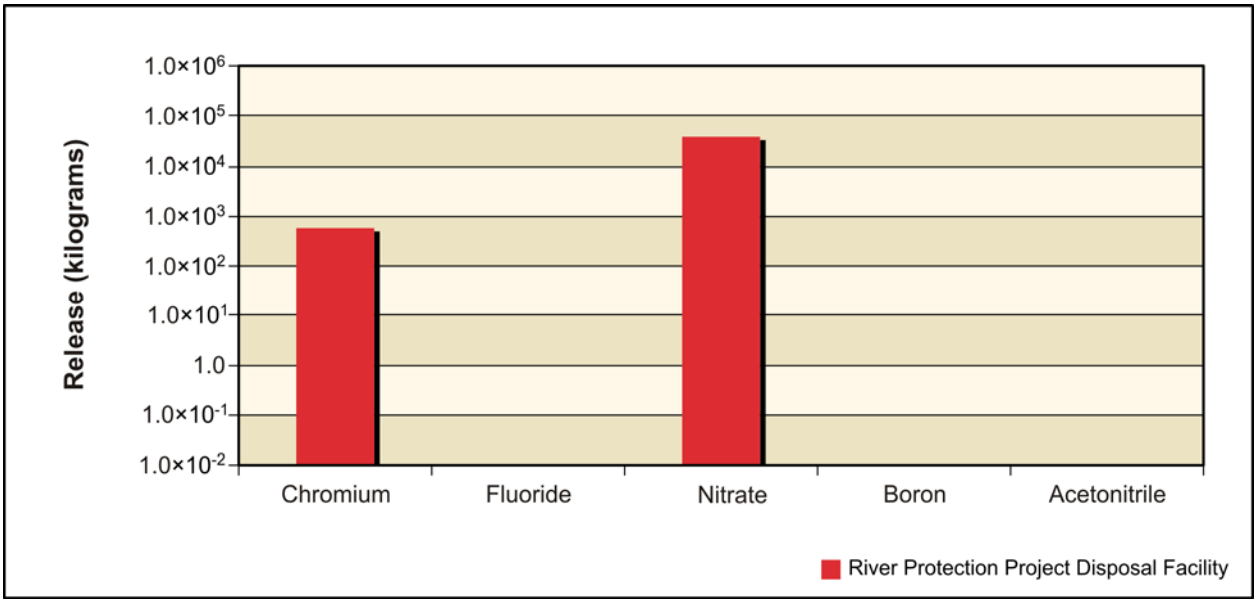


Figure 5–438. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, 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 (see Figures 5–439 through 5–443). 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 5–79 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–439 through 5–442 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). For technetium-99, a small rise in concentration is evident in the early years, peaking around CY 3940 but remaining over an order of magnitude below the benchmark concentration. Beginning in CY 5400, concentrations at the Core Zone Boundary begin climbing again, stabilizing very near to the benchmark concentration at CY 7940. Iodine-129 follows a similar pattern, stabilizing slightly above the benchmark concentration, while chromium and nitrate peak below the benchmark.

Figure 5–443 shows concentration versus time for total uranium. Because of the high retardation of uranium, no contamination appears until CY 9940, when total uranium concentrations at the Core Zone Boundary first surpass 1.0×10^{-8} micrograms per liter.

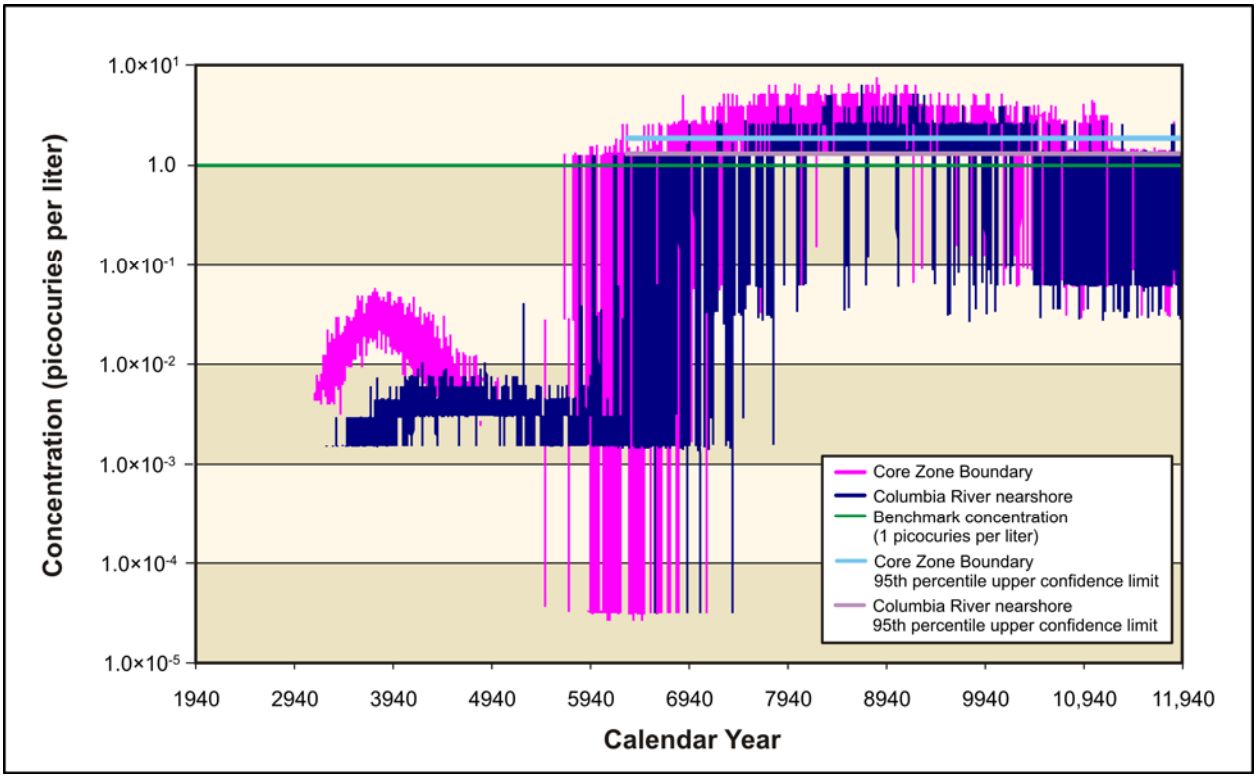


Figure 5–439. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Iodine-129 Concentration Versus Time

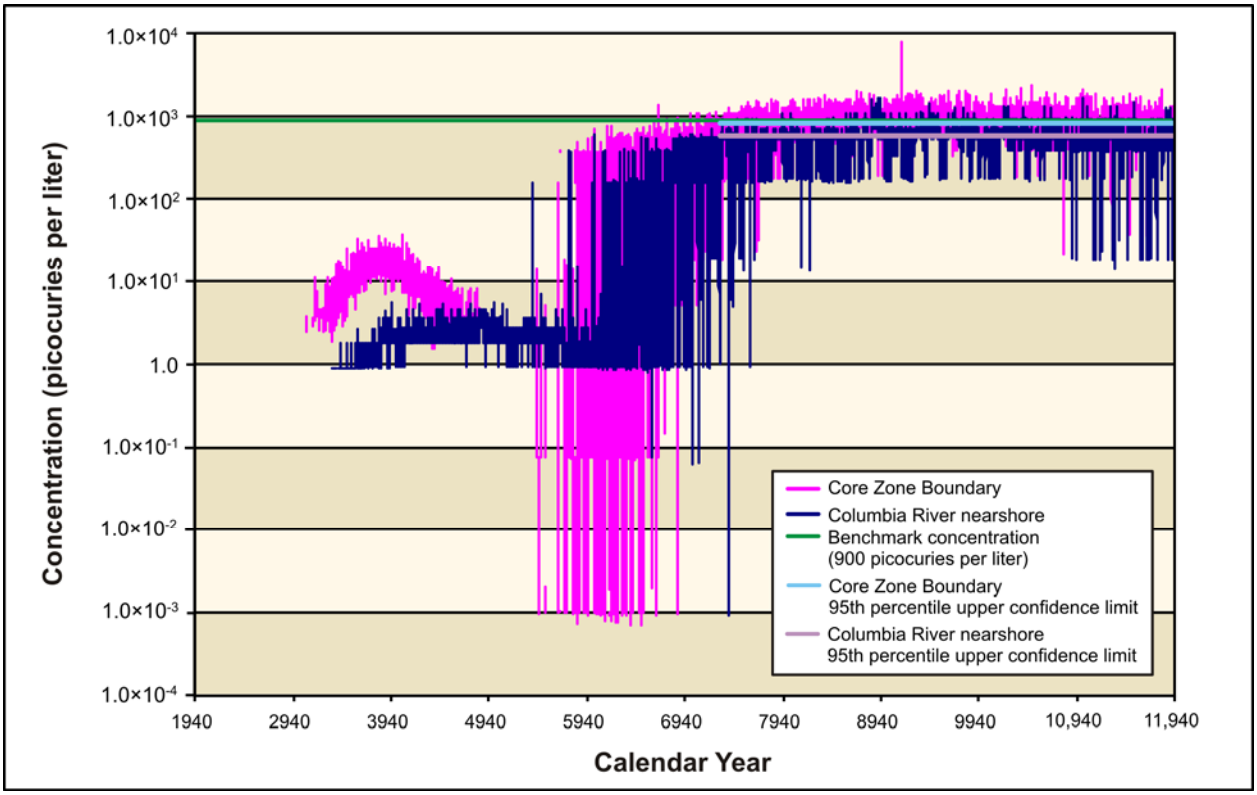


Figure 5–440. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Technetium-99 Concentration Versus Time

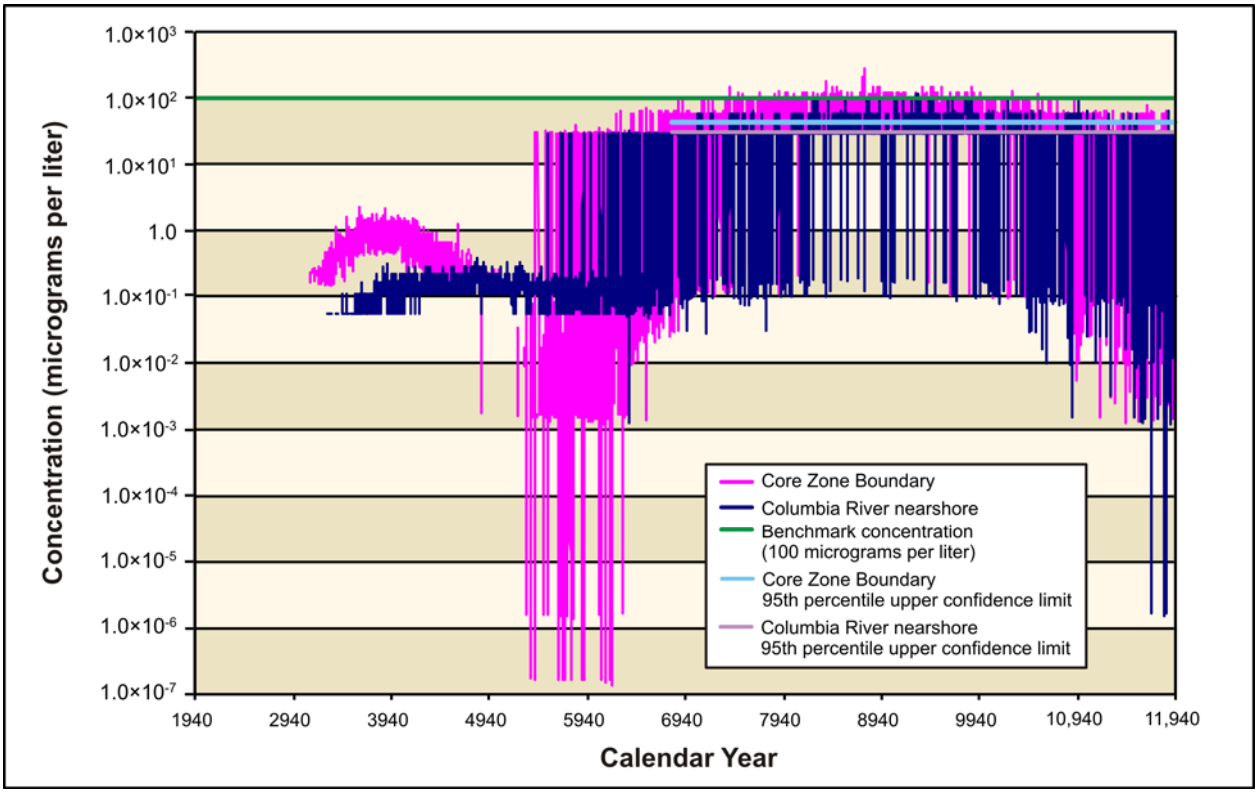


Figure 5–441. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Chromium Concentration Versus Time

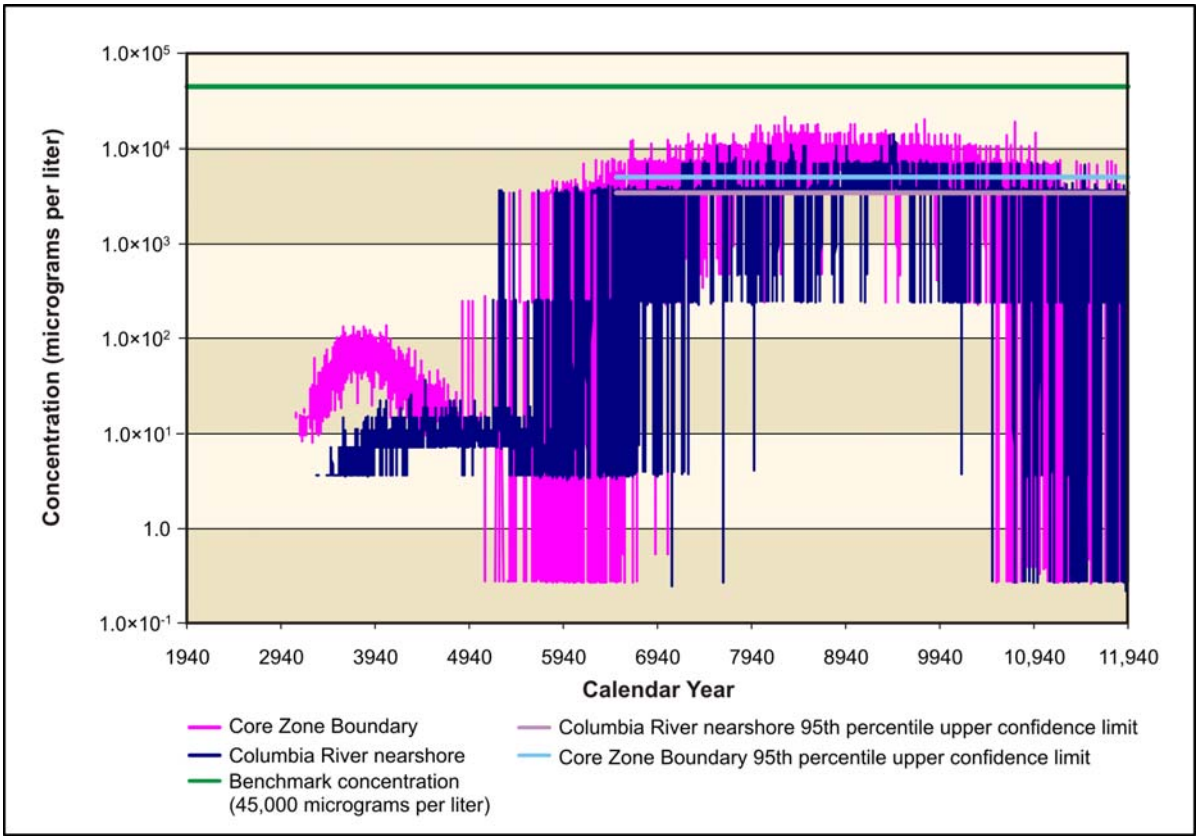


Figure 5–442. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Nitrate Concentration Versus Time

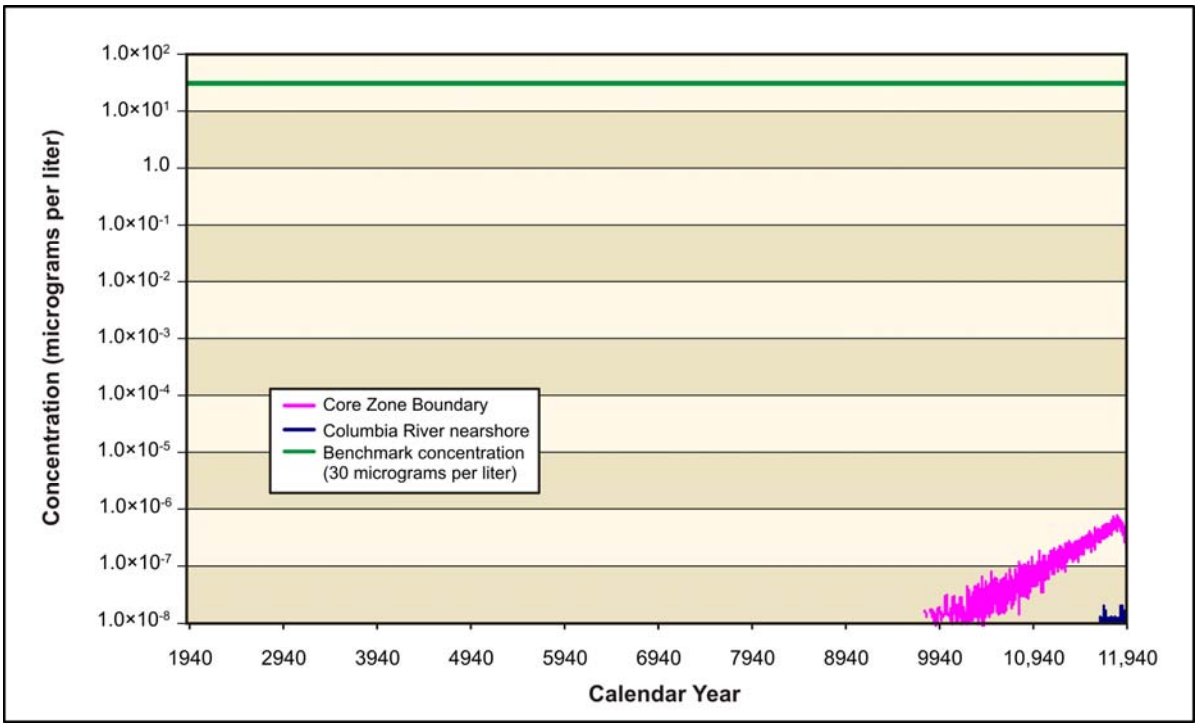


Figure 5–443. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Total Uranium Concentration Versus Time

Table 5–79. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore Groundwater

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**5,660** (9048)	33 (3825)	**8,160** (9163)	**1,690** (8927)	900
Iodine-129	**18** (8491)	0.1 (3772)	**8** (8858)	**7** (8700)	1
Chemical in micrograms per liter					
Acetonitrile	25 (8281)	0 (1940)	9 (8313)	7 (8973)	100
Chromium	**437** (8940)	2 (3856)	**265** (8760)	**116** (9311)	100
Fluoride	0 (8035)	0 (1940)	1 (7258)	0 (8913)	4,000
Nitrate	**50,200** (8665)	149 (3811)	21,200 (8290)	14,100 (9453)	45,000

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

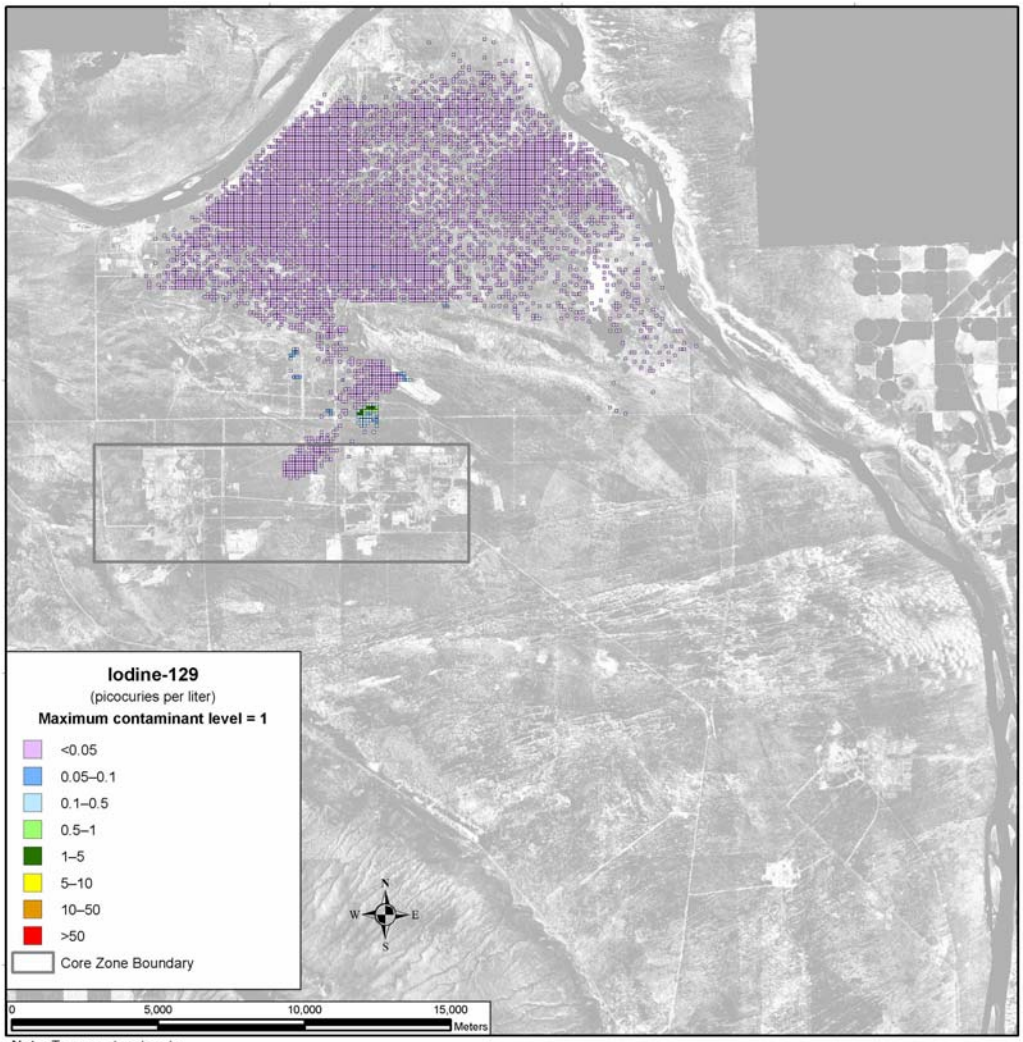
Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, 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 (see Figures 5–444 through 5–456). 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.

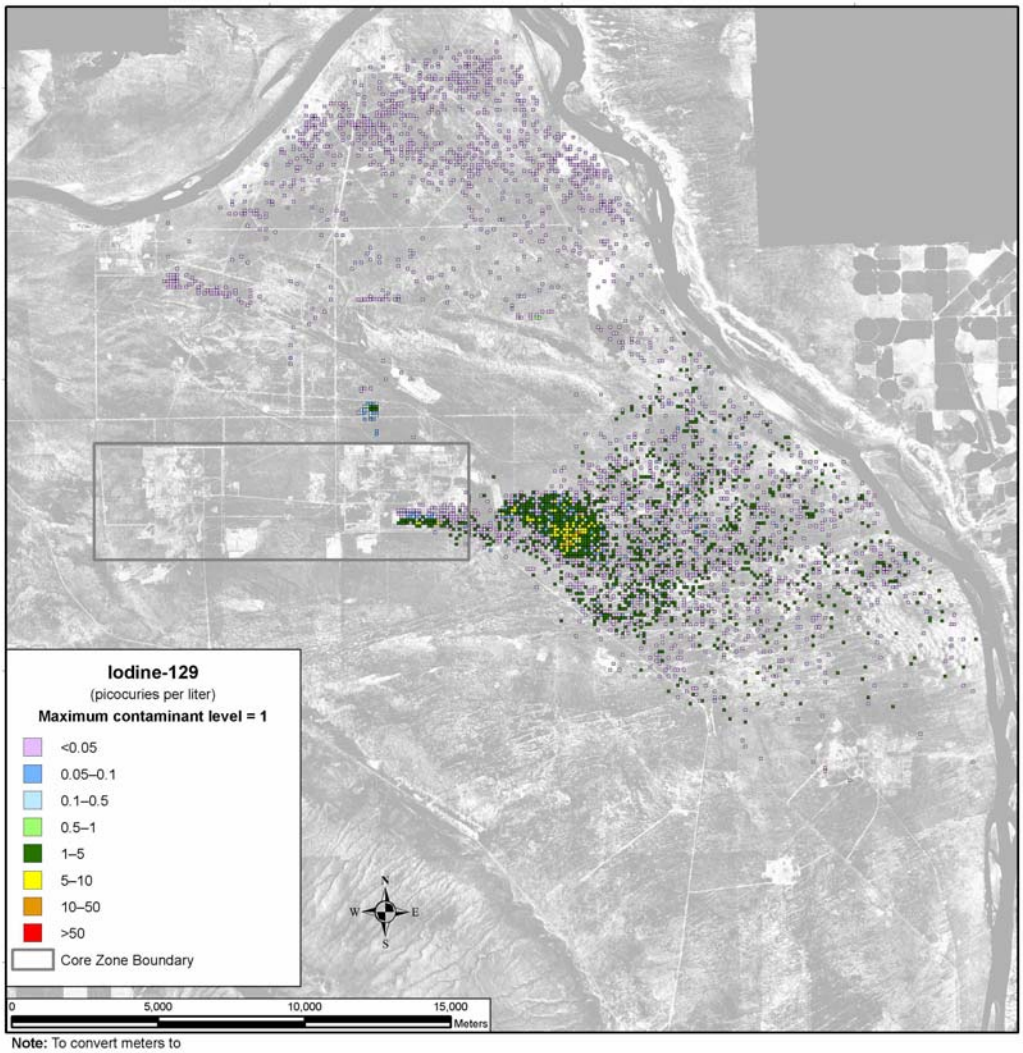
At CY 3890, there is a low-concentration plume of iodine-129 (see Figure 5–444) that stretches north from the RPPDF and through Gable Gap. By CY 7140 (see Figure 5–445), the plume from the RPPDF is gone, but a new plume has formed, traveling east from IDF-East. Concentrations in this plume are over an order of magnitude above the benchmark. Figure 5–446 shows the iodine-129 concentration for CY 11,885. Technetium-99 (see Figures 5–447 through 5–449), chromium (see Figures 5–450 through 5–452), and nitrate (see Figures 5–453 through 5–455) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

Total uranium shows a different spatial distribution over time. It is 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 plume extending through Gable Gap from the RPPDF (see Figure 5–456). Concentrations in all areas of the plume remain below one-twentieth of the benchmark.



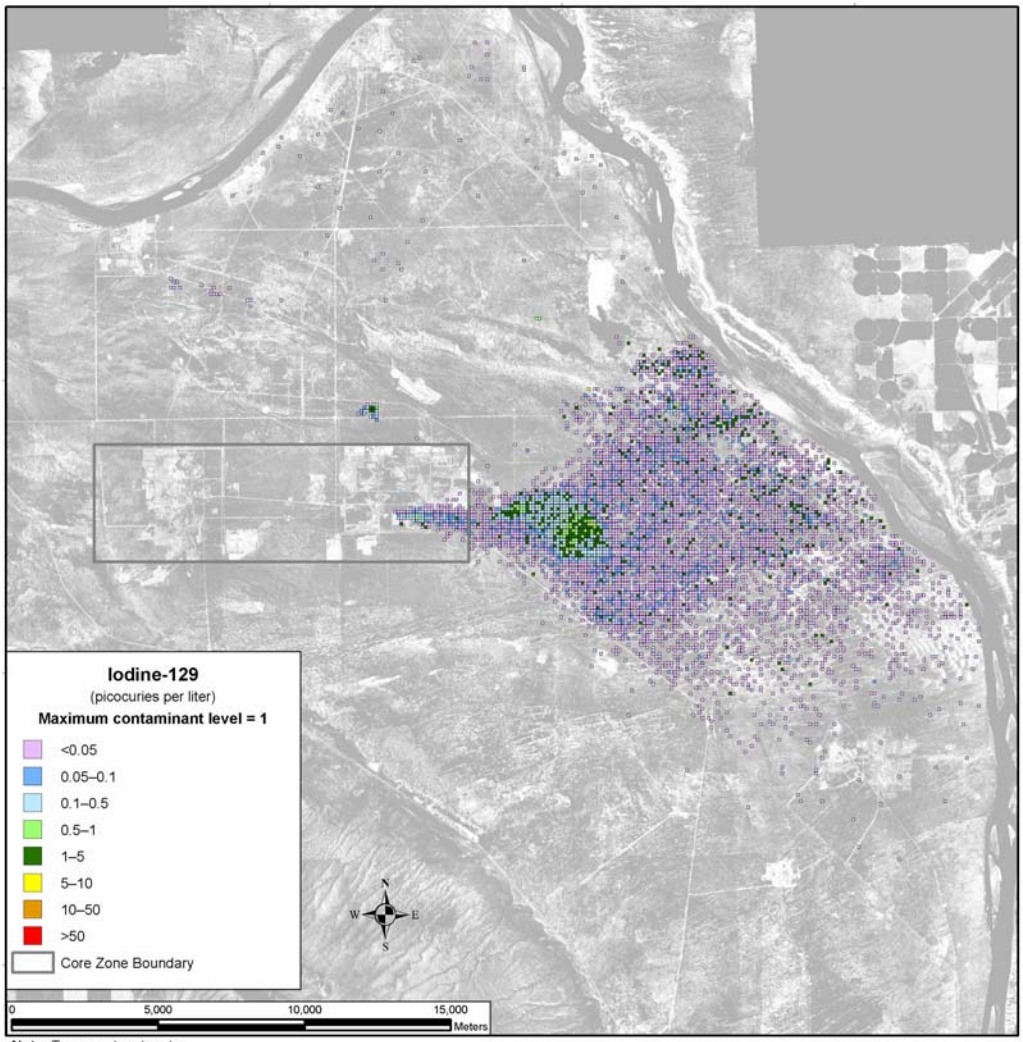
Note: To convert meters to feet, multiply by 3.281

Figure 5–444. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



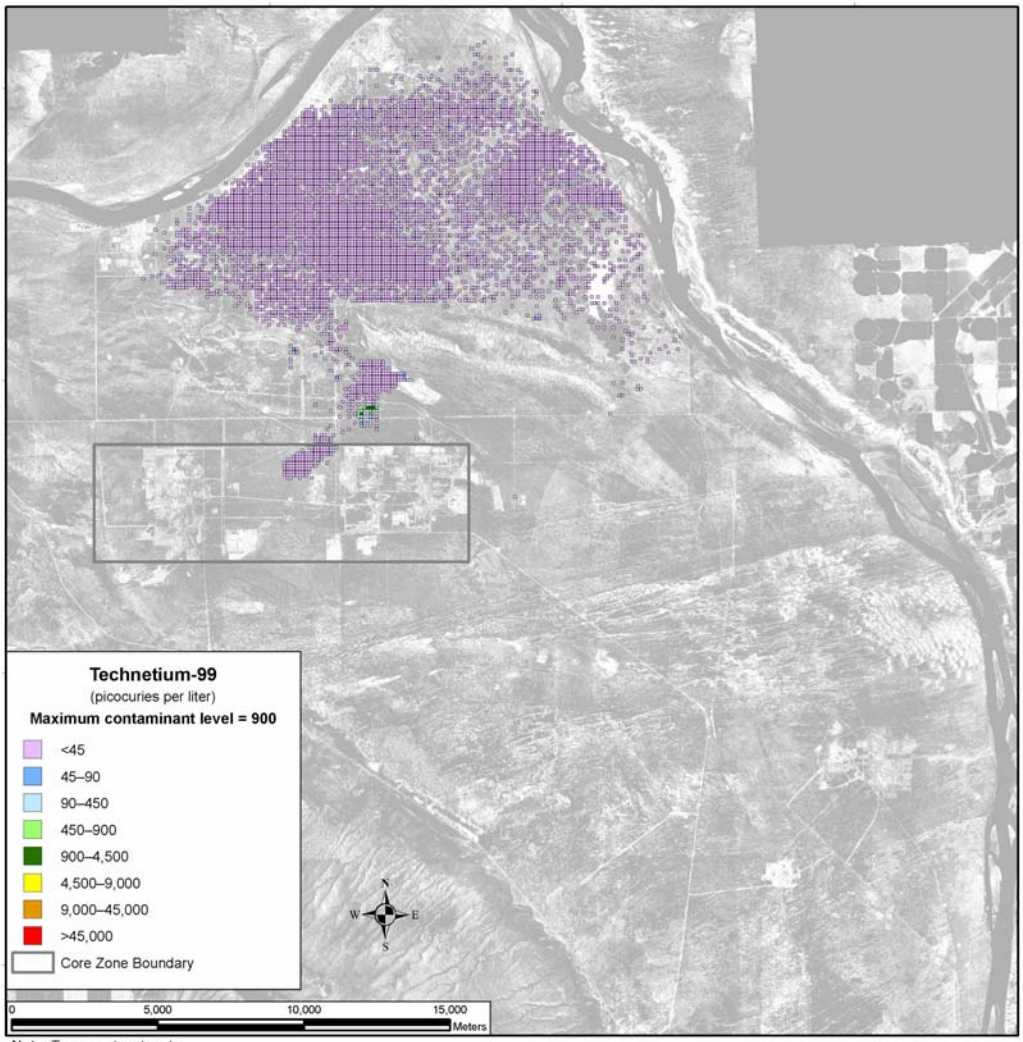
Note: To convert meters to feet, multiply by 3.281

Figure 5–445. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



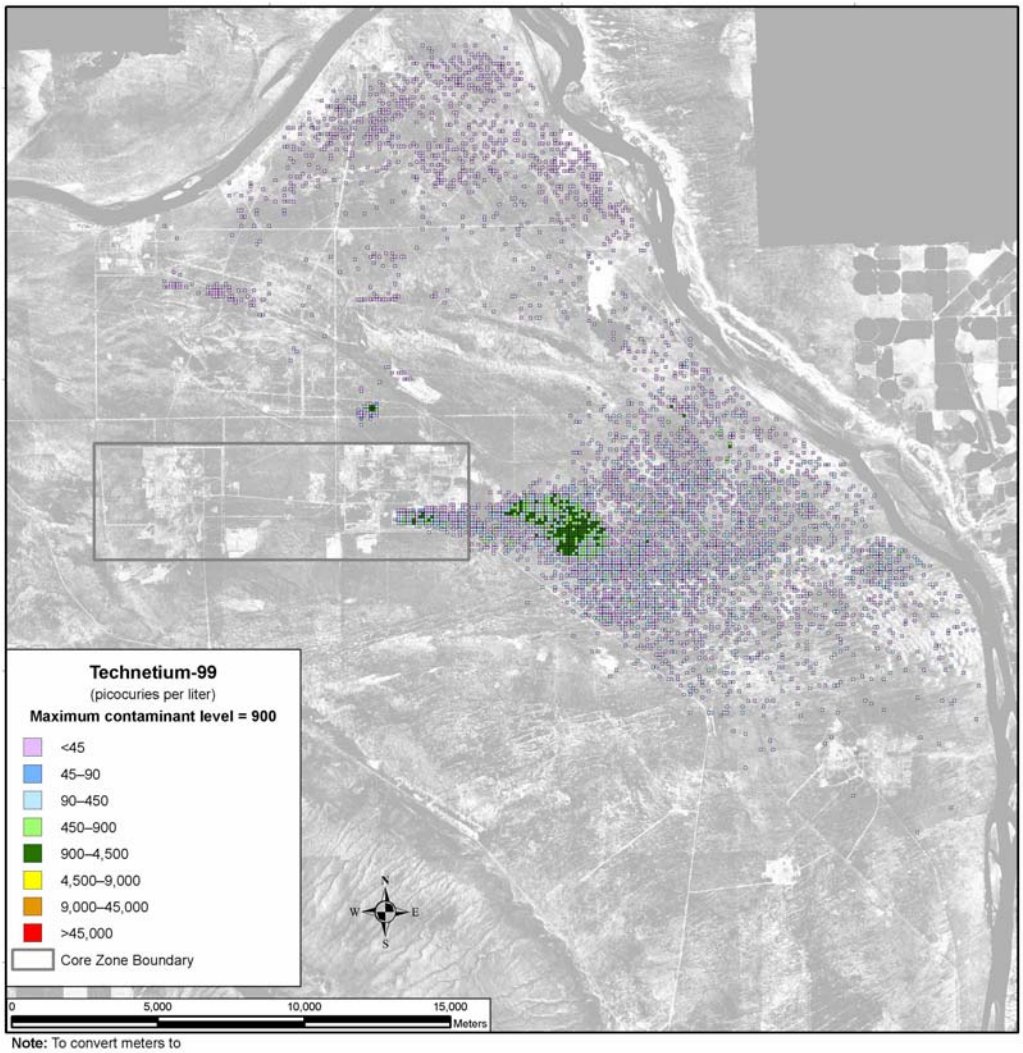
Note: To convert meters to feet, multiply by 3.281

Figure 5–446. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



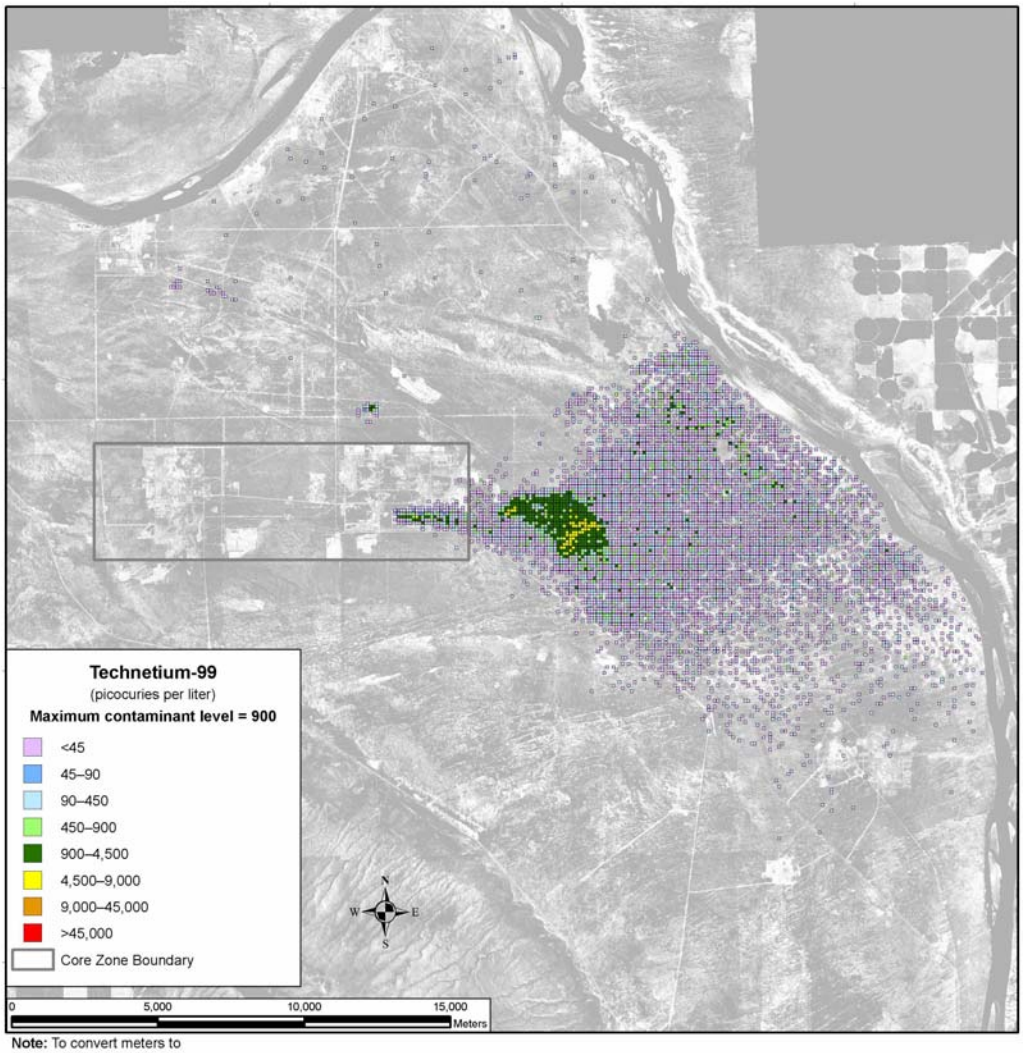
Note: To convert meters to feet, multiply by 3.281

Figure 5–447. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



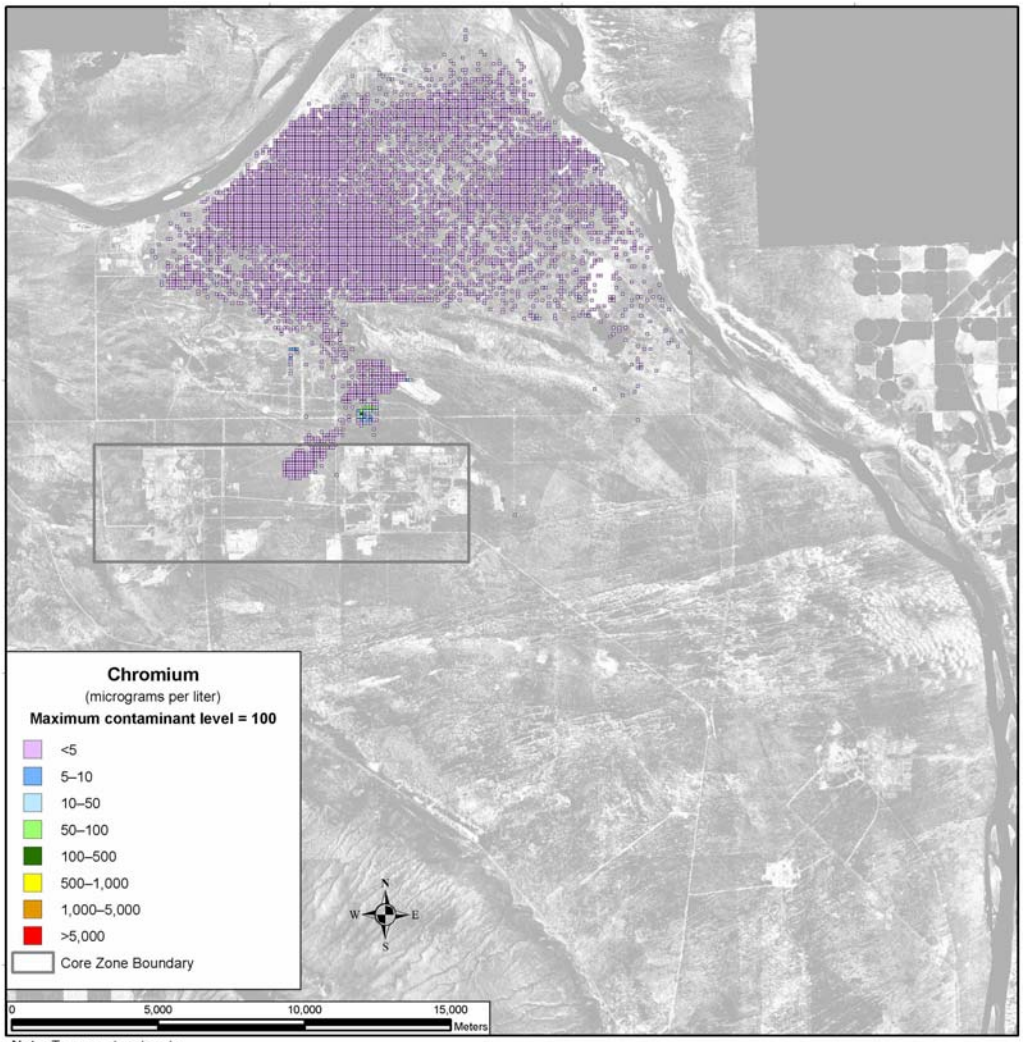
Note: To convert meters to feet, multiply by 3.281

Figure 5–448. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



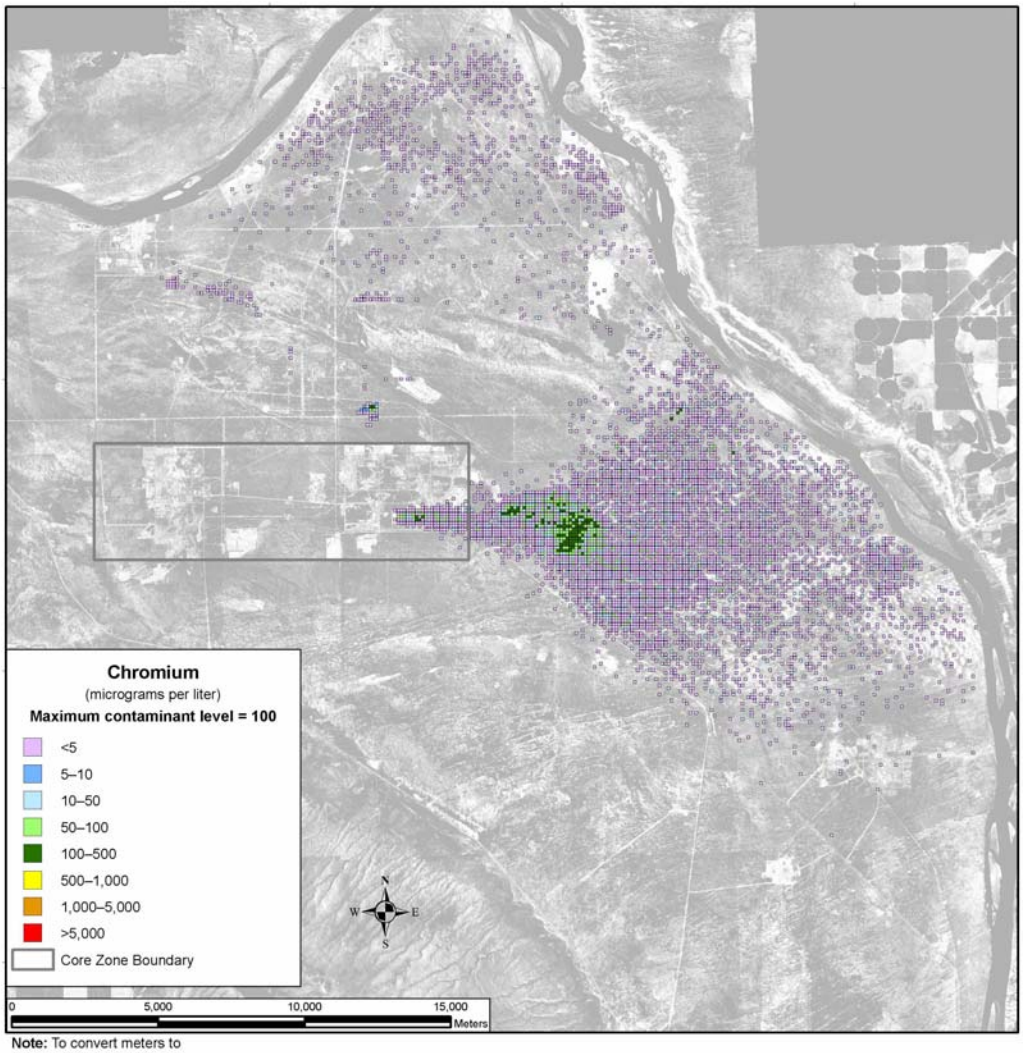
Note: To convert meters to feet, multiply by 3.281

Figure 5–449. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



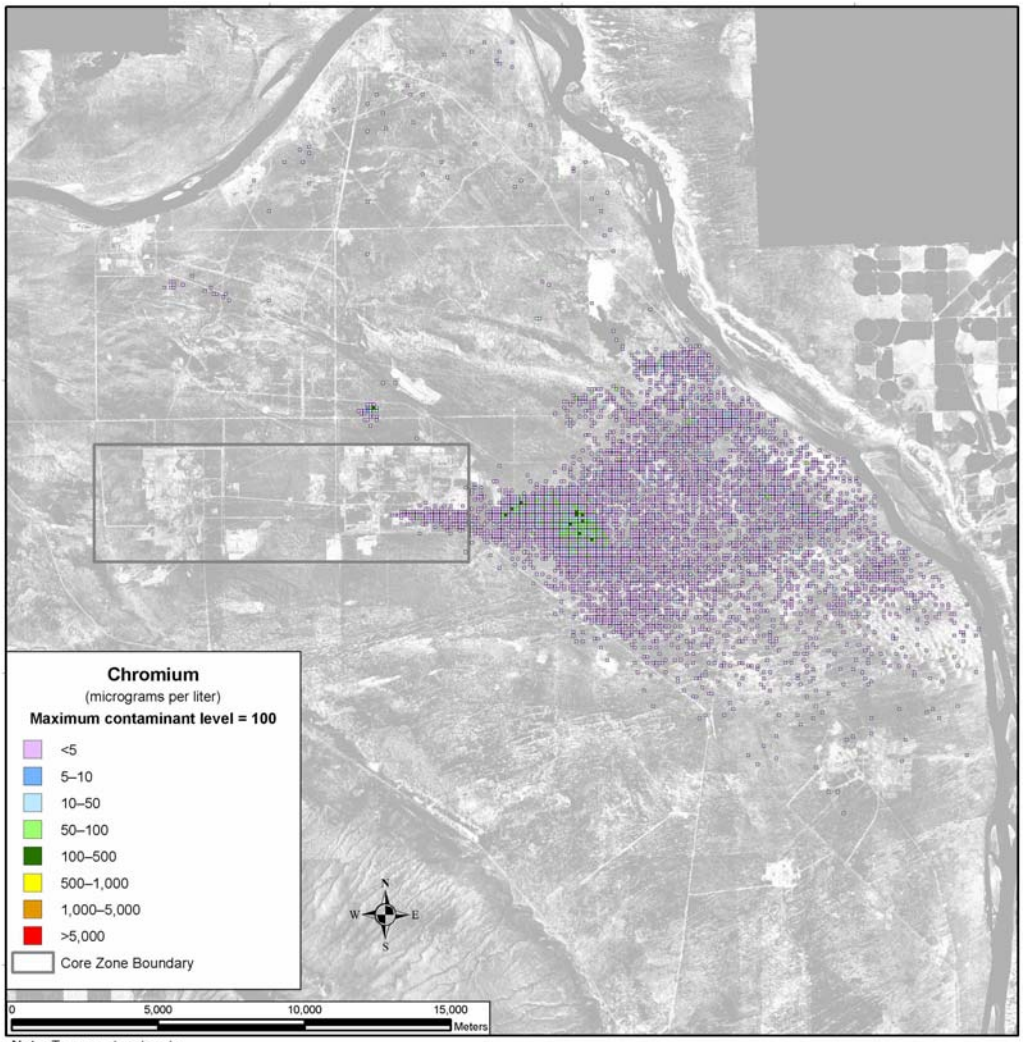
Note: To convert meters to feet, multiply by 3.281

Figure 5–450. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



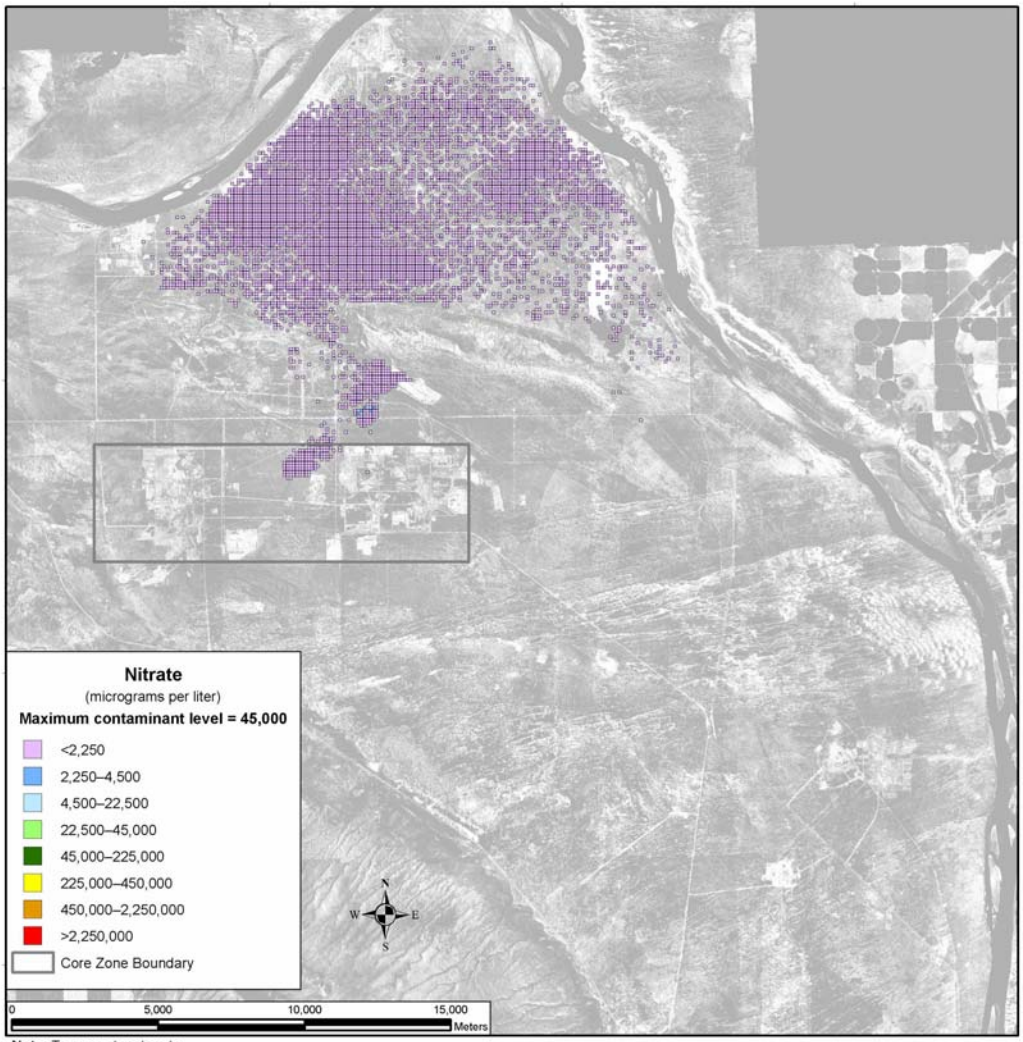
Note: To convert meters to feet, multiply by 3.281

Figure 5–451. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



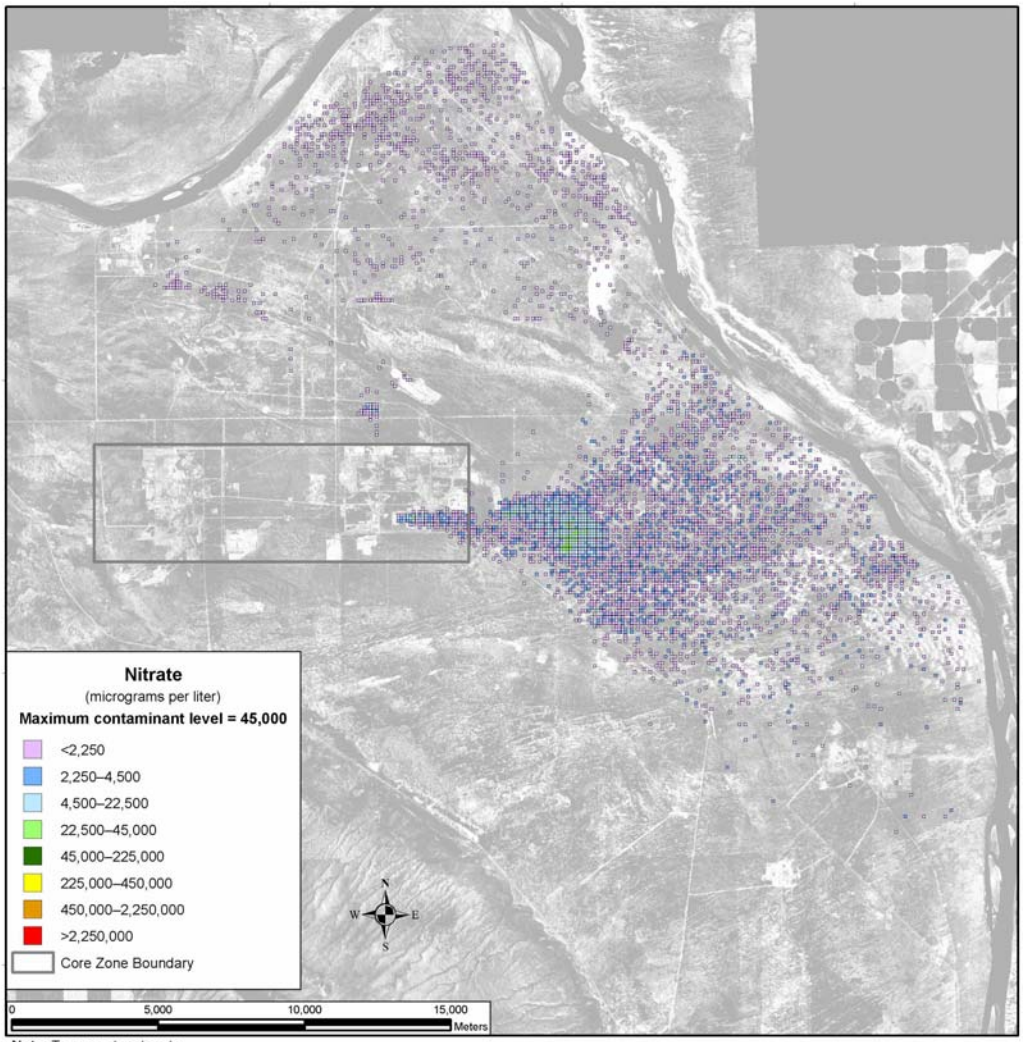
Note: To convert meters to feet, multiply by 3.281

Figure 5–452. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



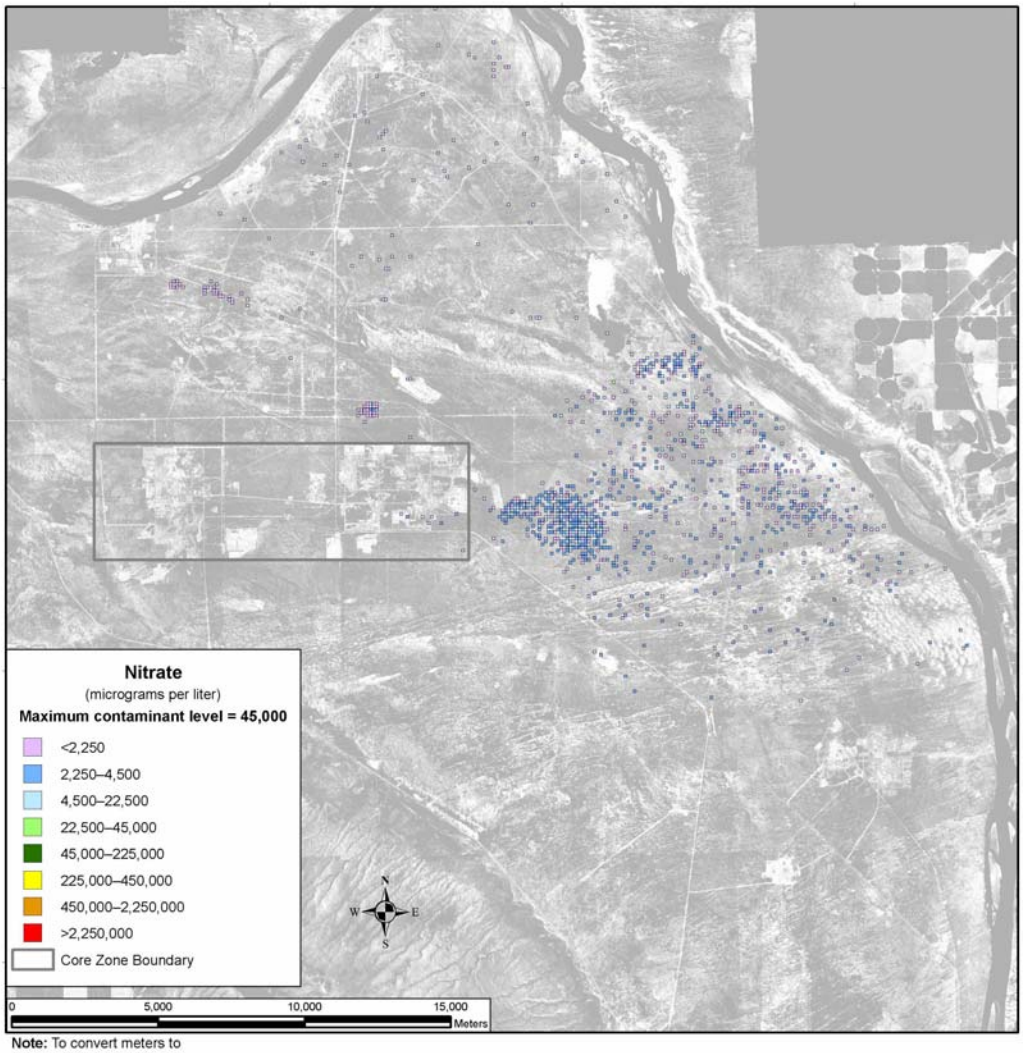
Note: To convert meters to feet, multiply by 3.281

Figure 5–453. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



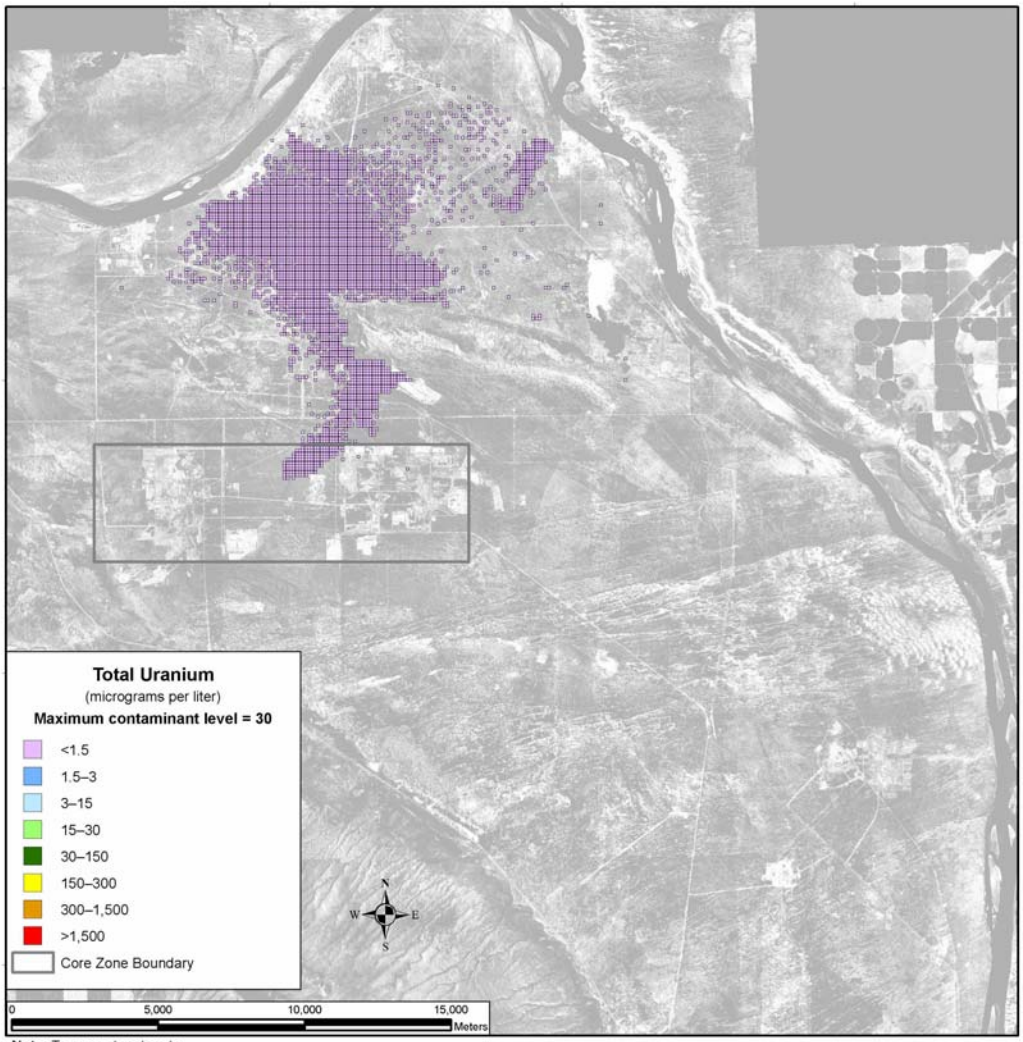
Note: To convert meters to feet, multiply by 3.281

Figure 5–454. Waste Management Alternative 2, 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 5–455. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-C, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–456. Waste Management Alternative 2, 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 2, Disposal Group 1, Subgroup 1-C, in general, discharges from IDF-East are the predominant contributors. The RPPDF is a secondary contributor.

For 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 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 throughout the simulation. The peak intensity and area of the contamination plume are near the end of the period of analysis.

5.3.1.2.1.4 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. Waste would be converted to IHLW, ILAW glass, and steam reforming waste. IHLW would be stored on site, while ILAW glass and steam reforming waste would be disposed of at IDF-East.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and the RPPDF in CY 2009 and continue through CY 2050, when these 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 the facilities become available for release to the environment, and modified RCRA Subtitle C barriers would be emplaced over IDF-East and the RPPDF to limit infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2 is focused on the following COPC drivers:

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

The COPC drivers for Waste Management Alternative 2 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 2.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, chromium, fluoride, nitrate, and boron) 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. Total uranium was added to the list because it begins to appear toward the end of the period of analysis. Total uranium is long-lived, or stable, but is not as mobile as the other COPC drivers; it moves about seven times more slowly than groundwater. 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 Disposal Group 1, Subgroup 1-D, in terms of the 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 5–457 through 5–468). Eight subtotals are plotted for IDF-East representing releases from ILAW glass, ETF-generated secondary waste, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, onsite- and offsite-generated waste, steam reforming waste, retired melters, and waste management secondary waste. Release plots from the RPPDF are also included. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over eight orders of magnitude.

Figure 5–457 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–458, the chemical hazard drivers. Technetium-99 is released to the vadose zone from each of the subtotaled sources, with steam reforming waste and offsite-generated waste contributing the most. Iodine-129 had releases in the analysis from six of the sources, with steam reforming waste and offsite-generated waste also contributing the most. Chromium had six sources, with steam reforming waste and tank closure secondary waste providing the most releases. Nitrate was released only from ETF-generated secondary waste, waste management secondary waste, and onsite-generated waste. Fluoride and boron both were released only from waste management secondary waste and onsite-generated waste.

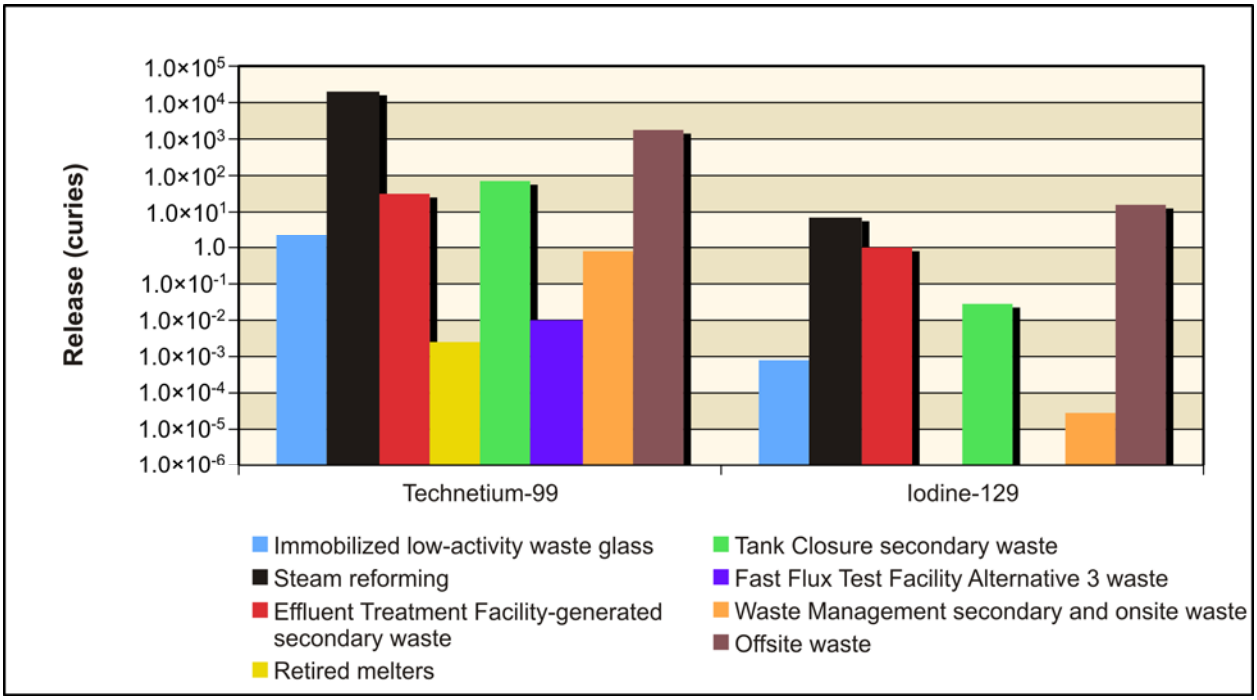


Figure 5–457. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

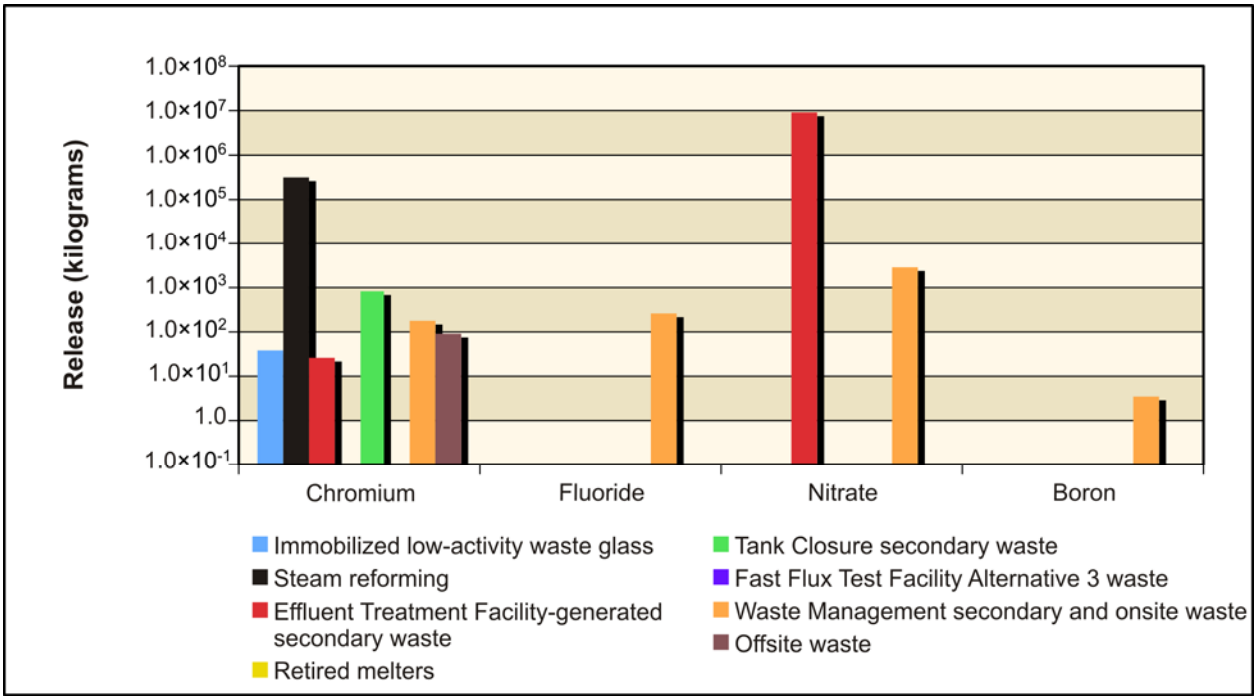


Figure 5–458. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–459 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–460, the chemical hazard drivers. 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 (technetium-99, iodine-129, chromium, nitrate, fluoride, and boron), the amount released to groundwater is typically equal to the amount released to the vadose zone. For technetium-99, the amount released to groundwater was essentially equal to that released to the vadose zone for steam reforming waste, ETF-generated secondary waste, and offsite-generated waste. For ILAW glass, retired melters, and tank closure secondary waste, about 45 to 50 percent of the technetium-99 released to the vadose zone was transferred to the groundwater. For FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite-generated waste, about 60 to 65 percent of the technetium-99 released to the vadose zone was transferred to the groundwater. For iodine-129, the amount released to groundwater was essentially equal to that released to the vadose zone for steam reforming waste and offsite-generated waste. For ILAW glass, ETF-generated secondary waste, tank closure secondary waste, waste management secondary waste, and onsite-generated waste, about 40 to 50 percent of the iodine-129 released to the vadose zone was transferred to the groundwater. For chromium, the amount released to groundwater was essentially equal to that released to the vadose zone for steam reforming waste, ETF-generated secondary waste, tank closure secondary waste, waste management secondary waste, and onsite- and offsite-generated waste. For ILAW glass, about 40 percent of the chromium released to the vadose zone was transferred to the groundwater. For nitrate, the amount released to groundwater was essentially equal to that released to the vadose zone for ETF-generated secondary waste, waste management secondary waste, and onsite- and offsite-generated waste. For fluoride, the amount released to groundwater was essentially equal to that released to the vadose zone for waste management secondary waste and onsite-generated waste. For boron, the amount released to groundwater was essentially equal to that released to the vadose zone for waste management secondary waste and onsite-generated waste.

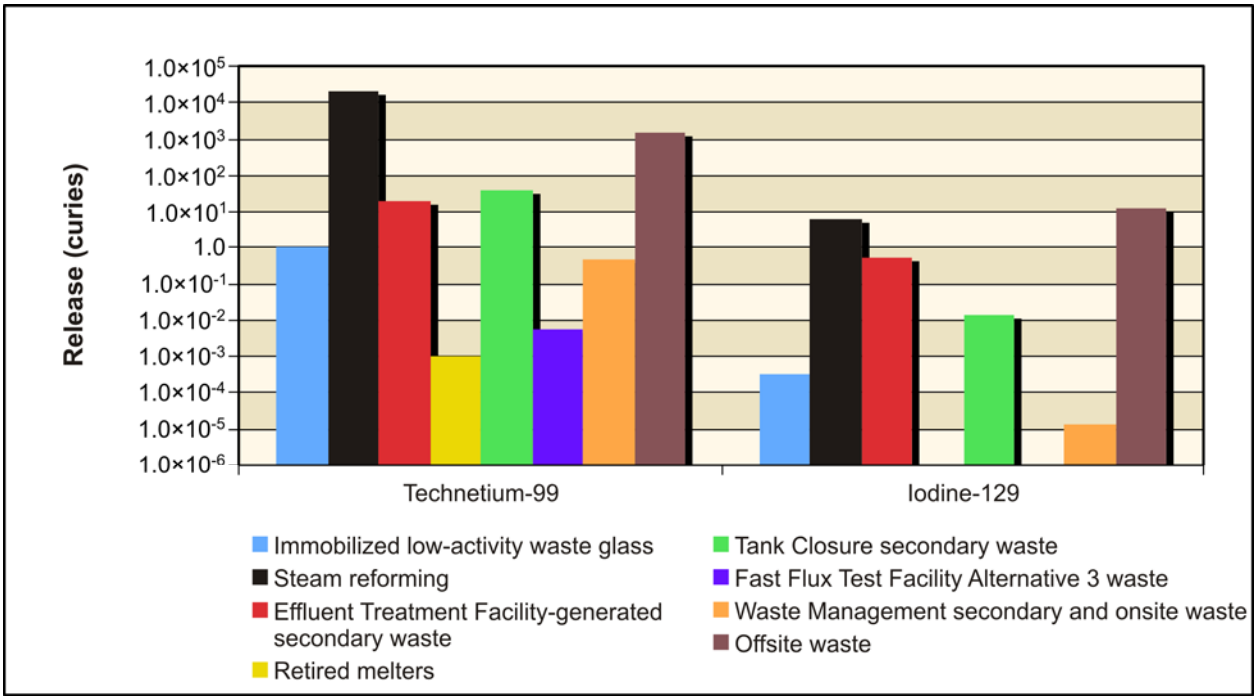


Figure 5–459. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

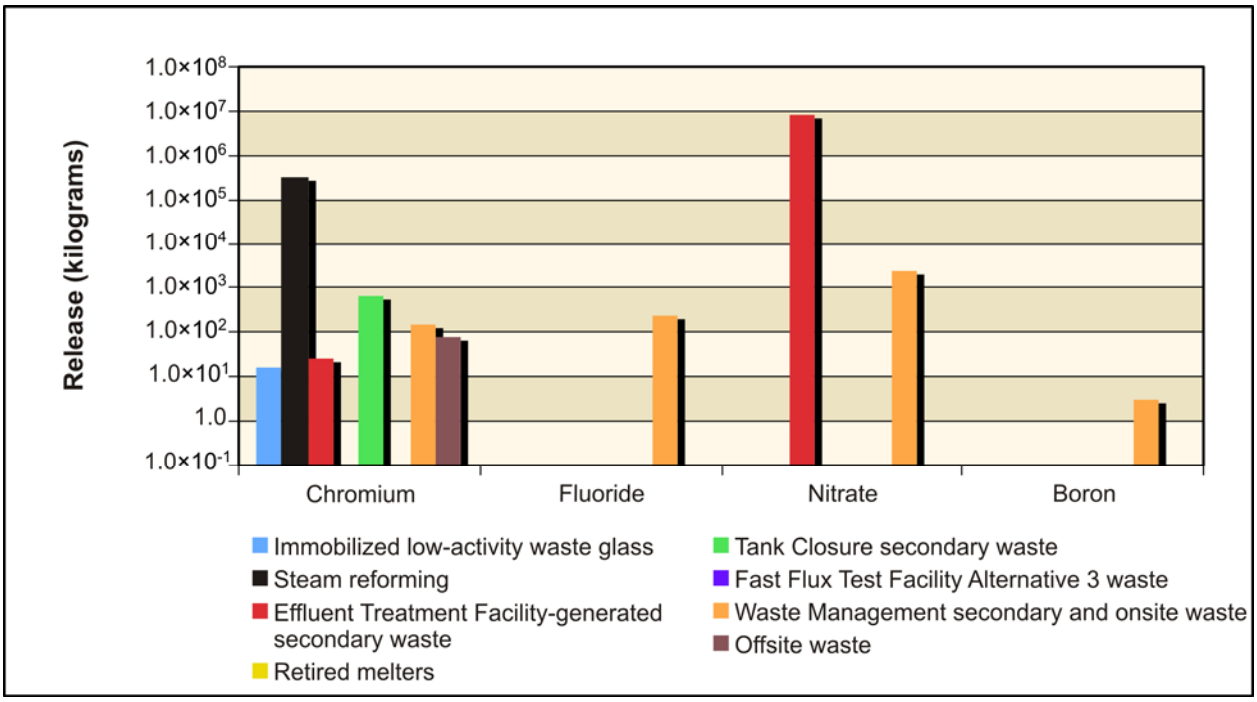


Figure 5–460. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–461 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–462, the chemical hazard drivers. For the conservative tracers (technetium-99, iodine-129, chromium, nitrate, fluoride, and boron), the amount released to the Columbia River is typically essentially equal to the amount released to the vadose zone. For technetium-99, the amount released to the Columbia River from the groundwater was about 90 to 98 percent for ILAW glass, steam reforming waste, ETF-generated secondary waste, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary waste, and onsite- and offsite-generated waste. For iodine-129, the amount released to the Columbia River from the groundwater was about 90 to 100 percent for ILAW glass, stream reforming waste, ETF-generated secondary waste, tank closure secondary waste, and offsite-generated waste. Essentially none of the iodine-129 released from waste management secondary waste and onsite-generated waste from the groundwater was transferred to the Columbia River. For chromium, the amount released to the Columbia River from the groundwater was about 90 to 100 percent for ILAW glass, stream reforming waste, ETF-generated secondary waste, tank closure secondary waste, waste management secondary waste, and onsite- and offsite-generated waste. For nitrate, the amount released to the Columbia River was essentially equal to that released to the groundwater for ETF-generated secondary waste, waste management secondary waste, and onsite- and offsite-generated waste. For fluoride, the amount released to the Columbia River was essentially equal to that released to the groundwater for waste management secondary waste and onsite-generated waste. For boron, the amount released to the Columbia River was essentially equal to that released to the groundwater for waste management secondary waste and onsite-generated waste.

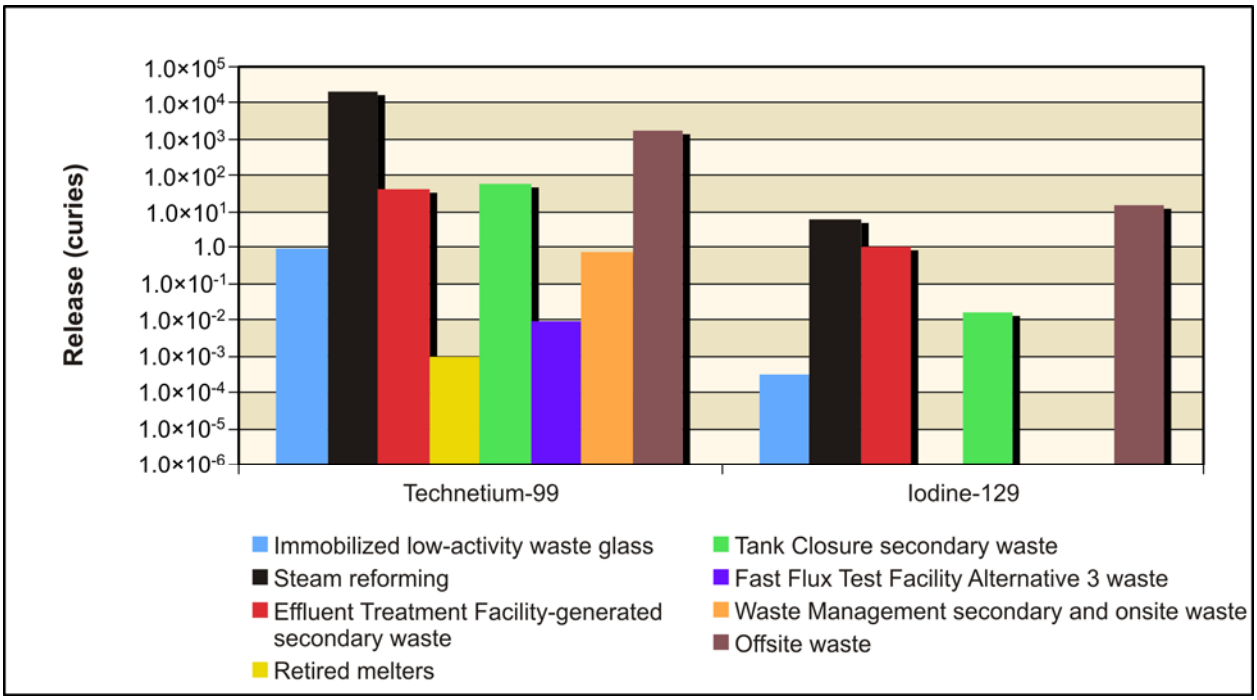


Figure 5–461. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

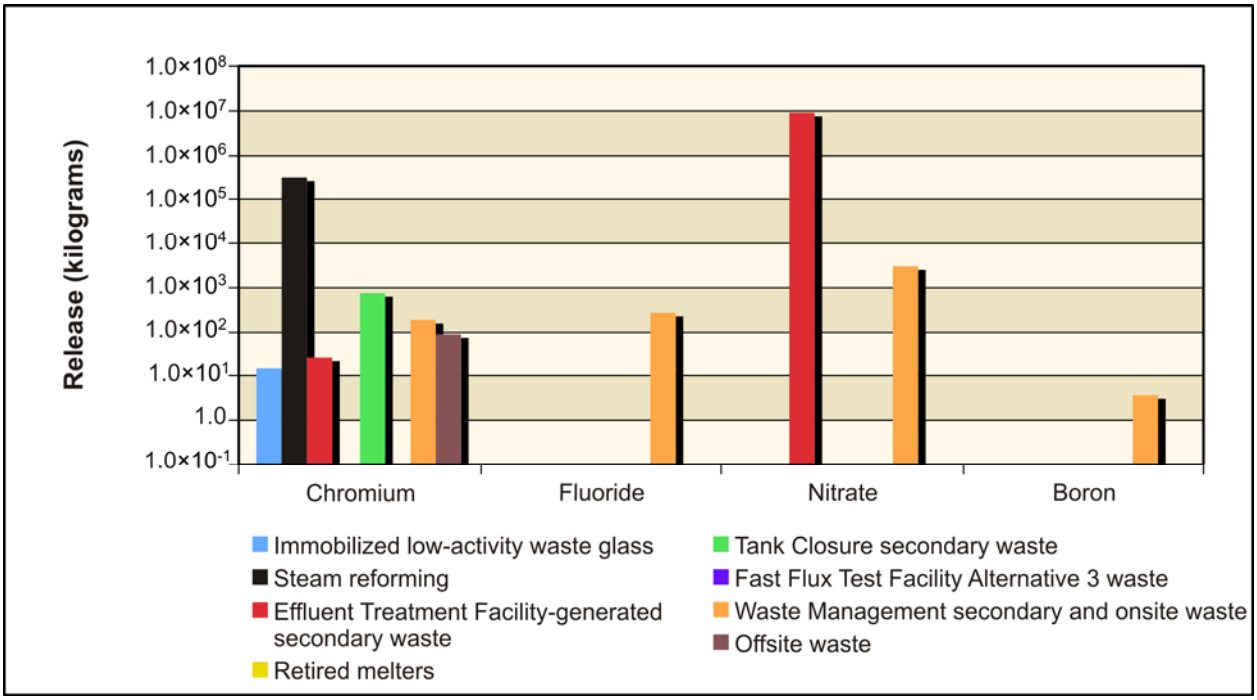


Figure 5–462. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

Figure 5–463 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–464, the chemical hazard drivers. The only constituents released to the vadose zone from the RPPDF were technetium-99, iodine-129, chromium, and nitrate.

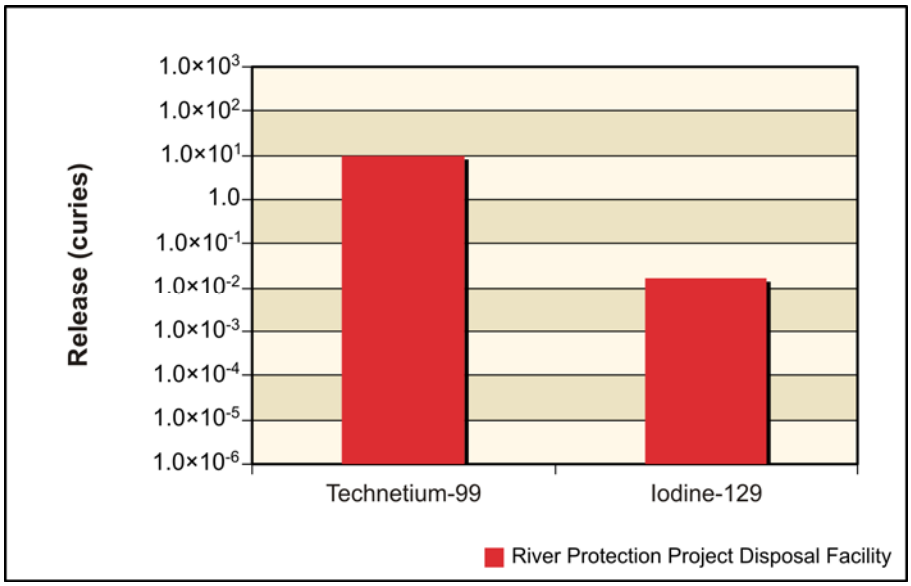


Figure 5–463. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

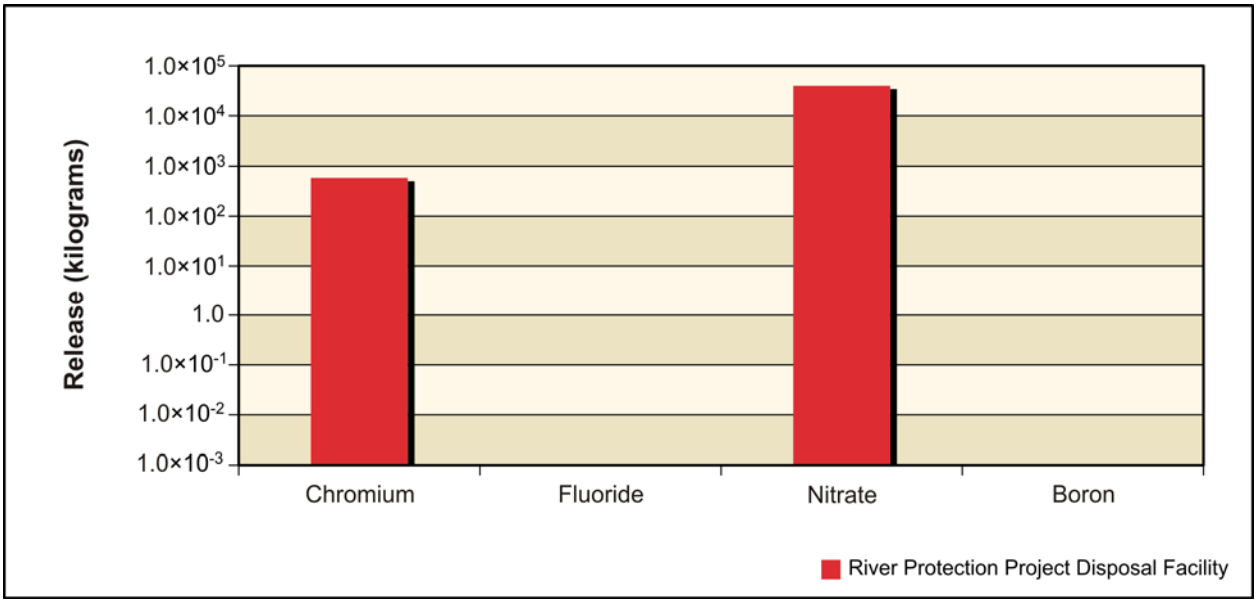


Figure 5–464. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–465 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–466, the chemical hazard drivers. For the RPPDF, the amount released to groundwater was essentially equal to that released to the vadose zone for technetium-99, iodine-129, chromium, and nitrate.

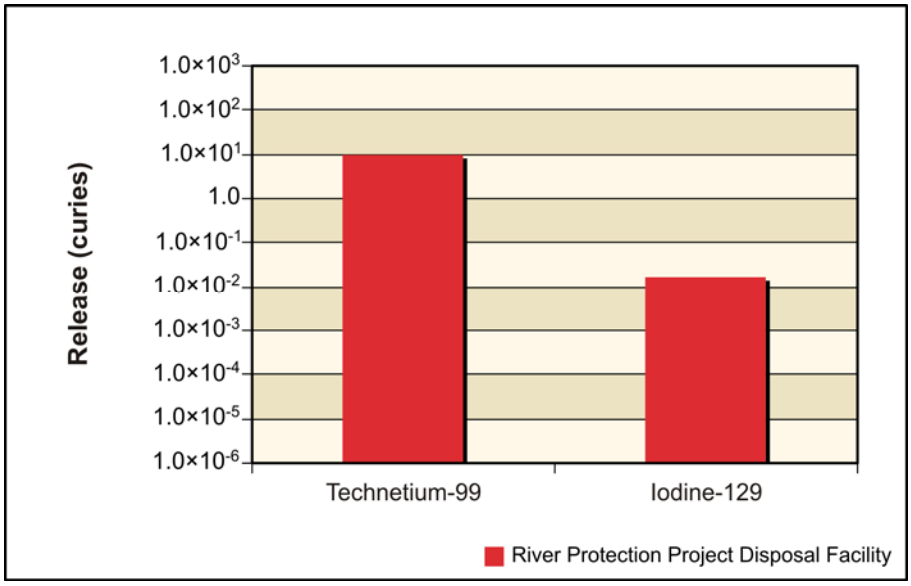


Figure 5–465. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Groundwater

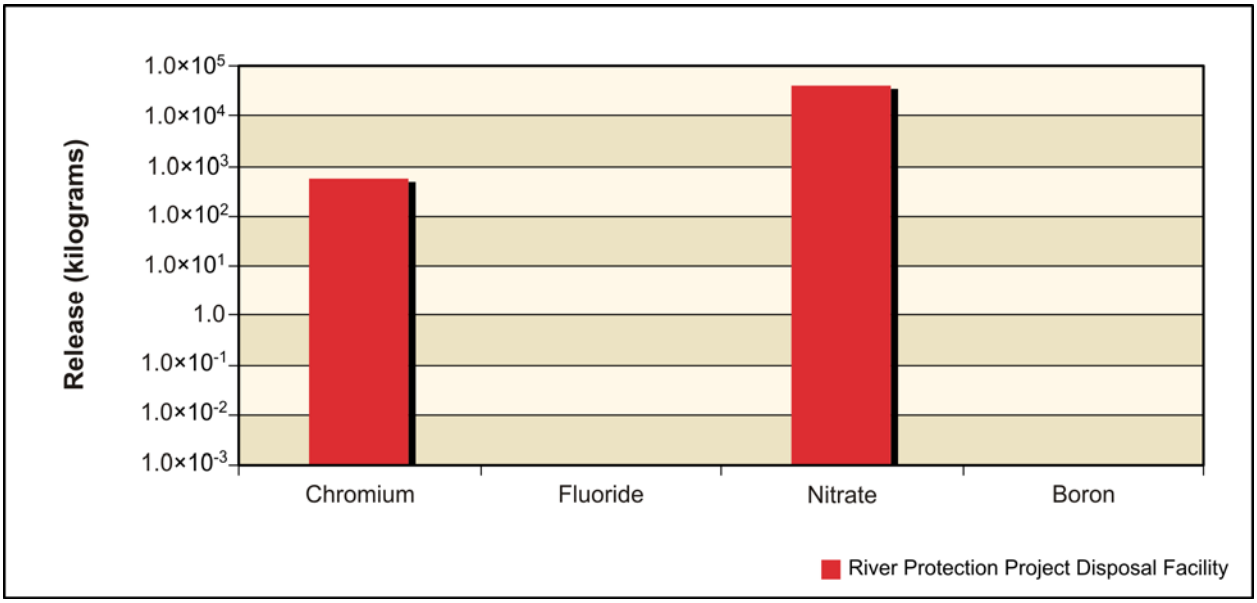


Figure 5–466. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–467 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–468, the chemical hazard drivers. For the RPPDF, about 95 percent of technetium-99, iodine-129, chromium, and nitrate released from the groundwater reached the Columbia River.

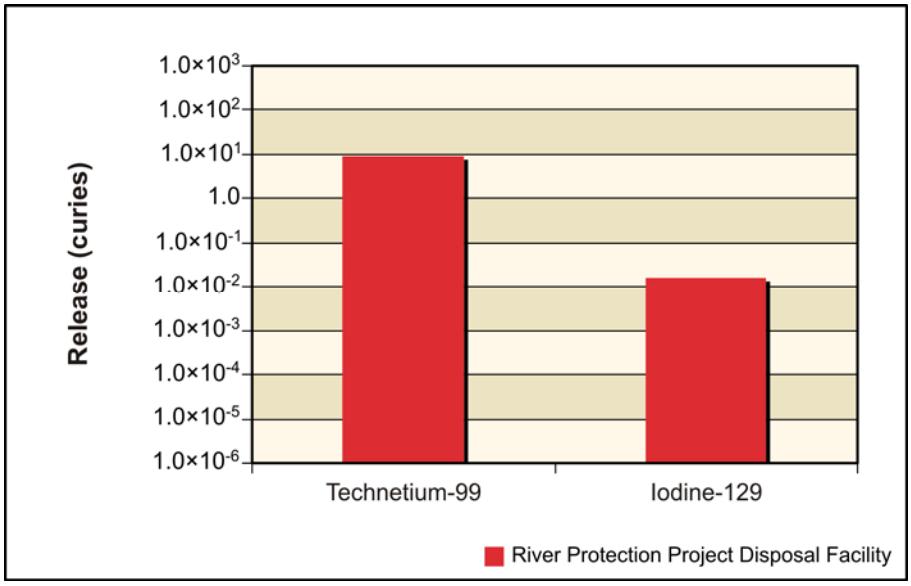


Figure 5–467. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Radiological Releases at River Protection Project Disposal Facility to Columbia River

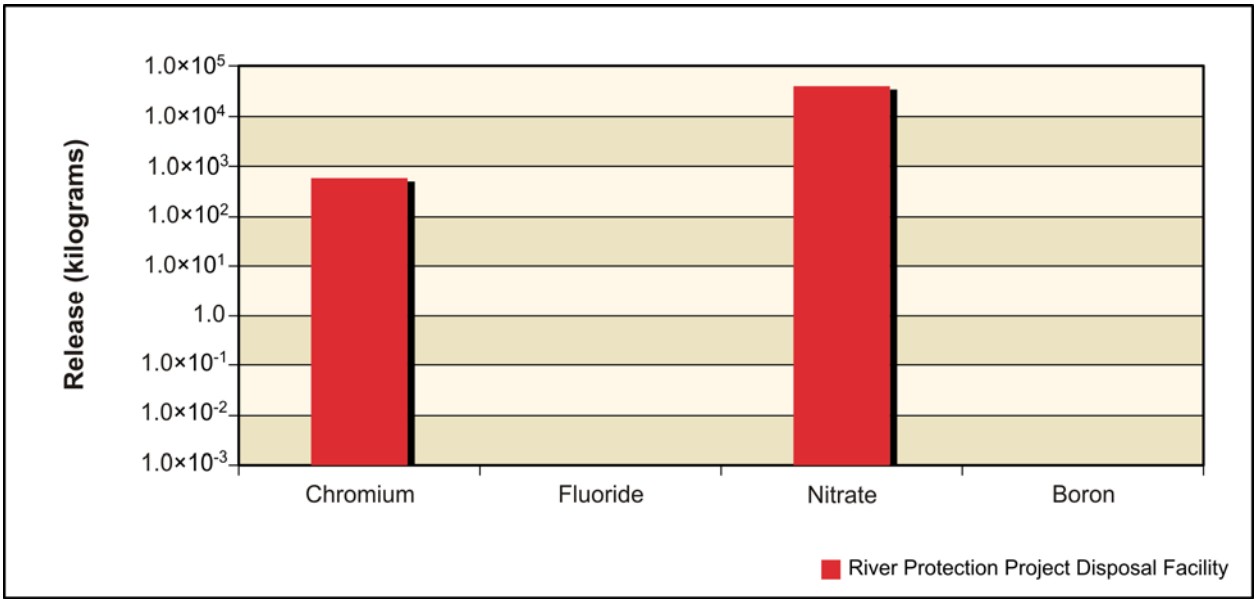


Figure 5–468. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, 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 (see Figures 5–469 through 5–473). 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 a few 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 5–80 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figure 5–469 shows the concentration versus time plot for technetium-99. Releases cause the groundwater concentrations at the Core Zone Boundary and at the Columbia River nearshore to exceed the benchmark concentration by about one-half of an order of magnitude at around CY 6000. The concentrations at the Core Zone Boundary and the Columbia River nearshore remain above the benchmark concentration through the end of the period of analysis.

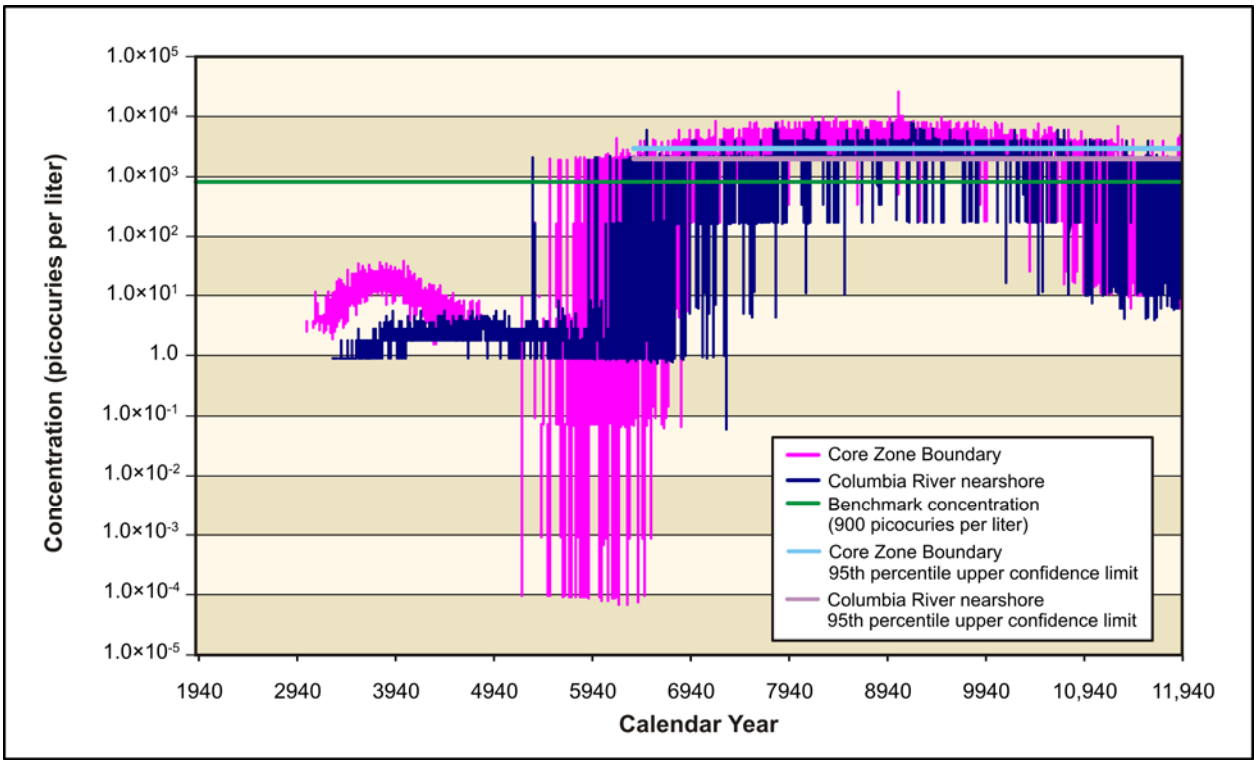


Figure 5–469. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Technetium-99 Concentration Versus Time

The plot of concentration of iodine-129 versus time shows a pattern similar to that of technetium-99 (see Figure 5–470).

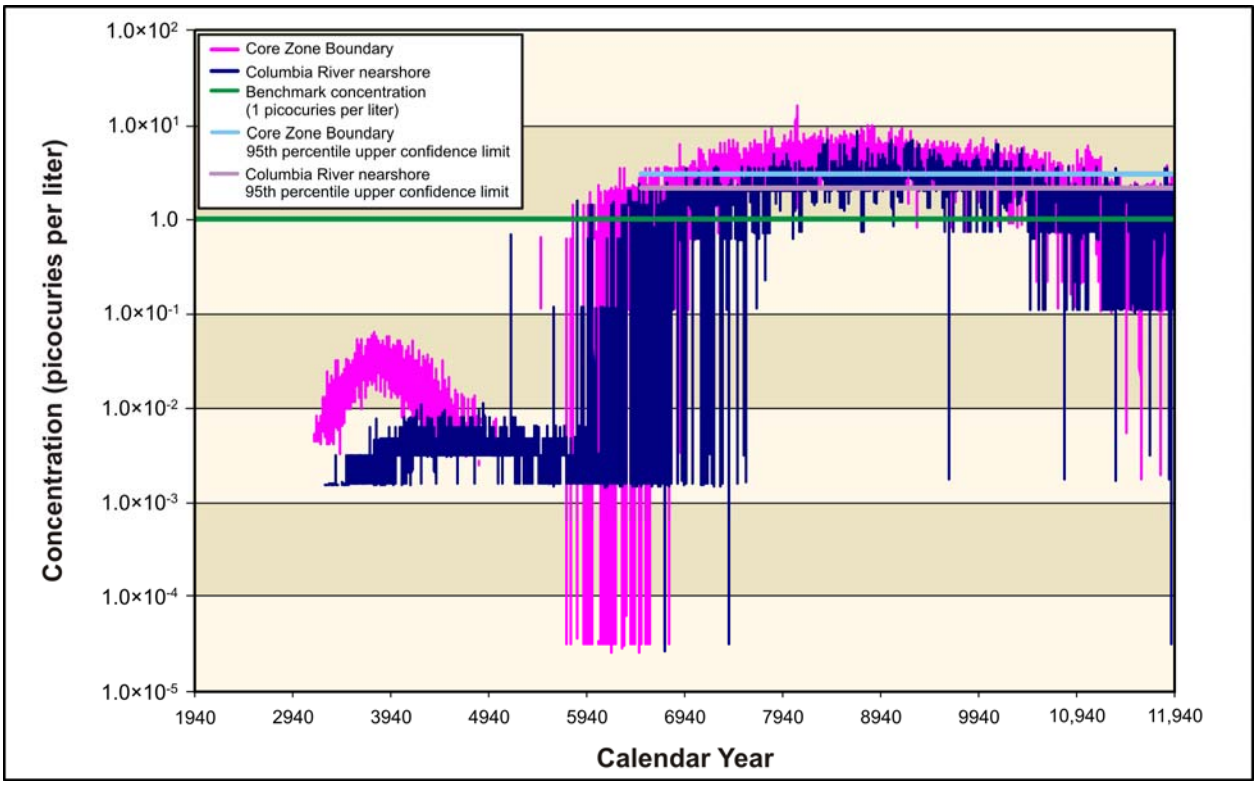


Figure 5–470. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Iodine-129 Concentration Versus Time

Figure 5–471 shows the concentration versus time plot for chromium. The concentrations at the Core Zone Boundary exceed the benchmark from about CY 7000 to 10,000. During the same time period, concentrations from the Columbia River nearshore approach the benchmark, but never reach it. The concentrations at the Core Zone Boundary and the Columbia River nearshore both remain about one-half of an order of magnitude below the benchmark at the end of the period of analysis.

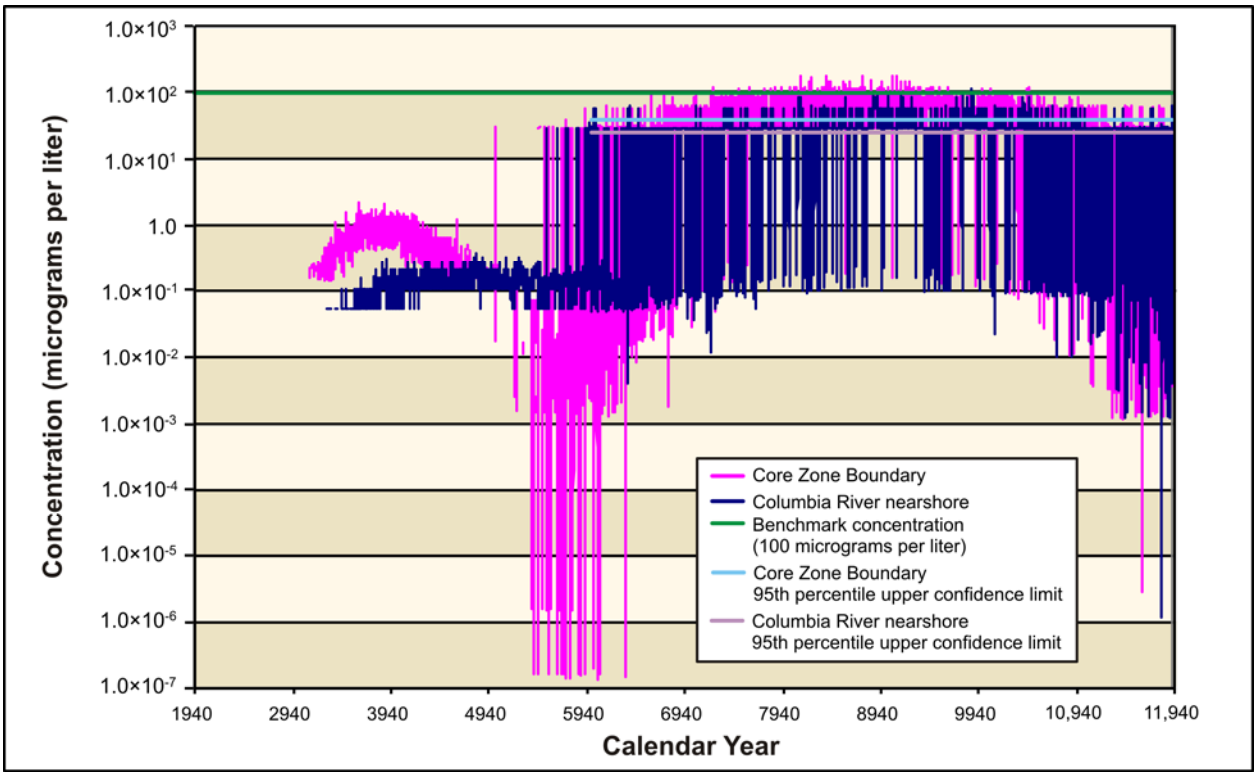


Figure 5–471. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Chromium Concentration Versus Time

Figure 5–472 shows the concentration versus time plot for nitrate. The concentrations at the Core Zone Boundary and the Columbia River nearshore both peak at around CY 8000. Even at the concentration's peak, nitrate levels still remain about one to one and one-half orders of magnitude below the benchmark level.

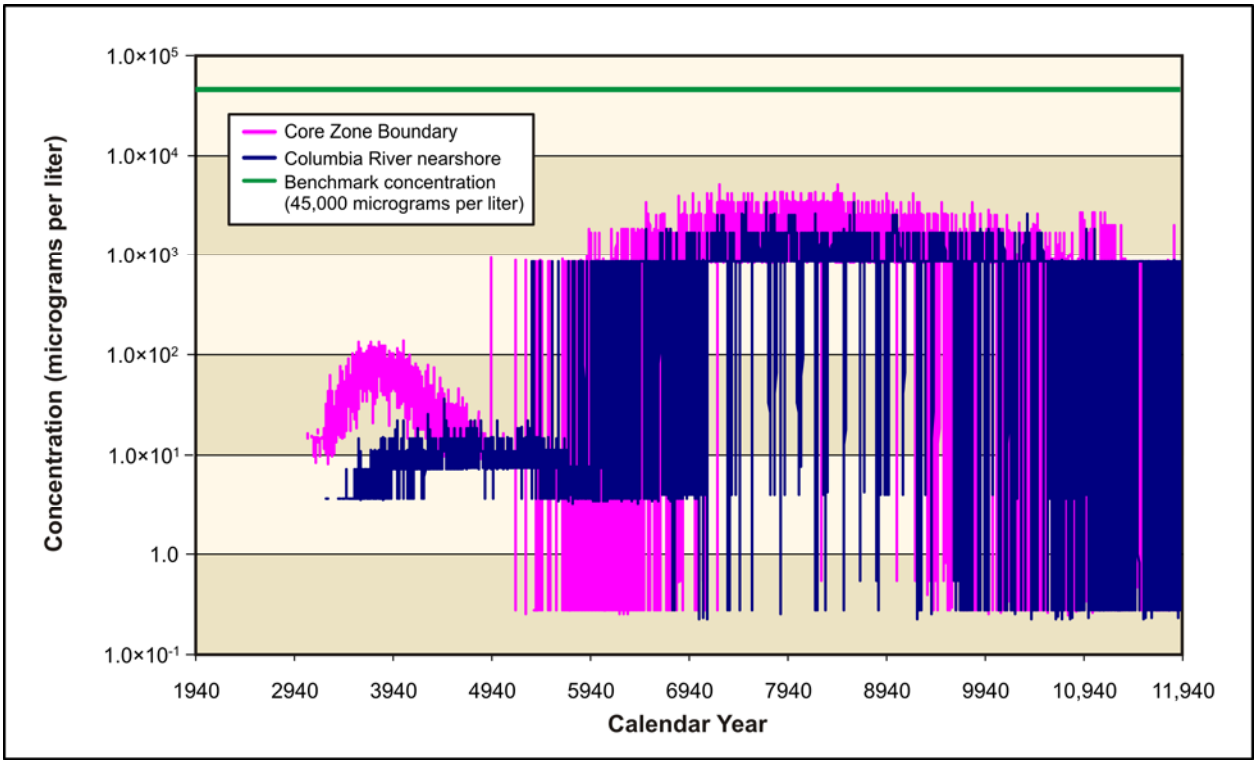


Figure 5–472. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Nitrate Concentration Versus Time

Figure 5–473 shows the concentration versus time plot for total uranium. It is not until around CY 9900 that concentrations begin to appear on the graph. The concentrations at the Core Zone Boundary and the Columbia River nearshore both remain about eight to nine orders of magnitude below the benchmark level.

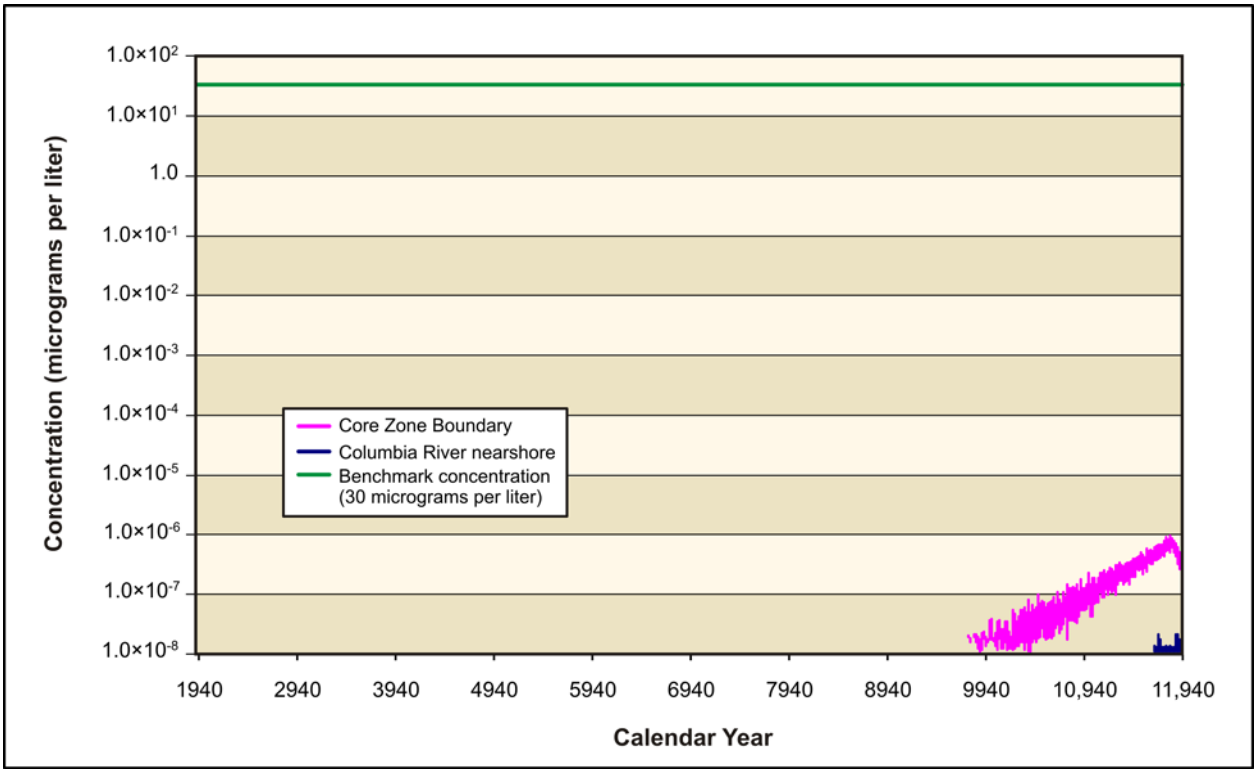


Figure 5–473. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Total Uranium Concentration Versus Time

Table 5–80. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**30,100**	33	**24,800**	**7,610**	900
	(9032)	(3825)	(9067)	(8274)	
Iodine-129	**24**	0.1	**16**	**8**	1
	(8195)	(3772)	(8082)	(8699)	
Chemical in micrograms per liter					
Chromium	**436**	2	**174**	**116**	100
	(9071)	(3856)	(8397)	(9878)	
Fluoride	0	0	1	0	4,000
	(8035)	(1940)	(7258)	(8913)	
Nitrate	14,500	149	4,970	3,320	45,000
	(7859)	(3811)	(7269)	(7744)	

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

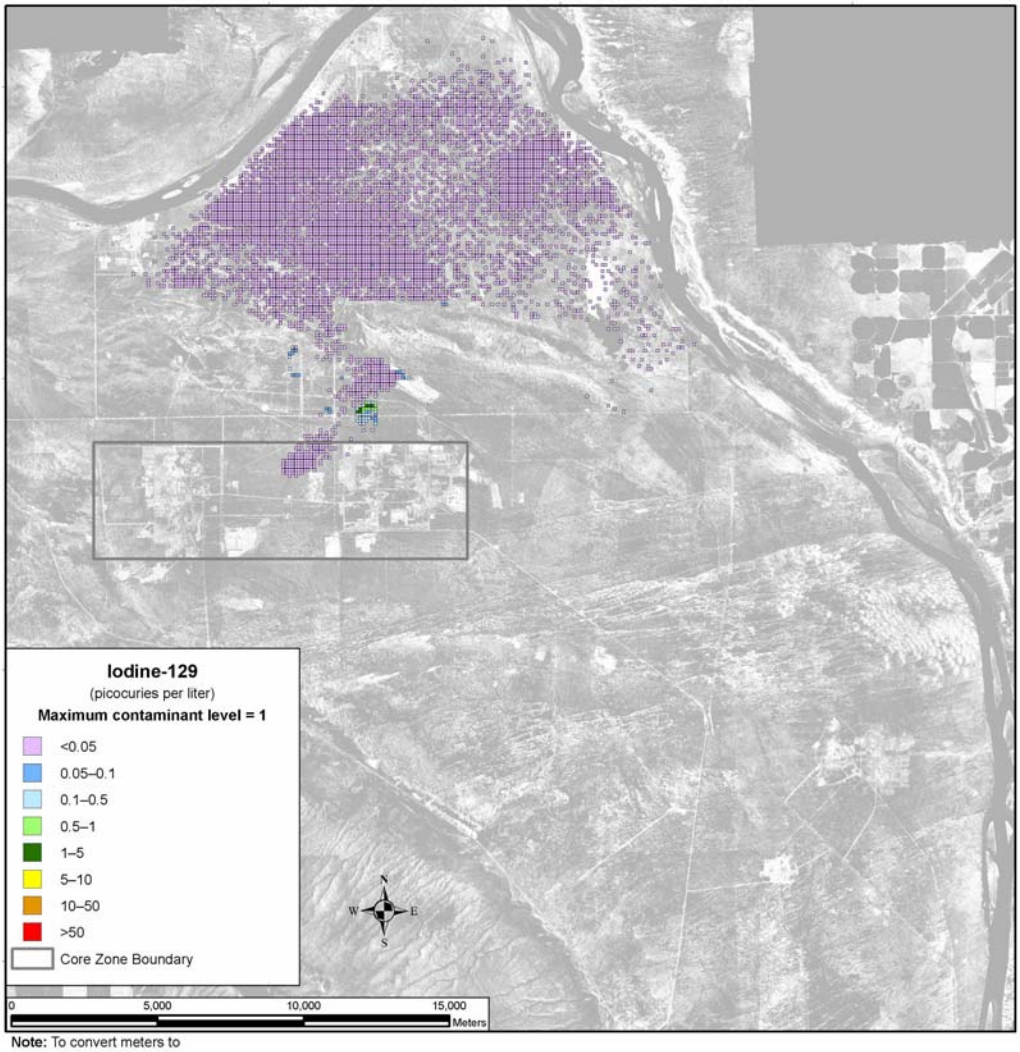
Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of 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 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.

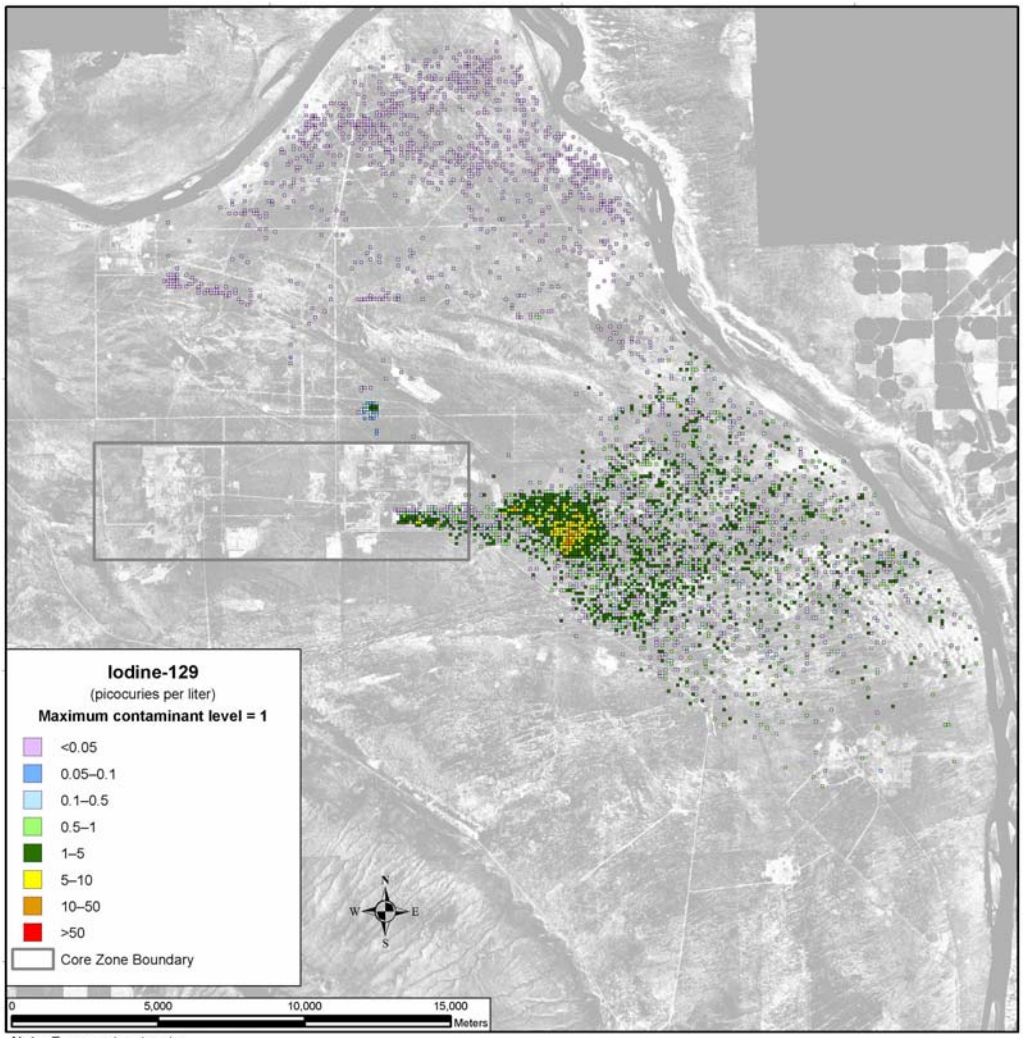
Figure 5–474 shows the spatial distribution of groundwater concentration of iodine-129 during CY 3890. Releases from the RPPDF create a plume extending northerly through Gable Gap toward the Columbia River. Peak concentrations in this plume exceed the benchmark by about one to five times, although the majority of the plume has concentrations less than one-twentieth of the benchmark. By CY 7140, releases from IDF-East create a new plume extending easterly toward the Columbia River (see Figure 5–475). Peak concentrations in this plume exceed the benchmark by 10 to 50 times. By the end of the period of analysis (CY 11,885), the plume created by the RPPDF has mostly dissipated, while the IDF-East plume continues to persist, with small patches exceeding the benchmark by about 5 to 10 times (see Figure 5–476). Technetium-99 shows a similar spatial distribution over time (see Figure 5–477 through 5–479). Chromium and nitrate also show a similar spatial distribution over time, but with less-intense areas of peak concentration (see Figures 5–480 through 5–485).

Total uranium is not as mobile as those 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. Figure 5–486 shows the distribution of total uranium during CY 11,885. A plume that is less than one-twentieth of the benchmark was released from the RPPDF and is extending northerly through Gable Gap toward the Columbia River. Because of the slow nature of the pore water velocity, most of the uranium releases are expected to occur after the period of analysis is over.



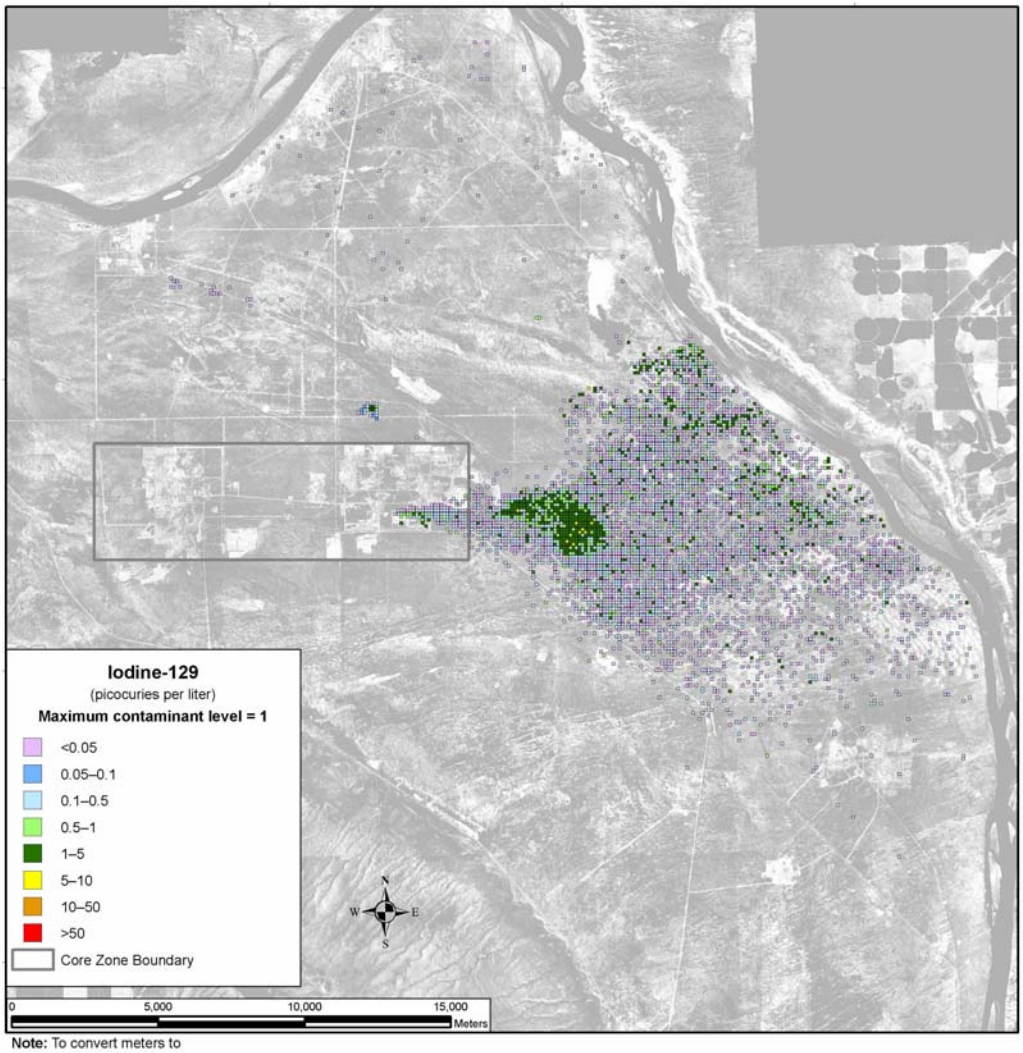
Note: To convert meters to feet, multiply by 3.281

Figure 5–474. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



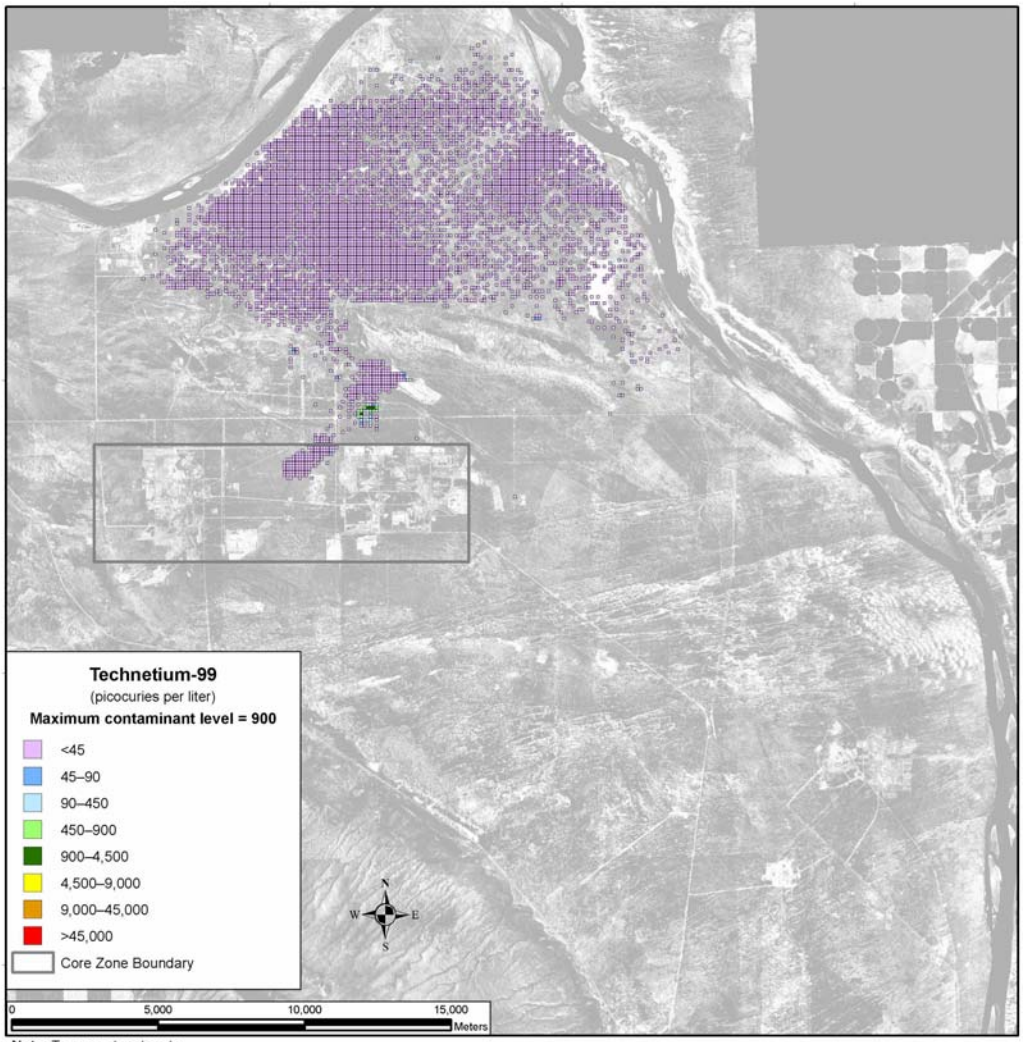
Note: To convert meters to feet, multiply by 3.281

Figure 5–475. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



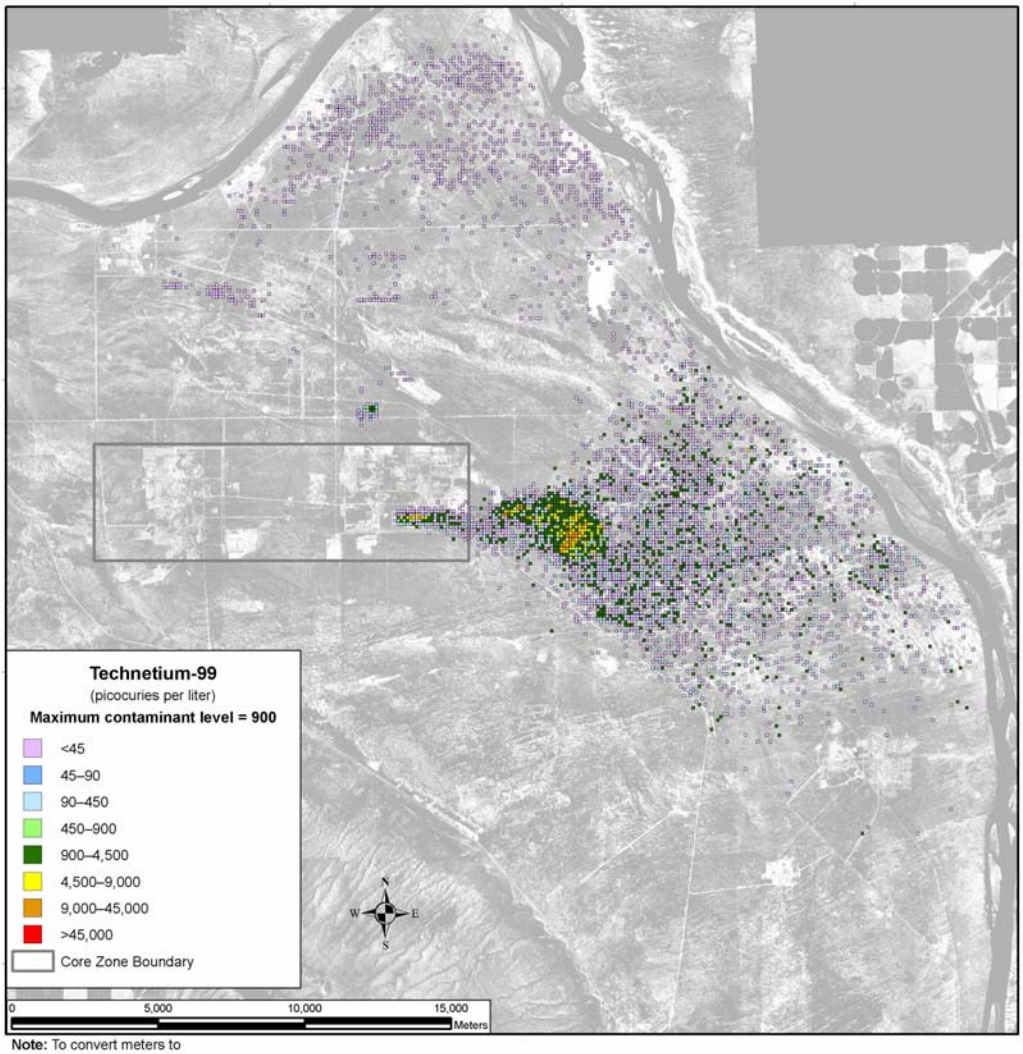
Note: To convert meters to feet, multiply by 3.281

Figure 5–476. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



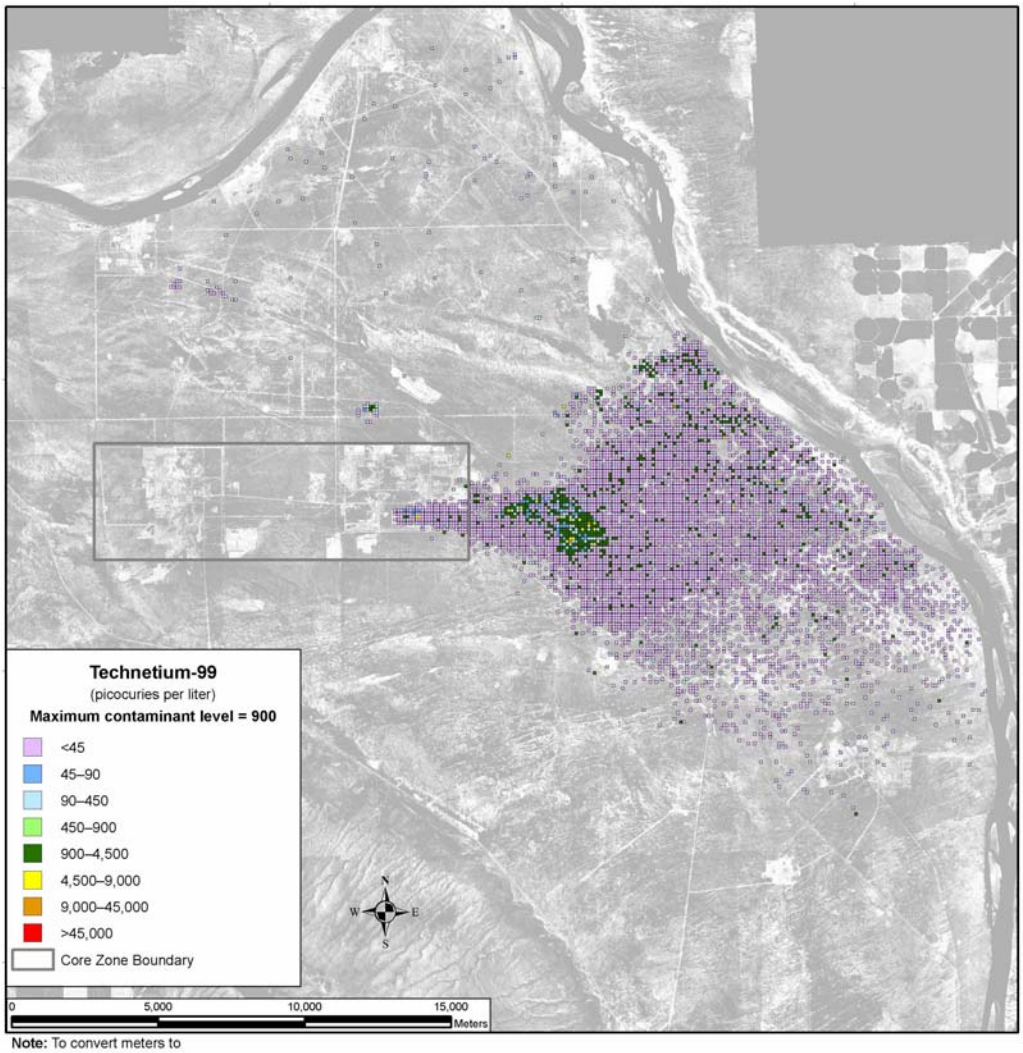
Note: To convert meters to feet, multiply by 3.281

Figure 5–477. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



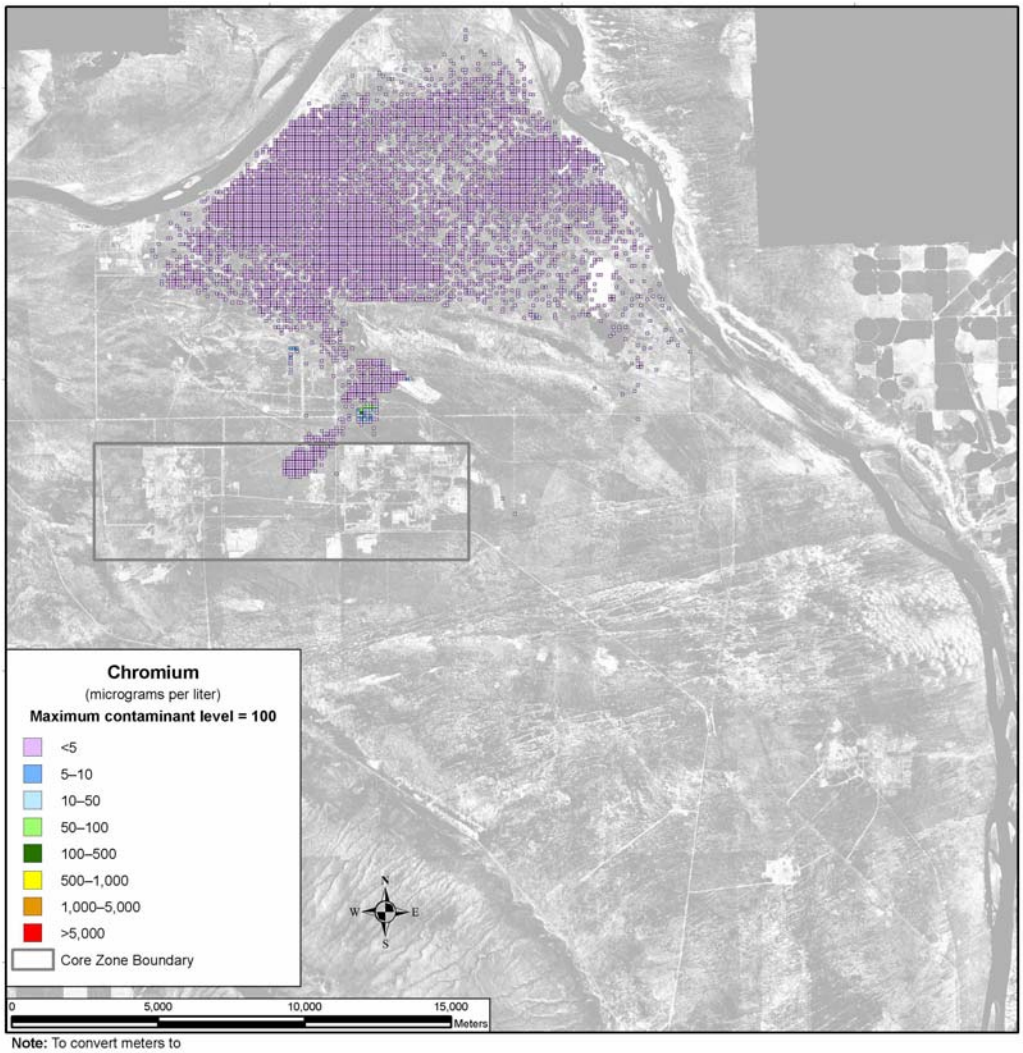
Note: To convert meters to feet, multiply by 3.281

Figure 5–478. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



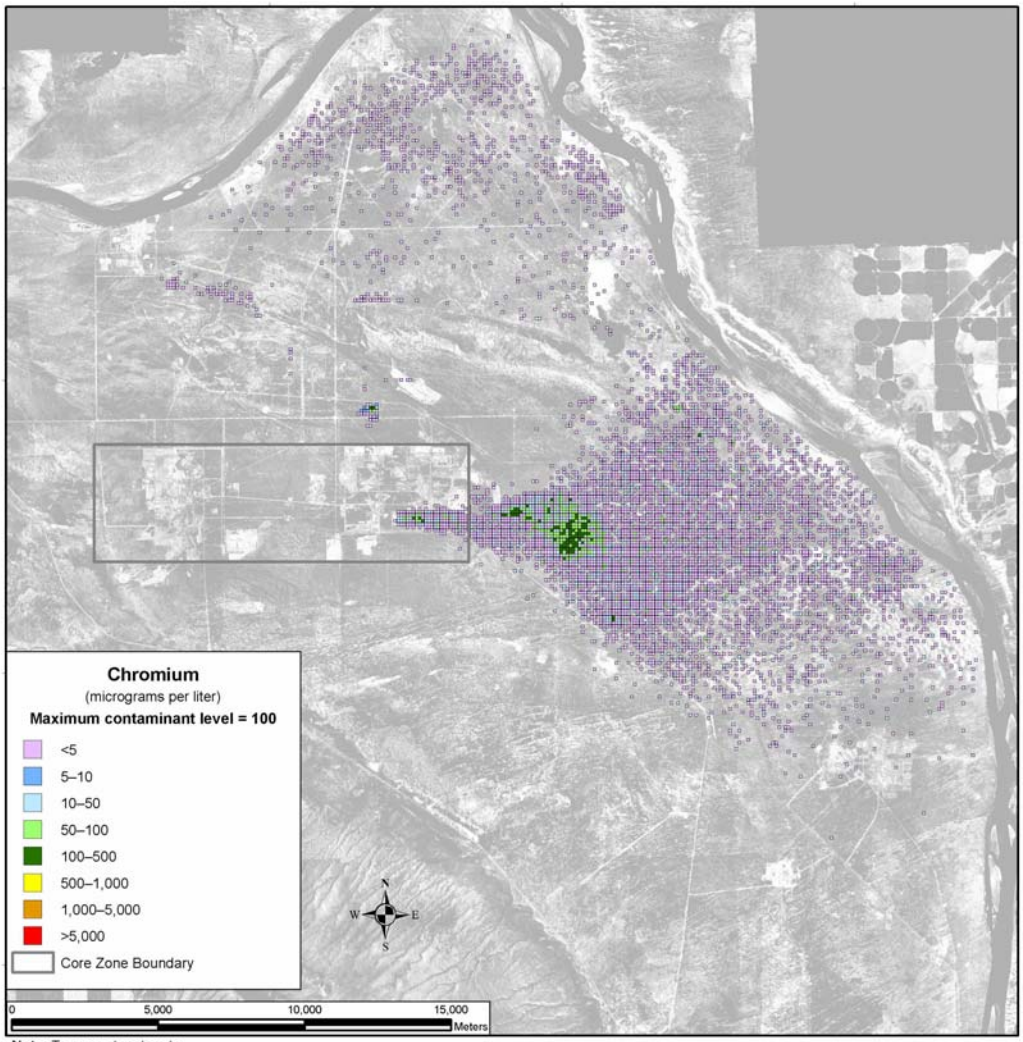
Note: To convert meters to feet, multiply by 3.281

Figure 5–479. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



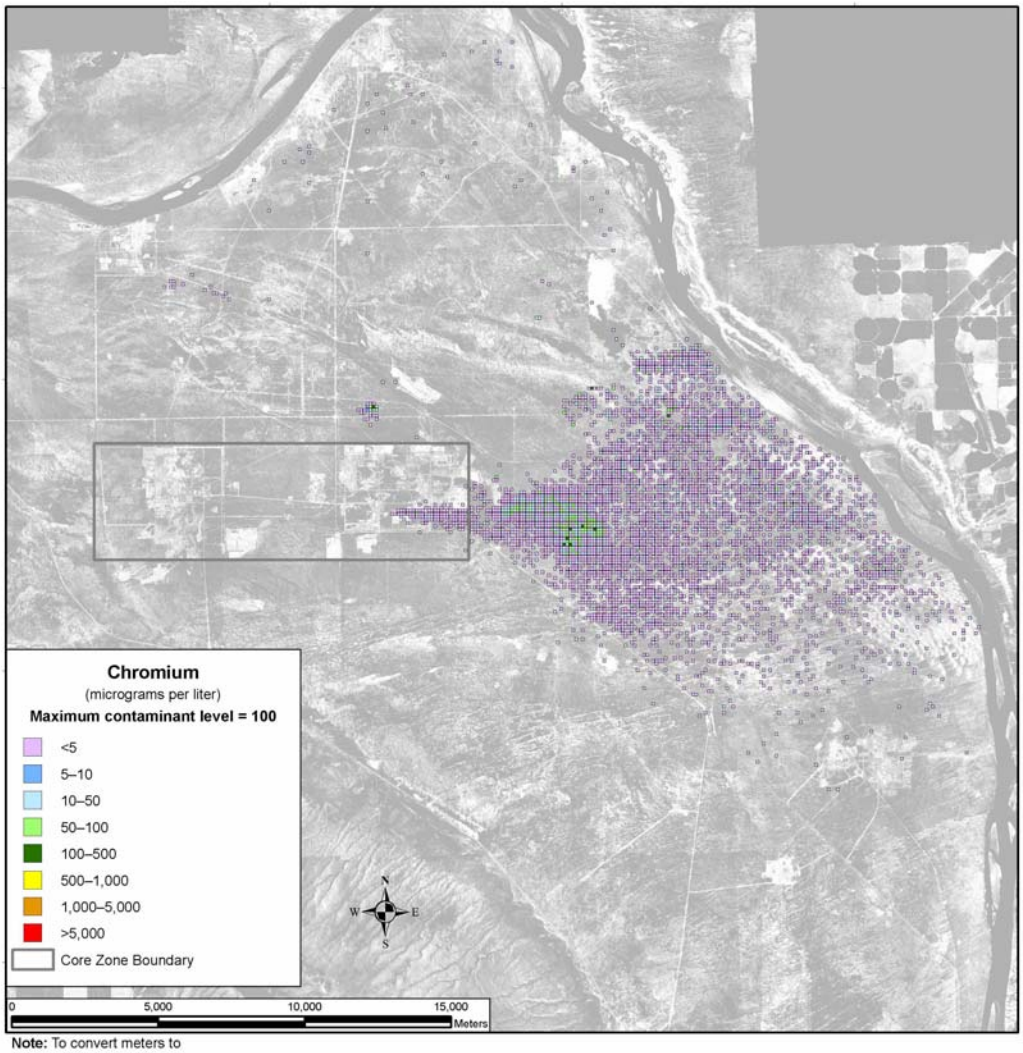
Note: To convert meters to feet, multiply by 3.281

Figure 5–480. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



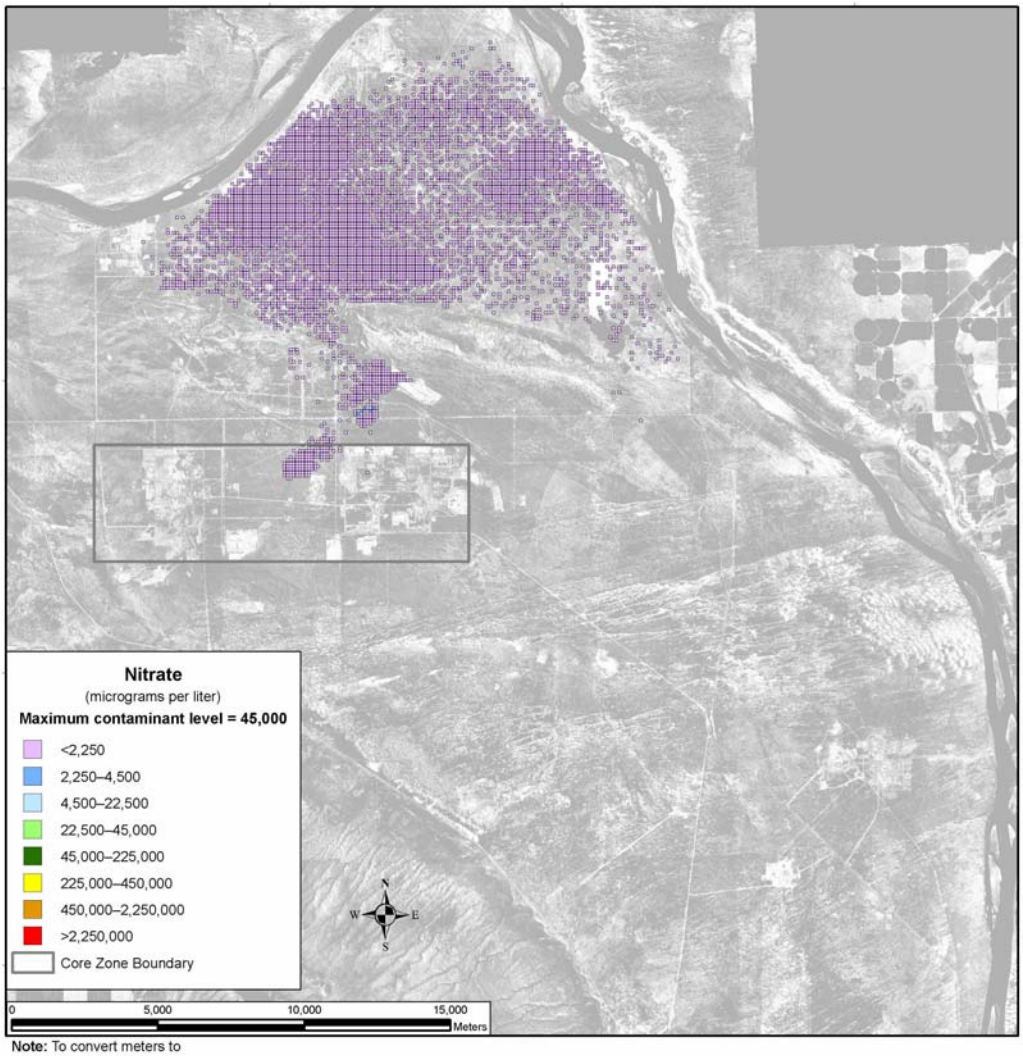
Note: To convert meters to feet, multiply by 3.281

Figure 5–481. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



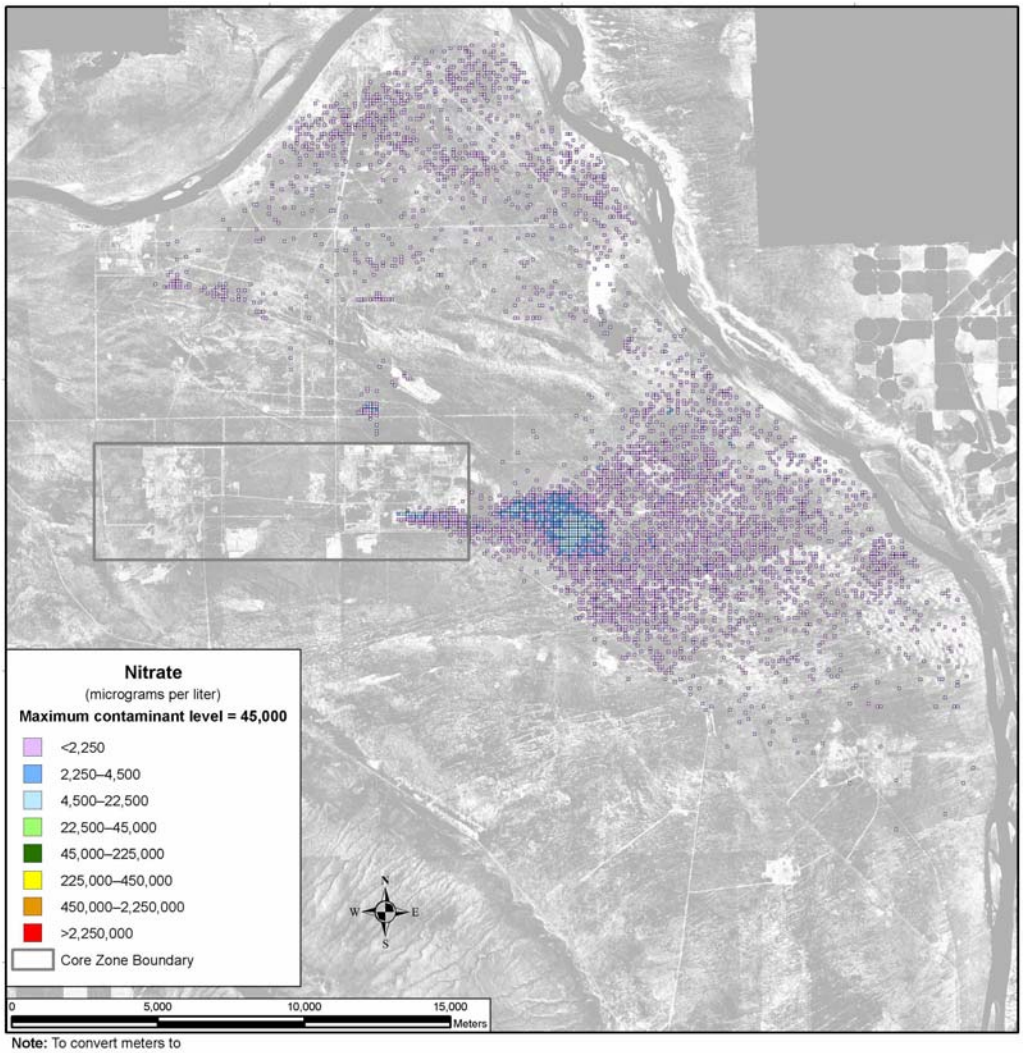
Note: To convert meters to feet, multiply by 3.281

Figure 5–482. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



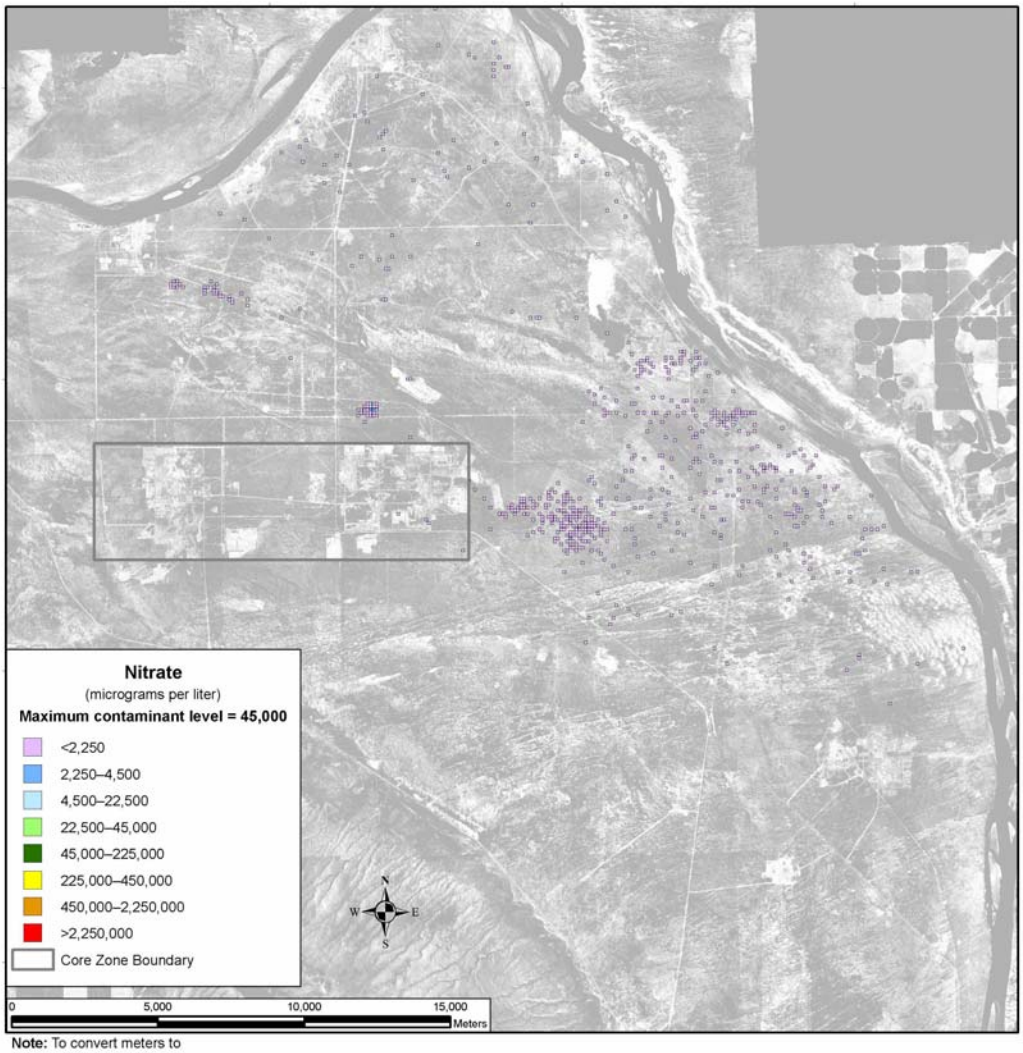
Note: To convert meters to feet, multiply by 3.281

Figure 5–483. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



Note: To convert meters to feet, multiply by 3.281

Figure 5–484. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–485. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

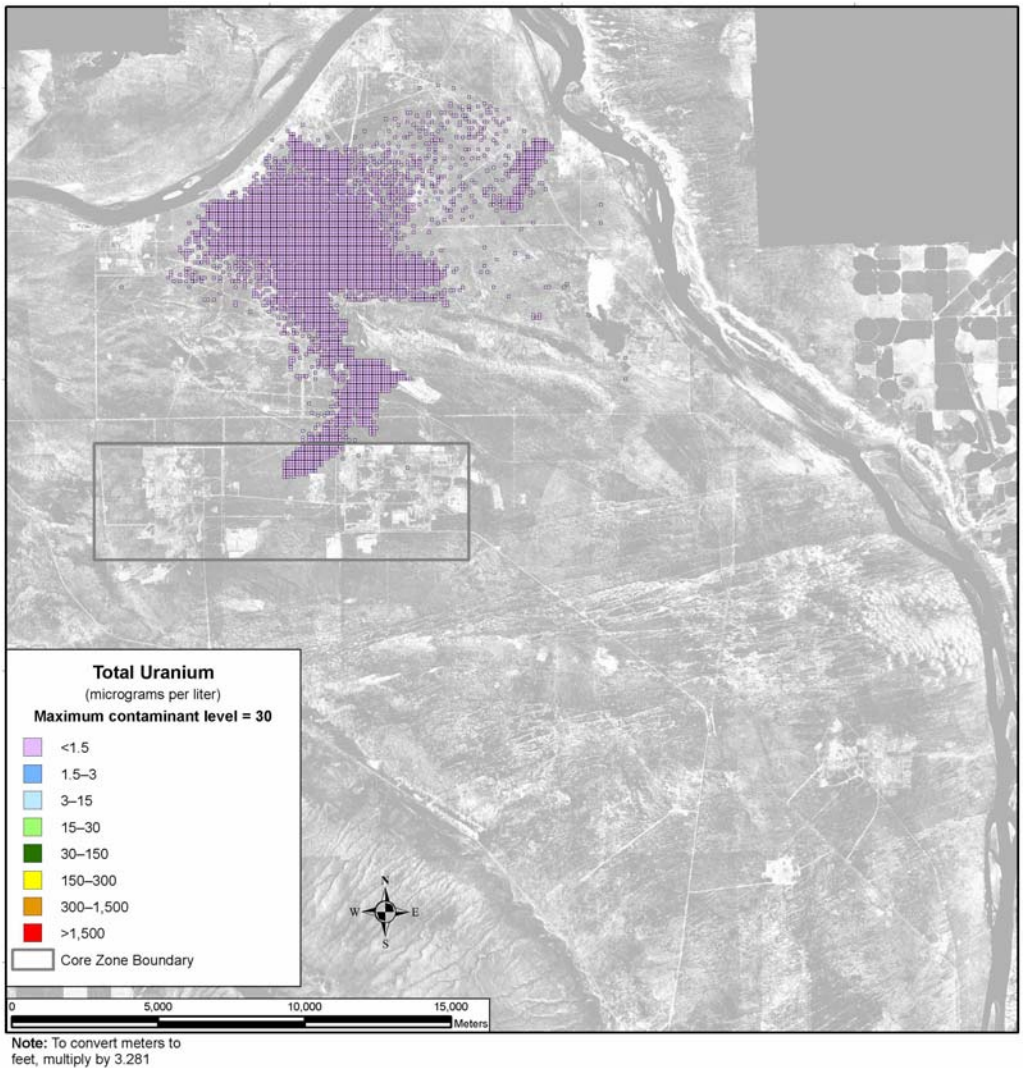


Figure 5–486. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-D, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For technetium-99, releases cause the groundwater concentrations at the Core Zone Boundary and at the Columbia River nearshore to exceed the benchmark concentration by about one-half of an order of magnitude at around CY 6000. The concentrations at the Core Zone Boundary and at the Columbia River nearshore remain above the benchmark concentration through the end of the period of analysis. Iodine-129 showed a pattern similar to that of technetium-99.

For chromium, the concentrations at the Core Zone Boundary exceed the benchmark from about CY 7000 to 10,000. During the same time period, concentrations from the Columbia River nearshore approach the benchmark, but never reach it. The concentrations at the Core Zone Boundary and the Columbia River nearshore both remain about one-half of an order of magnitude below the benchmark at the end of the period of analysis.

Nitrate concentrations at the Core Zone Boundary and the Columbia River nearshore both peak at around CY 8000. Even at the concentration's peak, nitrate levels still remain about one to one and one-half orders of magnitude below the benchmark level.

It is not until around CY 9900 that total uranium concentrations begin to register on the graph. The concentrations at the Core Zone Boundary and the Columbia River nearshore both remain at about eight to nine orders of magnitude below the benchmark level.

5.3.1.2.1.5 Disposal Group 1, Subgroup 1-E

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-E covers disposal of waste generated under Tank Closure Alternative 4 and either FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Waste would be converted to IHLW, ILAW glass, bulk vitrification glass, and cast stone waste. IHLW would be stored on site, while ILAW glass, bulk vitrification glass, and cast stone waste would be disposed of at IDF-East.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, 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 the RPPDF in CY 2009 and continue through CY 2050, when the 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 the facilities become available for release to the environment, and modified RCRA Subtitle C barriers would be emplaced over IDF-East and the RPPDF to limit infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2, 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 2, 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 2, 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 2, 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, 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 2, Disposal Group 1, Subgroup 1-E (IDF-East and the RPPDF releases), in terms of the 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 5–487 through 5–498). 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 nine subtotals plotted representing releases from ILAW glass, bulk vitrification 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- and offsite-generated waste.

Figure 5–487 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–488, the chemical hazard drivers. For all nine 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 cast stone waste and of iodine-129 is offsite-generated waste. For chemicals, the predominant source of chromium, nitrate, and acetonitrile is cast stone waste. The predominant sources of fluoride and boron are waste management secondary waste and onsite-generated waste.

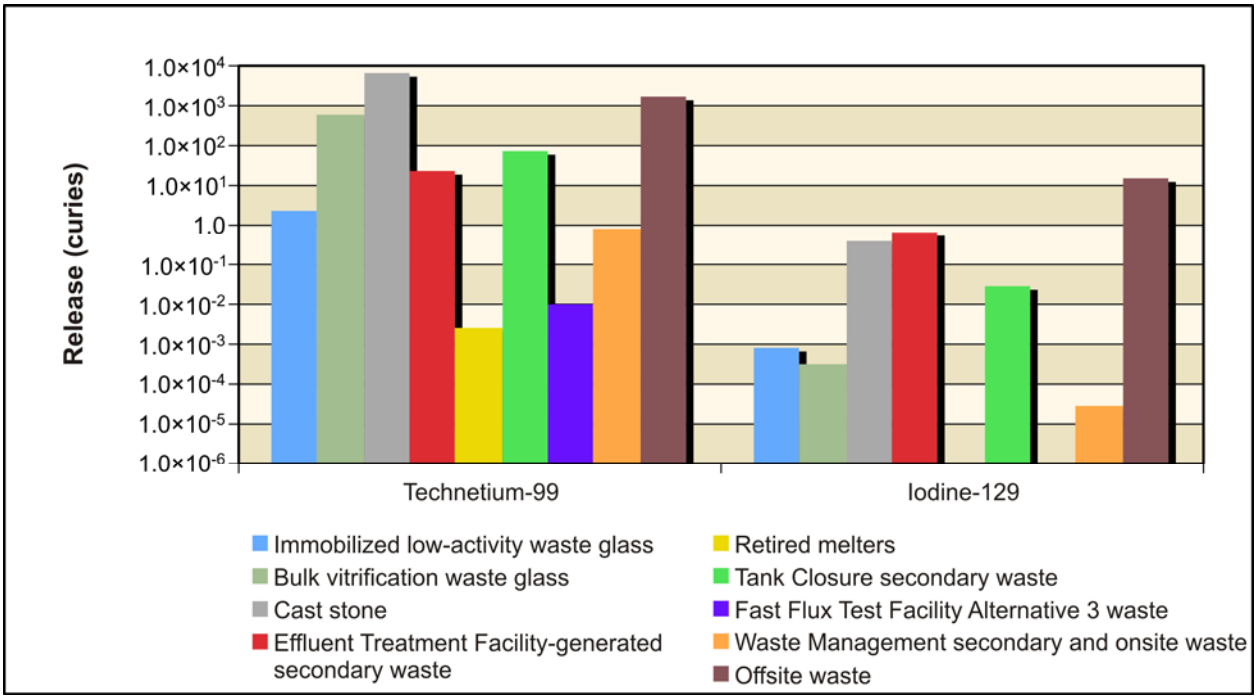


Figure 5–487. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Radiological Release at 200-East Area Integrated Disposal Facility to Vadose Zone

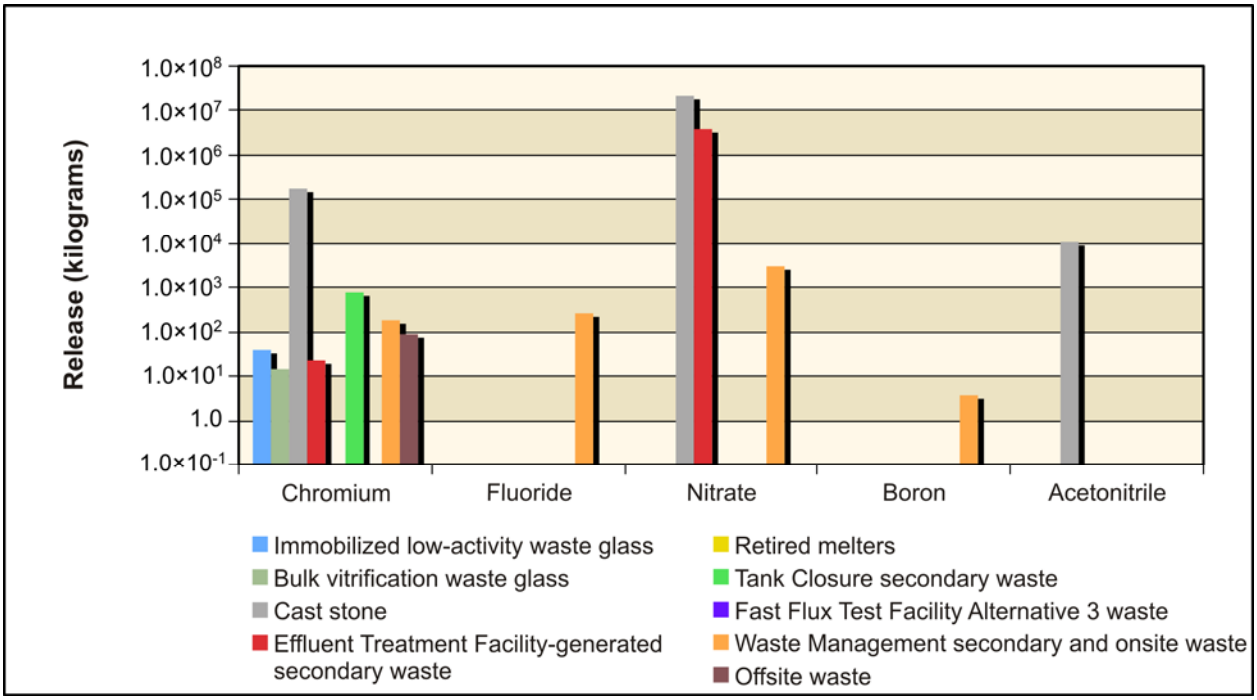


Figure 5–488. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chemical Release at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–489 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–490, 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, fluoride, boron, and acetonitrile, 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 53 percent of the radionuclide amount (curies) released to the vadose zone during the period of analysis reached the groundwater; approximately 99 percent of the chemical quantity (kilograms) reached the groundwater.

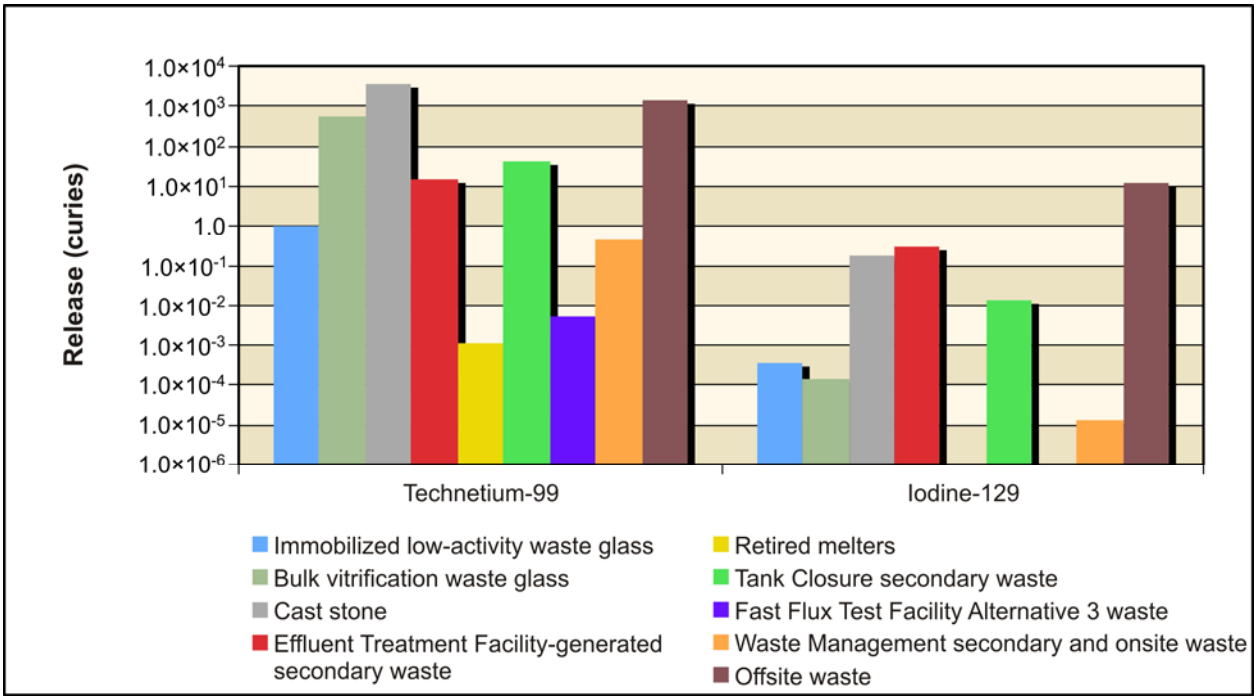


Figure 5–489. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Radiological Release at 200-East Area Integrated Disposal Facility to Groundwater

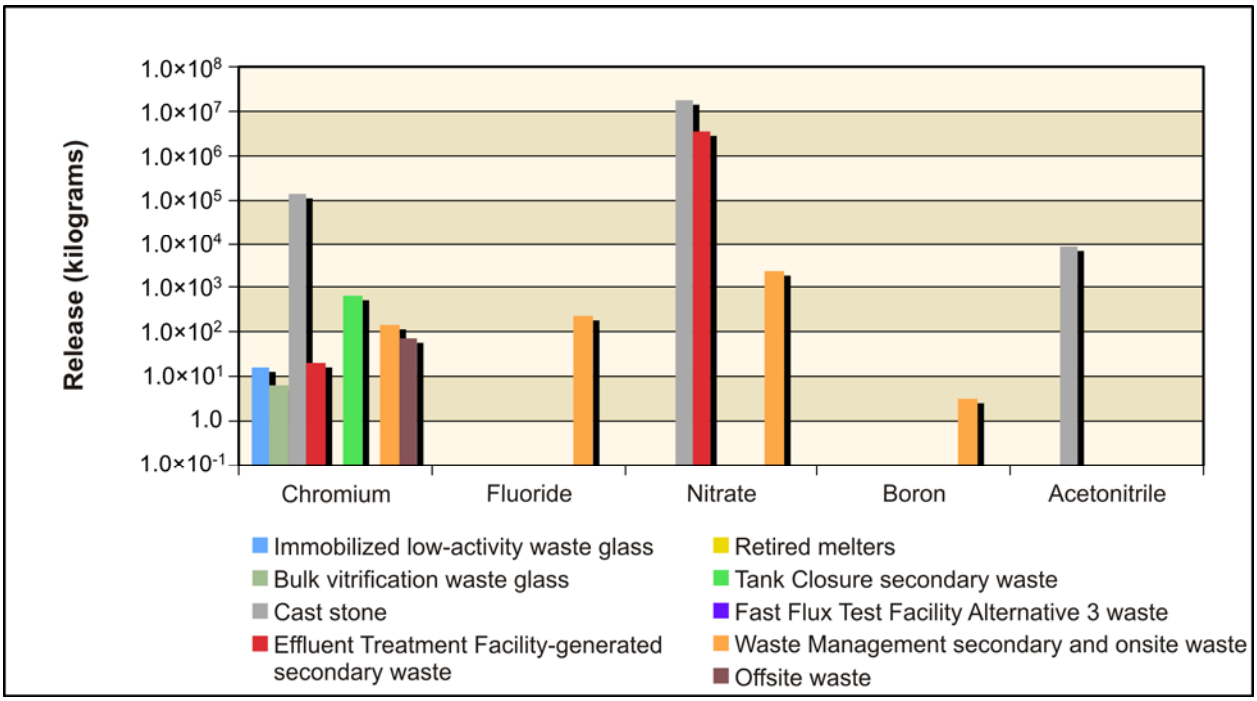


Figure 5–490. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chemical Release at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–491 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–492, 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, nitrate, fluoride, boron, and acetonitrile, the amount released to the Columbia River is essentially equal to the amount released to groundwater. Overall, about 75 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.

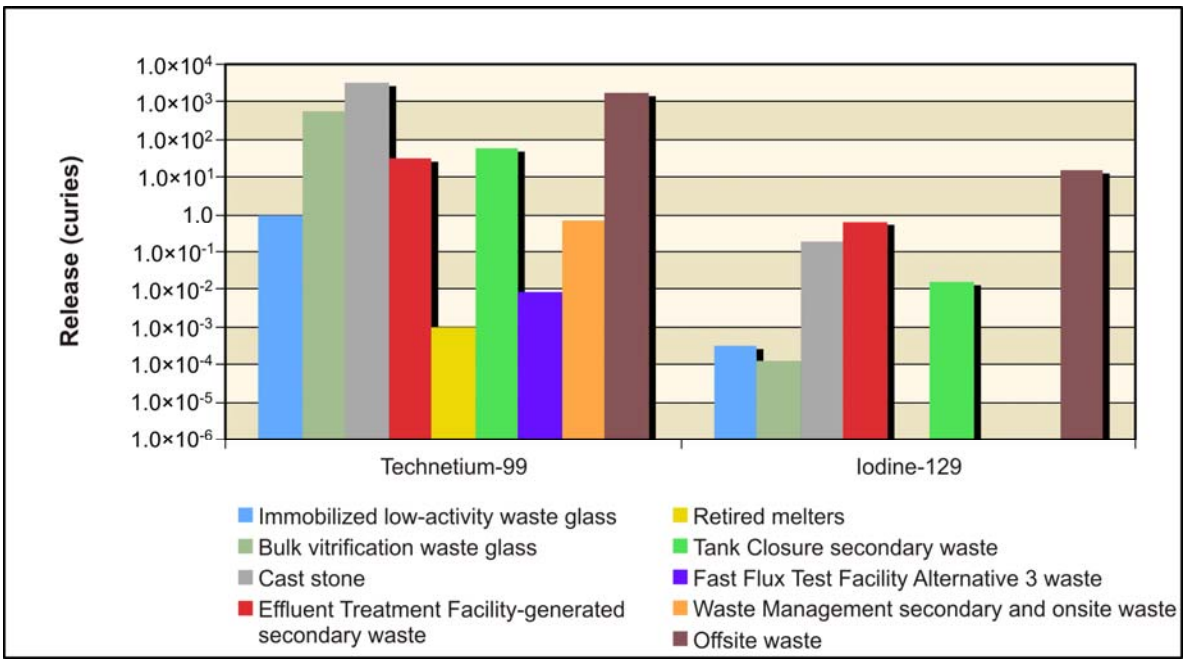


Figure 5–491. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Radiological Release at 200-East Area Integrated Disposal Facility to Columbia River

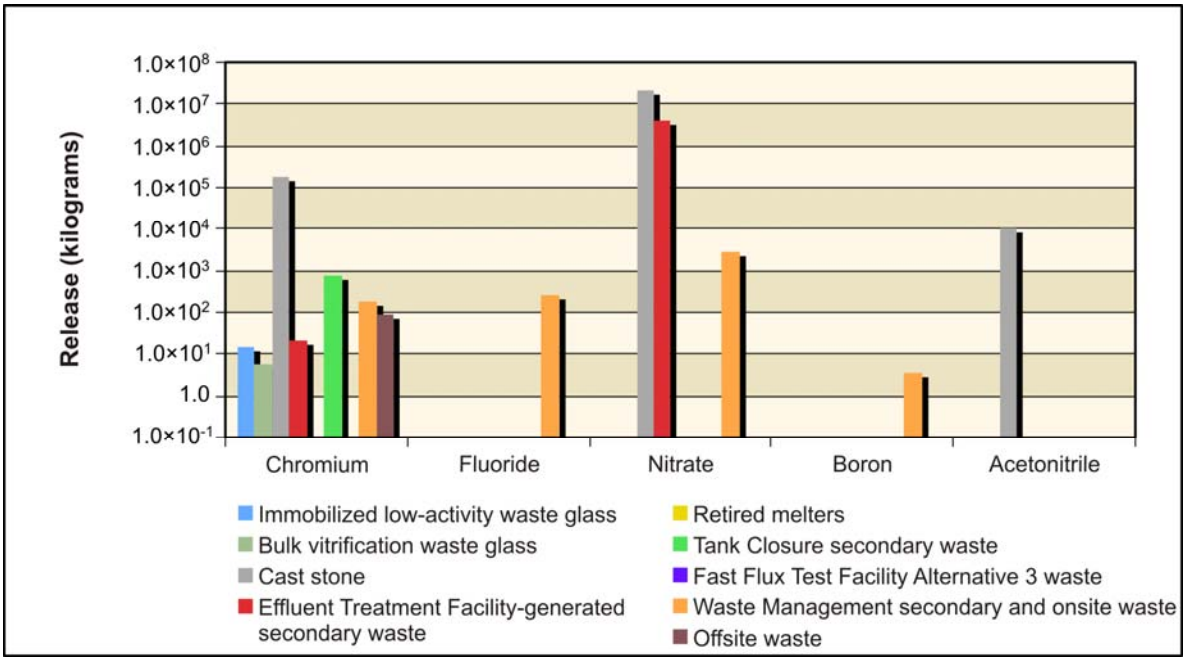


Figure 5–492. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chemical Release at 200-East Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–493 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–494, 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, boron, and acetonitrile are not released from the RPPDF.

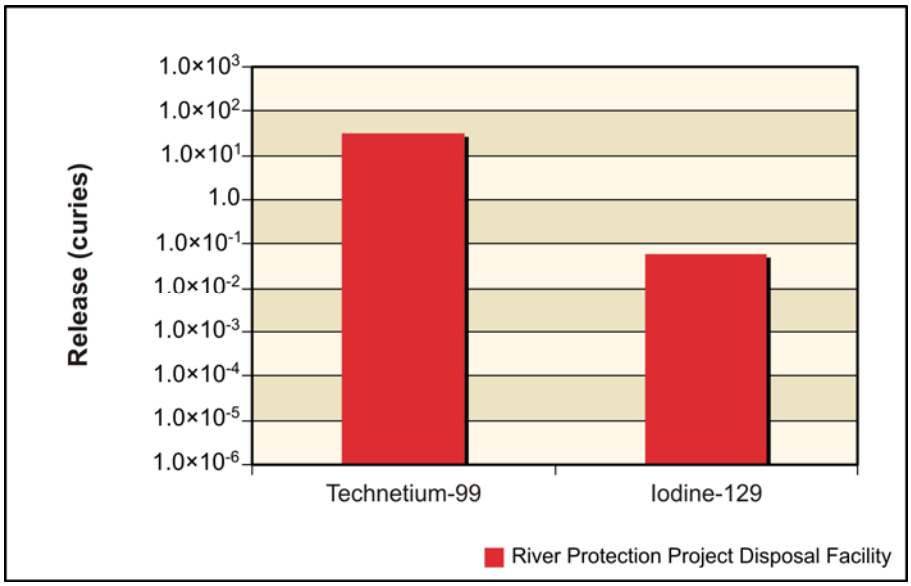


Figure 5–493. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Radiological Release at River Protection Project Disposal Facility to Vadose Zone

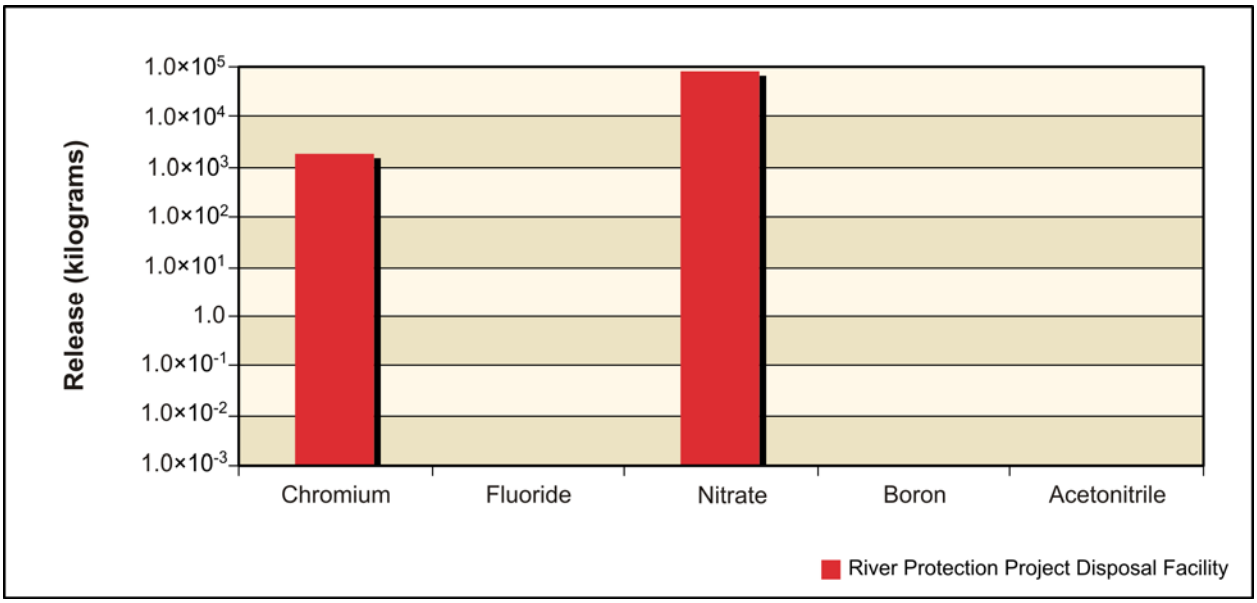


Figure 5–494. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chemical Release at River Protection Project Disposal Facility to Vadose Zone

Figure 5–495 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–496, 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.

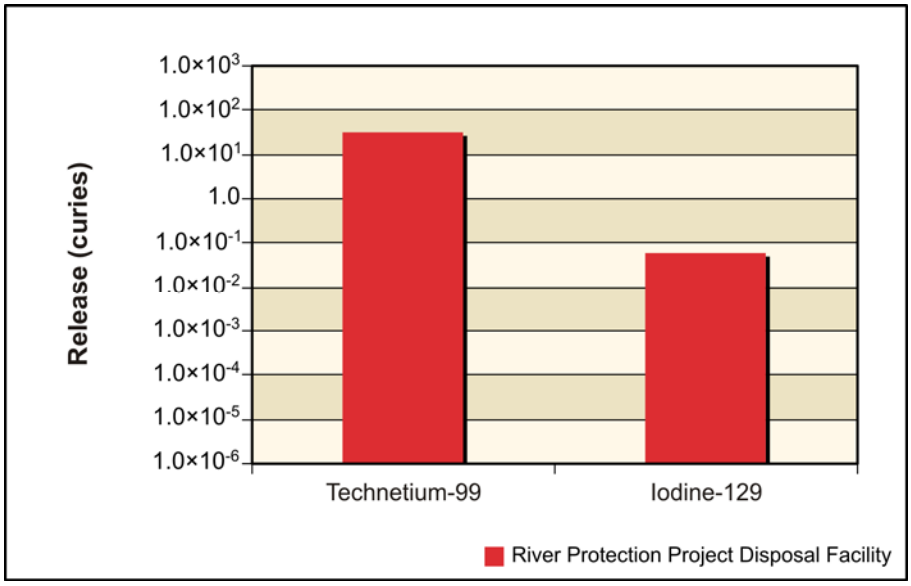


Figure 5–495. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Radiological Release at River Protection Project Disposal Facility to Groundwater

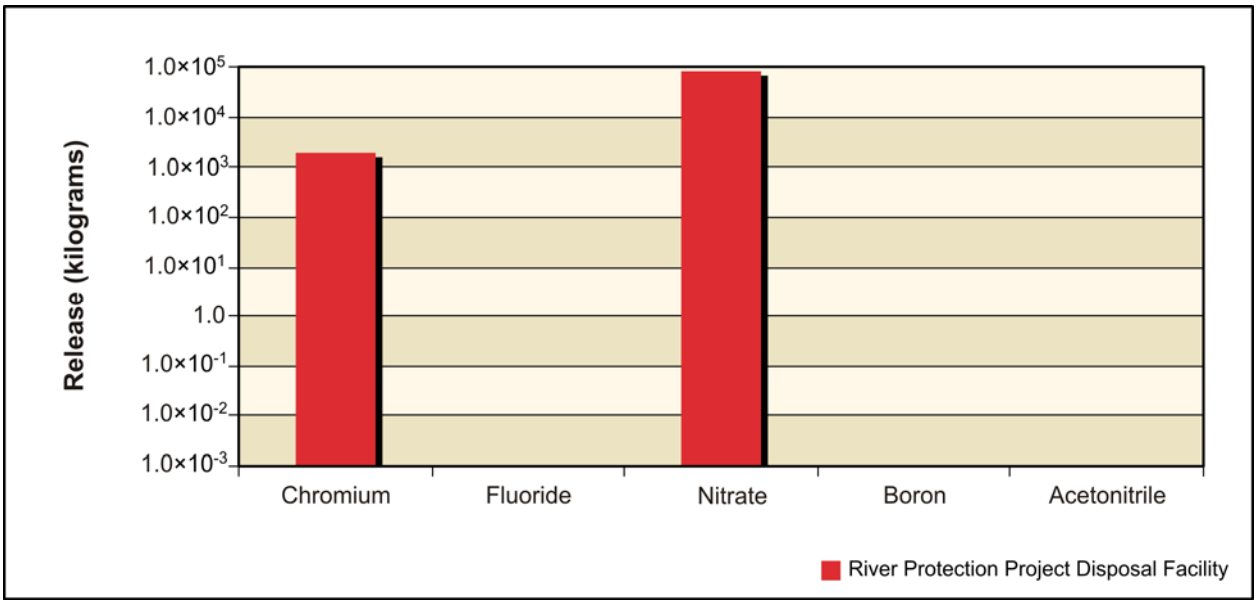


Figure 5–496. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chemical Release at River Protection Project Disposal Facility to Groundwater

Figure 5–497 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–498, 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.

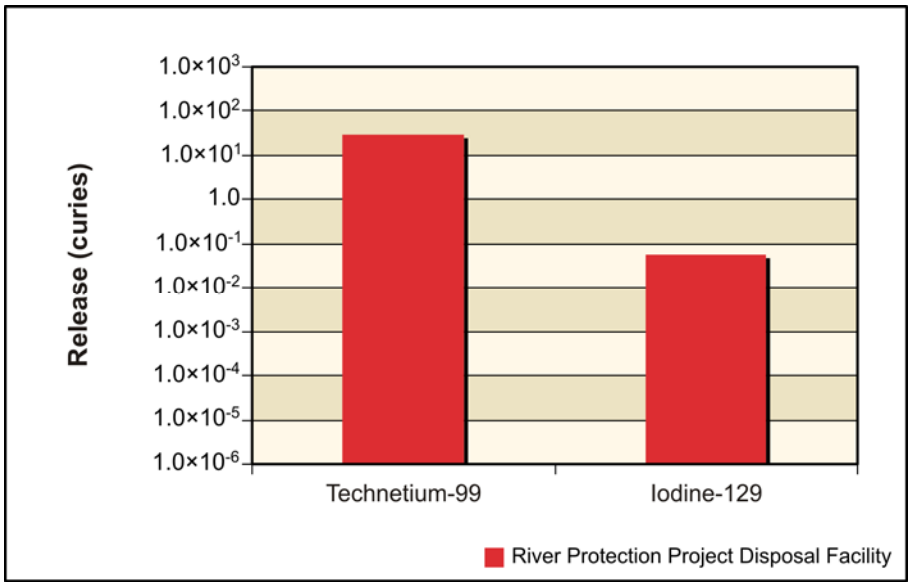


Figure 5–497. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Radiological Release at River Protection Project Disposal Facility to Columbia River

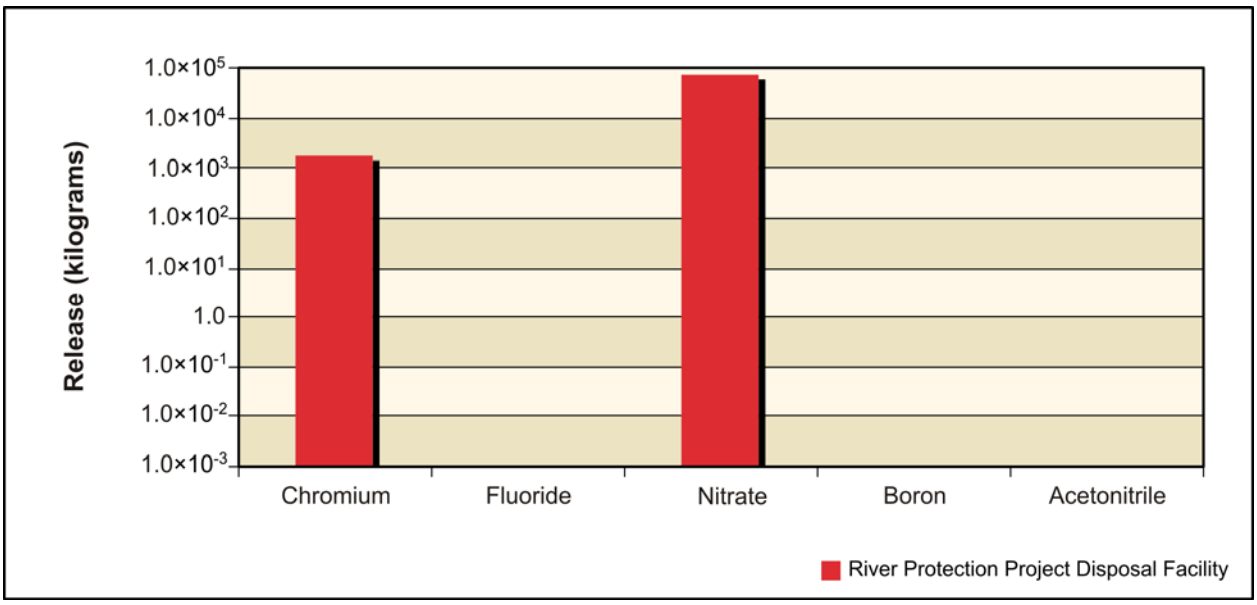


Figure 5–498. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chemical Release at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, 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 (see Figures 5–499 though 5–503). 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 5–81 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–499 through 5–502 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. Releases from IDF-East and the RPPDF cause technetium-99 and iodine-129 groundwater concentrations to exceed benchmark concentrations by less than one order of magnitude during the later part of the period of analysis. Nitrate and chromium do not exceed benchmark concentrations. During this time, technetium-99 and iodine-129 groundwater concentrations at the Columbia River nearshore exceed the benchmark concentrations. Releases from IDF-East and the RPPDF cause groundwater concentrations to exceed benchmark concentrations by less than one order of magnitude during the middle and later parts of the period of analysis.

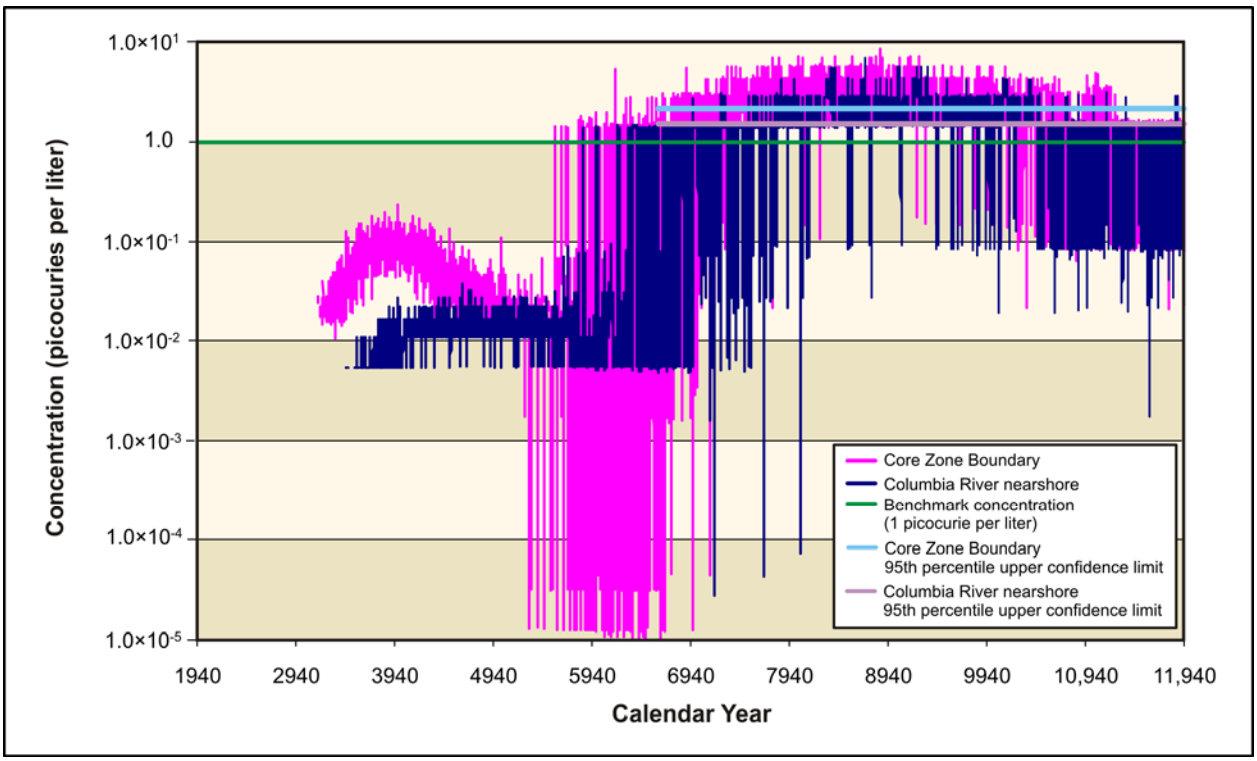


Figure 5–499. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Iodine-129 Concentration Versus Time

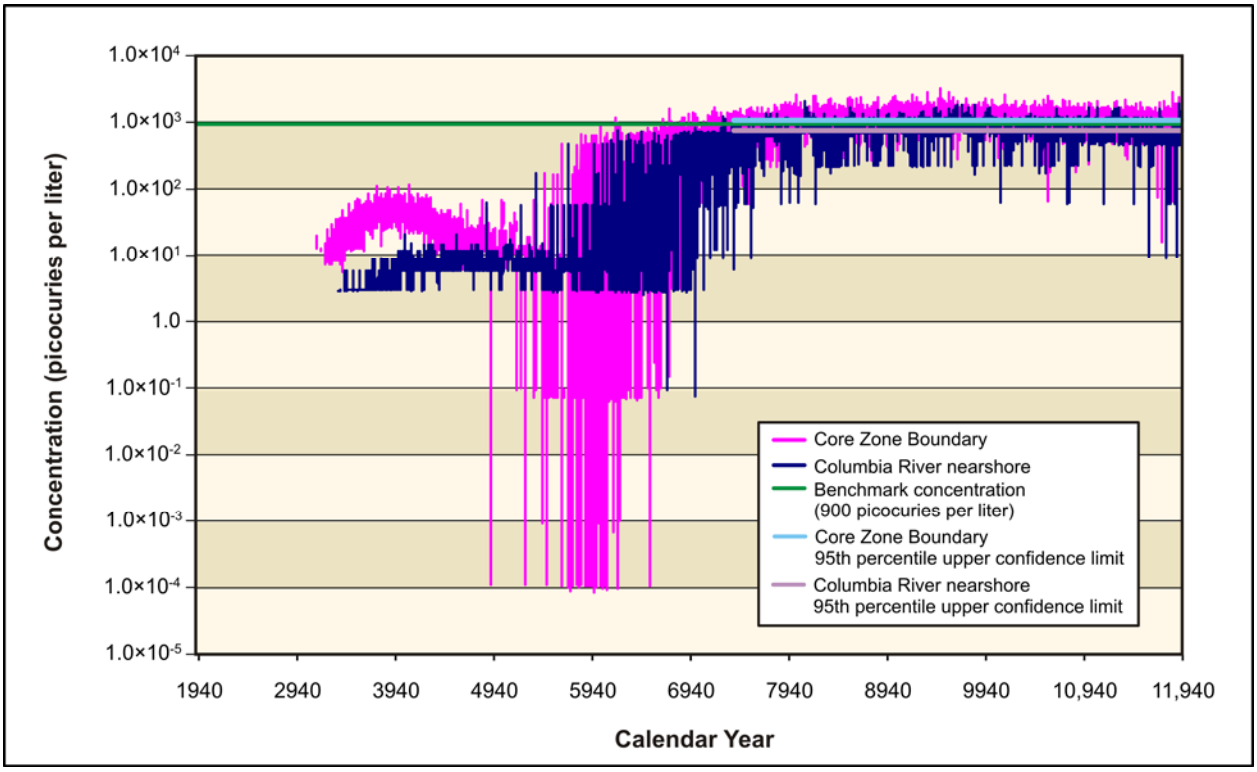


Figure 5–500. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Technetium-99 Concentration Versus Time

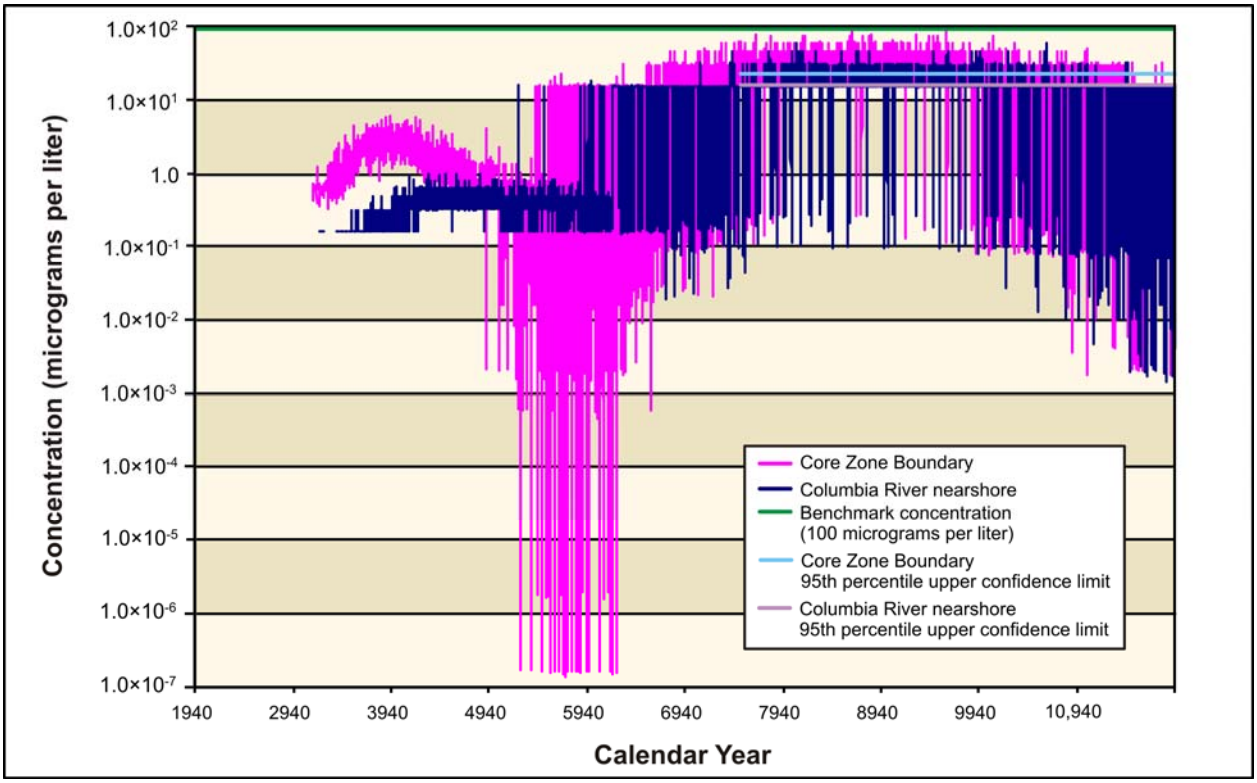


Figure 5–501. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Chromium Concentration Versus Time

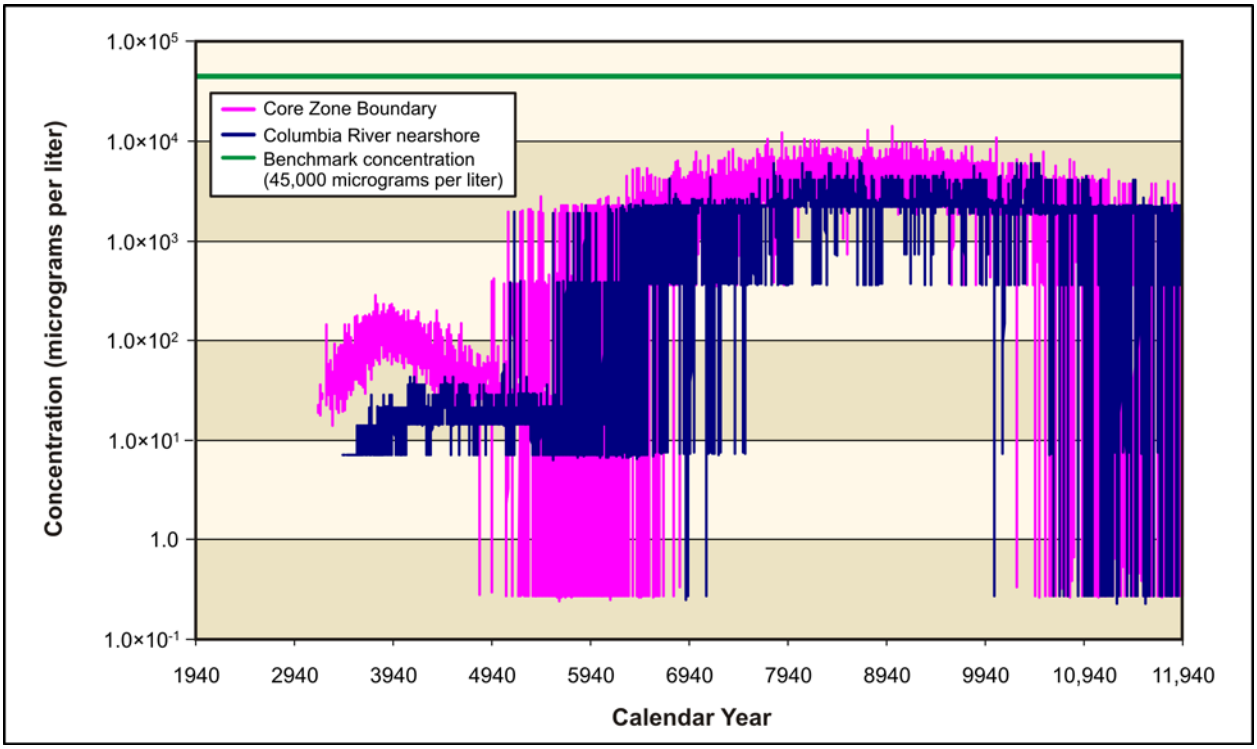


Figure 5–502. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Nitrate Concentration Versus Time

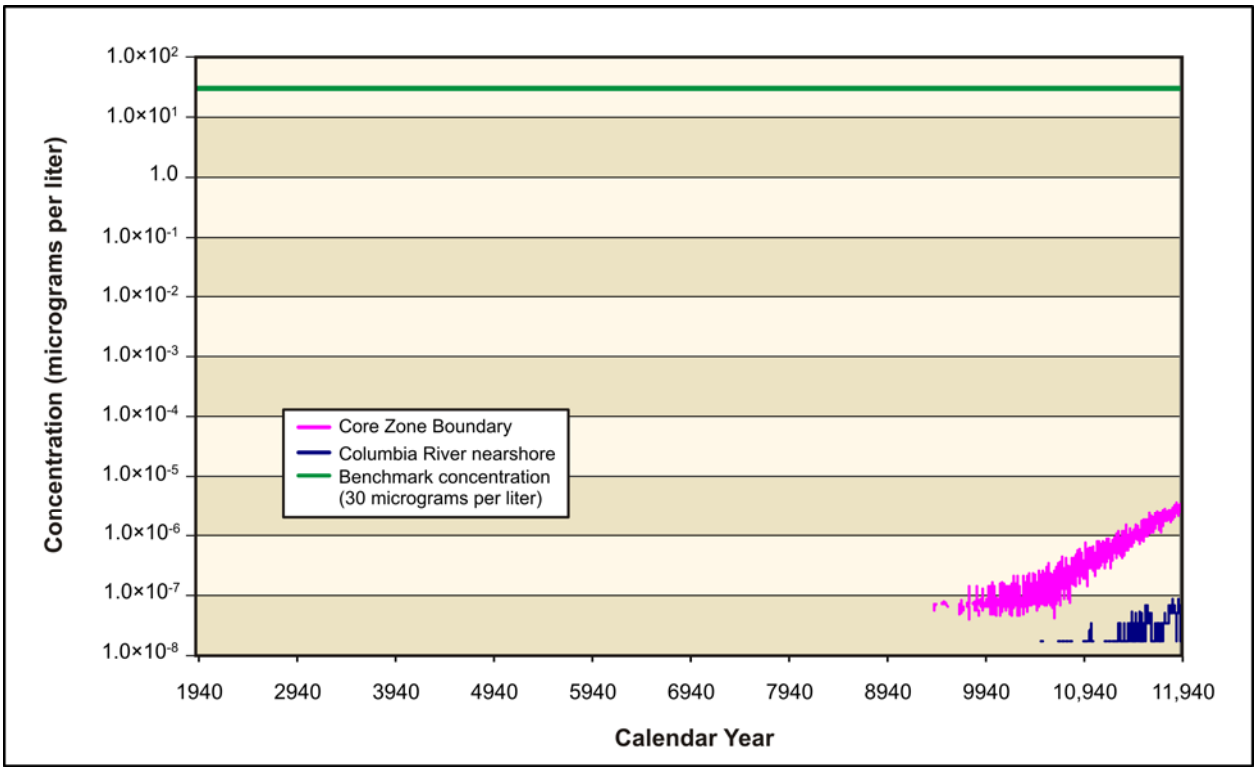


Figure 5–503. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Total Uranium Concentration Versus Time

Figure 5–503 shows concentration versus time for total uranium. Late releases from IDF-East and the RPPDF result in groundwater concentrations that are seven orders of magnitude lower than benchmark concentrations for total uranium. Total uranium concentrations, while very minimal, continue to rise throughout the duration of the period of analysis, but never exceed the benchmark concentrations by the end of the period of analysis.

Table 5–81. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**6,490**	103	**3,090**	**2,030**	900
	(9035)	(3822)	(9499)	(8117)	
Iodine-129	**18**	0.2	**8**	**7**	1
	(8491)	(3940)	(8858)	(8699)	
Chemical in micrograms per liter					
Acetonitrile	16	0	5	4	100
	(7959)	(1940)	(7381)	(6849)	
Chromium	**224**	6	96	64	100
	(9069)	(3804)	(8643)	(8079)	
Fluoride	0	0	1	0	4,000
	(8035)	(1940)	(7258)	(8913)	
Nitrate	29,000	229	13,900	6,380	45,000
	(9330)	(4042)	(8994)	(8673)	

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

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

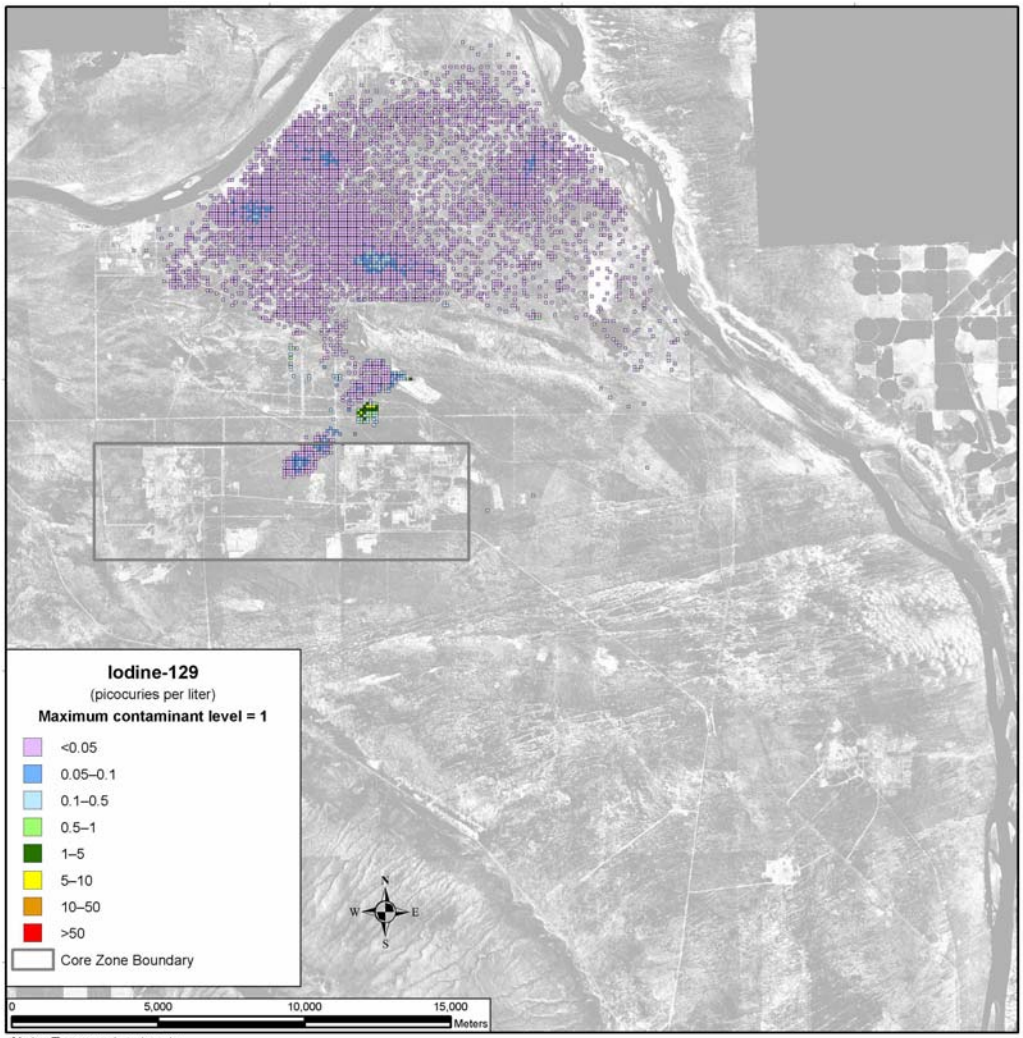
ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, 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 (see Figures 5–504 through 5–516). 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 5–504 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890. Releases from the RPPDF result in groundwater concentration plumes that exceed the benchmark concentration north of the Core Zone Boundary. Peak concentrations in this plume are only slightly greater than the benchmark concentration and only in a very small area north of the Core Zone Boundary. During year 7140, releases from IDF-East create a plume exceeding the benchmark, extending from the 200-East Area moving eastward toward the Columbia River (see Figure 5–505). Also by CY 7140, most of the RPPDF plume continues to move north and reaches the Columbia River. By CY 11,885, most of the mass in the IDF-East plume is still moving eastward toward the Columbia River, with only small, isolated pockets of high concentration exceeding the benchmark (see Figure 5–506). Technetium-99 (see Figures 5–507 through 5–509), chromium (see Figures 5–510 through 5–512), and nitrate

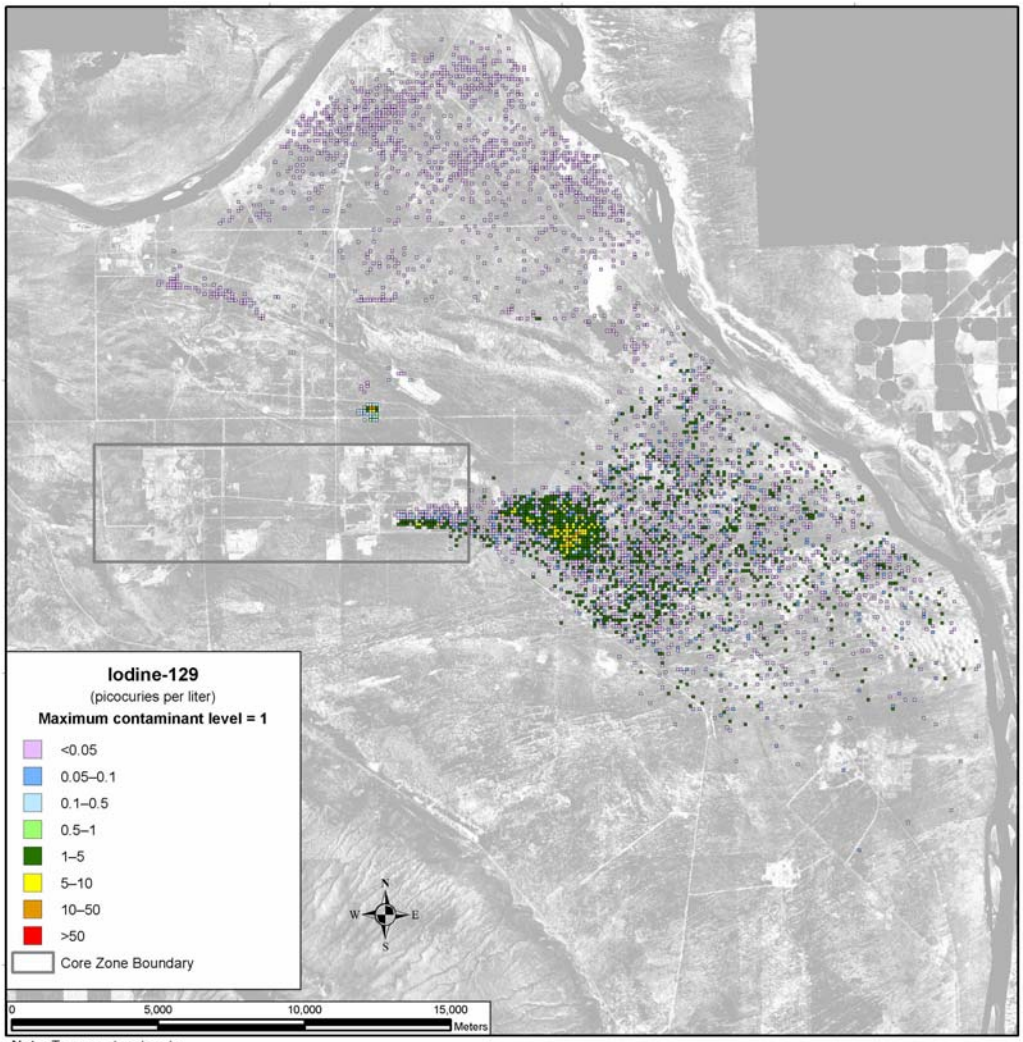
(see Figures 5–513 through 5–515) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

Total uranium shows a different spatial distribution over time. This COPC is not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–516 shows the distribution of total uranium during CY 11,885. Releases from 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.



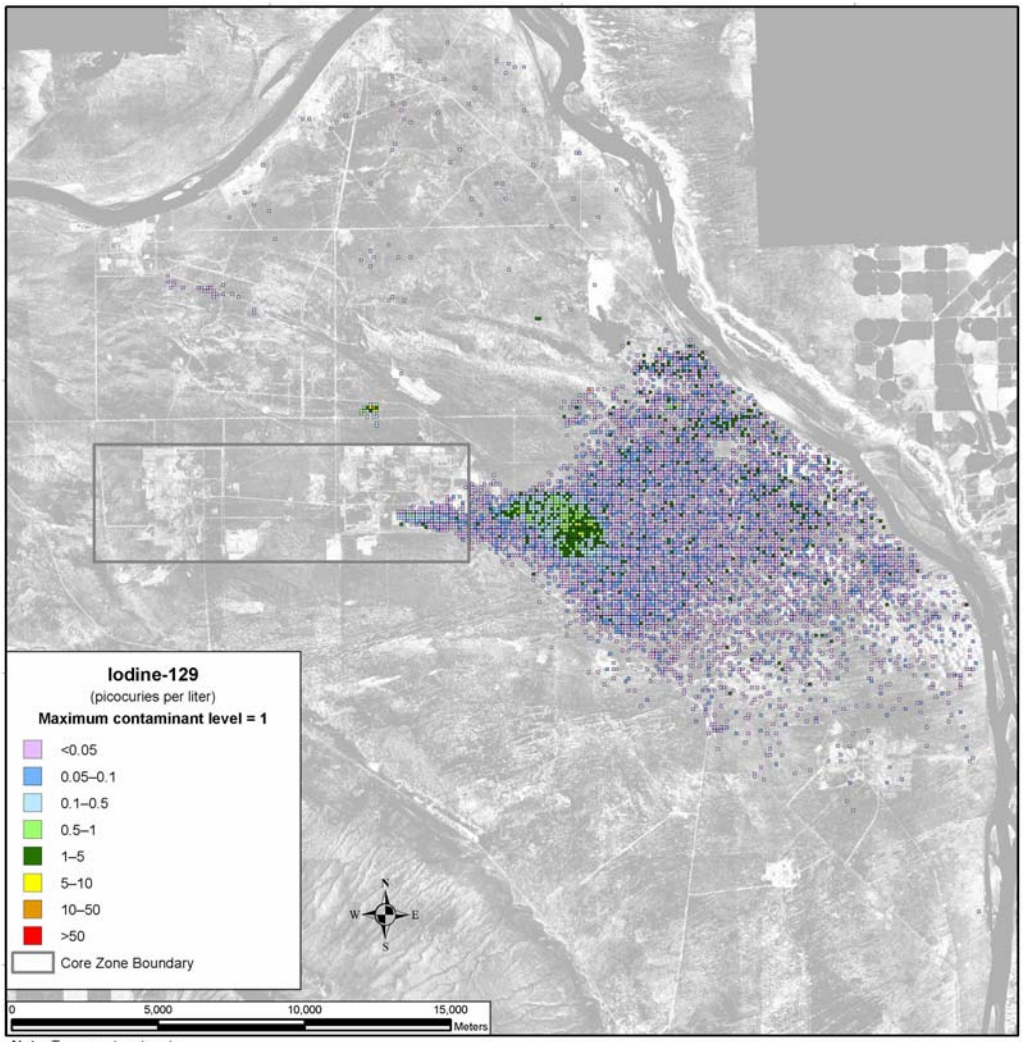
Note: To convert meters to feet, multiply by 3.281

Figure 5–504. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



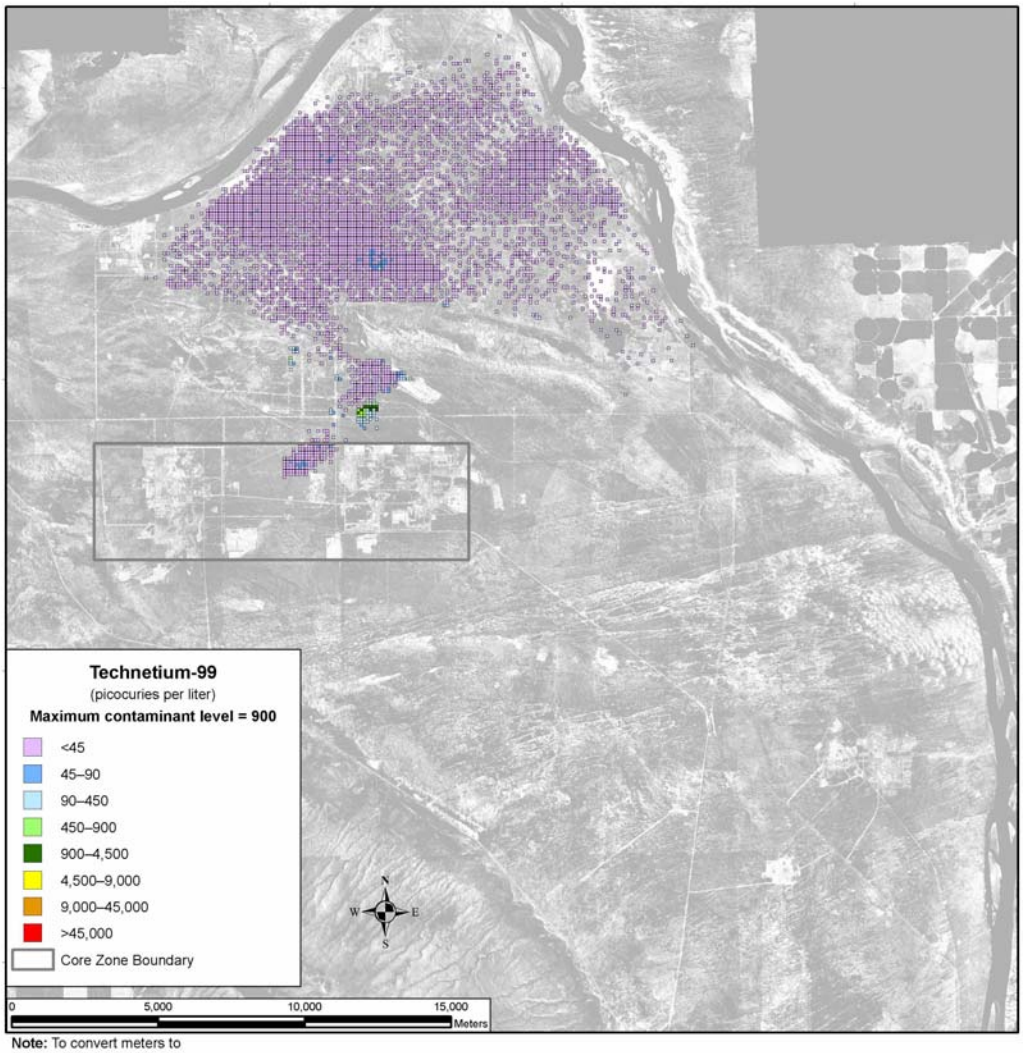
Note: To convert meters to feet, multiply by 3.281

Figure 5–505. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



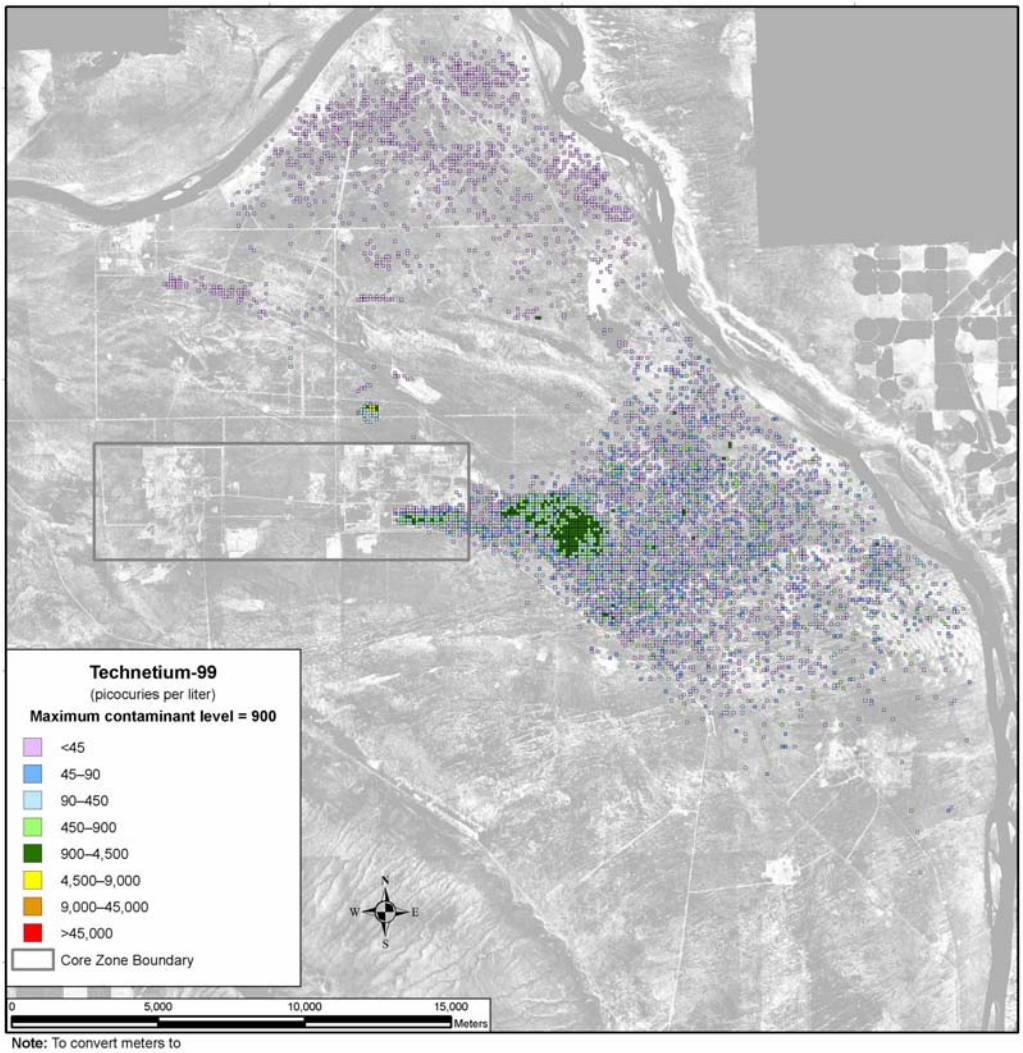
Note: To convert meters to feet, multiply by 3.281

Figure 5–506. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



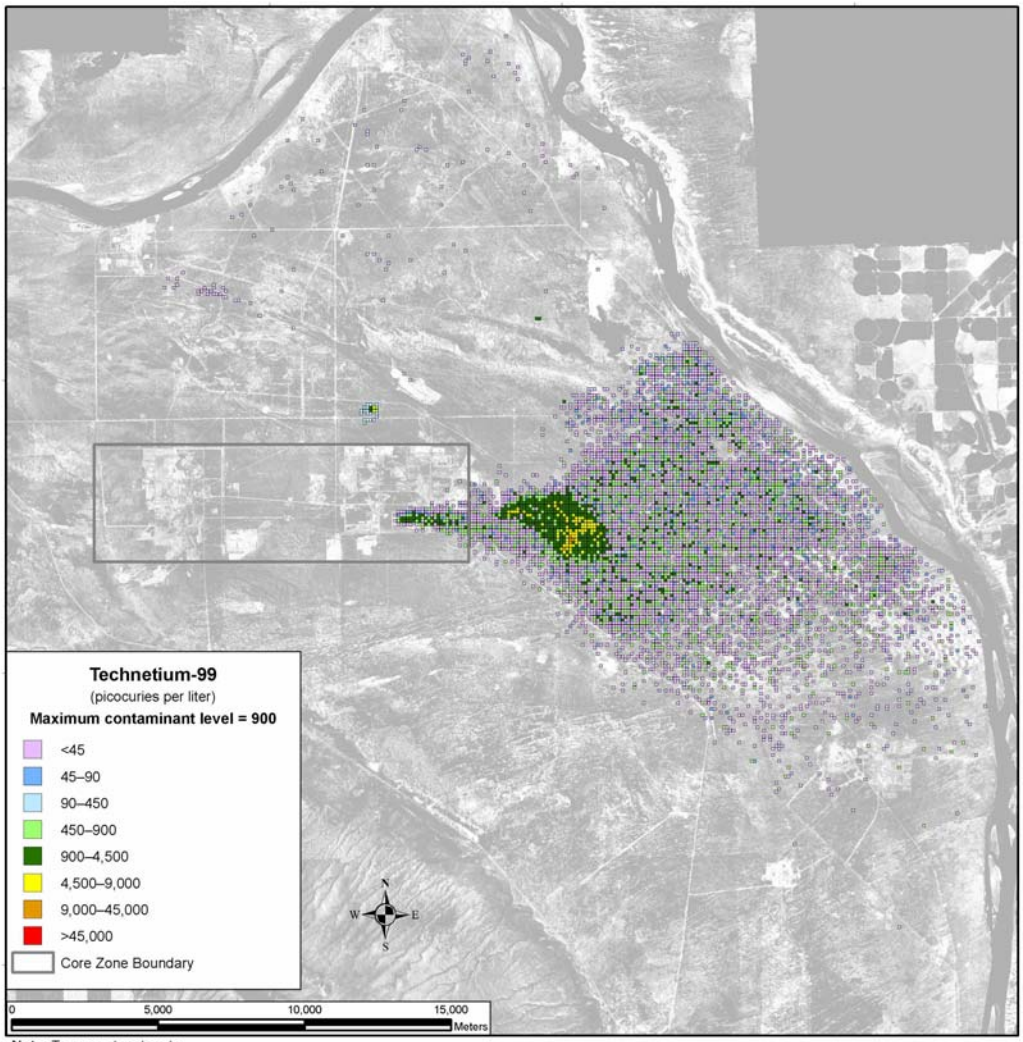
Note: To convert meters to feet, multiply by 3.281

Figure 5–507. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



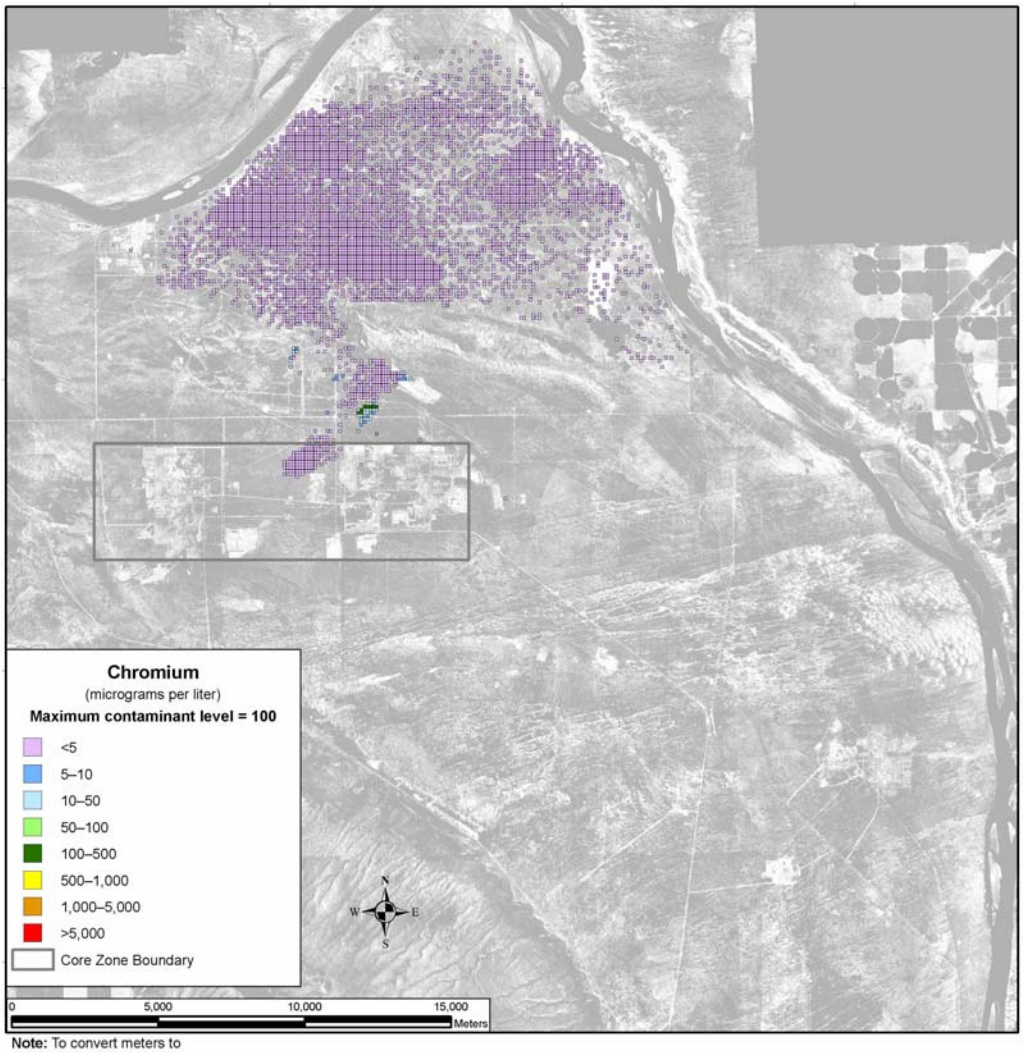
Note: To convert meters to feet, multiply by 3.281

Figure 5–508. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



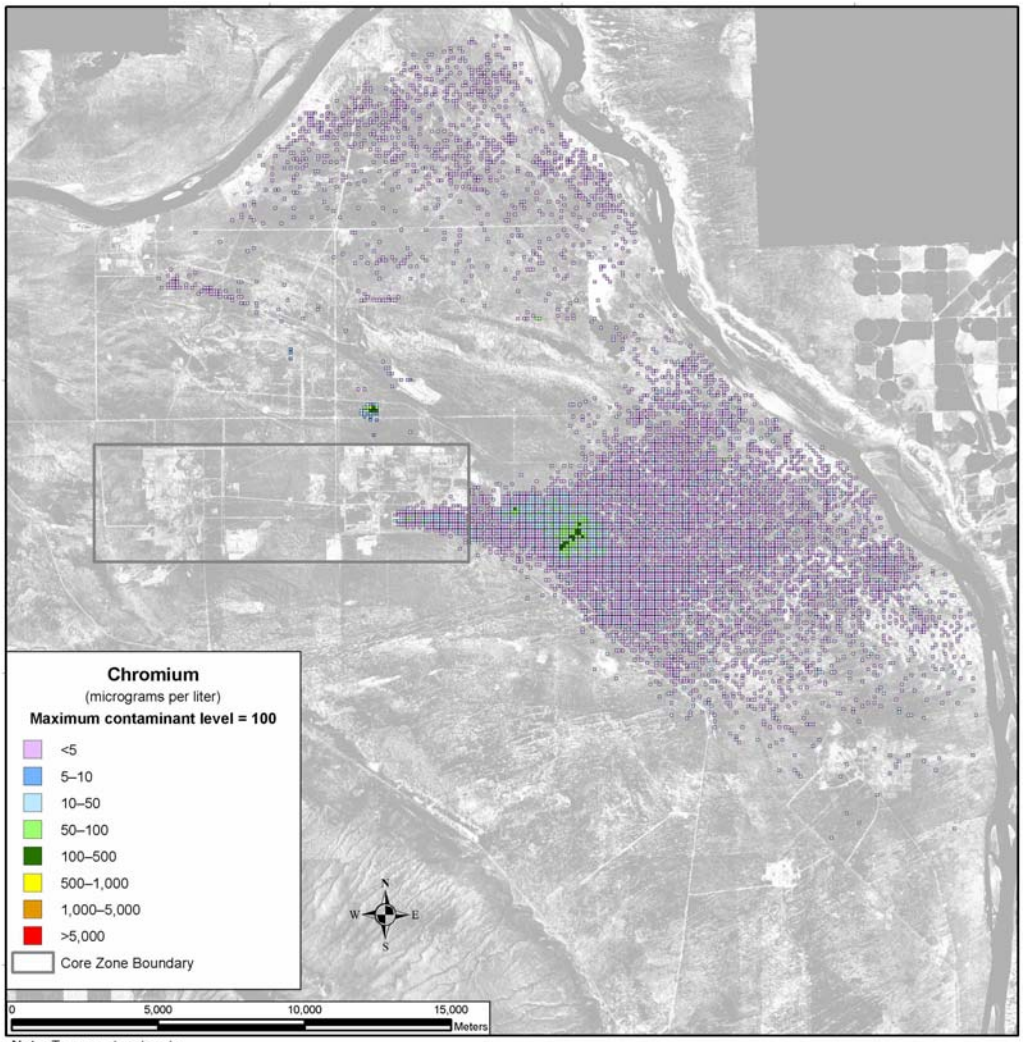
Note: To convert meters to feet, multiply by 3.281

Figure 5–509. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



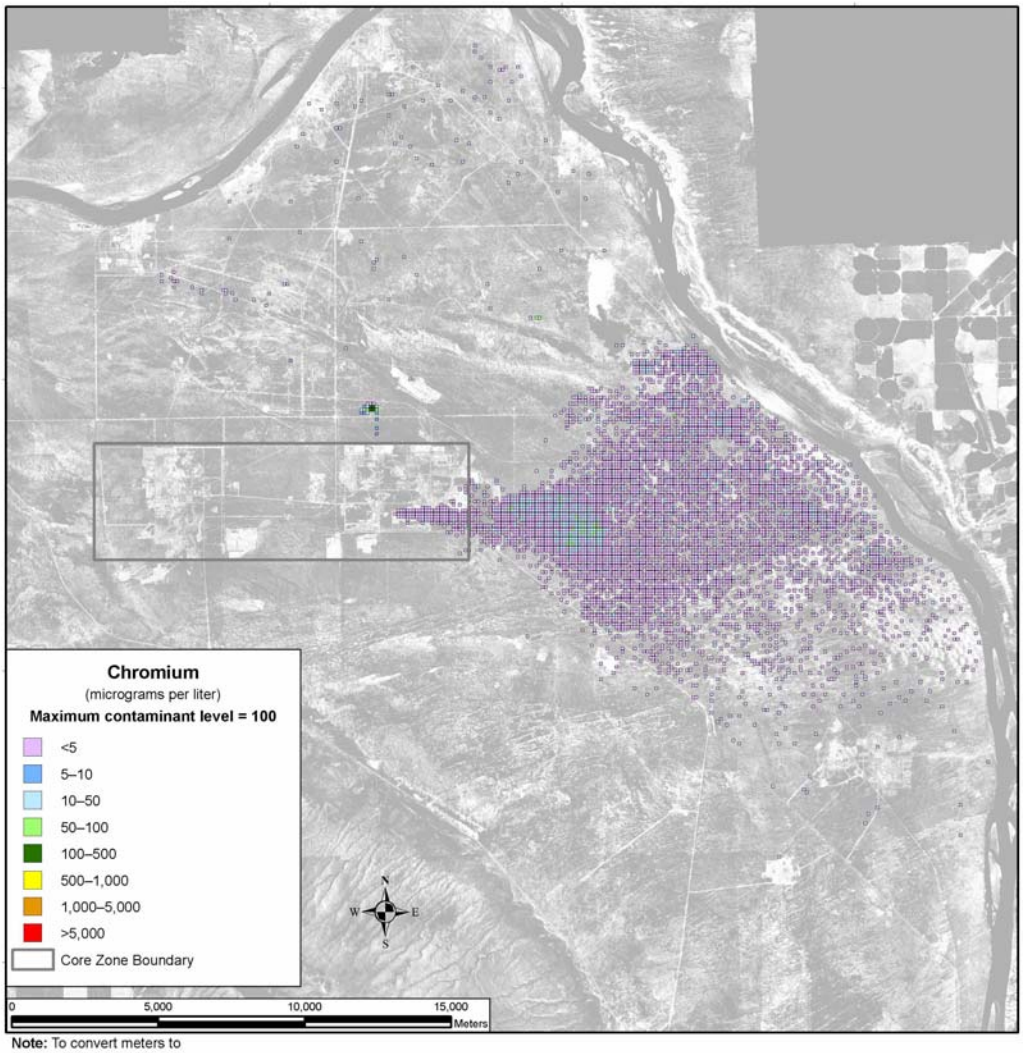
Note: To convert meters to feet, multiply by 3.281

Figure 5–510. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



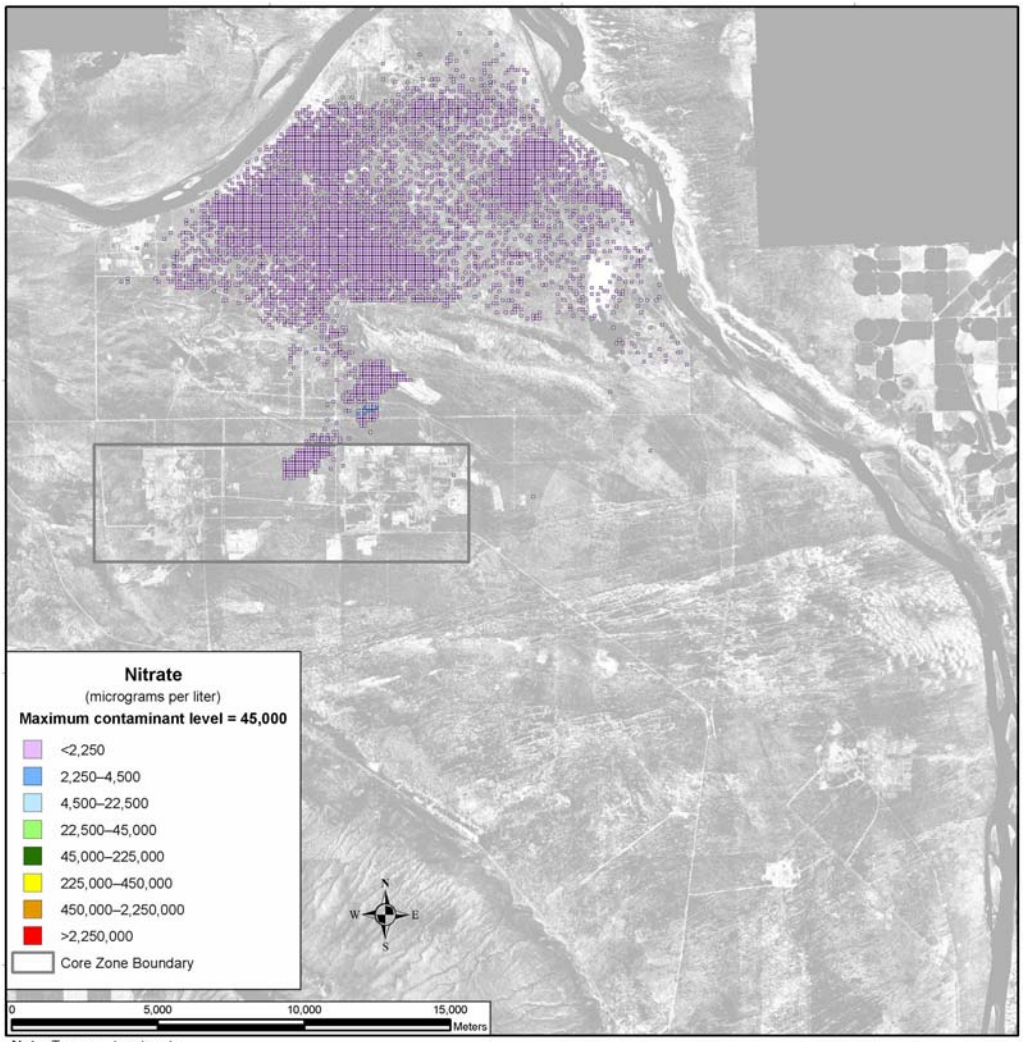
Note: To convert meters to feet, multiply by 3.281

Figure 5–511. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



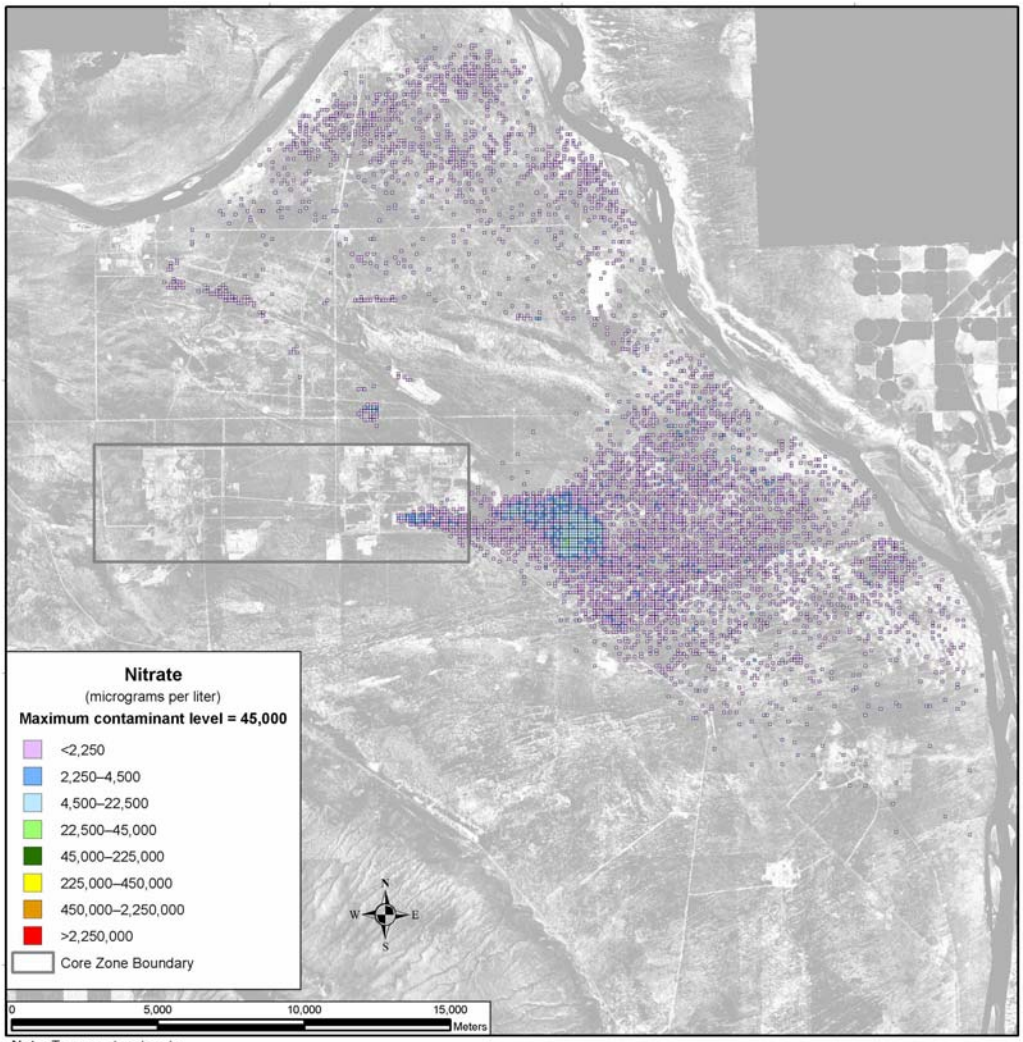
Note: To convert meters to feet, multiply by 3.281

Figure 5–512. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



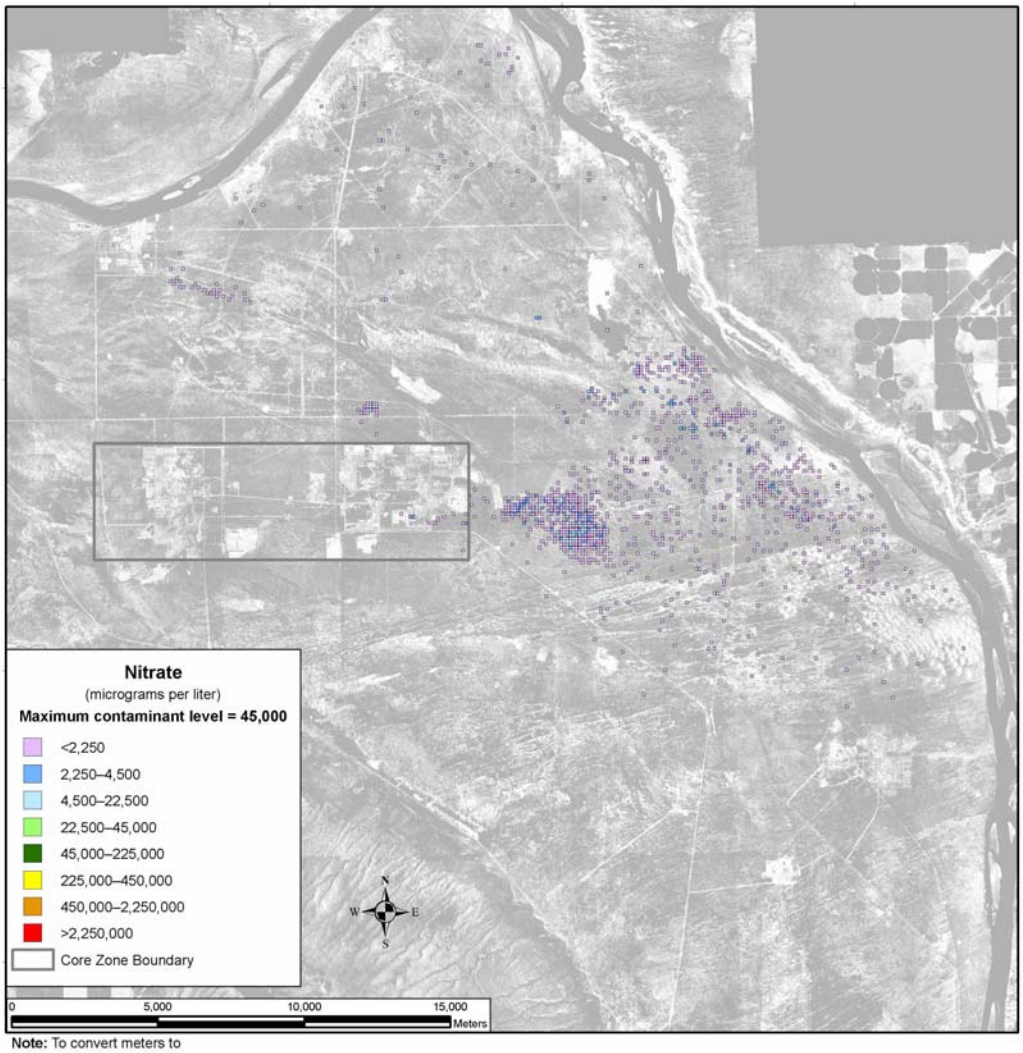
Note: To convert meters to feet, multiply by 3.281

Figure 5–513. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



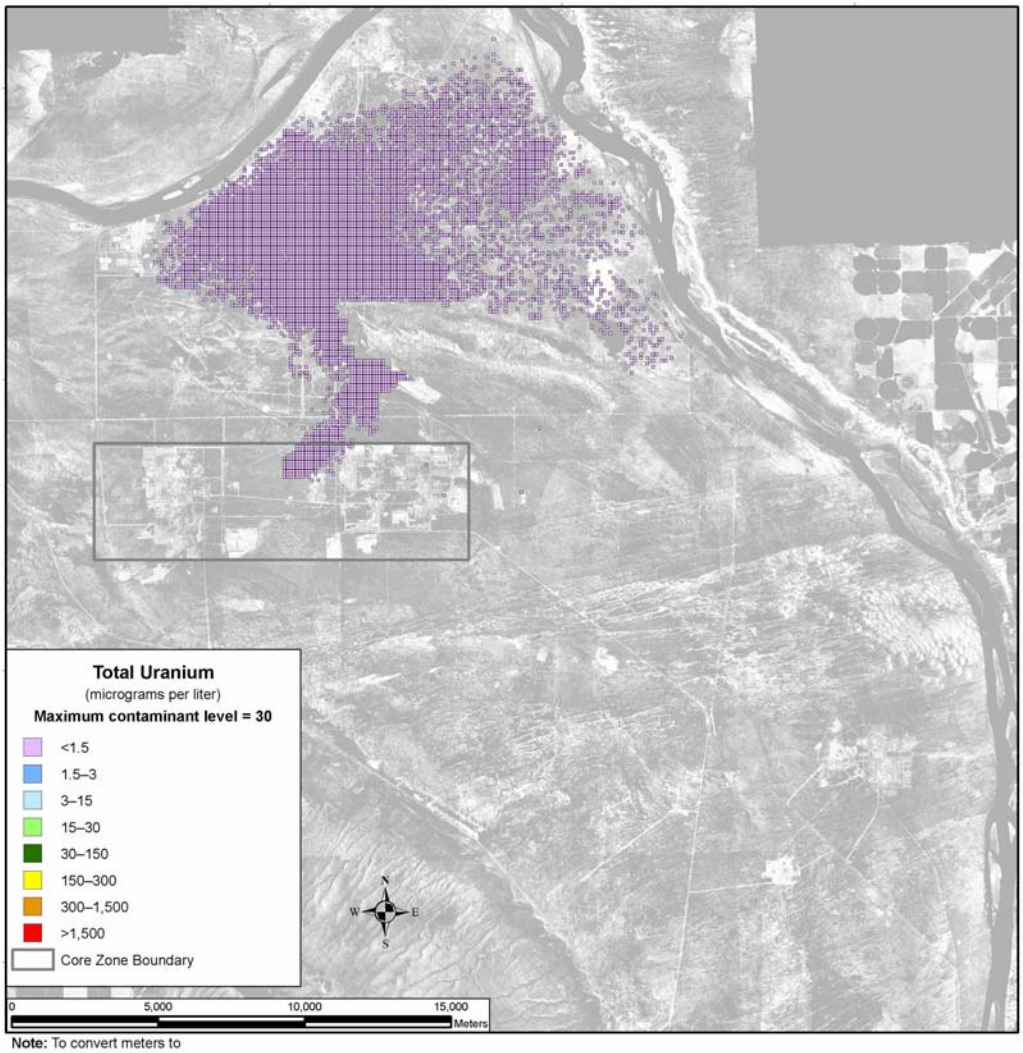
Note: To convert meters to feet, multiply by 3.281

Figure 5–514. Waste Management Alternative 2, 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 5–515. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–516. Waste Management Alternative 2, 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 2, Disposal Group1, Subgroup 1-E, in general, the inventories remaining at both IDF-East and the RPPDF, which would be 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 order of magnitude during most of the period of analysis. Concentrations at the Columbia River are about one order of magnitude smaller. The intensities and areas of these groundwater plumes peak between CYs 7140 and 11,885.

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.

5.3.1.2.1.6 Disposal Group 1, Subgroup 1-F

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-F covers disposal of Tank Closure Alternative 5, FFTF Decommissioning Alternative 3, and onsite and offsite waste. Waste would be converted to IHLW, ILAW glass, bulk vitrification glass, and cast stone waste. IHLW would be stored on site, while ILAW glass, bulk vitrification glass, and cast stone waste would be disposed of at IDF-East.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E, as follows:

- The disposal period was assumed to start with the onset of disposal operations for IDF-East in CY 2009 and continue through CY 2050, when the disposal facility would be operationally closed and postclosure care would cease. During the disposal period the materials in this permitted, operational facility is not available for release to the environment. The RPPDF is not constructed and operated for this subgroup.

- 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 become available for release to the environment, and modified RCRA Subtitle C barrier would be emplaced over IDF-East to limit infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F. Complete results for all 40 COPCs are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2, 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 2, 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 2, Disposal Group 1, Subgroup 1-F.

The COPC drivers that are discussed in detail in this section (iodine-129, technetium-99, acetonitrile, 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 2, Disposal Group 1, Subgroup 1-F, in terms of the total amounts of radionuclide and chemical COPCs released to the vadose zone,

groundwater, and Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms (see Figures 5–517 through 5–522). 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 5–517 shows the estimated release to the vadose zone for the radiological risk drivers and Figure 5–518, the chemical hazard drivers. The COPC inventories in the waste forms are a major factor in the release quantities of a COPC to the vadose zone. The predominant source of technetium-99 is cast stone waste (60 percent), followed by offsite-generated waste (28 percent) and bulk vitrification glass (9 percent). Most of the iodine-129 (87 percent) is released from offsite-generated waste, followed by ETF-generated secondary waste (12 percent). All of the fluoride and boron are released by waste management secondary waste and onsite-generated waste. All of the acetonitrile is released by cast stone waste. The predominant source for chromium (78 percent) is sulfate grout, with some from cast stone waste (22 percent). The sources of nitrate are ETF-generated secondary waste (57 percent) and cast stone waste (43 percent).

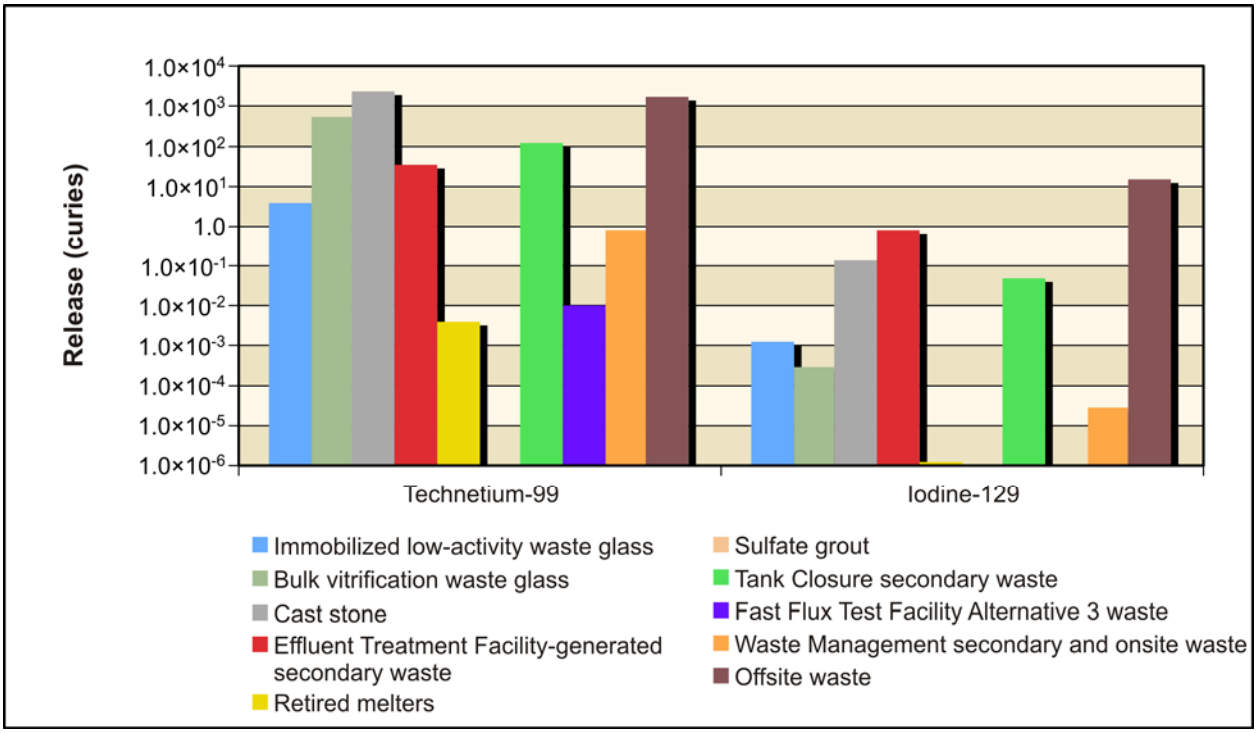


Figure 5–517. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

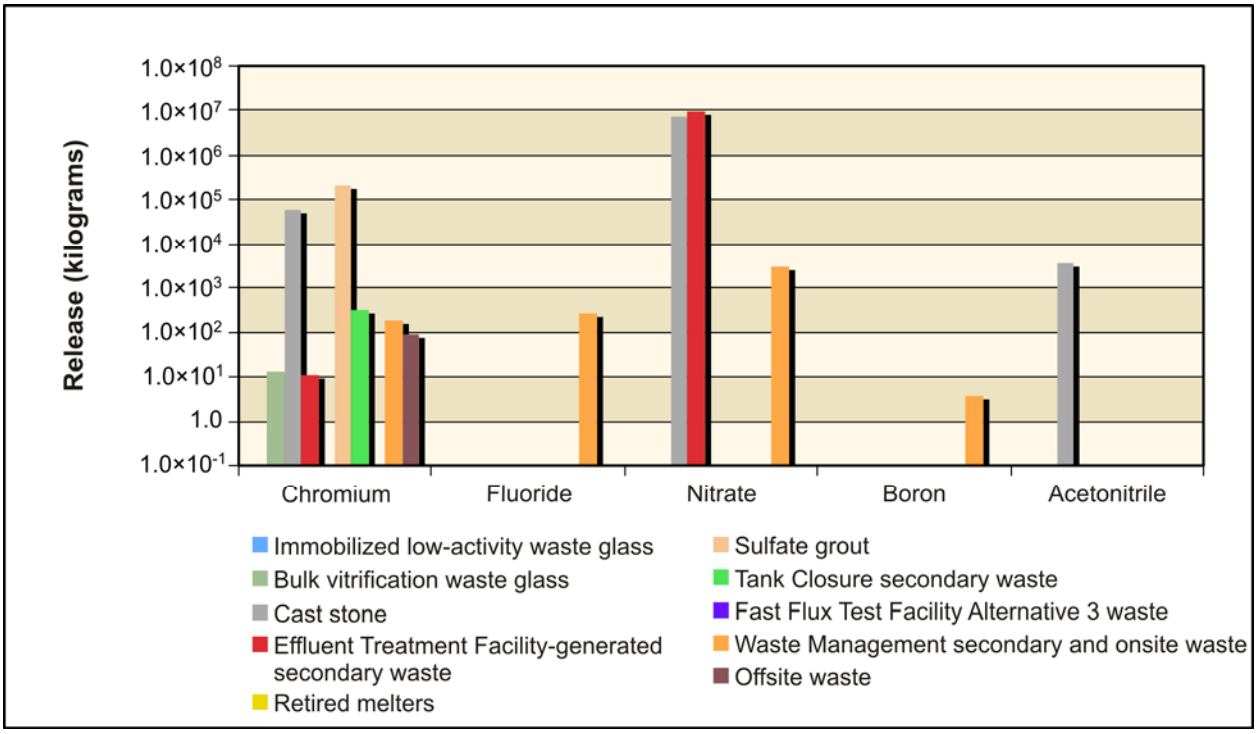


Figure 5–518. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–519 shows the estimated release to groundwater for the radiological risk drivers and Figure 5–520, 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 chromium, nitrate, fluoride, boron, and acetonitrile from the vadose zone are released to groundwater during the period of analysis. About 63 percent of the technetium-99 released to the vadose zone reached the groundwater in the analysis; about 92 percent of the iodine-129 reached the groundwater.

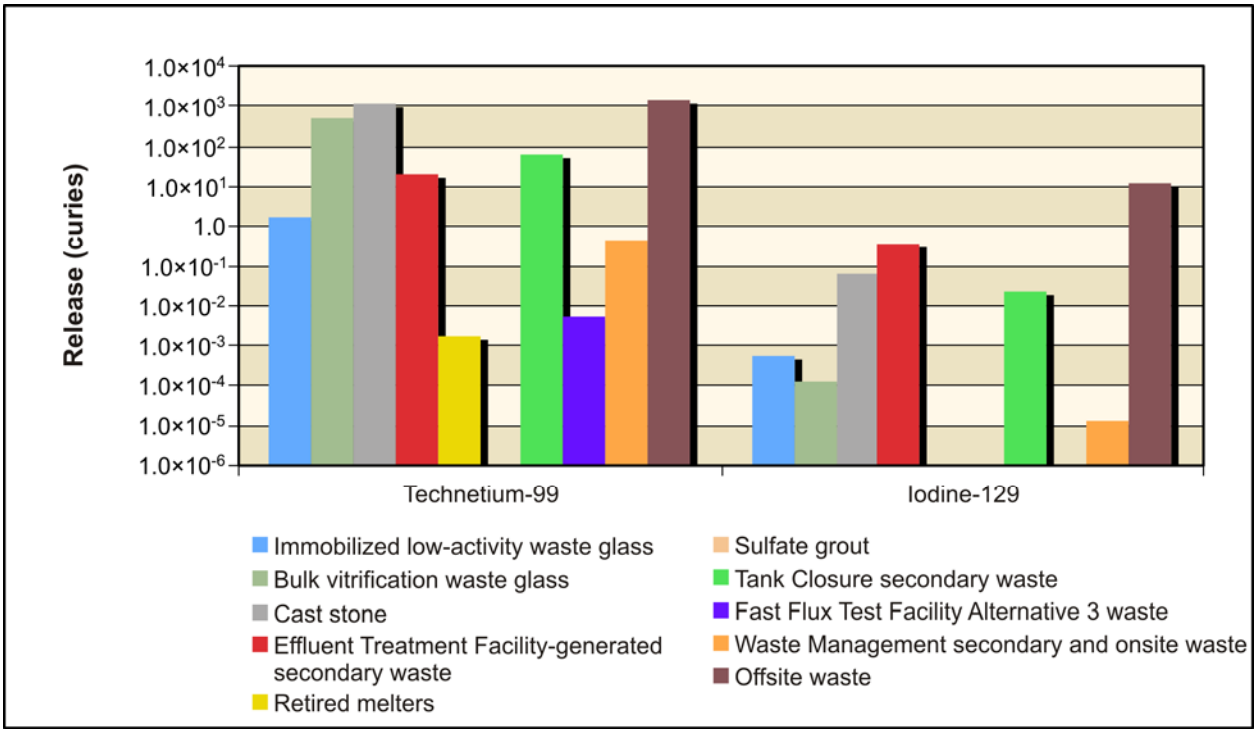


Figure 5–519. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

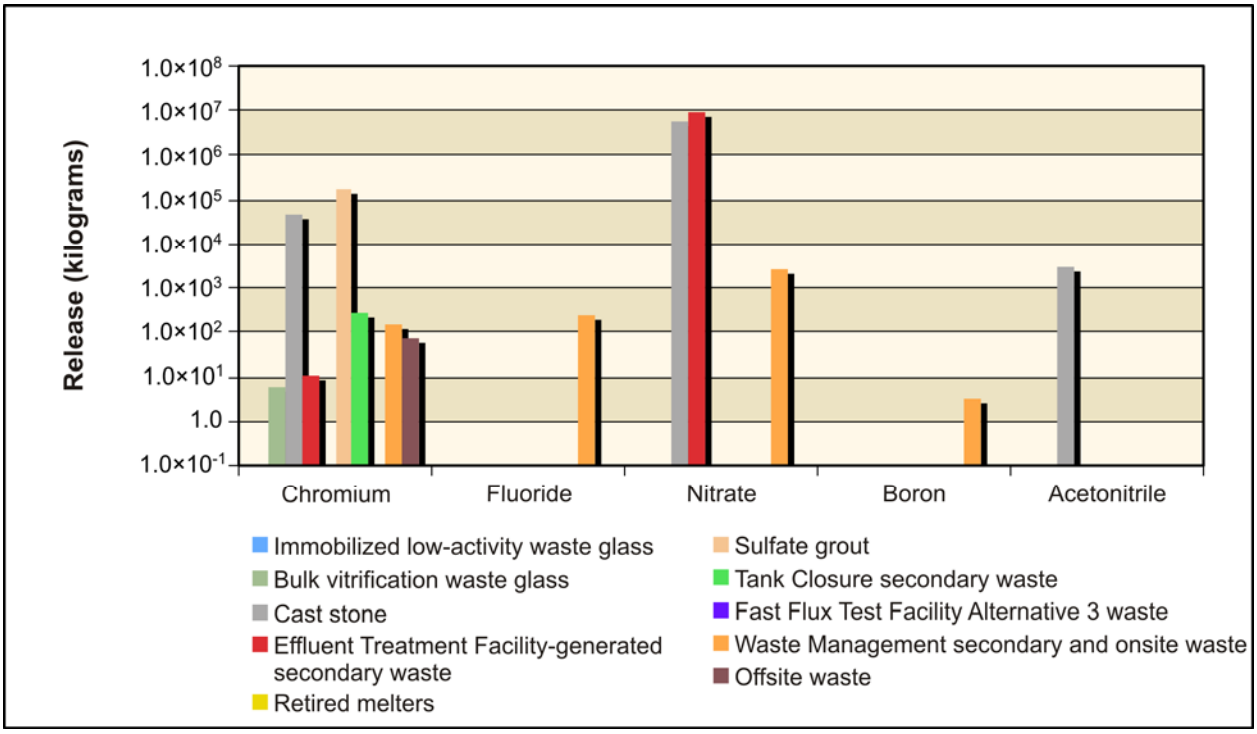


Figure 5–520. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–521 shows the estimated release to the Columbia River for the radiological risk drivers and Figure 5–522, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPCs. All of the groundwater technetium-99, iodine-129, chromium, nitrate, fluoride, boron, and acetonitrile, are released to the Columbia River.

Overall, about 60 percent of the vadose zone technetium-99 and 90 percent of the iodine-129 reached the Columbia River within the time period of this analysis. About 96 to 98 percent of the vadose zone chromium, nitrate, fluoride, boron, and acetonitrile reached the Columbia River during the period of analysis. No uranium-238 or total uranium is released to the groundwater or Columbia River.

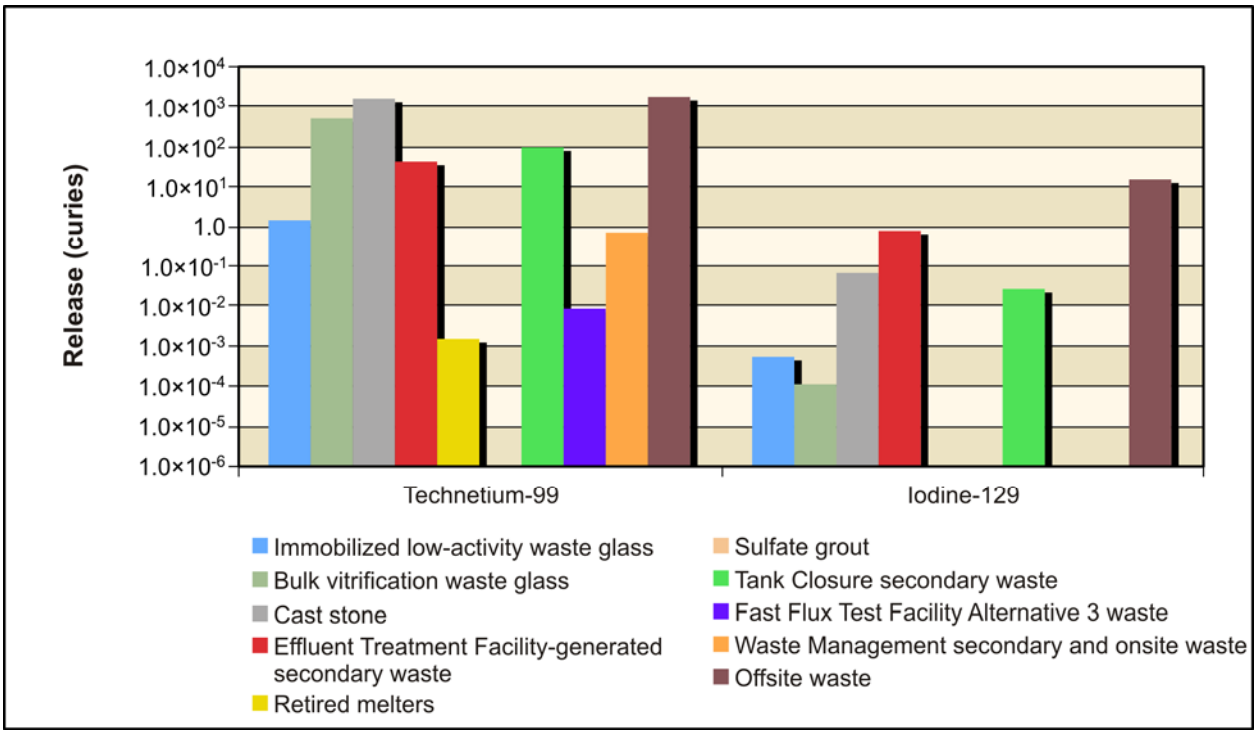


Figure 5–521. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

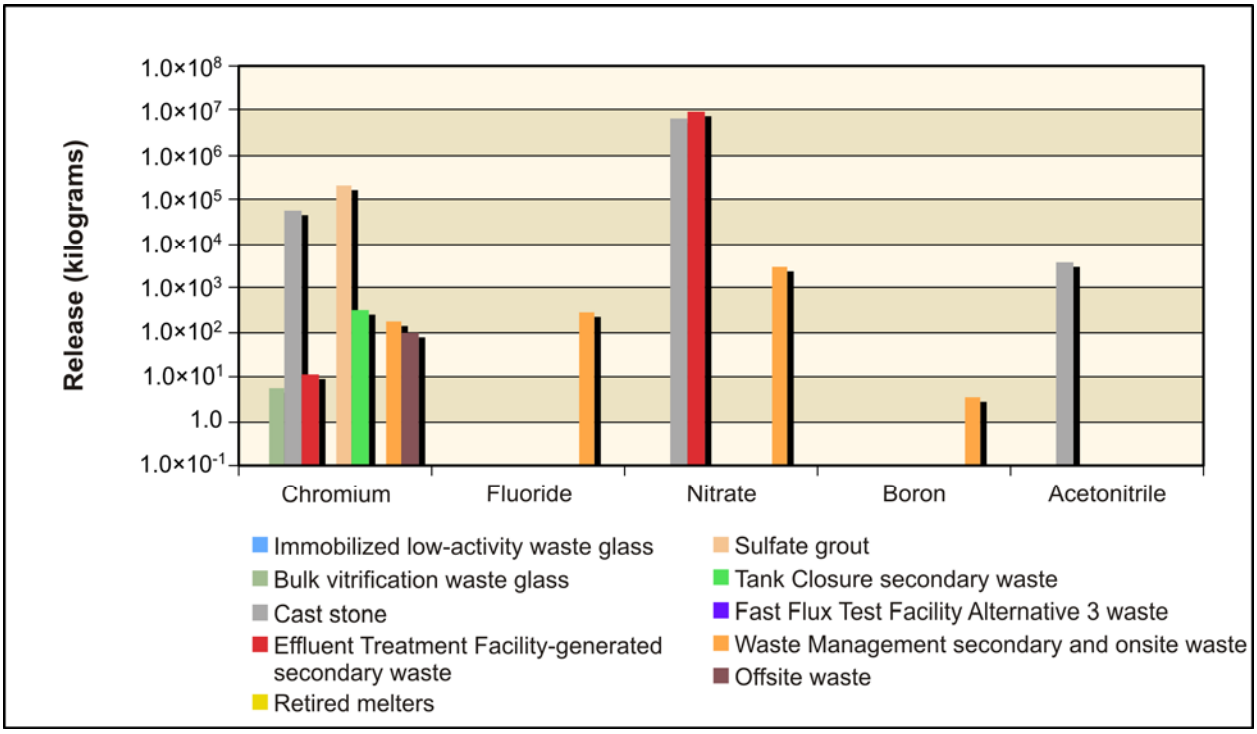


Figure 5–522. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River. In the concentration versus time graphs, the concentrations of radionuclides are in picocuries per liter, chemicals in micrograms per liter. The benchmark concentration is also shown for each radionuclide and chemical. 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 5–82 gives the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Table 5–82. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**3,510**	N/A	**1,500**	891	900
	(8276)		(9155)	(8090)	
Iodine-129	**18**	N/A	**8**	**7**	1
	(8195)		(8858)	(8699)	
Chemical in micrograms per liter					
Acetonitrile	5	N/A	2	1	100
	(8475)		(9519)	(8575)	
Chromium	**335**	N/A	**148**	**110**	100
	(8735)		(8764)	(8819)	
Fluoride	0	N/A	1	0	4,000
	(8035)		(7258)	(8913)	
Nitrate	21,400	N/A	7,420	4,560	45,000
	(8448)		(8887)	(8787)	

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

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; N/A=not applicable; RPPDF=River Protection Project Disposal Facility.

Figures 5–523 through 5–526 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. During the latter part of the analysis time period, the groundwater concentrations of iodine-129 from IDF-East exceed the benchmark concentrations at both the Core Zone Boundary and the Columbia River nearshore (see Figure 5–523). However, the concentrations of iodine-129 are never more than one order of magnitude above the benchmark concentration level. The concentrations of technetium-99 and chromium (see Figures 5–524 and 5–525) approach but never exceed their benchmark concentrations. The concentration of nitrate always remains at least one order of magnitude less than its benchmark concentration (see Figure 5–526).

There are no detectable releases of either uranium-238 or total uranium to the environment over this analysis period.

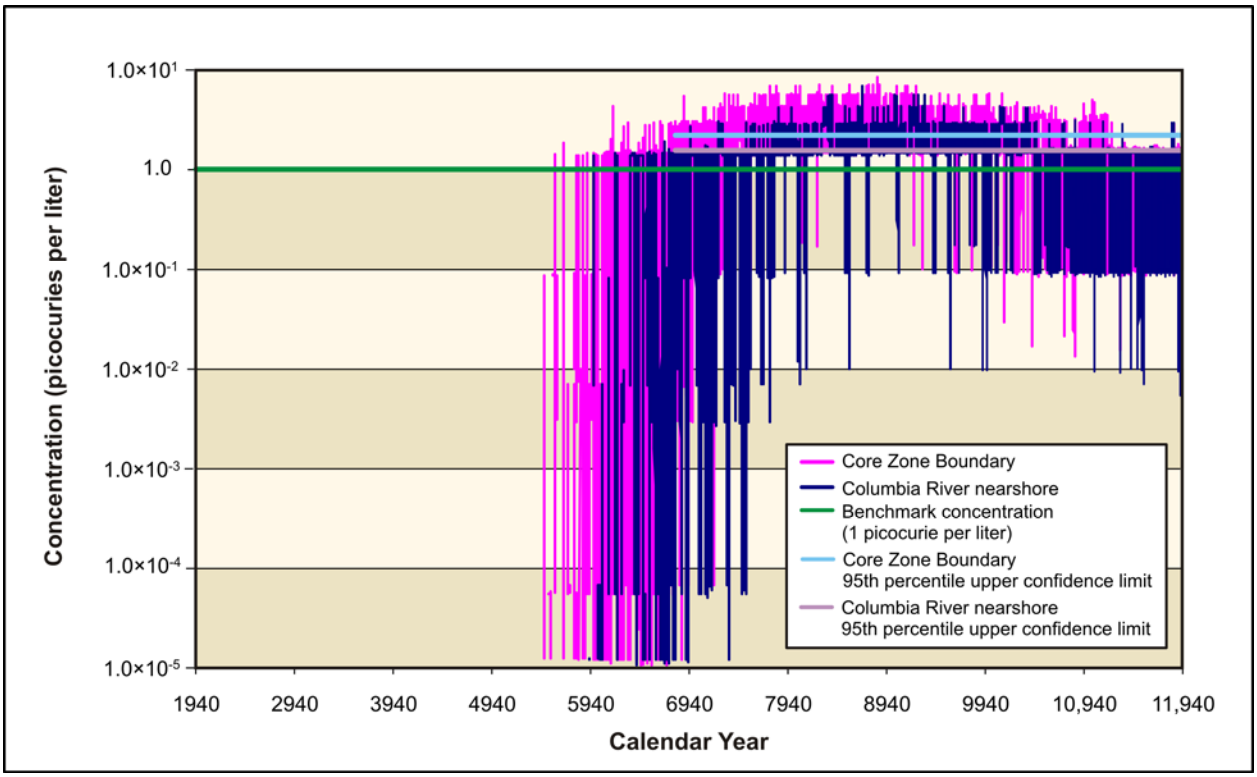


Figure 5–523. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Iodine-129 Concentration Versus Time

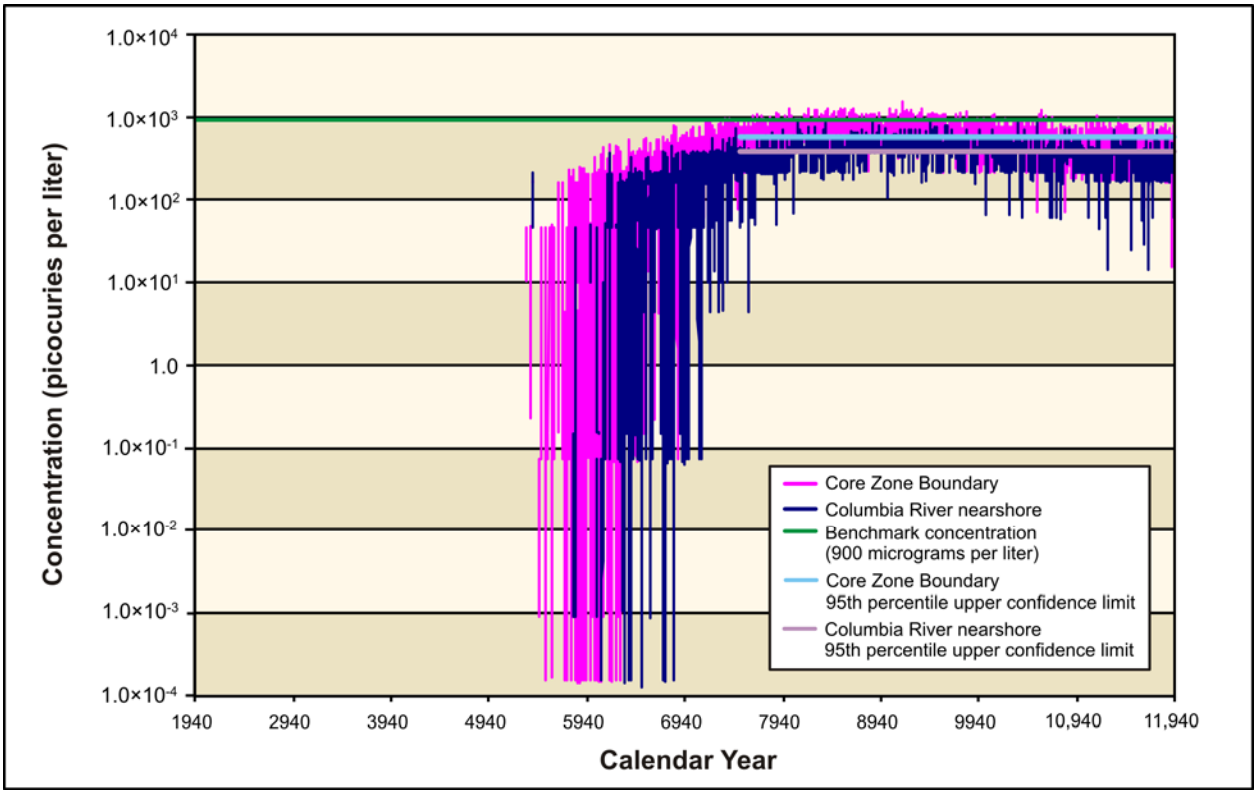


Figure 5–524. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Technetium-99 Concentration Versus Time

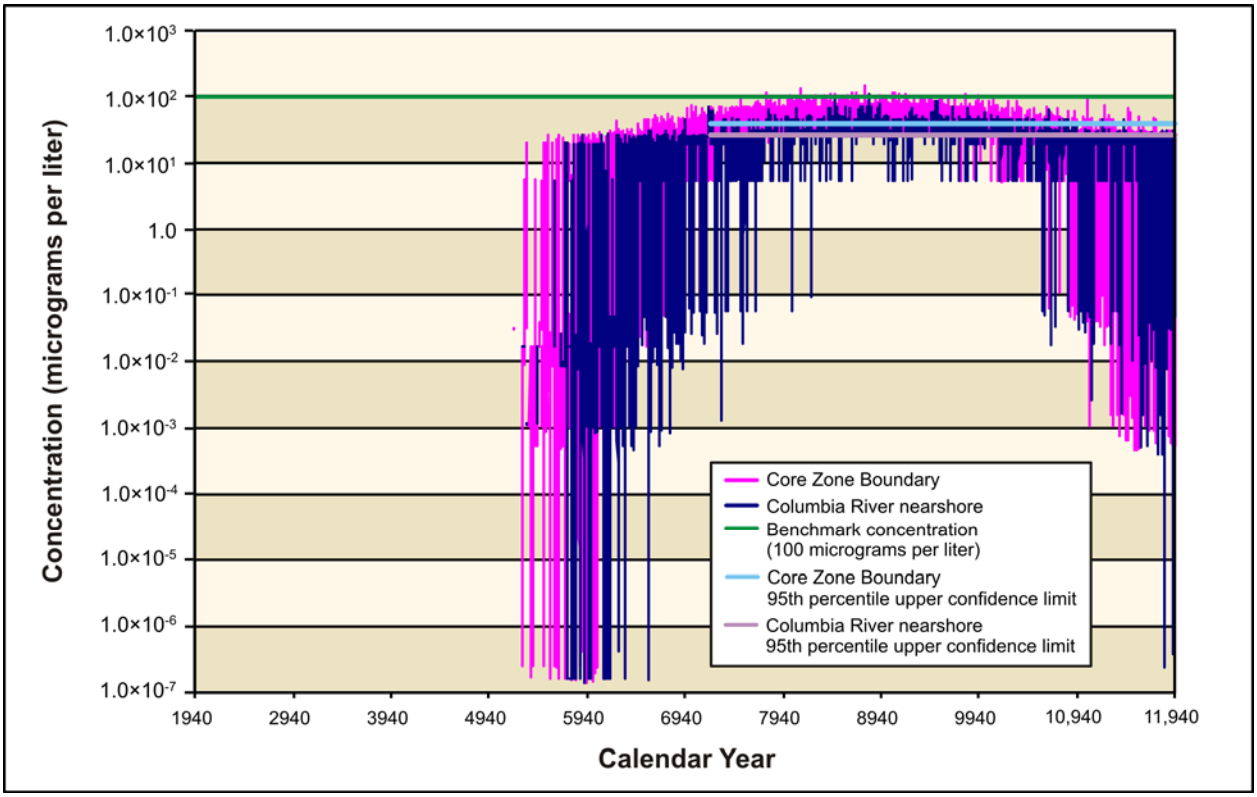


Figure 5–525. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Chromium Concentration Versus Time

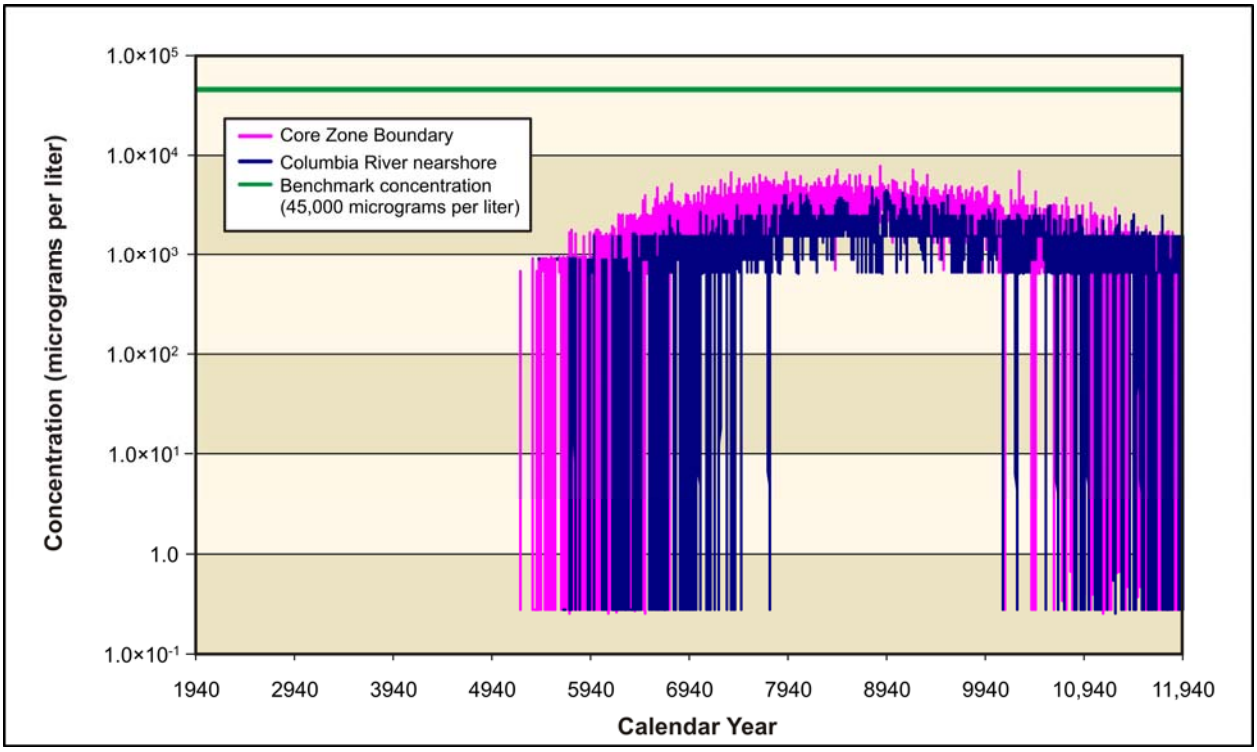


Figure 5–526. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Nitrate Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

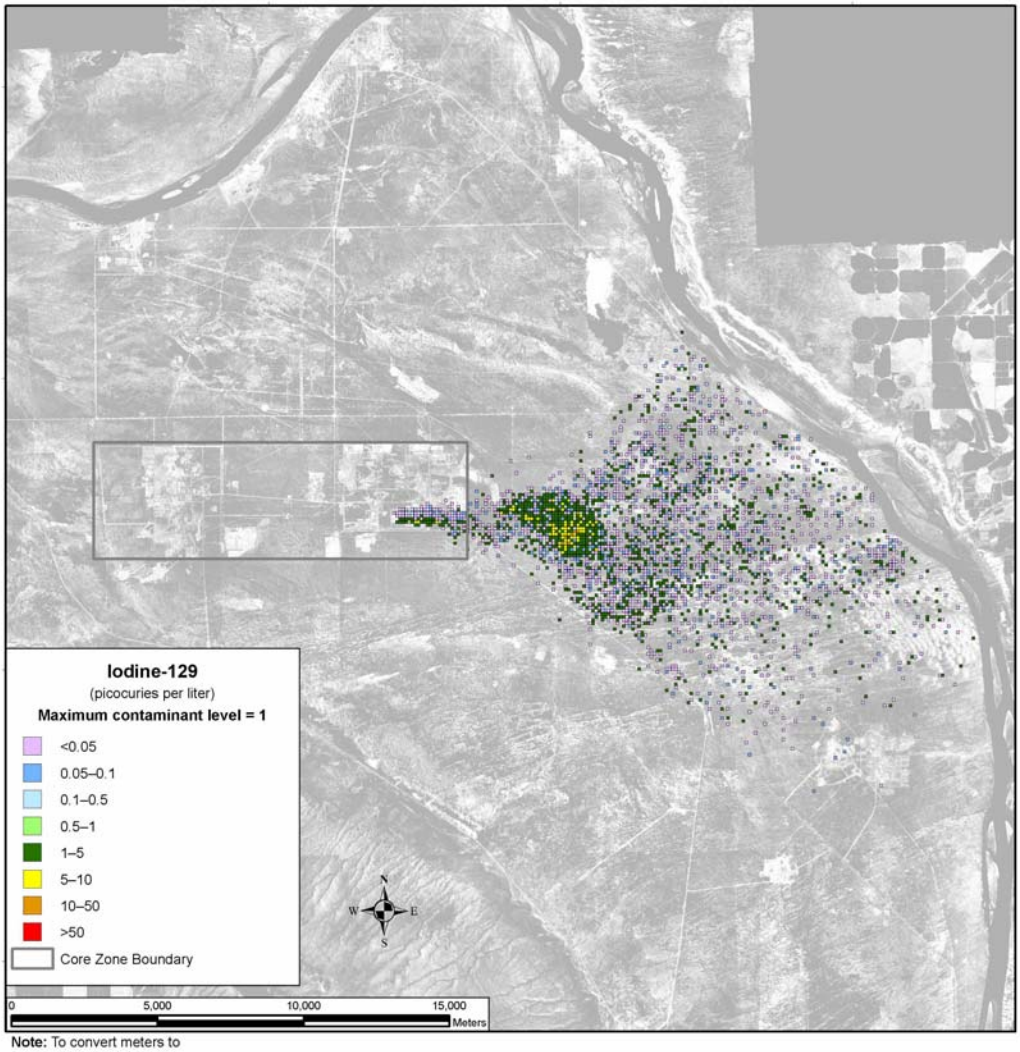
This section presents the impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, in terms of the spatial distribution of groundwater concentration at selected times in this analysis period. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–527 through 5–534). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Figures 5–527 through 5–534 show groundwater releases that extend from the east edge of the Core Zone Boundary to the Columbia River. The iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity). Releases from IDF-East result in groundwater concentrations that extend from the release source east to the Columbia River. For each map, the concentrations that are 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. The concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

All plumes from IDF-East releases are initially contained in a narrow area moving eastward until they reach about one-third of the distance to the Columbia River nearshore boundary, where they spread out significantly and continue to the Columbia River. Figures 5–527 and 5–528 show the spatial distribution of iodine-129 groundwater concentration for CYs 7140 and 11,885, respectively. The CY 7140 data show that a release from IDF-East creates a plume outside of the east boundary between the Core Zone Boundary and the Columbia River nearshore. These data also show that there is an area east of the Core Zone Boundary where the concentration exceeds the benchmark concentration. By CY 11,885 (see Figure 5–528), the plume mass has continued to spread out and is still moving eastward toward the Columbia River. The CY 11,885 plume also shows areas where the concentrations exceed the benchmark concentration.

Figures 5–529 and 5–530 show a similar technetium-99 release moving east toward the Columbia River for CYs 7140 and 11,885. The plumes show areas where the concentration of technetium-99 exceeds the benchmark concentration. The CY 11,885 data show that the chromium is dissipating, but high-concentration areas remain.

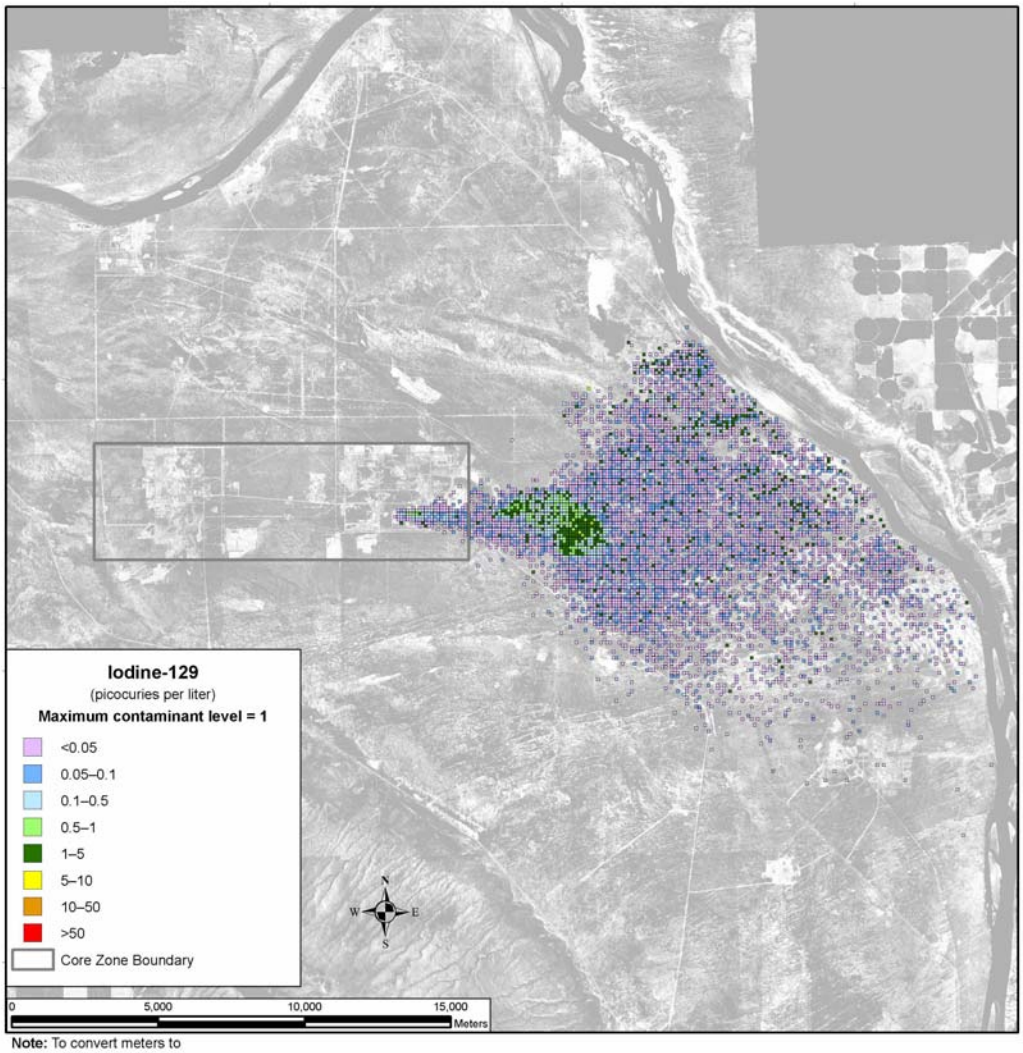
Figures 5–531 and 5–532 (CYs 7140 and 11,885 data) show a chromium plume with a small area where the concentration approaches the benchmark concentration. The CY 11,885 data show a reduced-size and reduced-concentration plume compared with the CY 7140 plume. The CY 11,885 data also shows that the chromium concentration continues between the release source and the Columbia River, but that the distribution is dissipating.

Figures 5–533 and 5–534 show the spatial distributions of groundwater concentrations of nitrate for CYs 7140 and 11,885. The nitrate release appears to approach the benchmark concentration in a small area east of the Core Zone Boundary. The CY 11,885 data show a nitrate plume significantly reduced in both area and concentration.



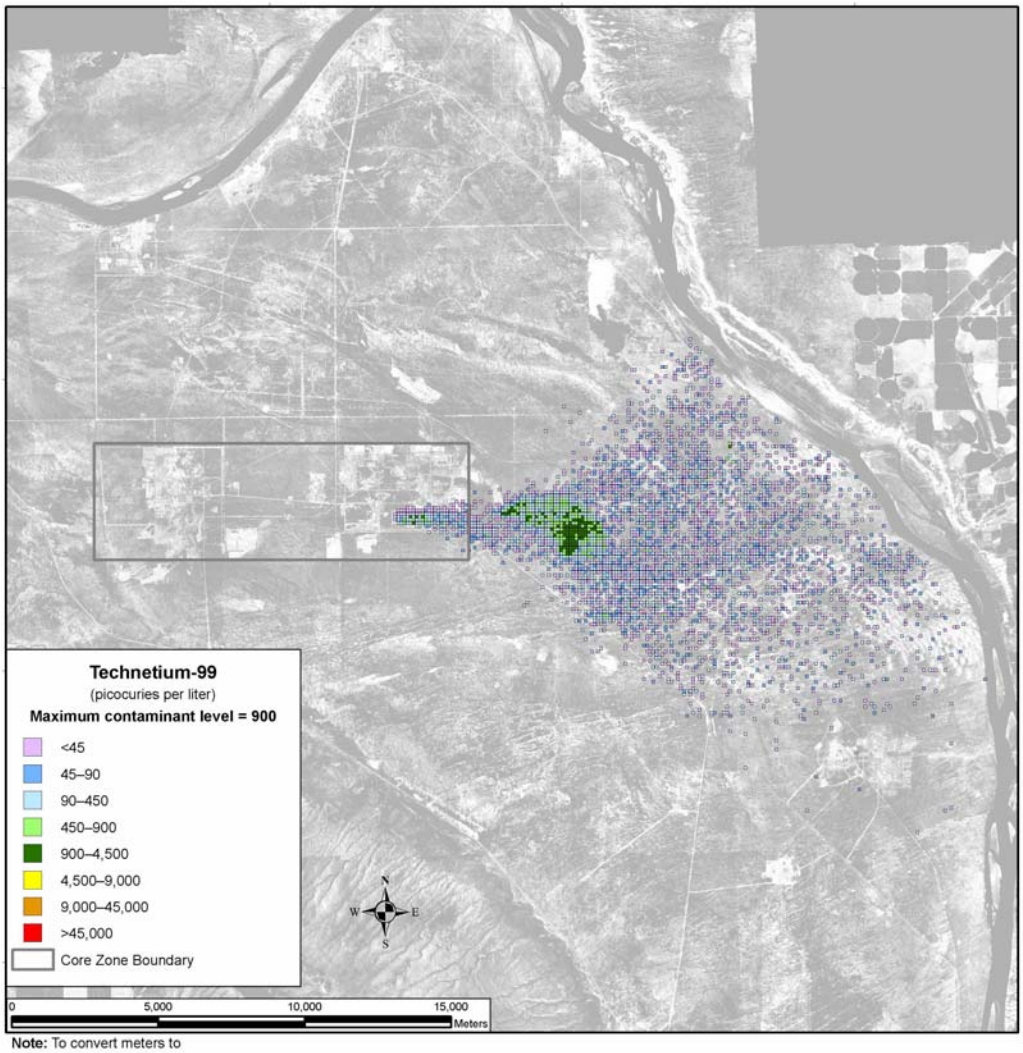
Note: To convert meters to feet, multiply by 3.281

Figure 5–527. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



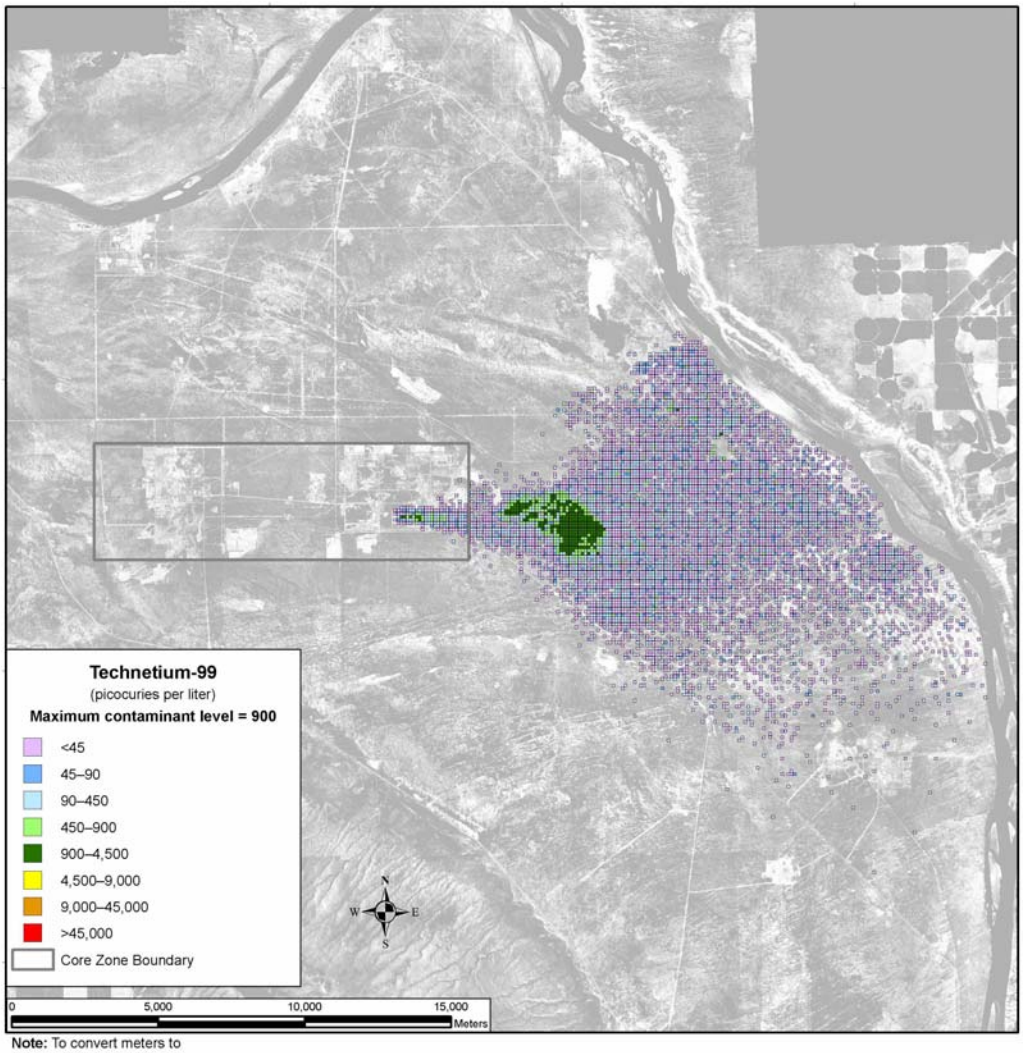
Note: To convert meters to feet, multiply by 3.281

Figure 5–528. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



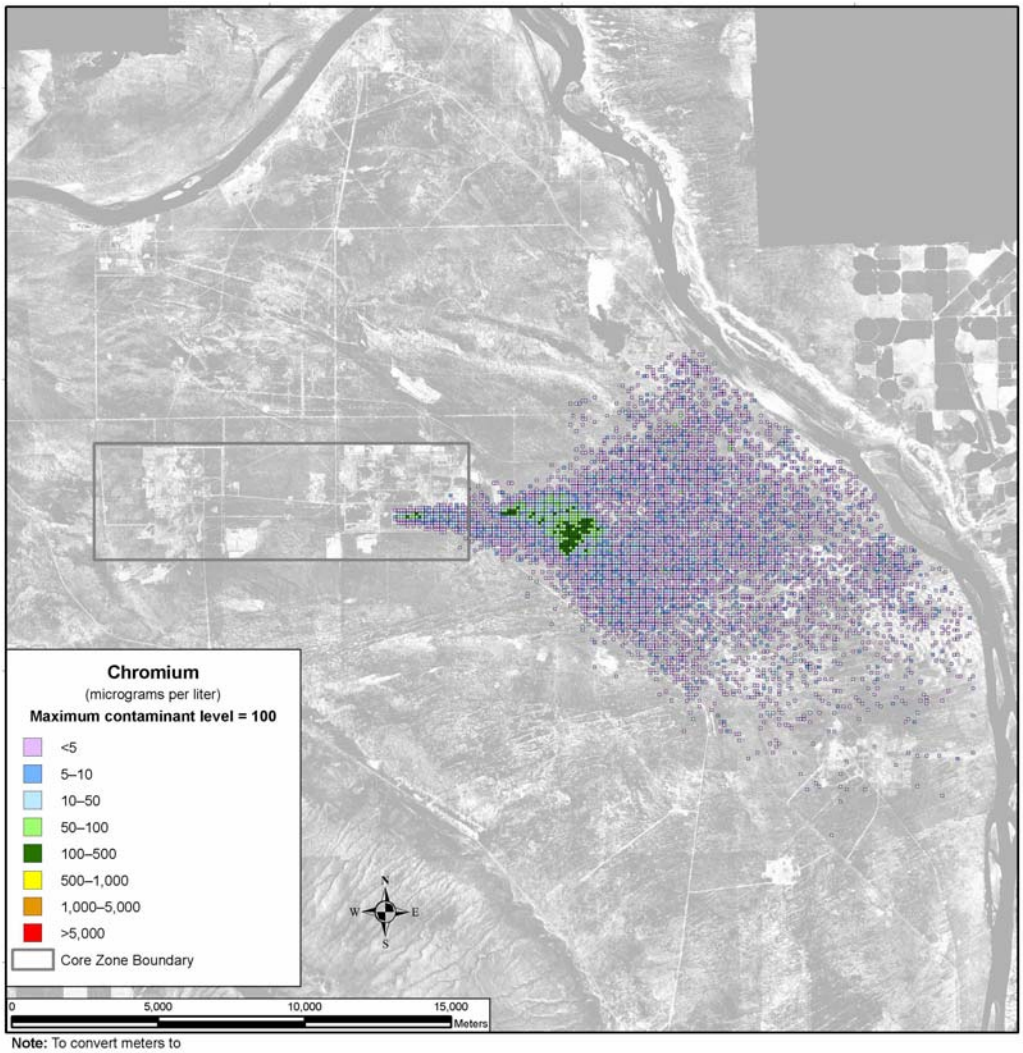
Note: To convert meters to feet, multiply by 3.281

Figure 5–529. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



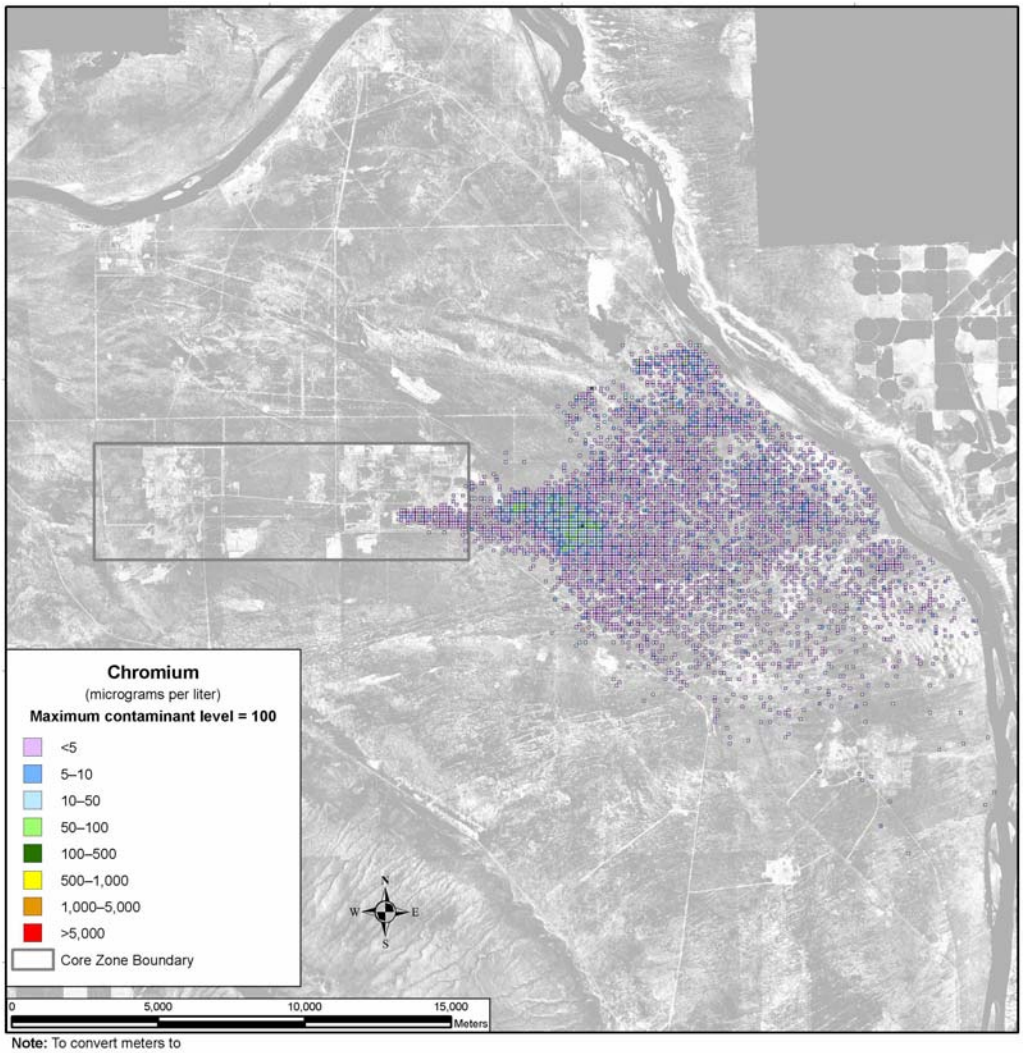
Note: To convert meters to feet, multiply by 3.281

Figure 5–530. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



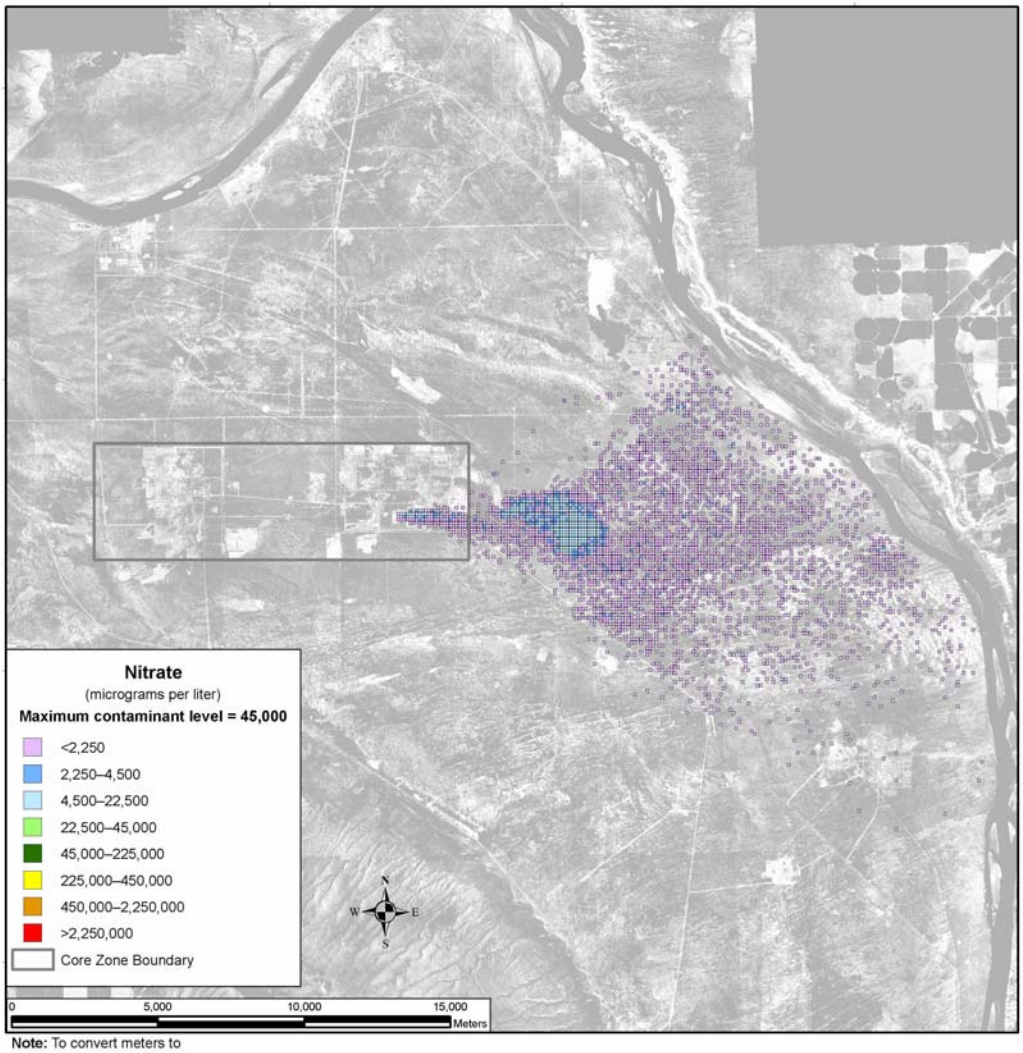
Note: To convert meters to feet, multiply by 3.281

Figure 5–531. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



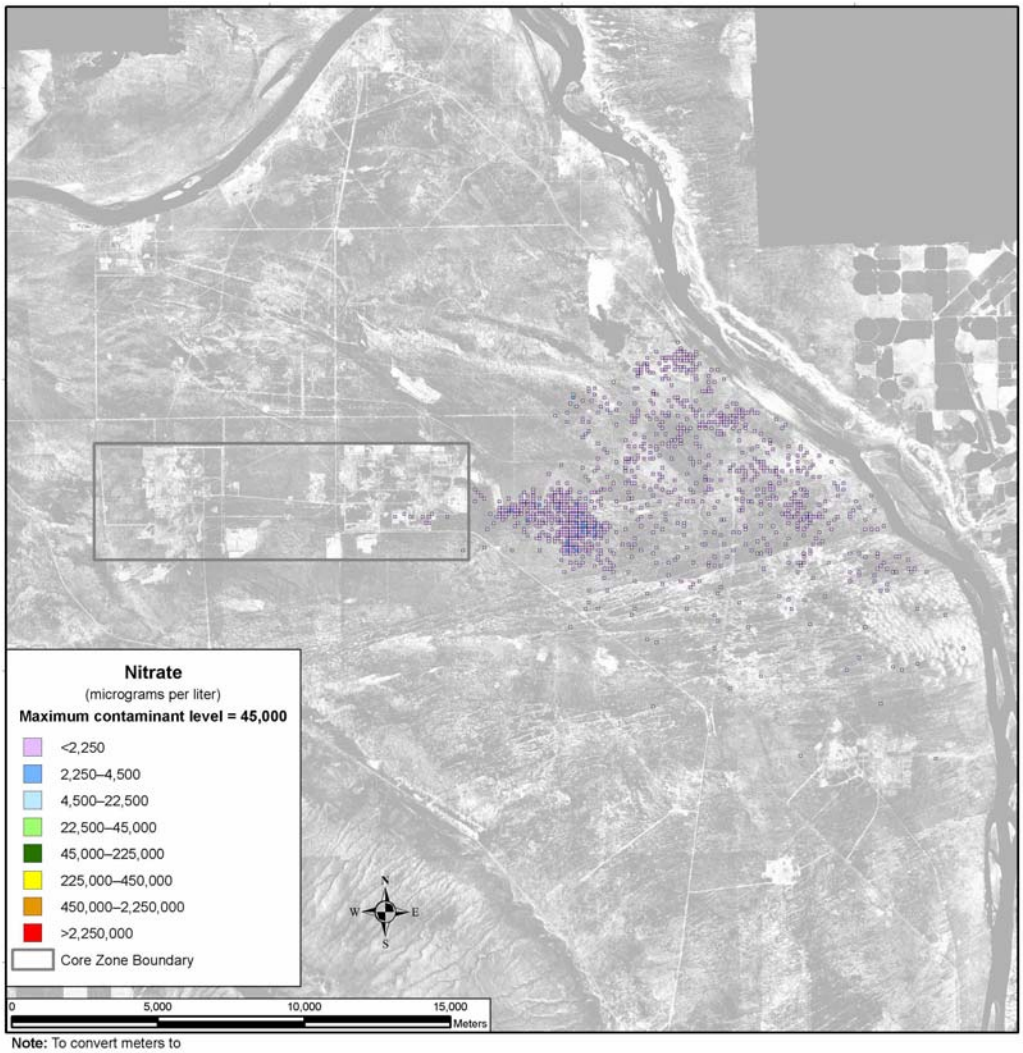
Note: To convert meters to feet, multiply by 3.281

Figure 5–532. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–533. Waste Management Alternative 2, 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 5–534. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 2, Disposal Group 1, Subgroup 1-F, in general, the predominant contributor is the iodine-129 inventory at IDF-East that is available for release to the environment at the start of the post-disposal period. The technetium-99, chromium, and nitrate concentrations do not appear to exceed benchmark standards during the period of analysis. These COPCs have concentrations at the Columbia River nearshore that are about one order of magnitude smaller than the benchmark concentrations. In general, the intensities are highest and the areas of these groundwater plumes largest between CYs 7000 and 9000, with concentrations declining through CY 11,885.

5.3.1.2.1.7 Disposal Group 1, Subgroup 1-G

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 1-G covers disposal of waste generated under Tank Closure Alternative 6C and FFTF Decommissioning Alternative 2 or 3, as well as onsite- and offsite-generated waste. Waste would be converted to IHLW and ILAW glass. IHLW would be stored on site, while ILAW glass would be disposed of at IDF-East. For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East and the RPPDF in CY 2009 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 the RPPDF would become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, IDF-East 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 2, Disposal Group 1, Subgroup 1-G. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, 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 2, 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 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 2, Disposal Group 1, Subgroup 1-G.

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 2, Disposal Group 1, Subgroup 1-G (IDF-East and RPPDF releases), in terms of the 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 Figure 5–535 through 5–546). 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 including ETF-generated secondary waste, tank closure and waste management secondary waste, FFTF Decommissioning Alternative 3 waste, and onsite- and offsite-generated waste.

Figure 5–535 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–536, 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 and iodine-129 is offsite-generated waste. For chemicals, the predominant source of chromium is tank closure secondary waste and for nitrate is offsite-generated waste. The predominant sources of fluoride and boron are waste management secondary waste and onsite-generated waste.

Figure 5–537 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–538 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, fluoride, and boron 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 90 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 5–539 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–540, 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, nitrate, fluoride, and boron the amount released to the Columbia River is essentially equal to the amount released to groundwater. Overall, about 97 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.

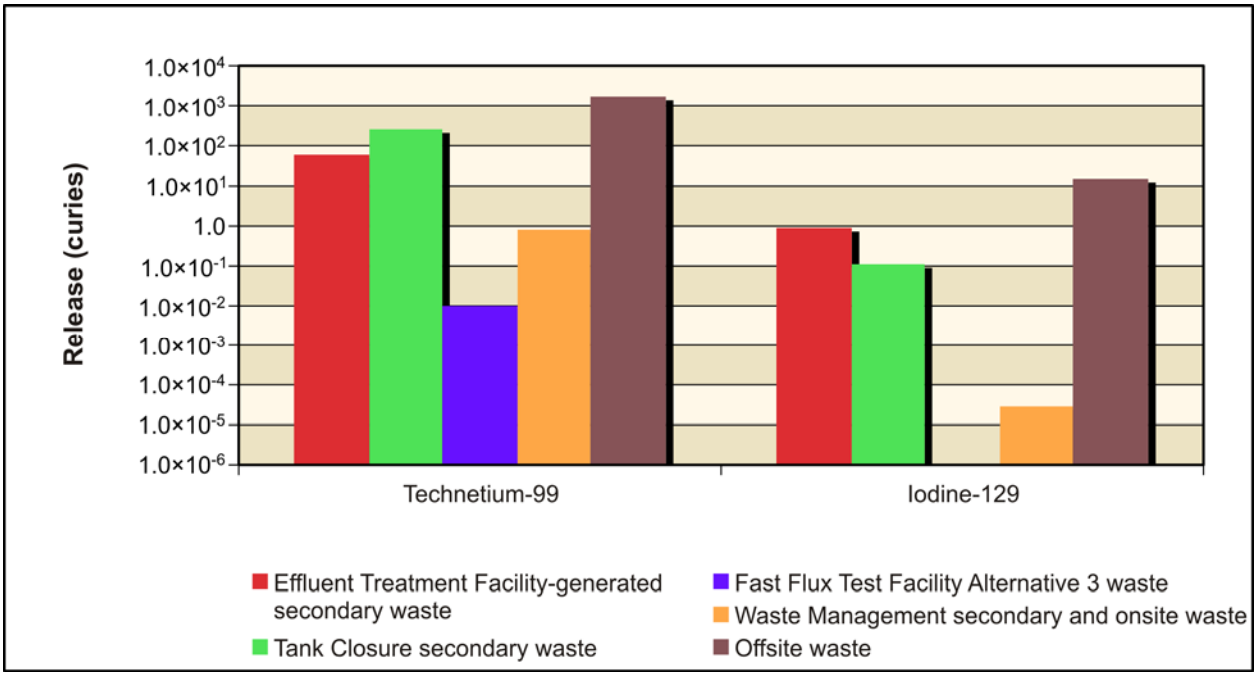


Figure 5–535. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

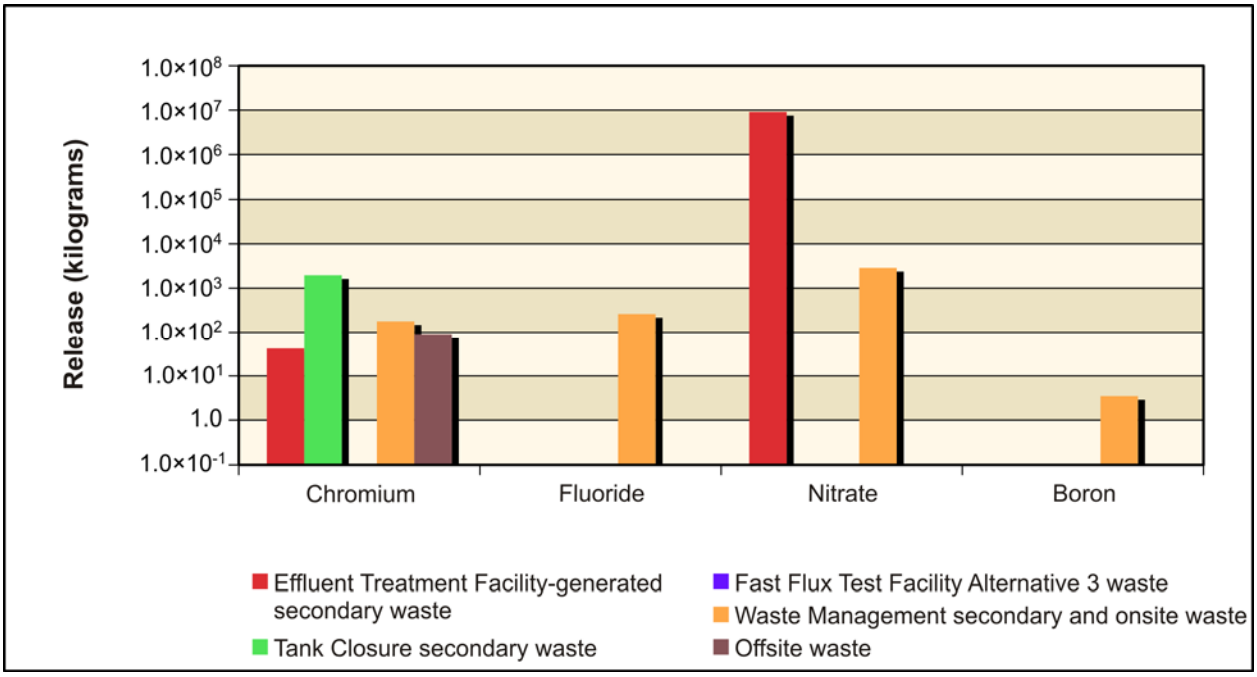


Figure 5–536. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

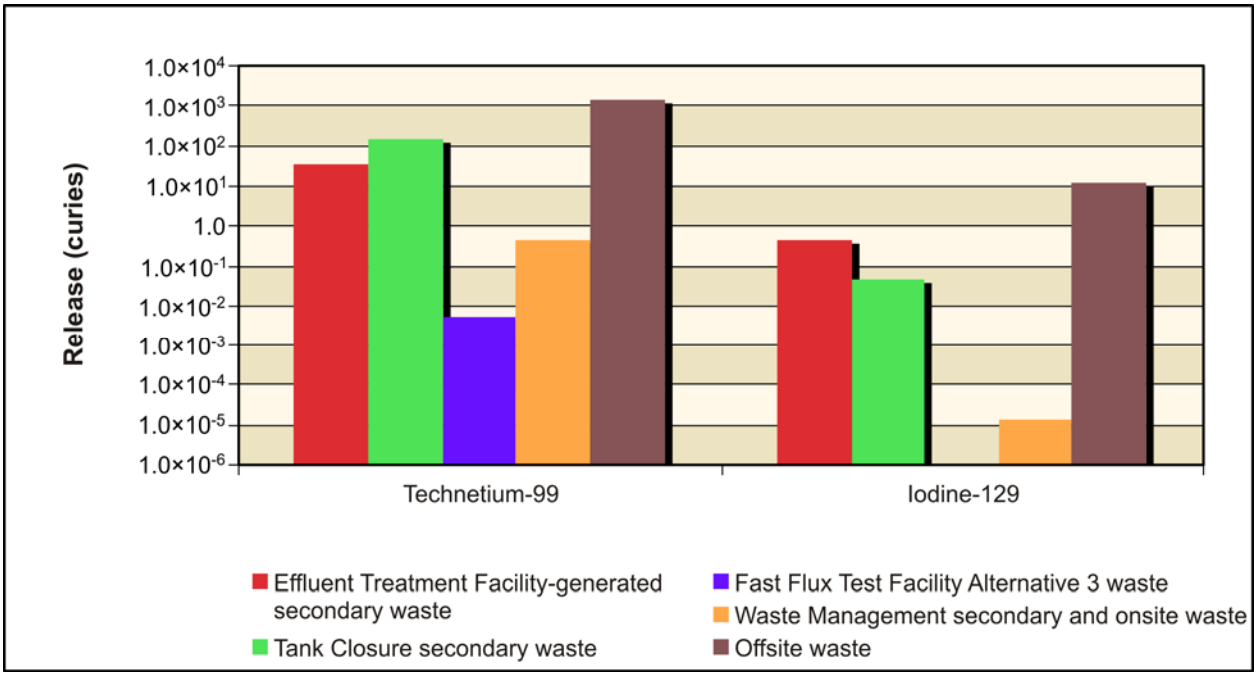


Figure 5–537. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

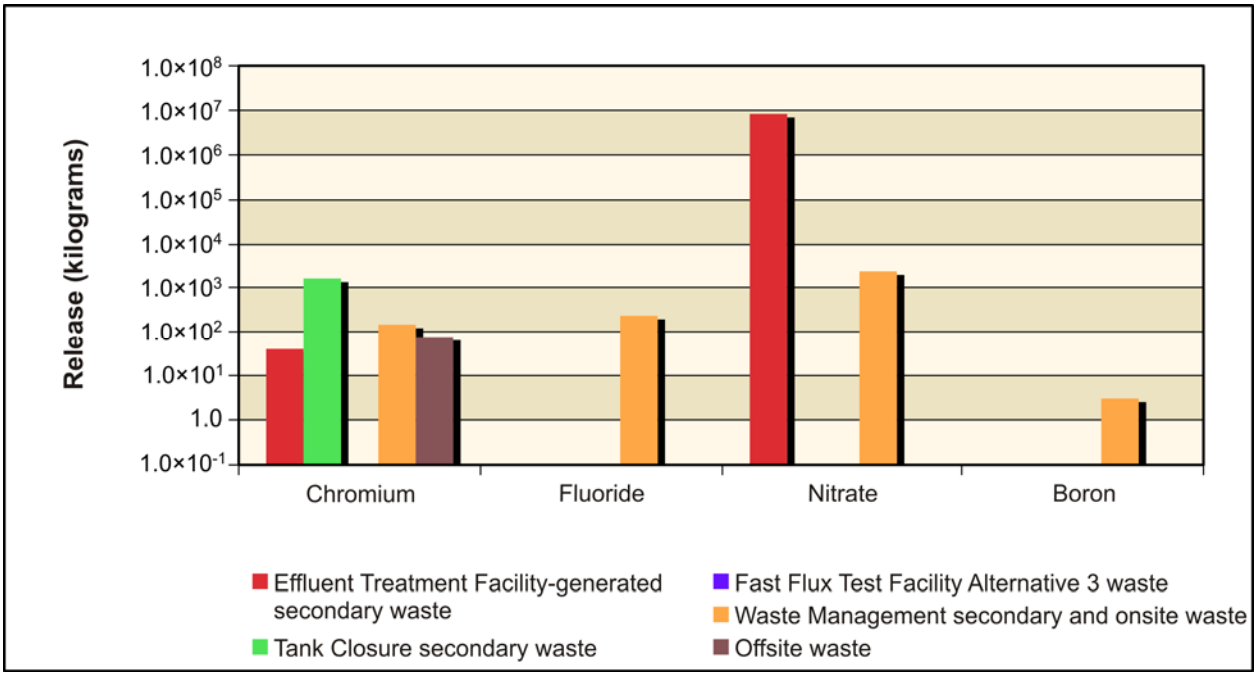


Figure 5–538. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

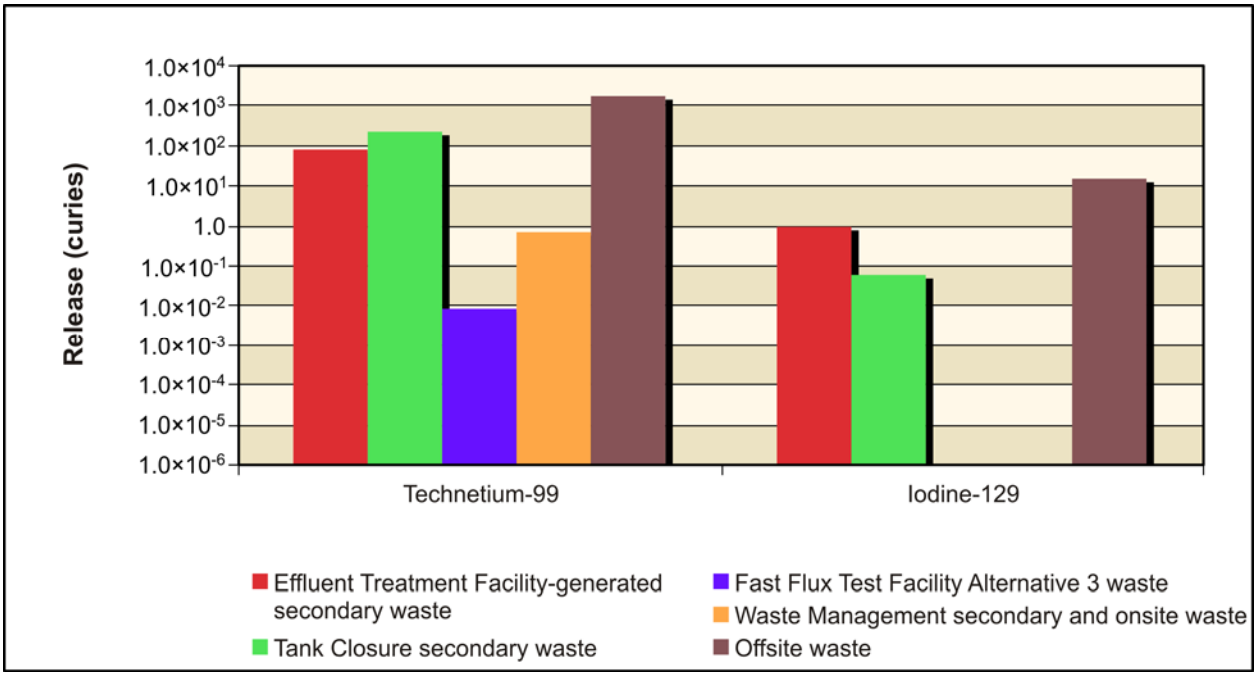


Figure 5–539. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

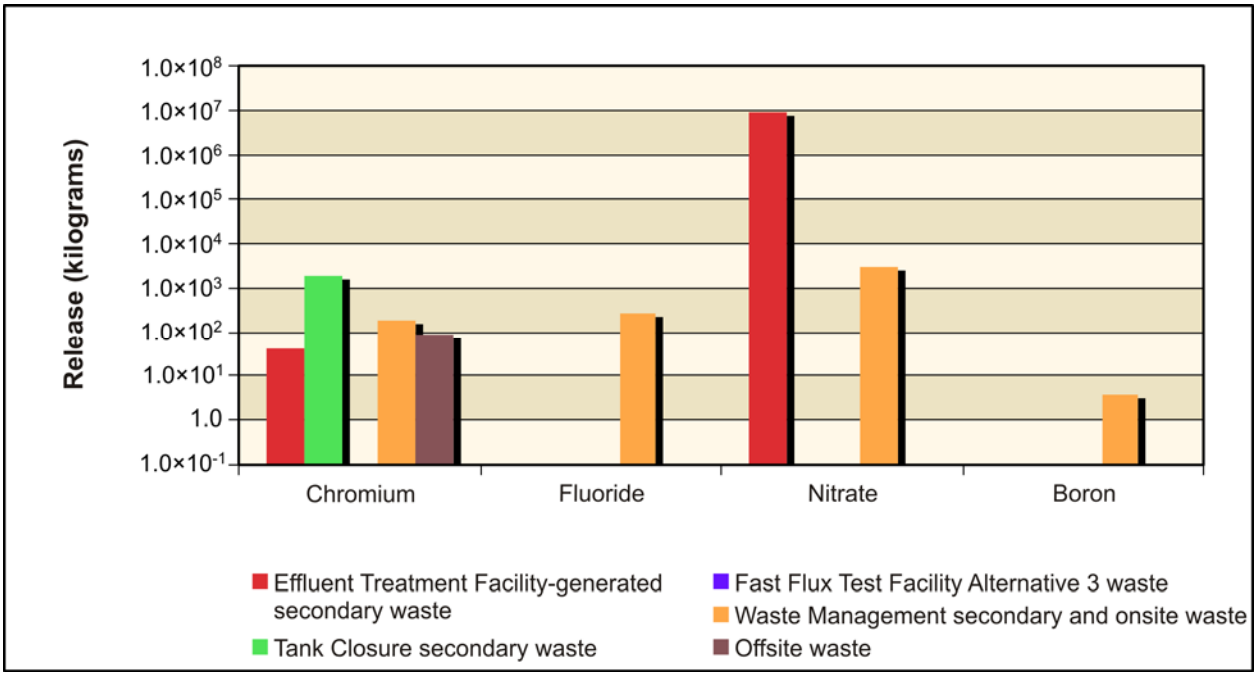


Figure 5–540. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–541 shows the estimated release at the RPPDF to the vadose zone for the radiological risk drivers and Figure 5–542, 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 5–543 shows the estimated release at the RPPDF to groundwater for the radiological risk drivers and Figure 5–544, 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 5–545 shows the estimated release at the RPPDF to the Columbia River for the radiological risk drivers and Figure 5–546, 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.

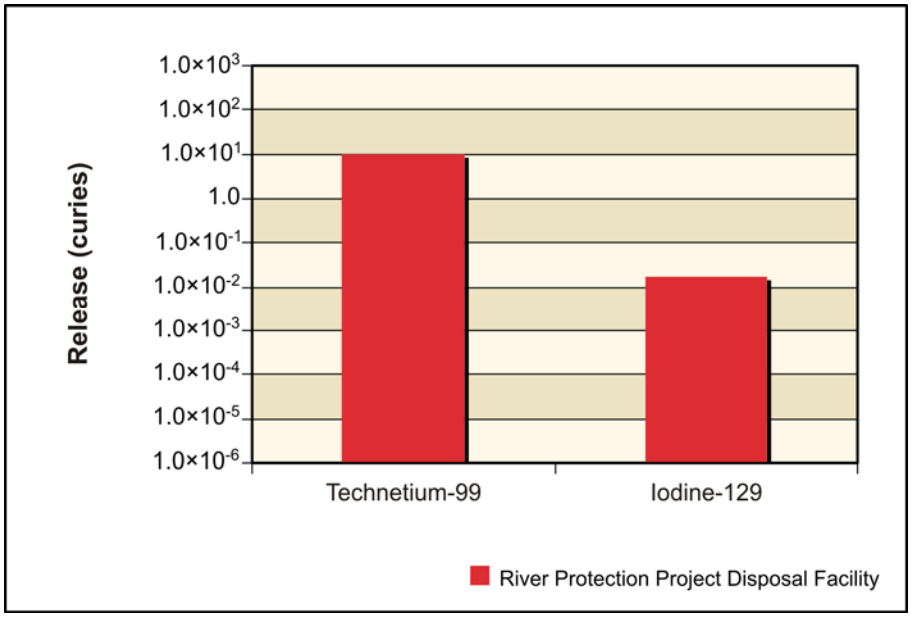


Figure 5–541. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Radiological Releases to River Protection Project Disposal Facility to Vadose Zone

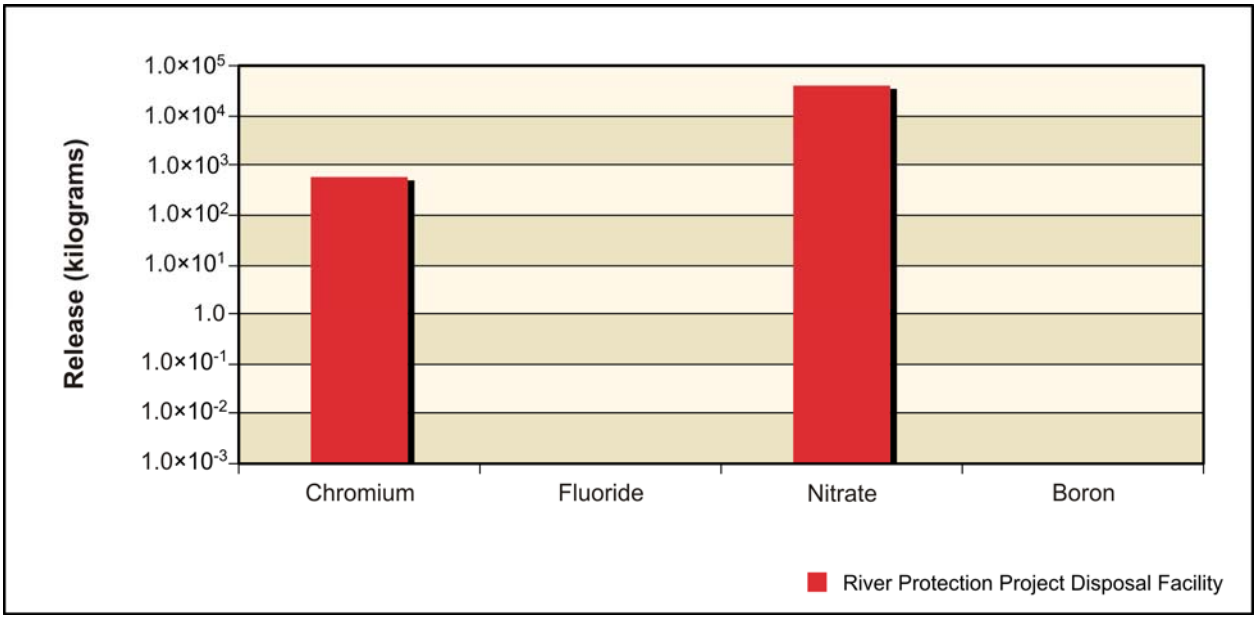


Figure 5–542. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chemical Releases to River Protection Project Disposal Facility to Vadose Zone

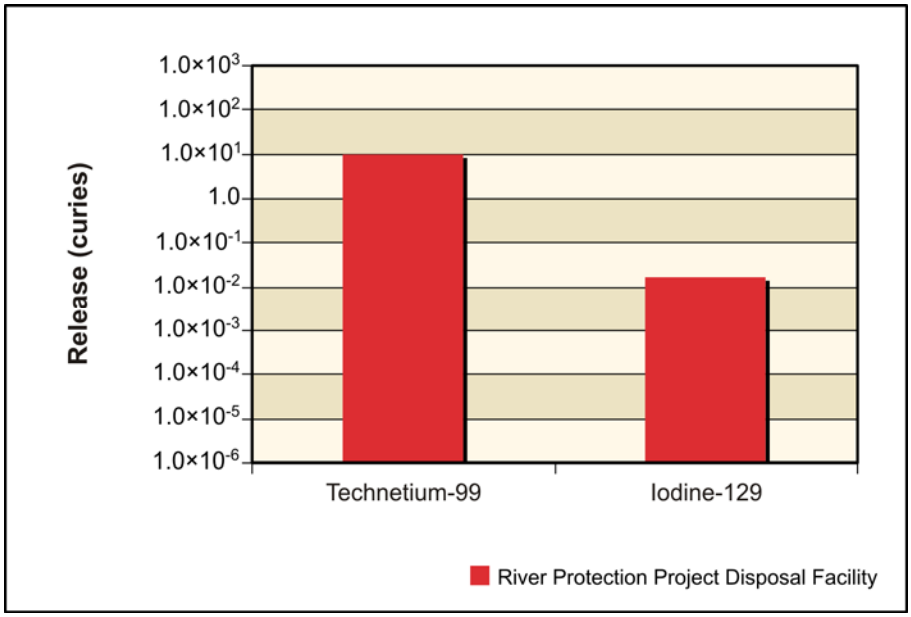


Figure 5–543. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Radiological Releases to River Protection Project Disposal Facility to Groundwater

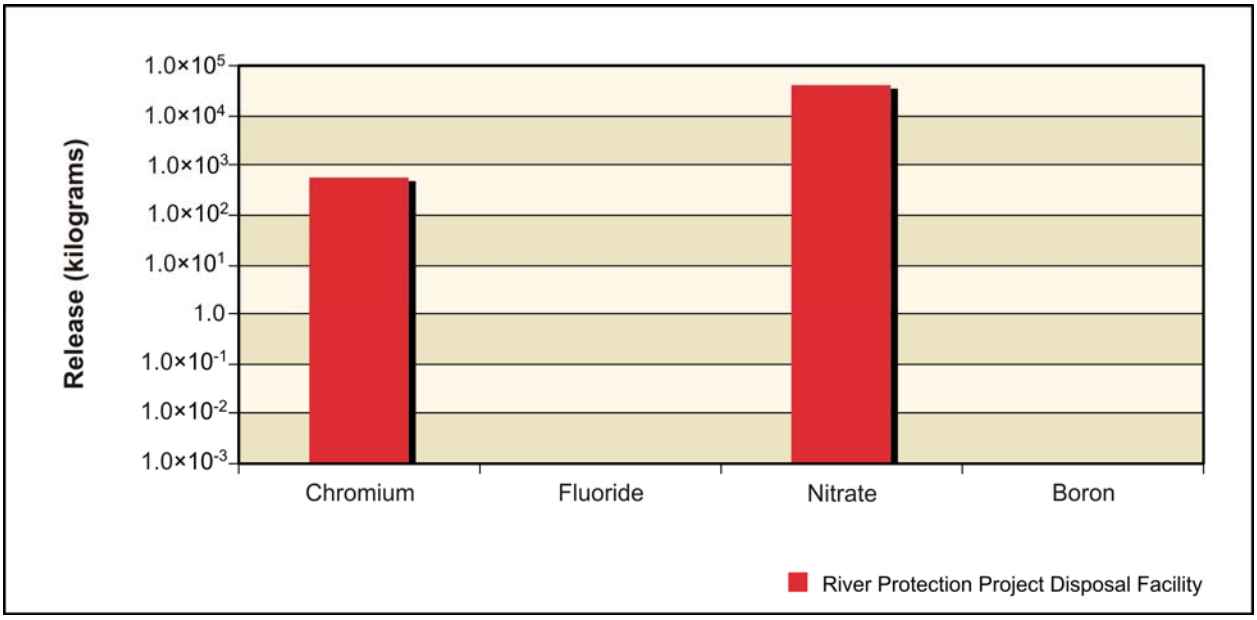


Figure 5–544. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chemical Releases to River Protection Project Disposal Facility to Groundwater

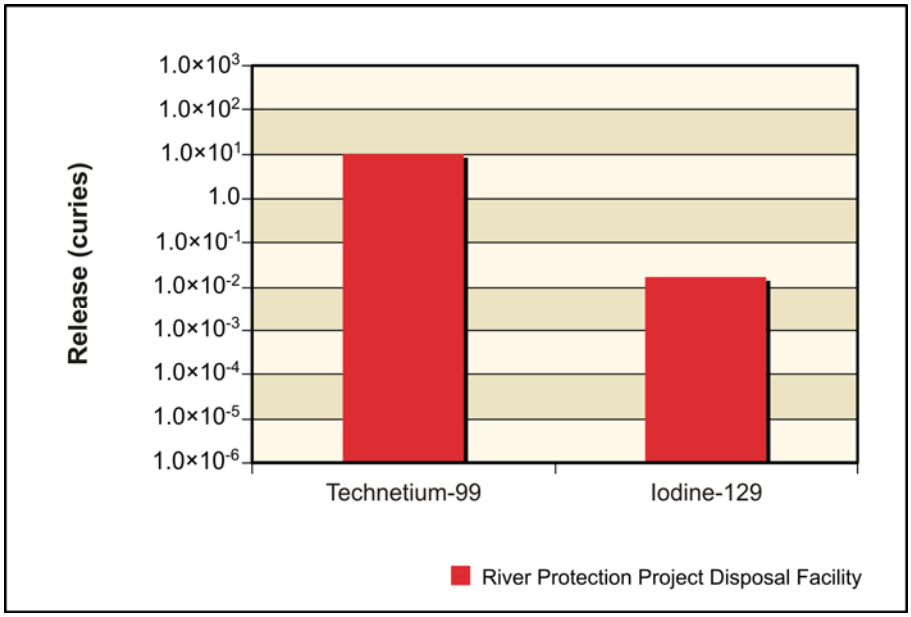


Figure 5–545. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Radiological Releases to River Protection Project Disposal Facility to Columbia River

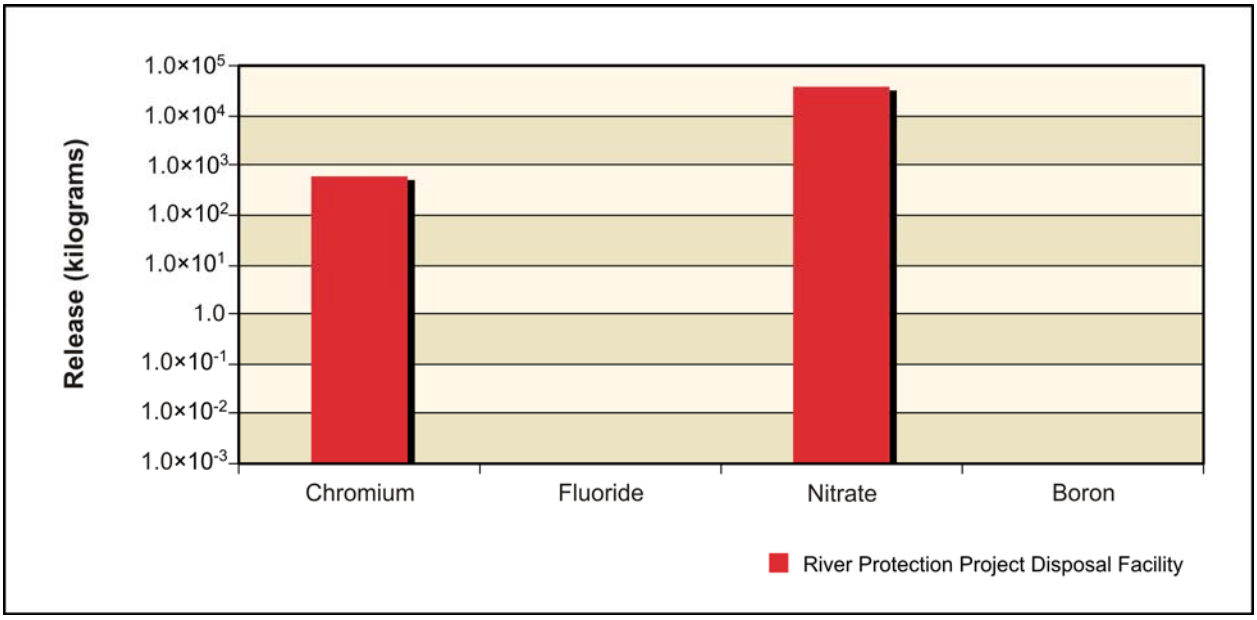


Figure 5–546. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chemical Releases to River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, 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 (see Figure 5–547 through 5–551). 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 5–83 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–547 through 5–550 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. Releases from IDF-East and the RPPDF cause groundwater concentrations to exceed benchmark concentrations at the Core Zone and Columbia River nearshore boundaries by less than one order of magnitude for iodine-129. Iodine-129 extends above the benchmark level during the later part of the period of analysis. Technetium-99, nitrate, and chromium do not exceed benchmark concentrations at the Core Zone or Columbia River nearshore boundaries.

Uranium-238 has no detectable release to the environment throughout the duration of the period of analysis. Figure 5–551 shows concentration versus time for total uranium.

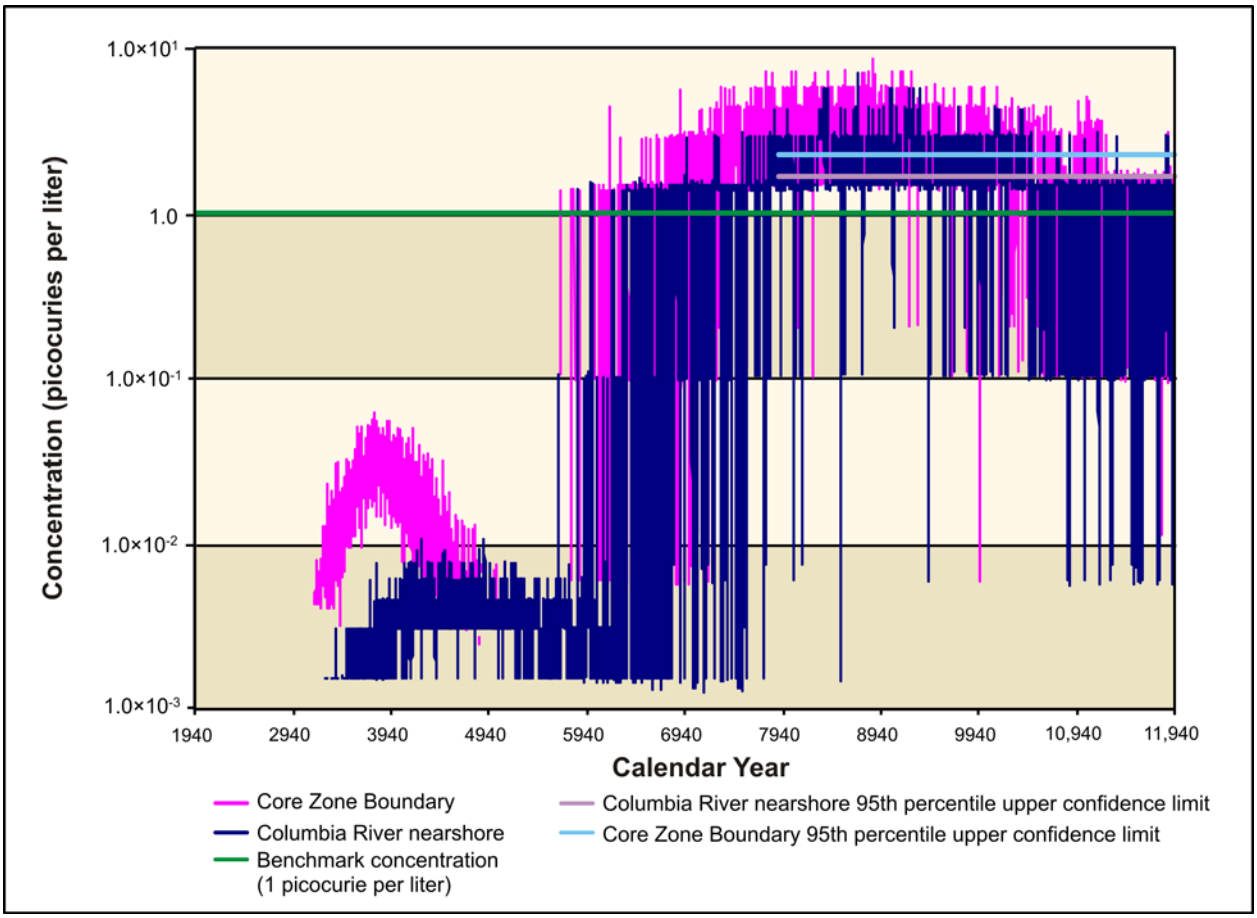


Figure 5–547. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Iodine-129 Concentration Versus Time

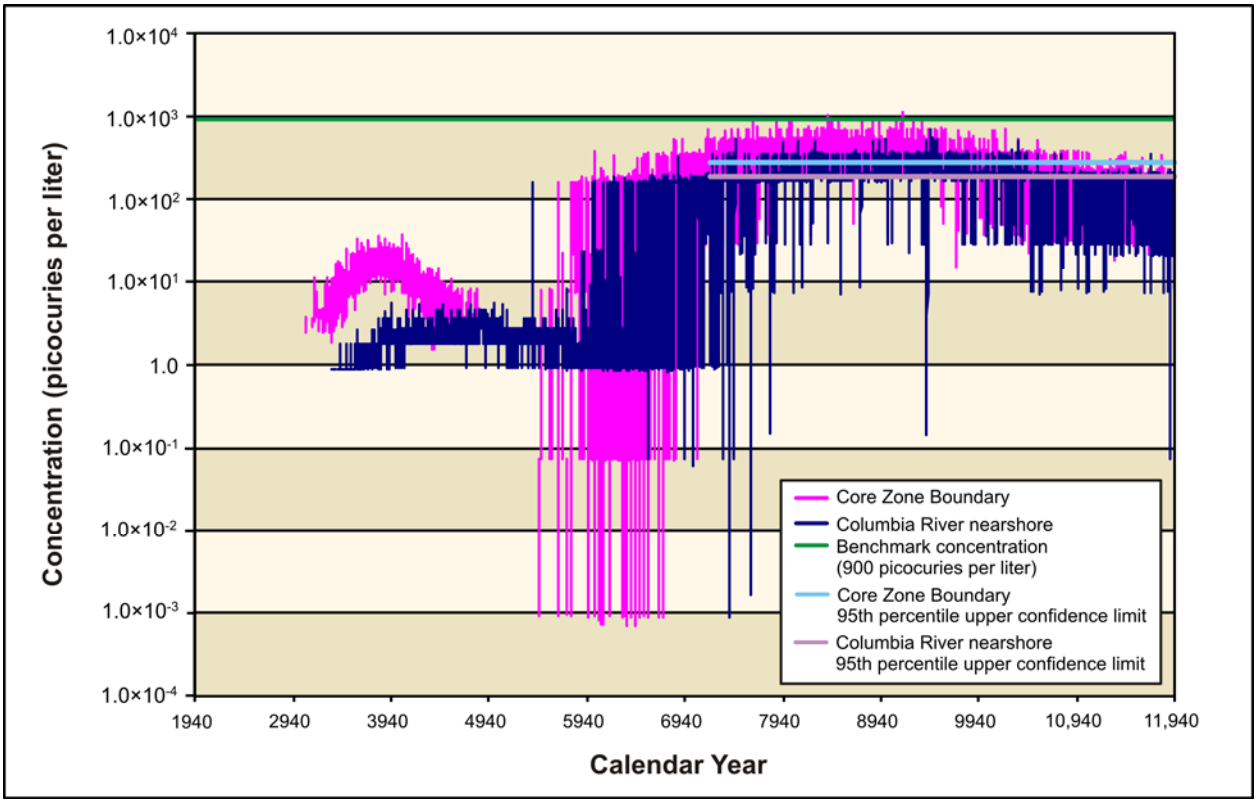


Figure 5–548. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Technetium-99 Concentration Versus Time

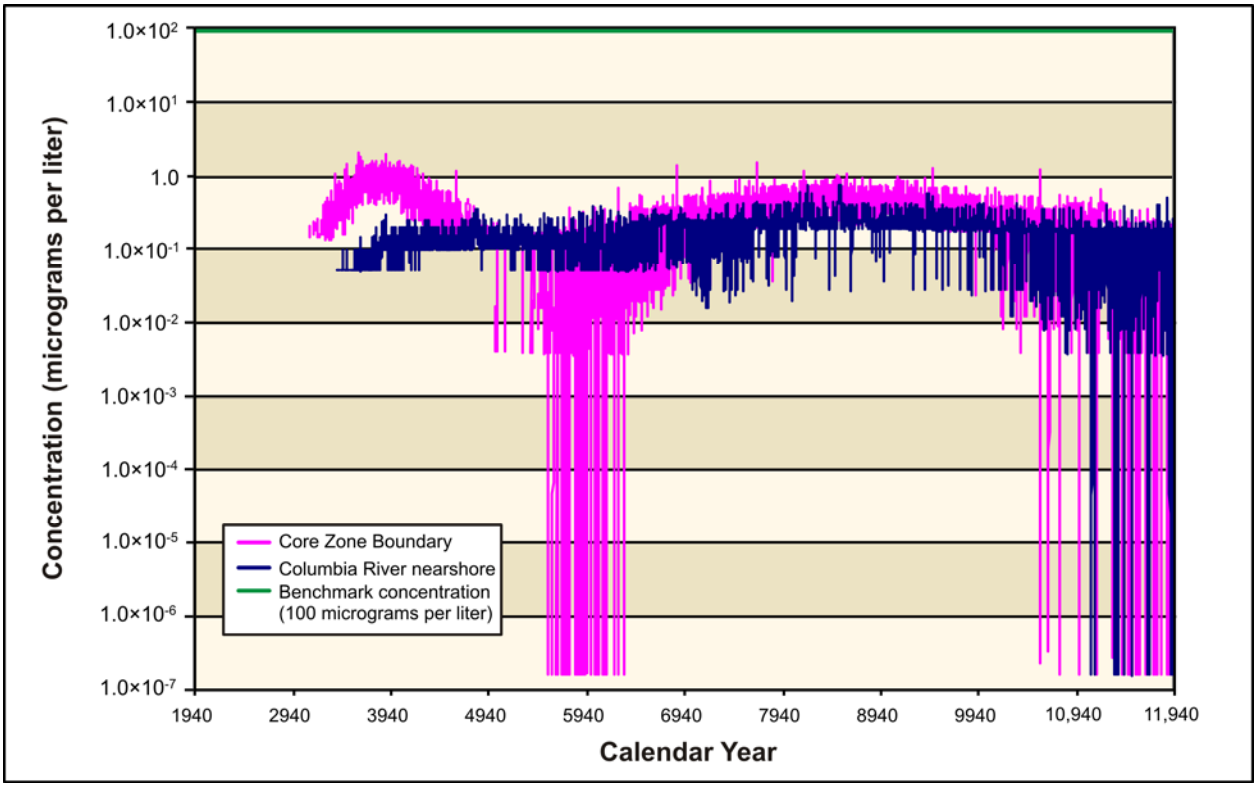


Figure 5–549. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Chromium Concentration Versus Time

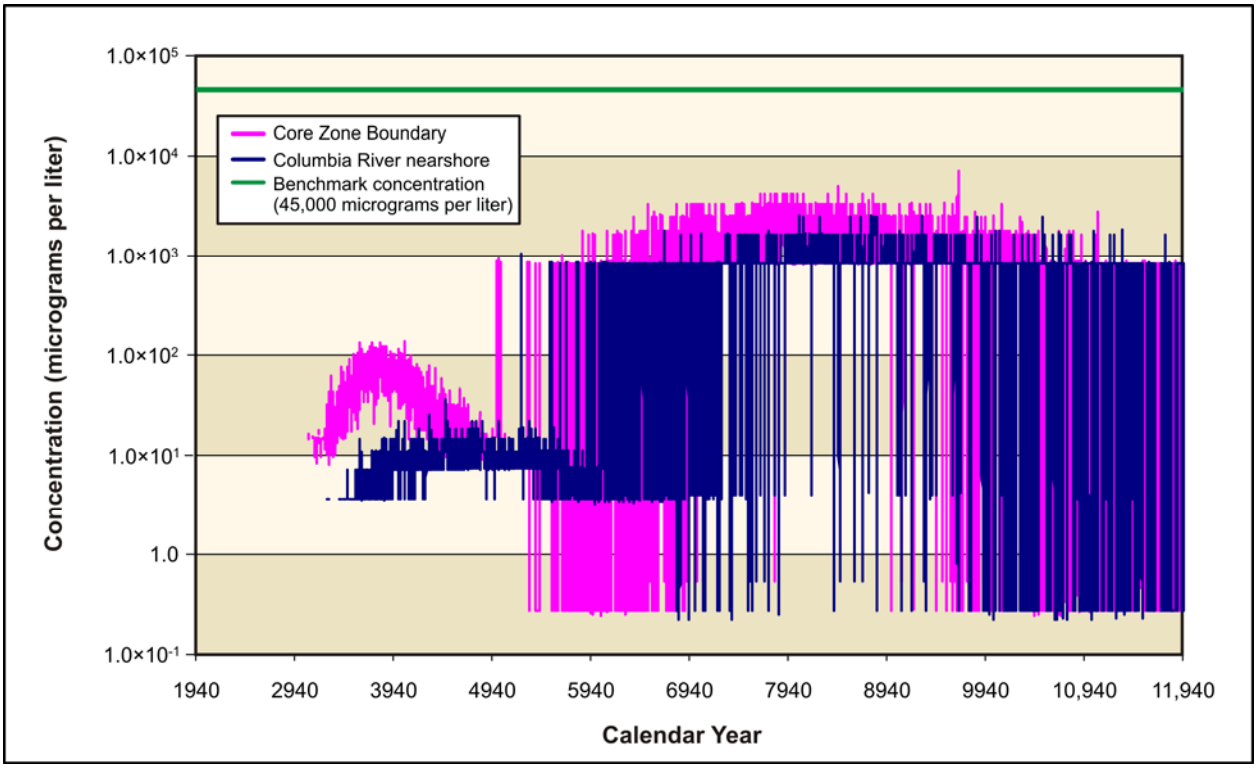


Figure 5–550. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Nitrate Concentration Versus Time

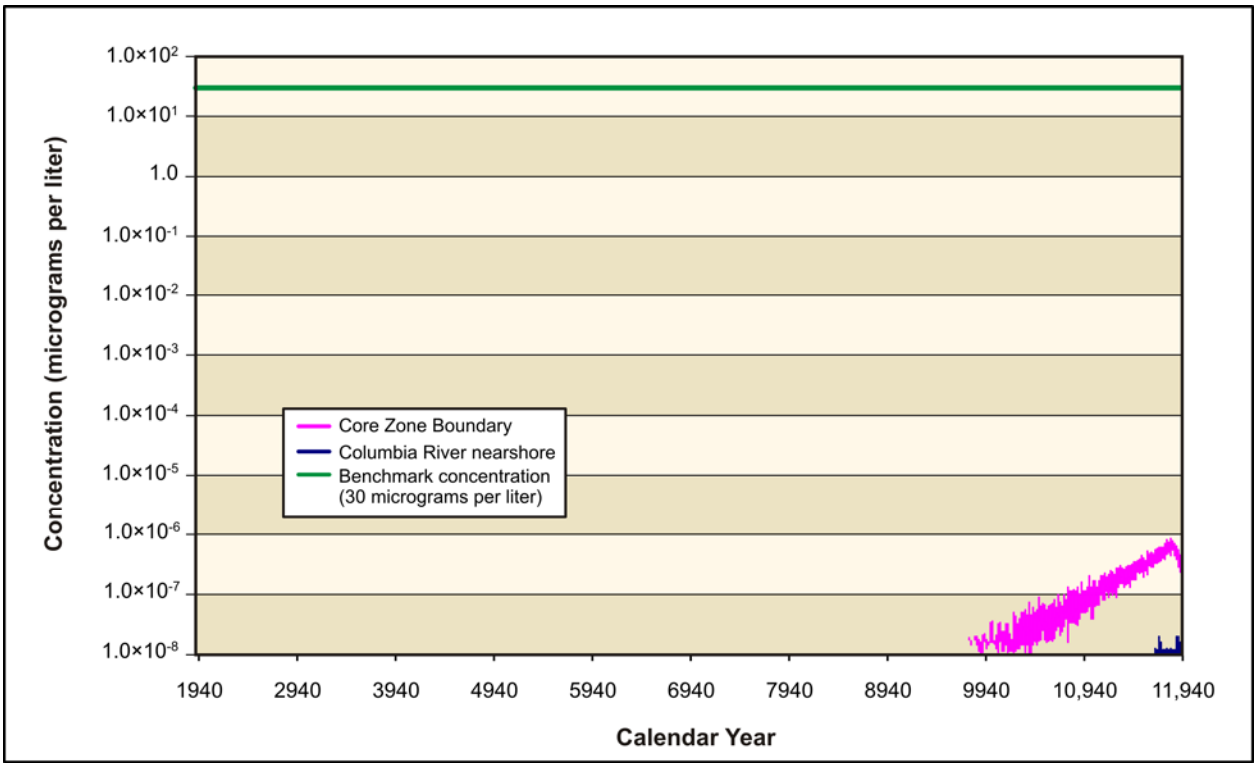


Figure 5–551. `Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Total Uranium Concentration Versus Time

Table 5–83. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**2,190**	33	**1,150**	674	900
	(9004)	(3825)	(9155)	(9451)	
Iodine-129	**19**	0.1	**9**	**7**	1
	(8739)	(3772)	(8858)	(8699)	
Chemical in micrograms per liter					
Chromium	4	2	2	1	100
	(8618)	(3856)	(3889)	(8528)	
Fluoride	0	0	1	0	4,000
	(8035)	(1940)	(7258)	(8913)	
Nitrate	14,200	149	5,630	2,440	45,000
	(8522)	(3811)	(9653)	(8827)	

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

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

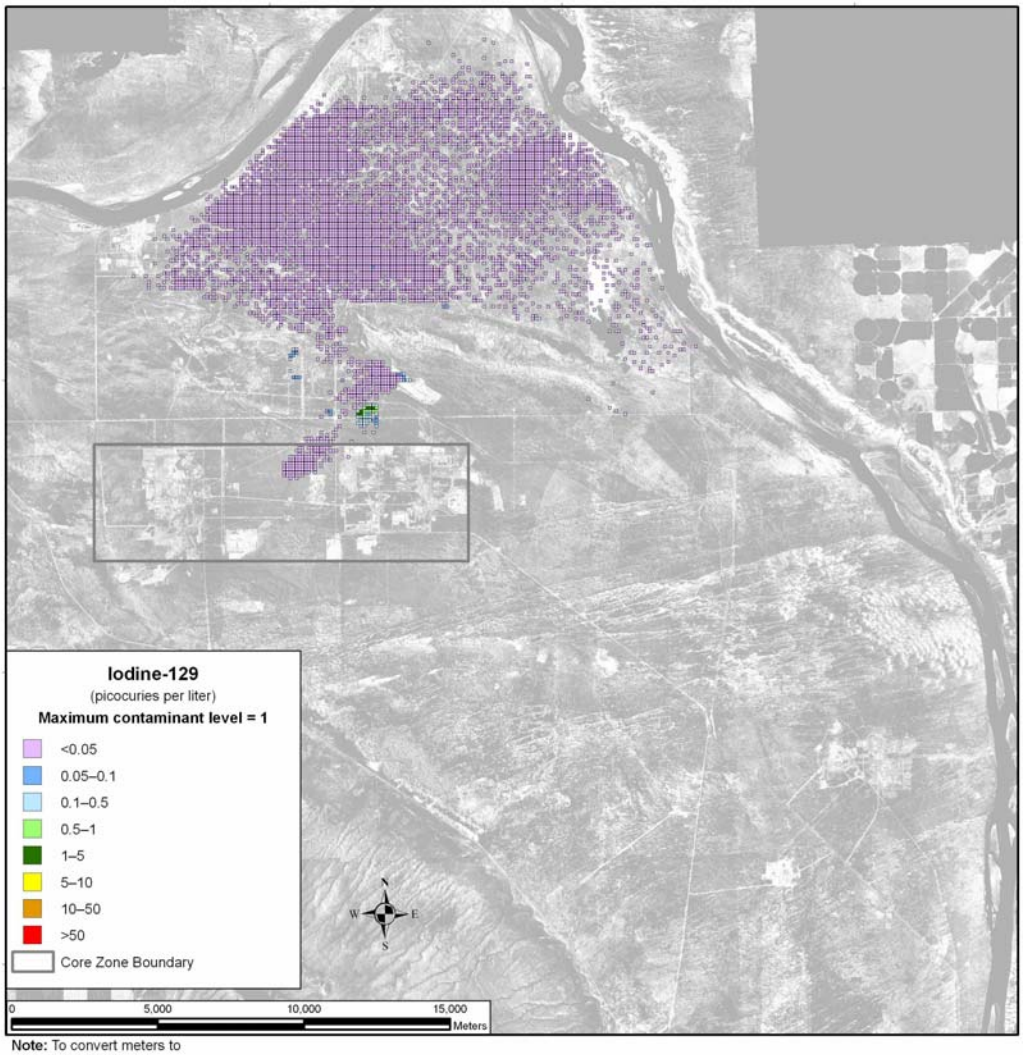
ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, 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 (see Figures 5–552 through 5–564). 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 5–552 shows the spatial distribution of groundwater concentration for iodine-129 during CY 3890. Releases from the RPPDF result in a groundwater plume heading north through Gable Mountain. This plume does not exceed iodine-129's benchmark concentration north of the Core Zone. During CY 7140, releases from IDF-East create a plume exceeding the benchmark, extending from the 200-East Area moving eastward towards the Columbia River (see Figure 5–553). Also by CY 7140, most of the RPPDF plume continues to move north and reaches the Columbia River. By CY 11,885 most of the mass in the IDF-East plume is still moving eastward toward the Columbia River, with only small, isolated pockets of high concentration exceeding the benchmark (see Figure 5–554). Technetium-99 (see Figures 5–555 through 5–557), chromium (see Figures 5–558 through 5–560), and nitrate (see Figures 5–561 through 5–563) show similar spatial distributions at selected times, except none of them exceed their benchmark concentrations. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity).

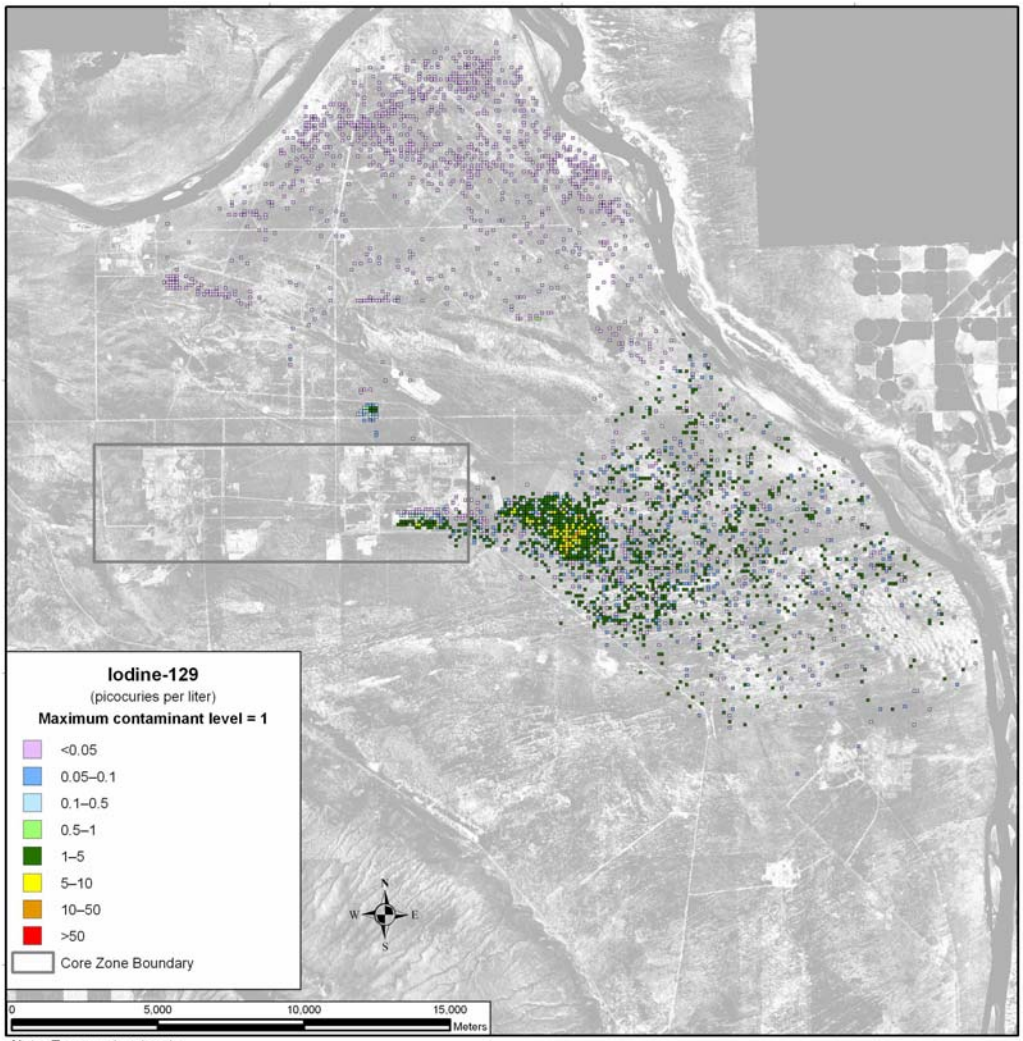
Total uranium shows a different spatial distribution over time. This COPC is not as mobile as those discussed above, moving about seven times slower than the pore water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–564 shows the distribution of total uranium during CY 11,885. Releases from 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.



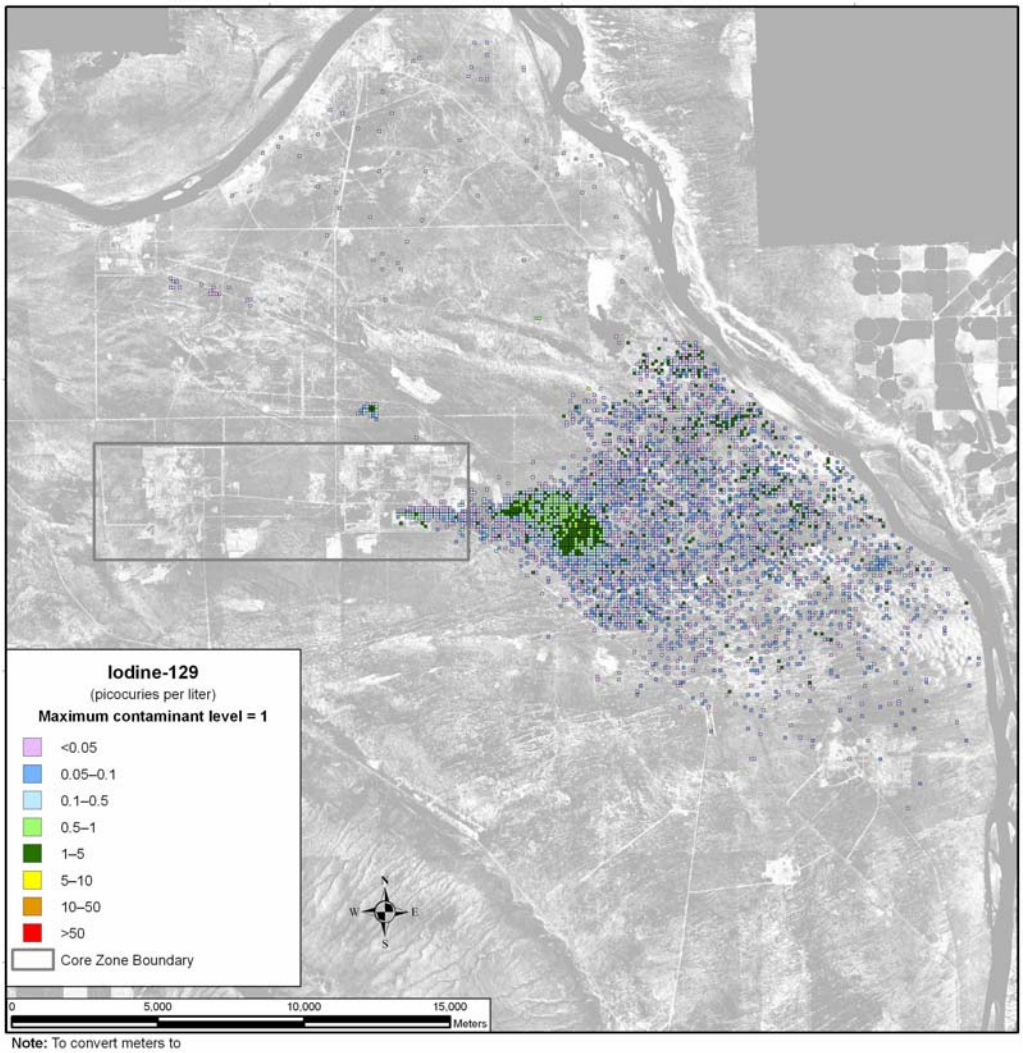
Note: To convert meters to feet, multiply by 3.281

Figure 5–552. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



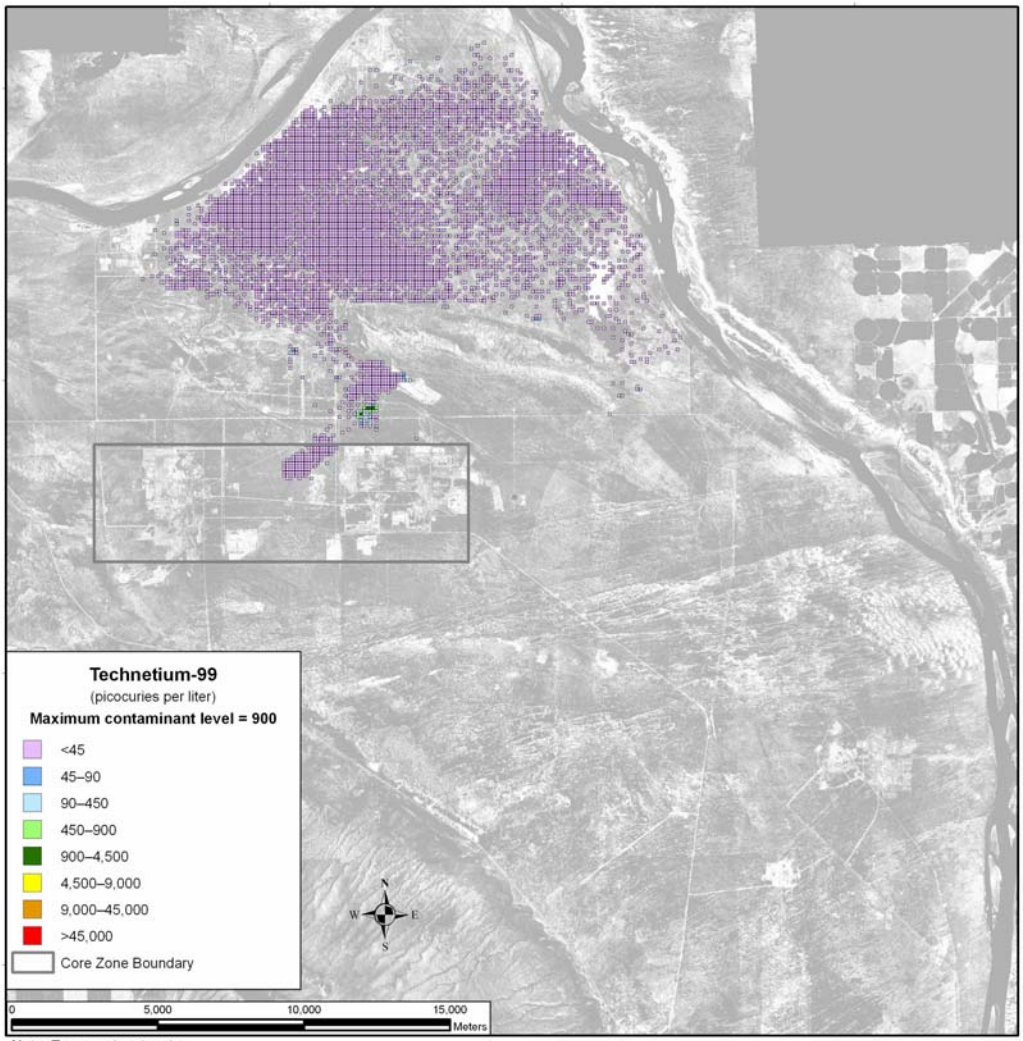
Note: To convert meters to feet, multiply by 3.281

Figure 5–553. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



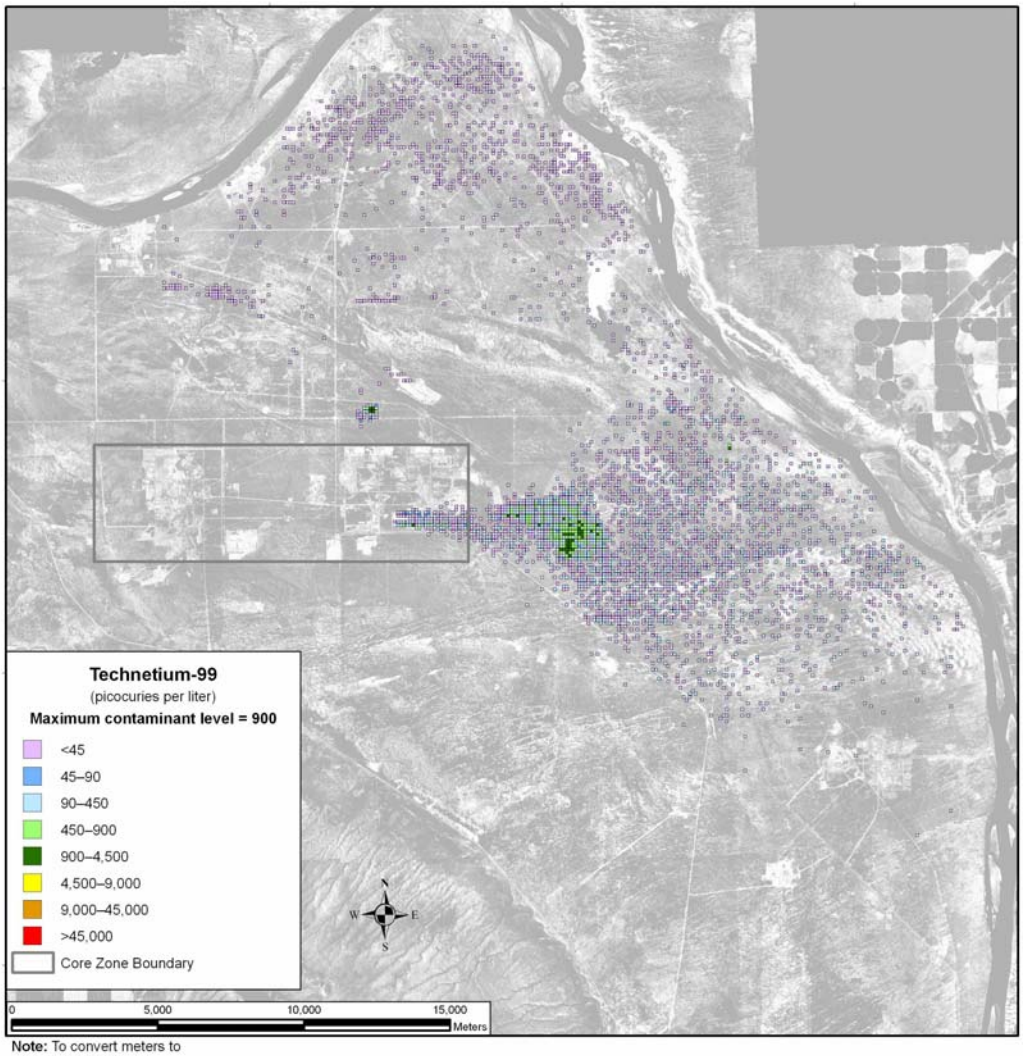
Note: To convert meters to feet, multiply by 3.281

Figure 5–554. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



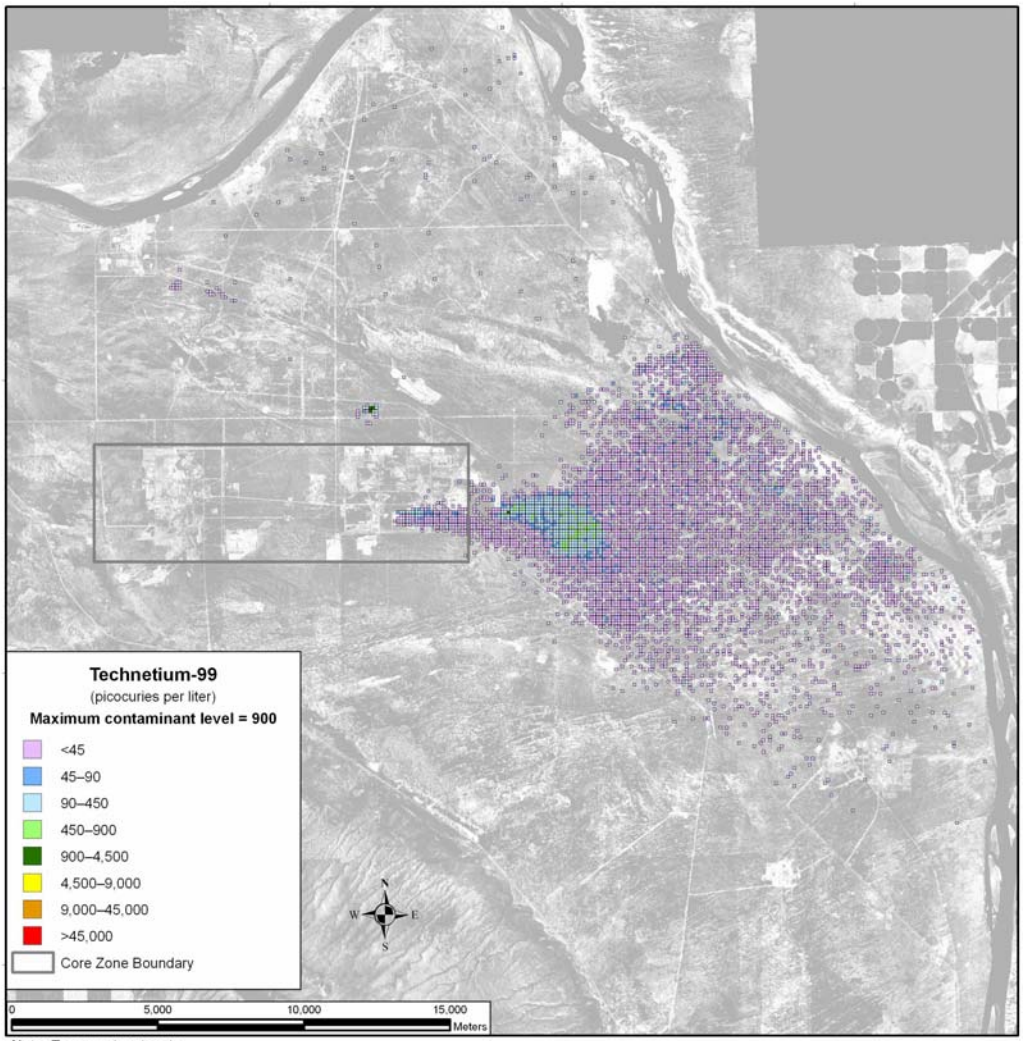
Note: To convert meters to feet, multiply by 3.281

Figure 5–555. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



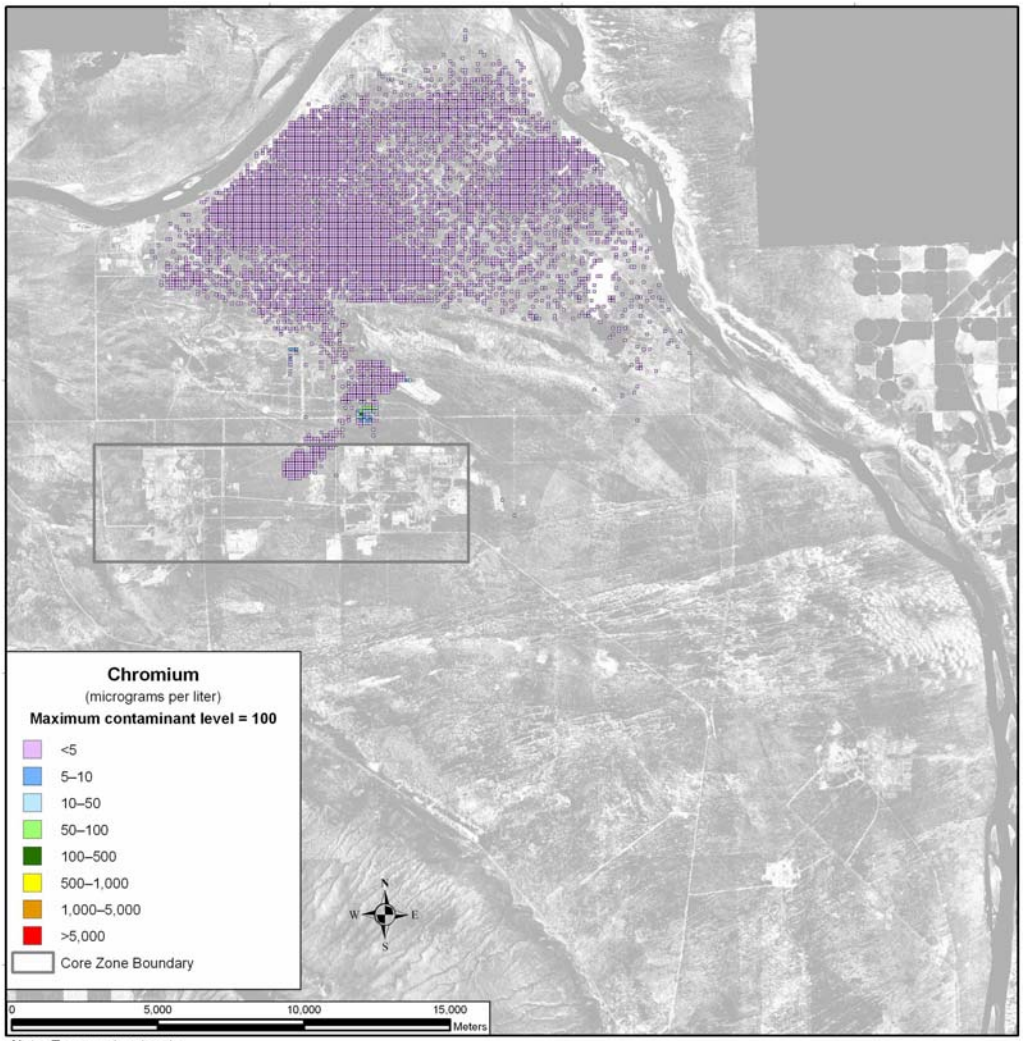
Note: To convert meters to feet, multiply by 3.281

Figure 5–556. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



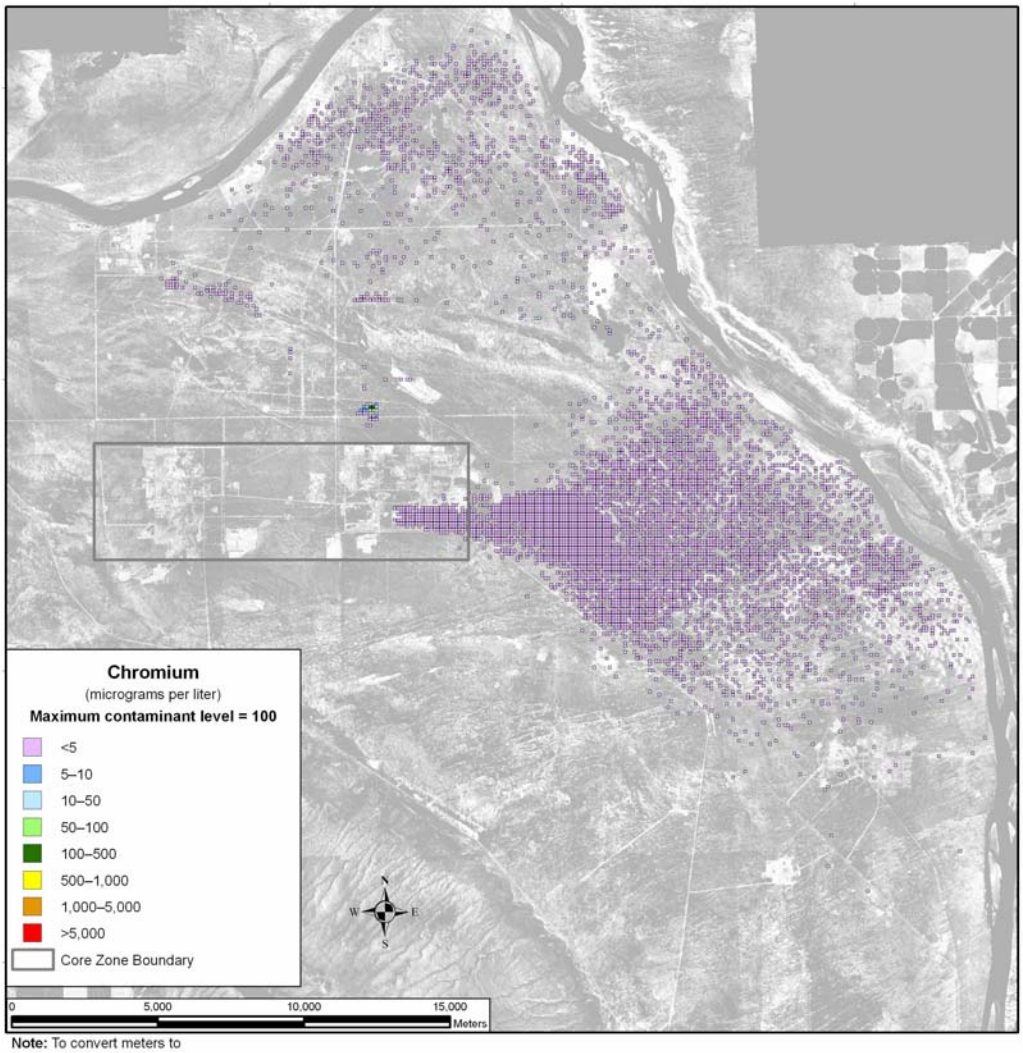
Note: To convert meters to feet, multiply by 3.281

Figure 5–557. Waste Management Alternative 2, 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 5–558. Waste Management Alternative 2, 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 5–559. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140

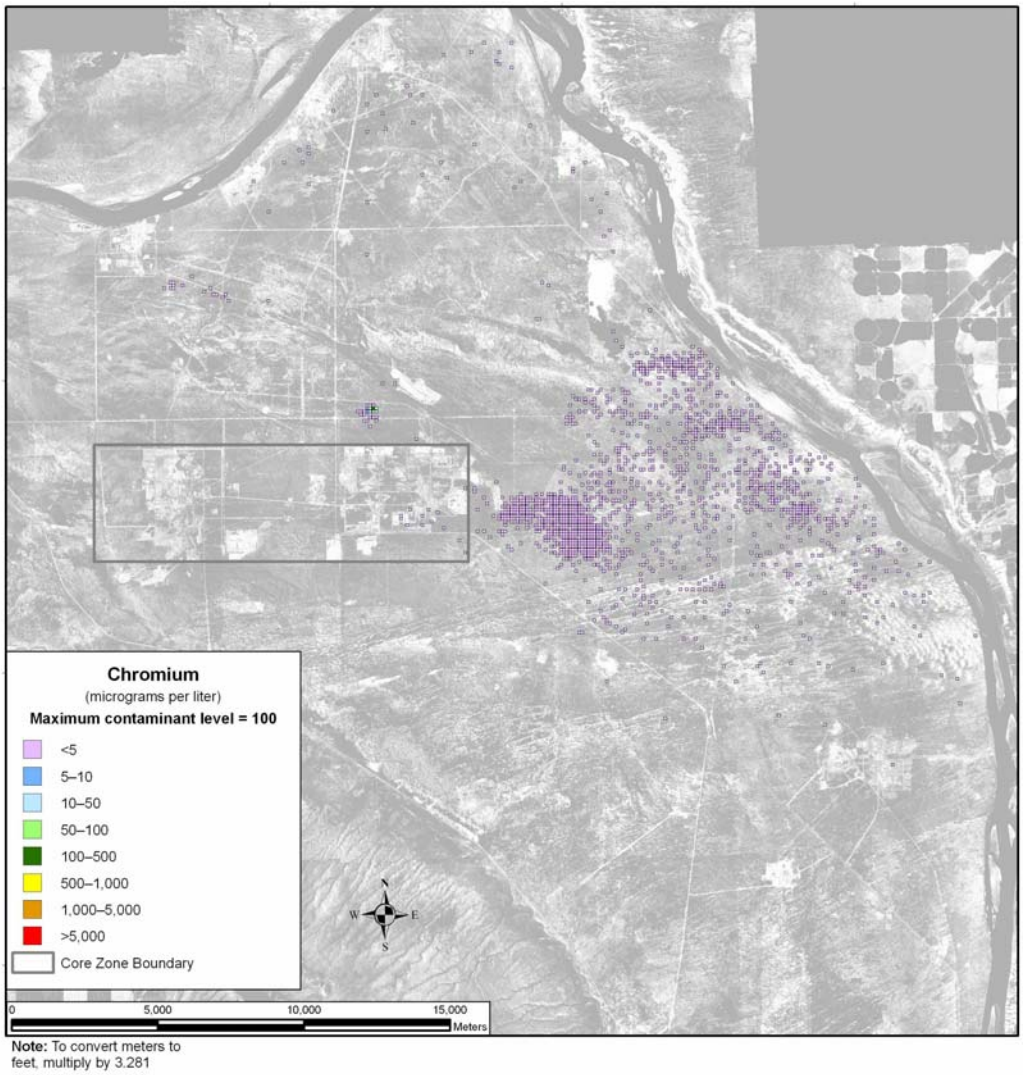
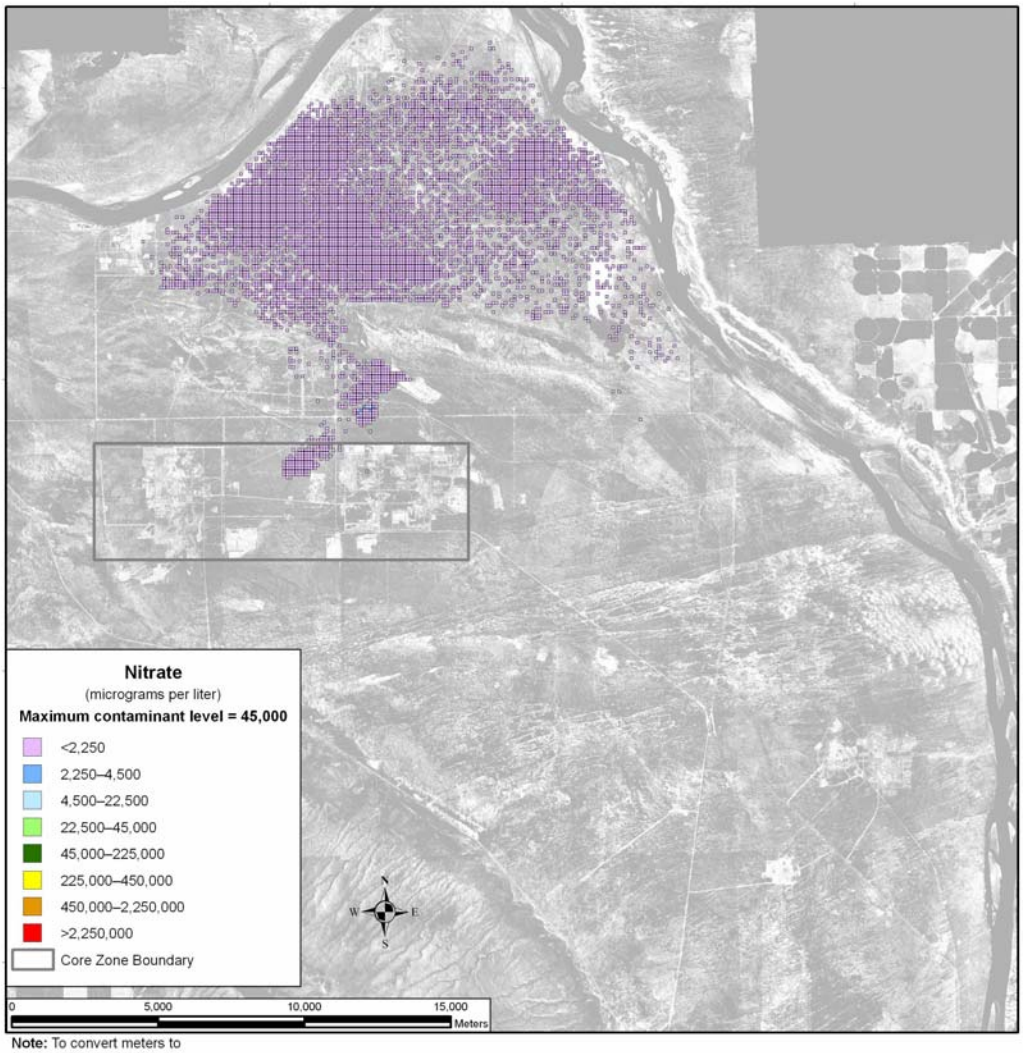
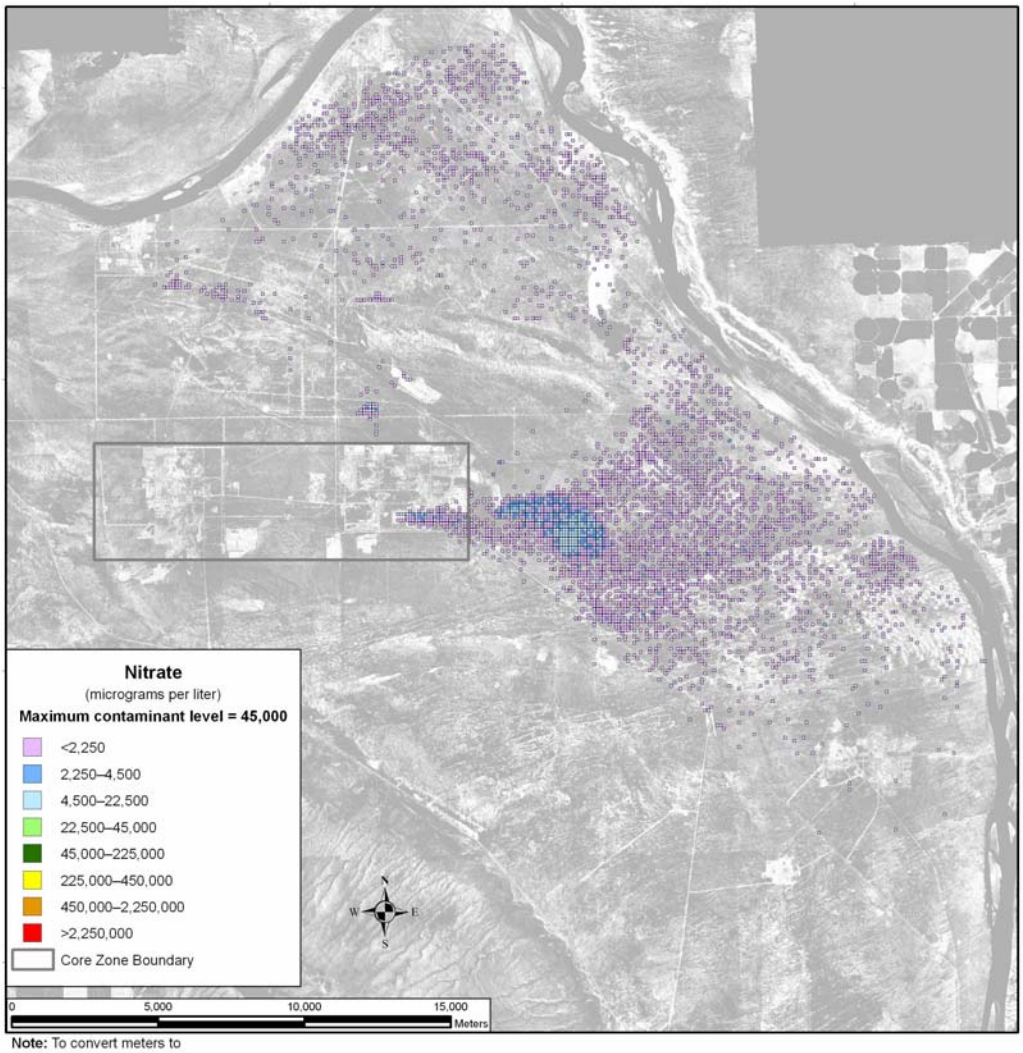


Figure 5–560. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



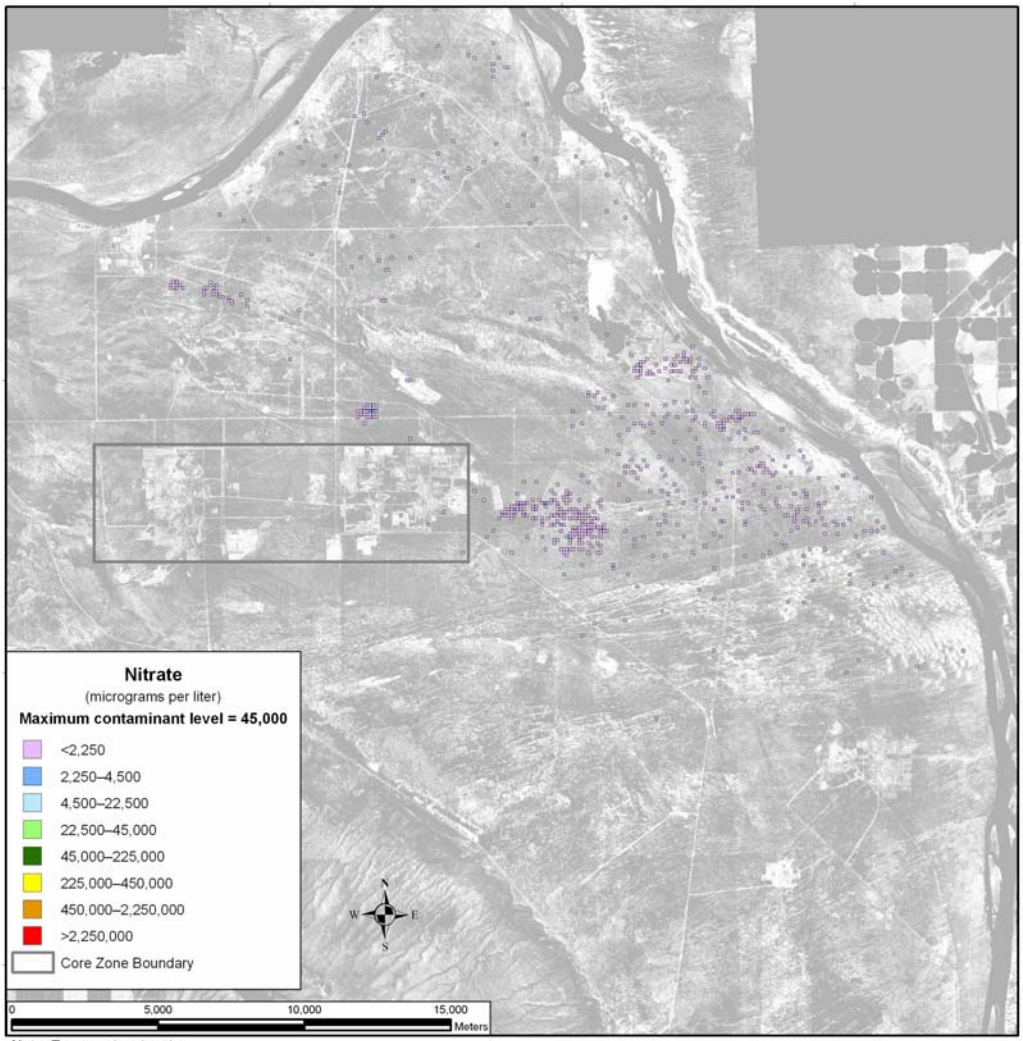
Note: To convert meters to feet, multiply by 3.281

Figure 5–561. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



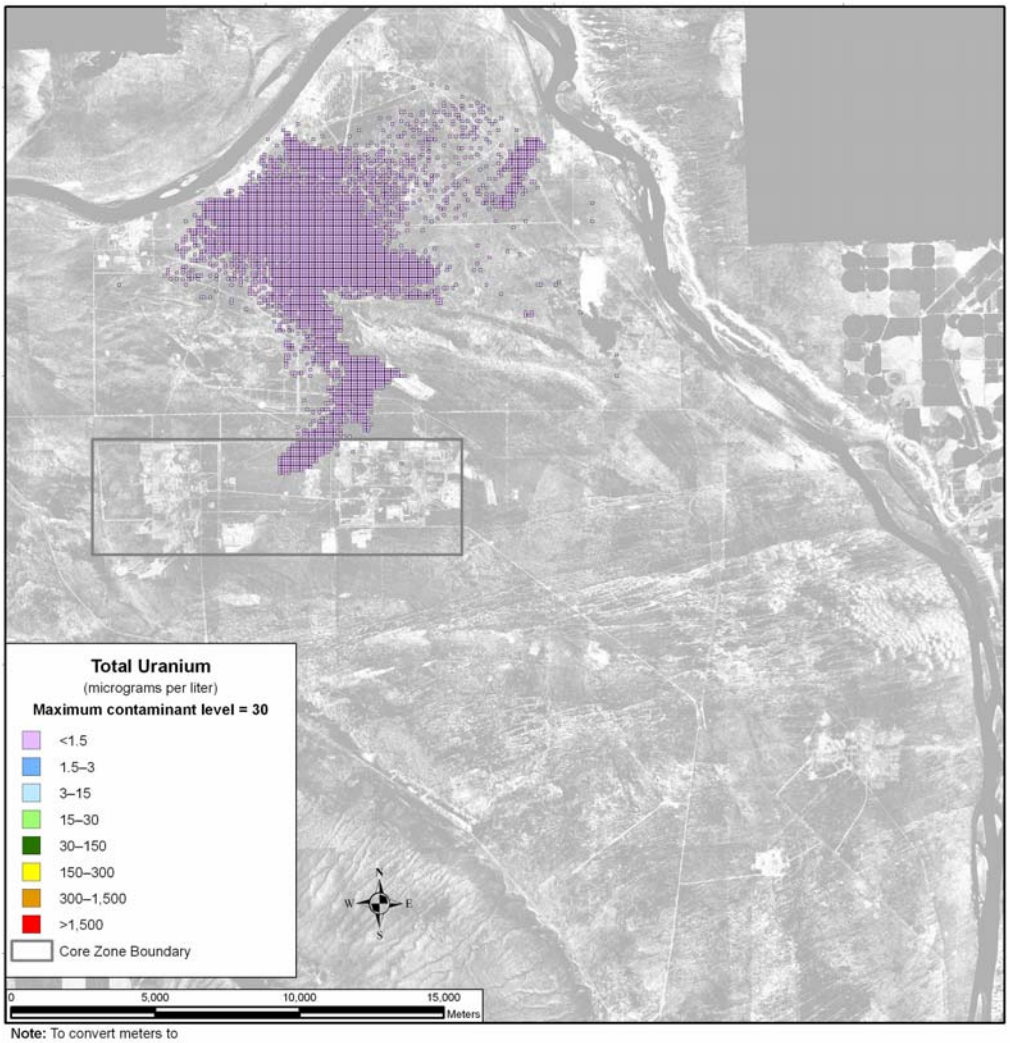
Note: To convert meters to feet, multiply by 3.281

Figure 5–562. Waste Management Alternative 2, 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 5–563. Waste Management Alternative 2, 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 5–564. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-G, in general, the inventory remaining at IDF-East 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 order of magnitude during most of the period of analysis. Concentrations at the Columbia River are about one order of magnitude smaller. The intensities and areas of these groundwater plumes peak between CYs 7140 and 11,885.

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.

5.3.1.2.2 Disposal Group 2

Disposal Group 2 is characterized by an operational completion date of CY 2100 for both IDF-East and the RPPDF. Under Disposal Group 2, IDF-East would have a large capacity (425,000 cubic meters [556,000 cubic yards]) and the RPPDF would have a larger capacity (8,370,000 cubic meters [10,900,000 cubic yards]). These capacities were designed to meet the waste generation volumes associated with Tank Closure Alternatives 2A and 6B, either FFTF Decommissioning Alternative 2 or 3, and onsite- and offsite-generated waste.

5.3.1.2.2.1 Disposal Group 2, Subgroup 2-A

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Subgroup 2-A covers disposal of waste generated under Tank Closure Alternative 2A and FFTF Decommissioning Alternative 2 or 3, as well as, onsite- and offsite-generated waste. Waste would be converted to IHLW and ILAW glass. IHLW would be stored on site, while ILAW glass would be disposed of at IDF-East.

For the long-term groundwater impact analysis, two major periods were identified for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, as follows:

- The disposal period was assumed to start with the onset of disposal operations in IDF-East in CY 2009 and continue through CY 2100, when the disposal facility would be operationally closed. During this disposal period, the materials in this permitted, operational facility would not be available for release to the environment due to engineered control of potential releases from materials placed in IDF-East.

- The post-disposal period for IDF-East was assumed to start in CY 2101. After CY 2101, the materials in IDF-East would become available for release to the environment. The post-disposal periods would continue through the 10,000-year period of analysis until CY 11,940. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 2, IDF-East is assumed to be covered by a barrier that limits infiltration for the first 500 hundred years of the IDF-East post-disposal period.

COPC DRIVERS

A total of 40 COPCs were analyzed for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A. Complete results are tabulated in Appendices M, N, and O. The discussion in this section of long-term impacts associated with Waste Management Alternative 2, 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 2, 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 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 2, Disposal Group 2, Subgroup 2-A.

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 2, Disposal Group 2, Subgroup 2-A, in terms of the total amounts of radionuclide and chemical COPCs released to the vadose zone, groundwater, and Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals in kilograms (see Figures 5–565 through 5–570). 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 5–565 shows the estimated release at IDF-East to the vadose zone for the radiological risk drivers and Figure 5–566, the chemical COPCs hazard drivers. The predominant source of technetium-99 in the vadose zone is offsite-generated waste (77 percent), followed by tank closure secondary waste (19 percent), and ETF-generated secondary waste (4 percent). The sources of the iodine-129 release are offsite waste (85 percent) and ETF-generated secondary waste (14 percent). All of the fluoride and boron released to the vadose zone are from waste management secondary waste and onsite-generated waste. All of the nitrate released is from ETF-generated secondary waste. The predominant source of chromium (81 percent) is tank closure secondary waste, followed by waste management secondary and onsite-generated waste (8 percent), ILAW glass (5 percent), and offsite-generated waste (4 percent).

Figure 5–567 shows the estimated release at IDF-East to groundwater for the radiological risk drivers and Figure 5–568, 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. Nearly all of the chromium (96 percent) and essentially all (99 percent) of the fluoride, boron, and nitrate are released to the groundwater from the vadose zone. Most of the technetium-99 (89 percent) and iodine-129 (91 percent) are released to the groundwater from the vadose zone.

Figure 5–569 shows the estimated release at IDF-East to the Columbia River for the radiological risk drivers and Figure 5–570, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPCs. About 89 percent of the groundwater technetium-99 and 91 percent of the iodine-129 is released to the Columbia River. Almost all of the groundwater chromium (97 percent), fluoride (97 percent), nitrate (greater than 98 percent), and boron (97 percent) are released to the Columbia River.

Overall, 86 percent of the technetium-99 and 89 percent of the iodine-129 from the vadose zone are released to the Columbia River. Overall, almost all of the chromium (93 percent), fluoride (96 percent), nitrate (98 percent), and boron (96 percent) from the vadose zone are released to the Columbia River. There is essentially no release of uranium-238 or total uranium to the groundwater or to the Columbia River.

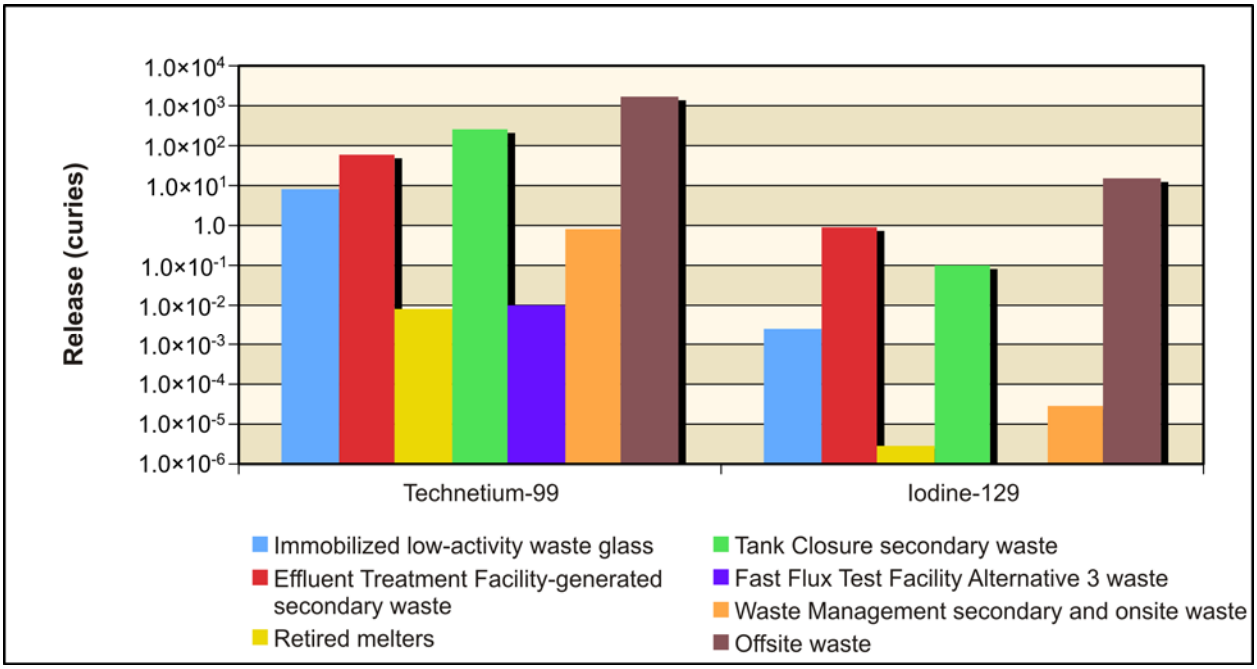


Figure 5–565. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

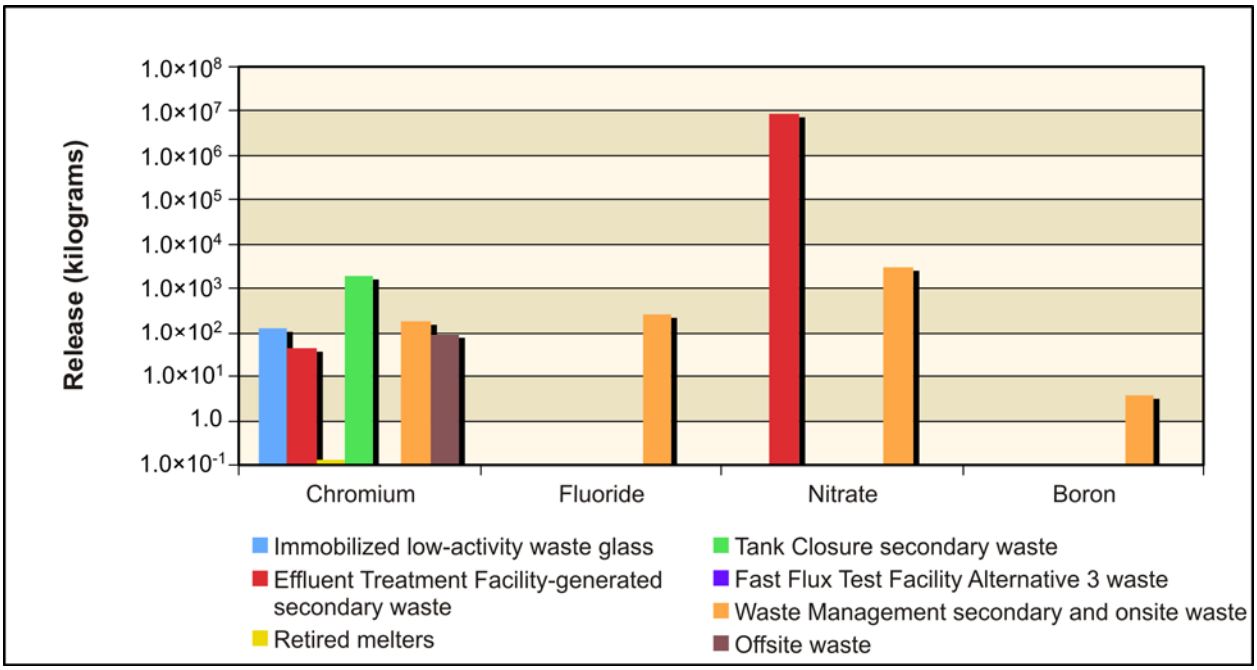


Figure 5–566. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

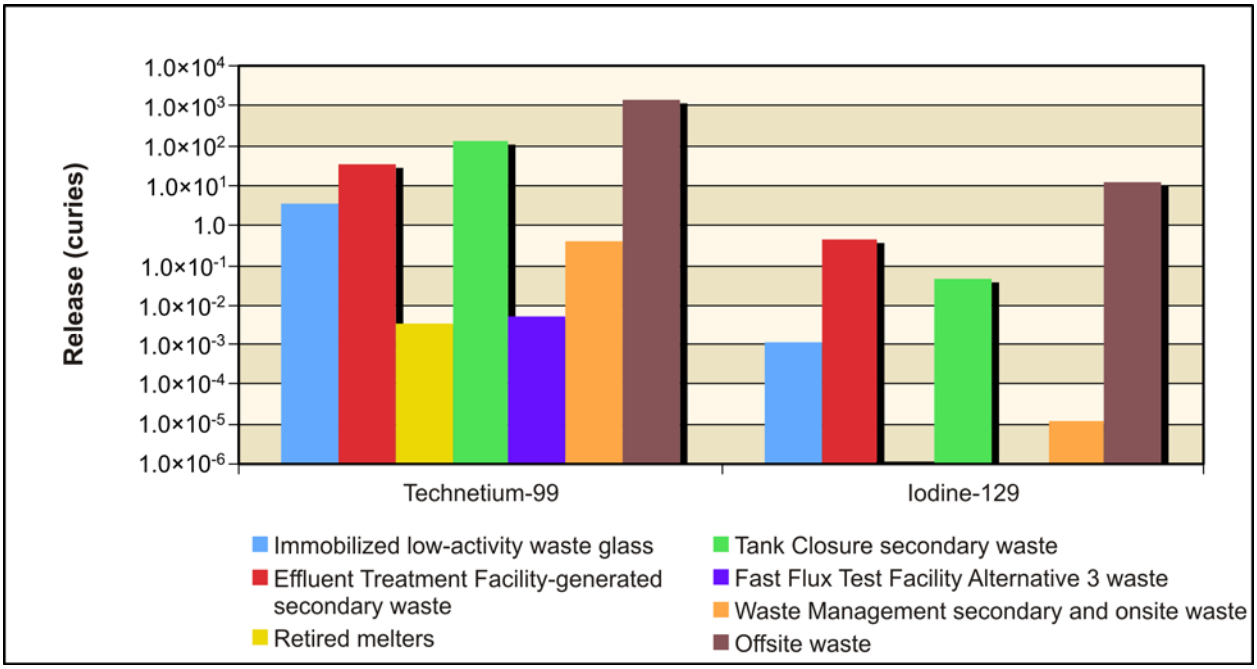


Figure 5–567. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

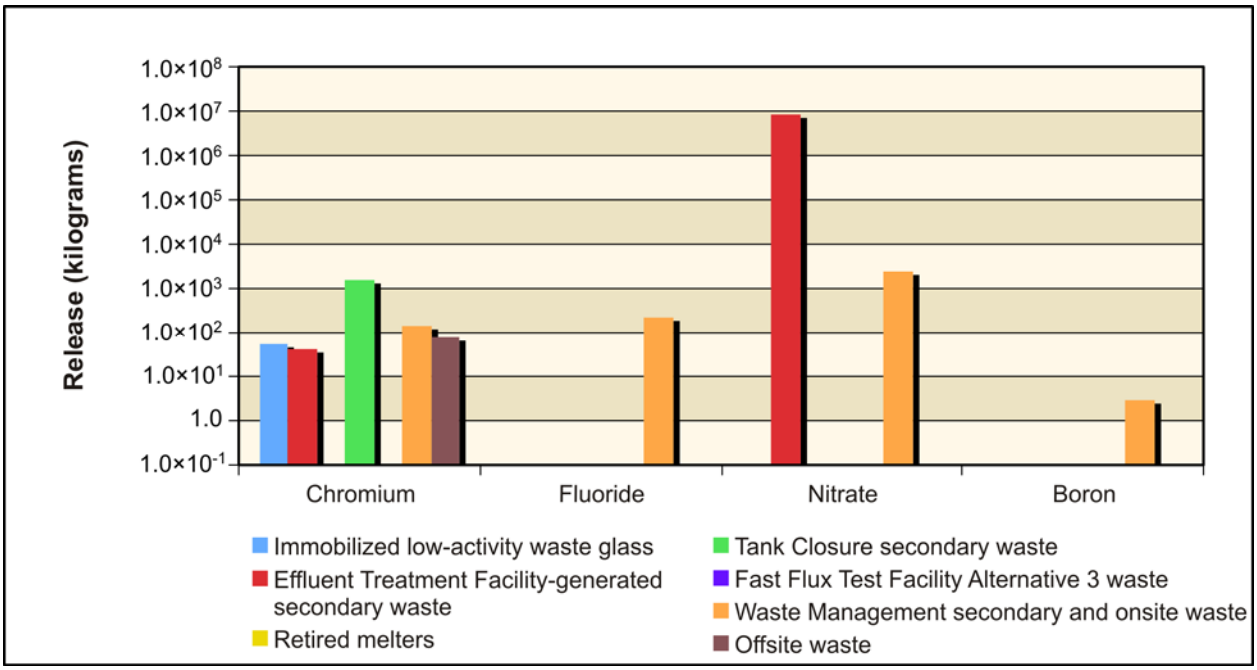


Figure 5–568. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

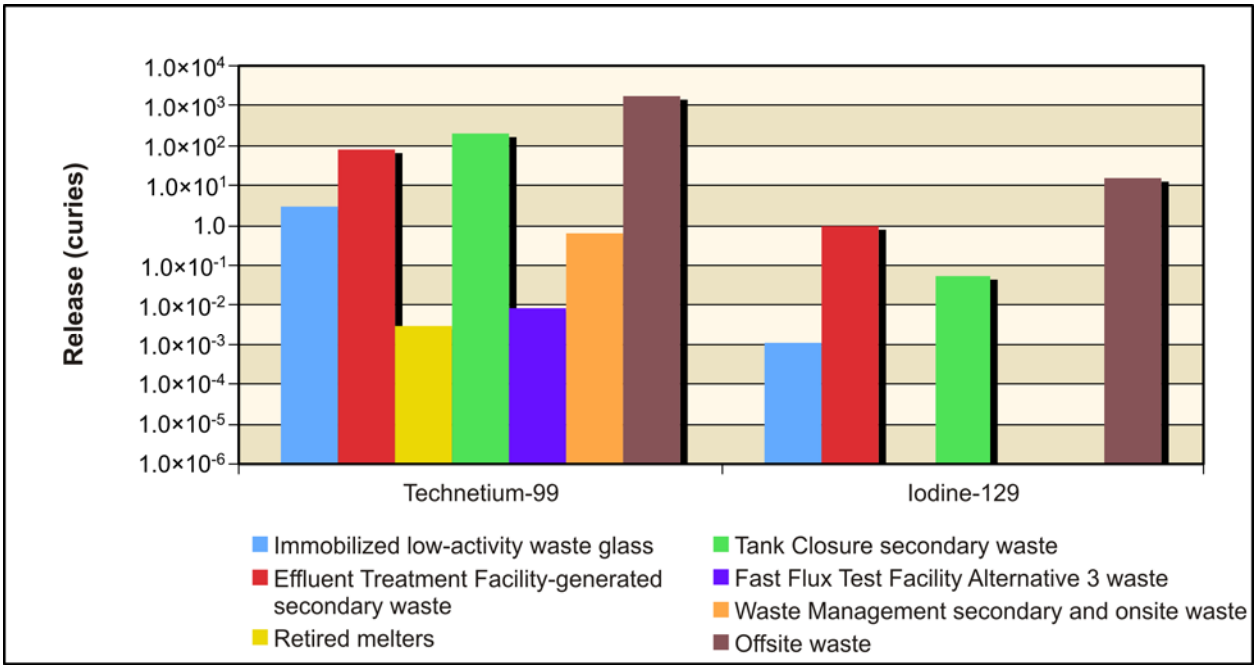


Figure 5–569. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

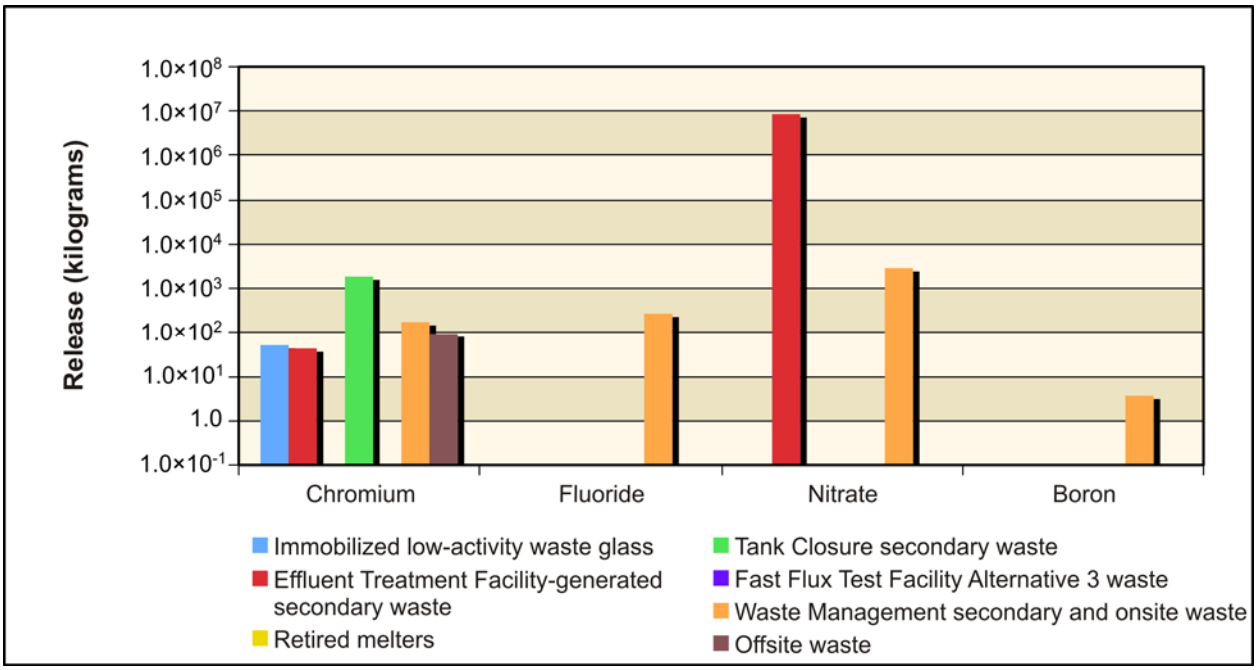


Figure 5–570. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the analysis of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, 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 (see Figures 5–571 through 5–574). The benchmark concentration is also shown for each radionuclide and chemical. Because of the discrete nature of the concentration carried across a barrier or the river, a line denoting the 95th percentile 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 5–84 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Figures 5–571 through 5–574 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate. During the later part of the analysis time period, the groundwater concentrations of iodine-129 from IDF-East exceed the benchmark concentrations at both the Core Zone and Columbia River nearshore boundaries. However, the iodine-129 concentrations are never greater than one order of magnitude above the benchmark concentration. After peaking, the iodine-129 concentrations continue to decrease through 11,940 (see Figure 5–571). The technetium-99 shows a similar response, with a peak near the latter quarter of the analysis period and then a continuing decline through 11,940 (see Figure 5–572). The technetium-99 concentrations at both the Core Zone and Columbia River nearshore boundaries never exceed the benchmark concentration. The chromium and nitrate concentrations show a similar trend (see Figures 5–573 and 5–574). The chromium concentrations approach but never exceed the benchmark concentration. The peak nitrate concentrations are always at least one order of magnitude less than the benchmark concentration.

There are no detectable releases of either uranium-238 or total uranium to the environment over the analysis period.

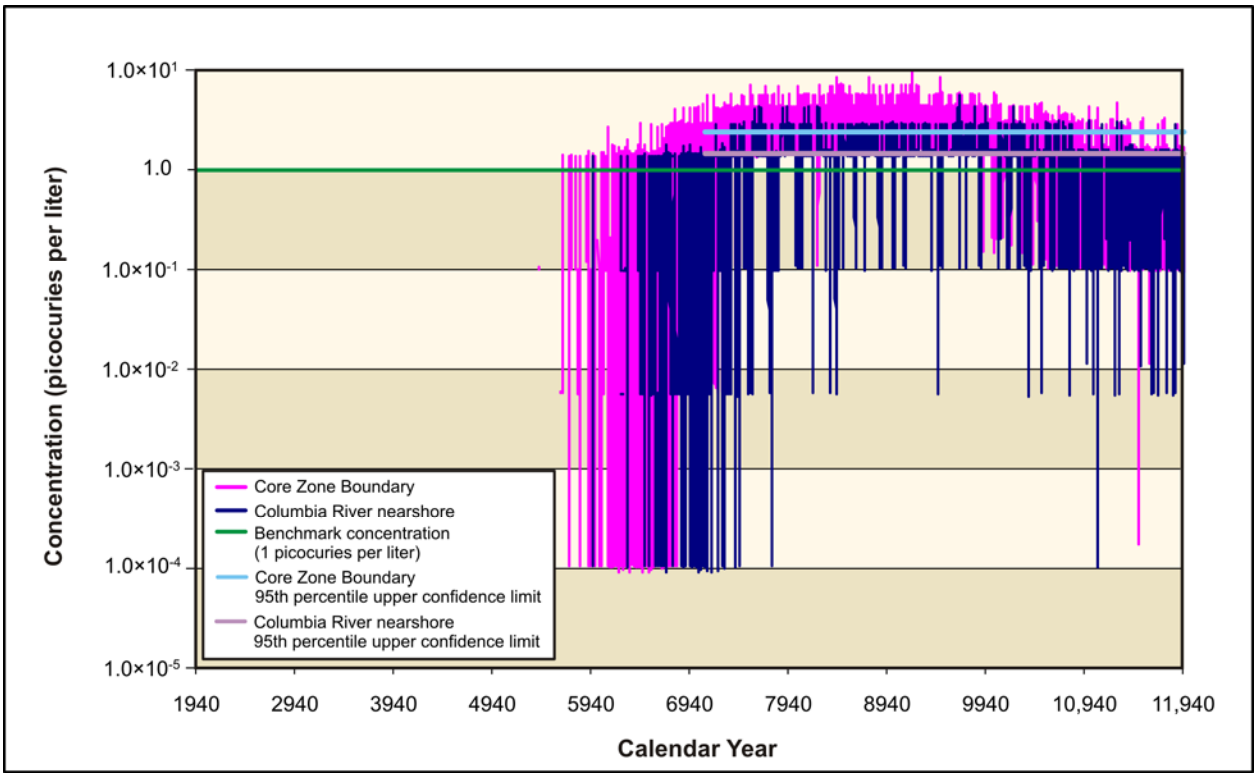


Figure 5–571. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Iodine-129 Concentration Versus Time

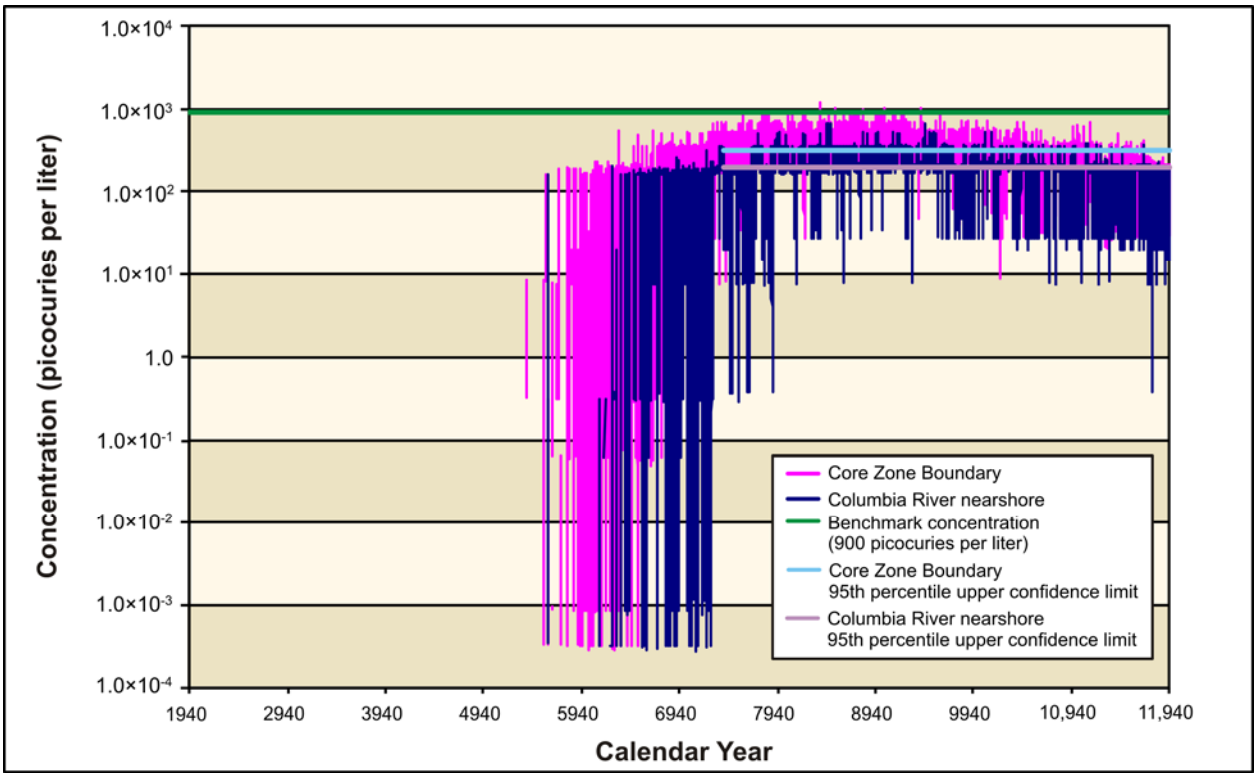


Figure 5–572. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Technetium-99 Concentration Versus Time

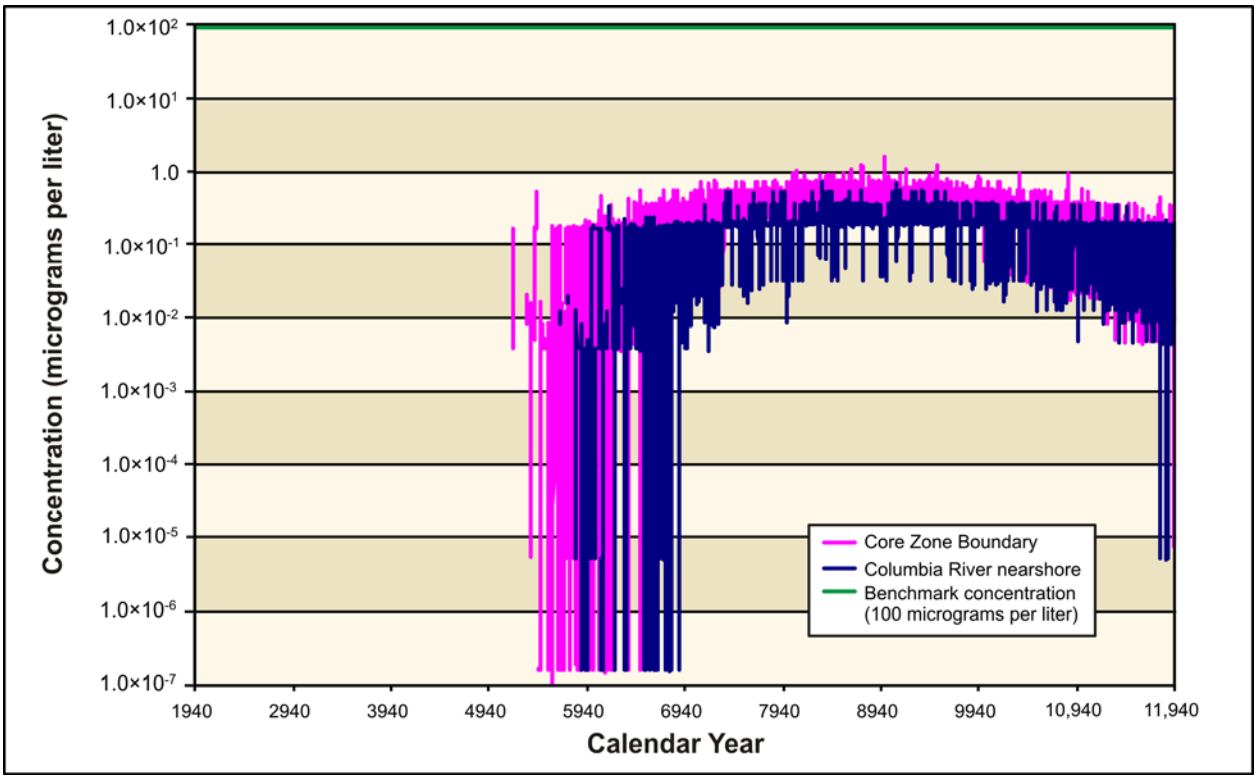


Figure 5–573. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Chromium Concentration Versus Time

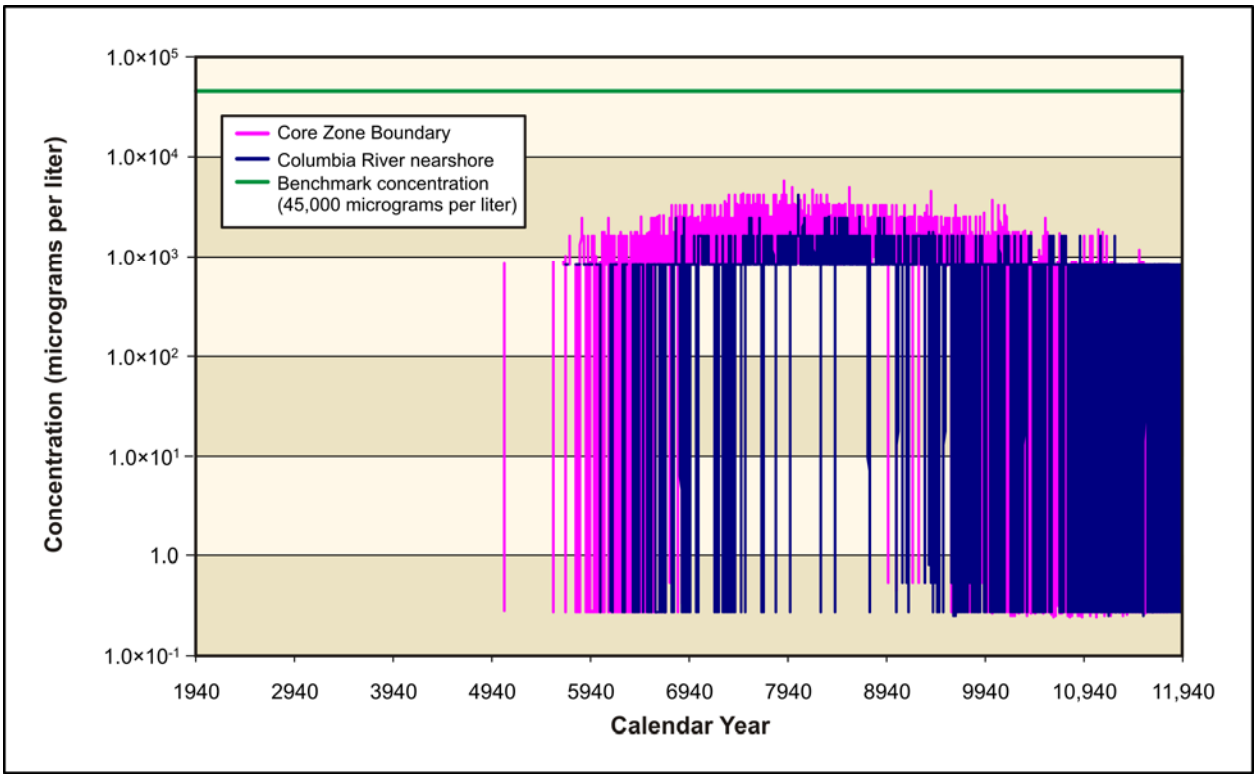


Figure 5–574. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Nitrate Concentration Versus Time

Table 5–84. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**2,820**	N/A	**1,150**	671	900
	(8580)		(8365)	(8478)	
Iodine-129	**24**	N/A	**10**	6	1
	(9058)		(9178)	(9652)	
Chemical in micrograms per liter					
Chromium	3	N/A	2	1	100
	(9308)		(8982)	(8354)	
Nitrate	15,500	N/A	5,700	4,070	45,000
	(8055)		(7905)	(8056)	

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

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; N/A=not applicable; RPPDF=River Protection Project Disposal Facility.

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, in terms of the spatial distribution of groundwater concentration at selected times in this analysis period. Concentrations of radionuclides are in picocuries per liter; chemicals in micrograms per liter (see Figures 5–575 through 5–582). Concentrations for each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration.

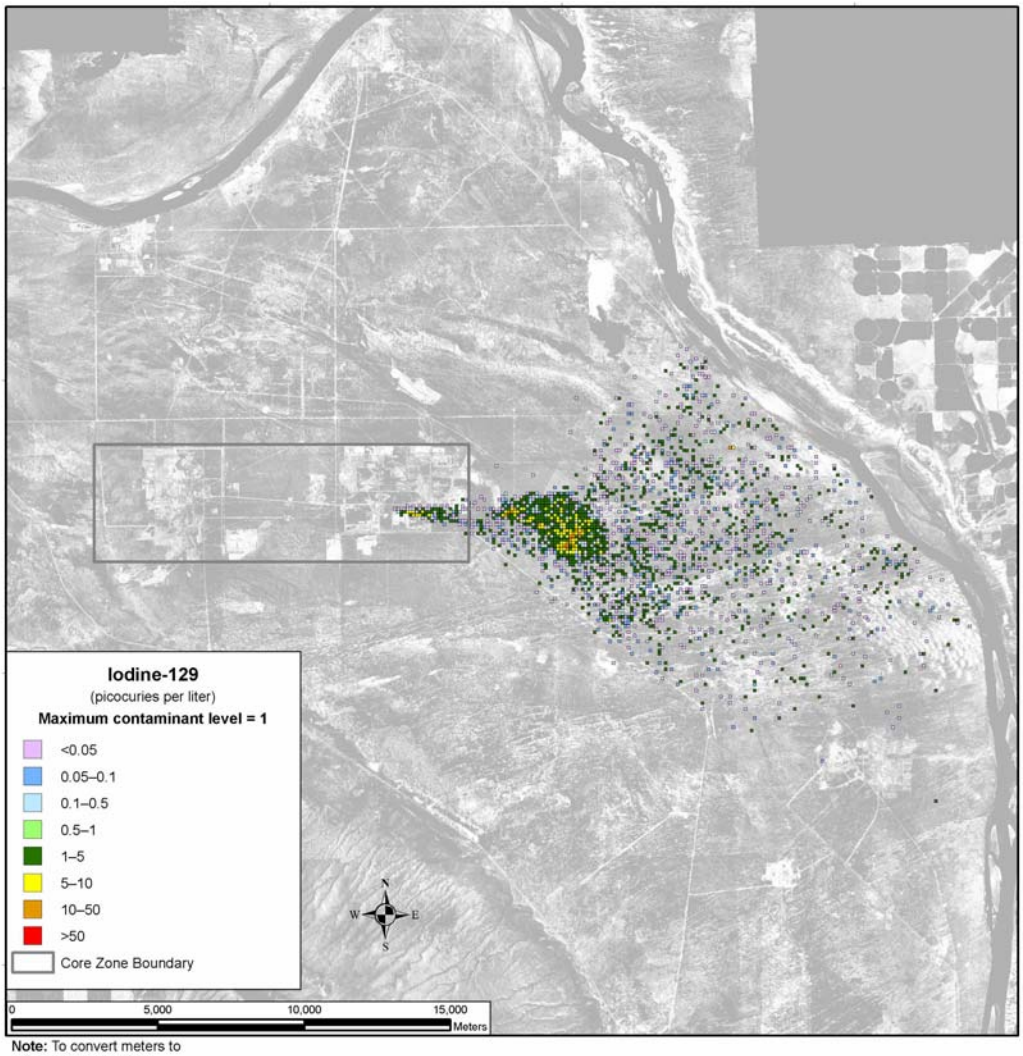
Figures 5–575 through 5–582 show that there are groundwater releases from IDF-East that extend to the Columbia River. The release distributions are confined in a narrow area until about a third of the distance to the Columbia River nearshore boundary, where they spread out significantly and continue to the Columbia River. The iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore water velocity) that are impacted by moisture content. For each distribution map, the concentrations that are 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. The concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations.

Figure 5–575 and 5–576 show the spatial distribution of groundwater concentration for iodine-129 during CYs 7140 and 11,885. These figures show a growing distribution in both size and concentration that is still present through CY 11,885. There are areas where concentration is above the benchmark concentration east of the Core Zone Boundary. However, over the period of analysis, most of the distribution concentration remains below the benchmark concentration.

Figures 5–577 and 5–578 show the technetium-99 release with a distribution from the release source to the Columbia River. There is also a small area east of the Core Zone Boundary where the technetium-99 concentration approaches (and potentially exceeds) the benchmark concentration. By CY 11,885 (see Figure 5–578), the distribution has increased over CY 7140 in size. Although most of the distribution is well below the benchmark concentration, this figure shows a distribution of technetium-99 through CY 11,885.

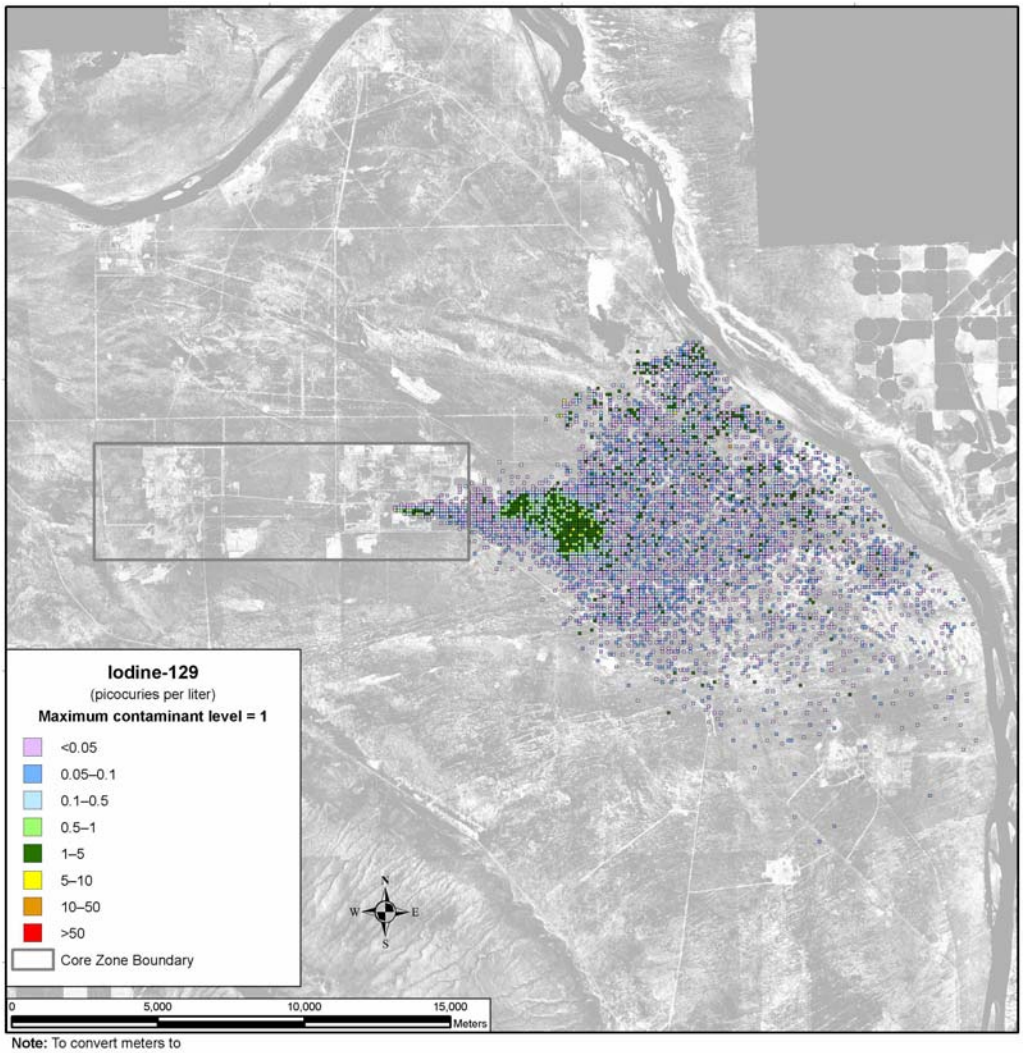
Figures 5–579 and 5–580 (CYs 7140 and 11,885) show a chromium release extending from the release source to the Columbia River. Comparisons of the CY 7140 and 11,885 distributions show about the same concentration and area for the releases. The concentration of chromium remains well below the benchmark concentration in both distributions.

Figures 5–581 and 5–582 show the spatial distribution of groundwater concentrations of nitrate for CYs 7140 and 11,885. There is an area east of the Core Zone Boundary where the nitrate release appears to approach the benchmark concentration. The CY 11,885 data show a significant reduction in concentration, especially for the isolated area of higher concentration. Most of the nitrate distribution is well below the benchmark concentration.



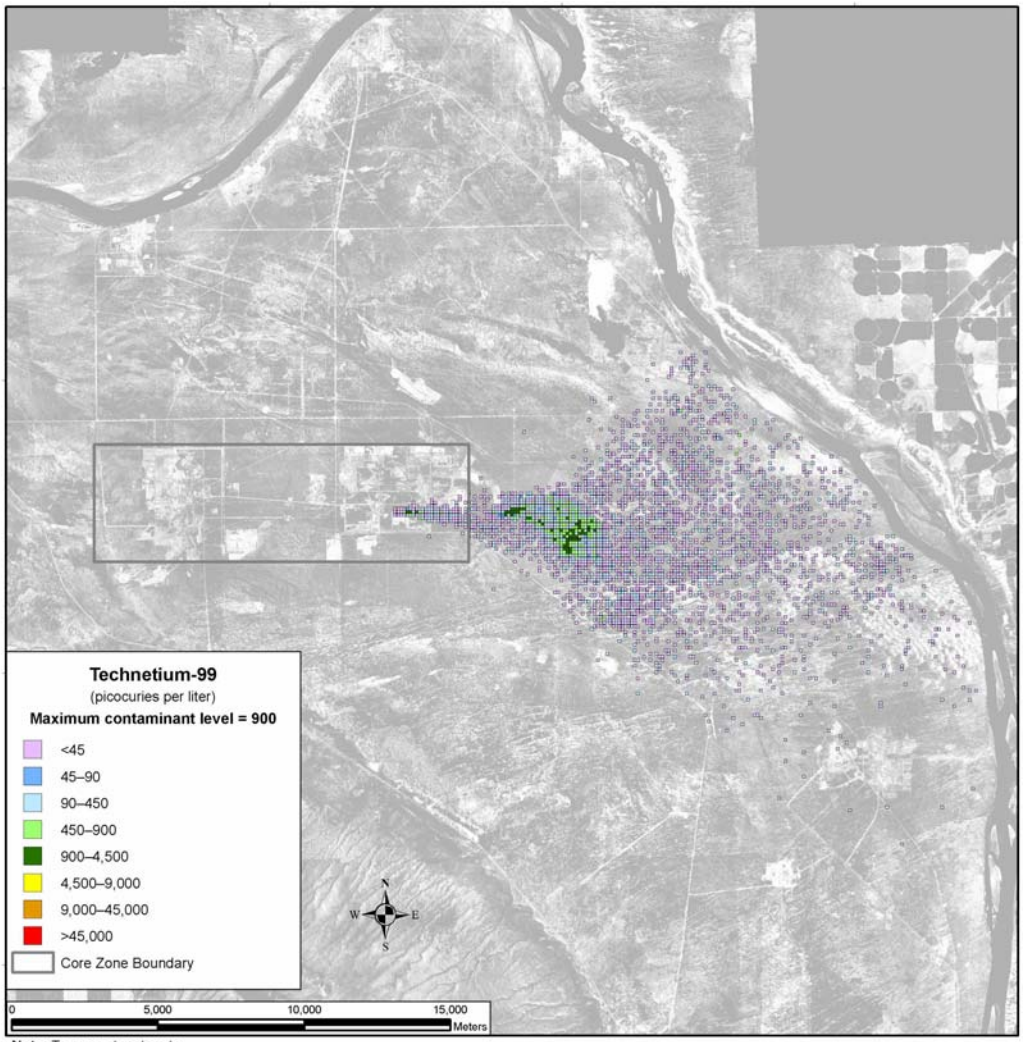
Note: To convert meters to feet, multiply by 3.281

Figure 5–575. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



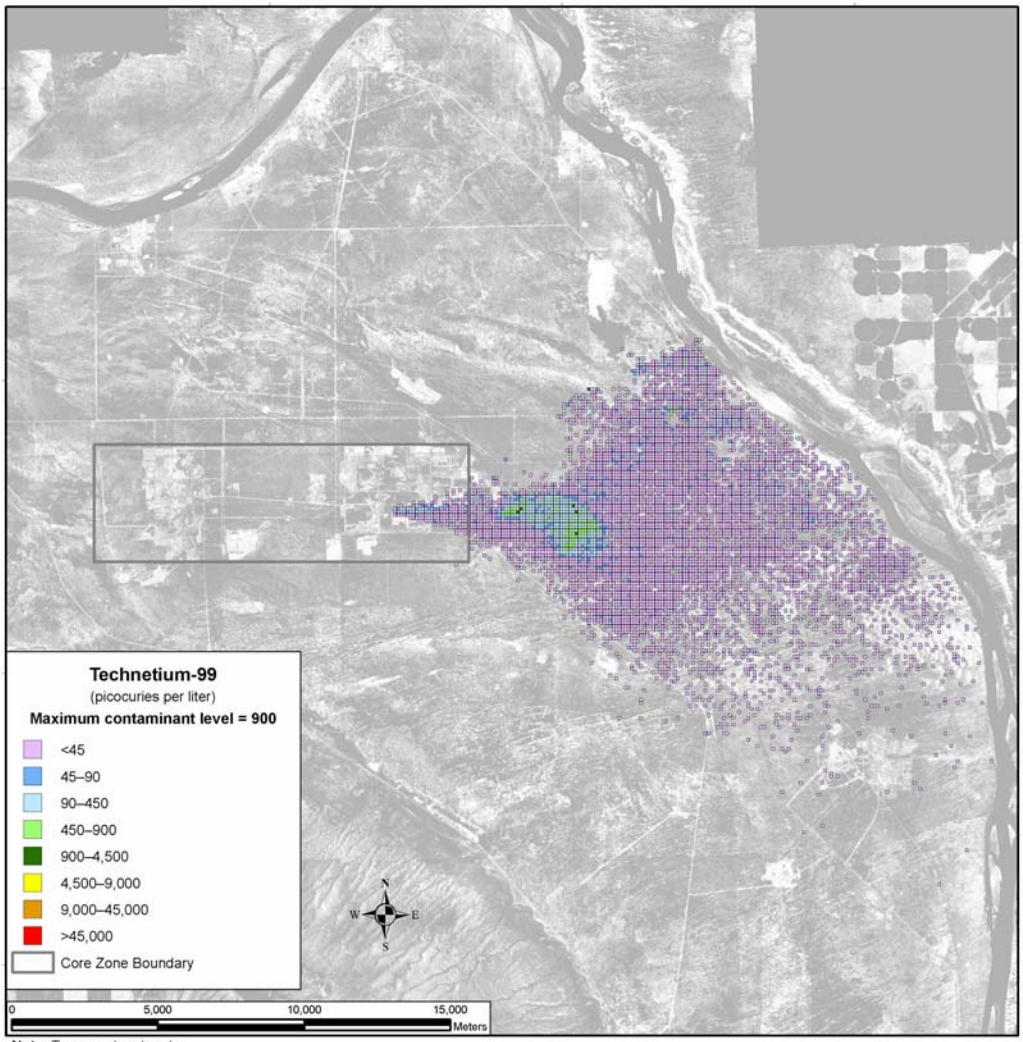
Note: To convert meters to feet, multiply by 3.281

Figure 5–576. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



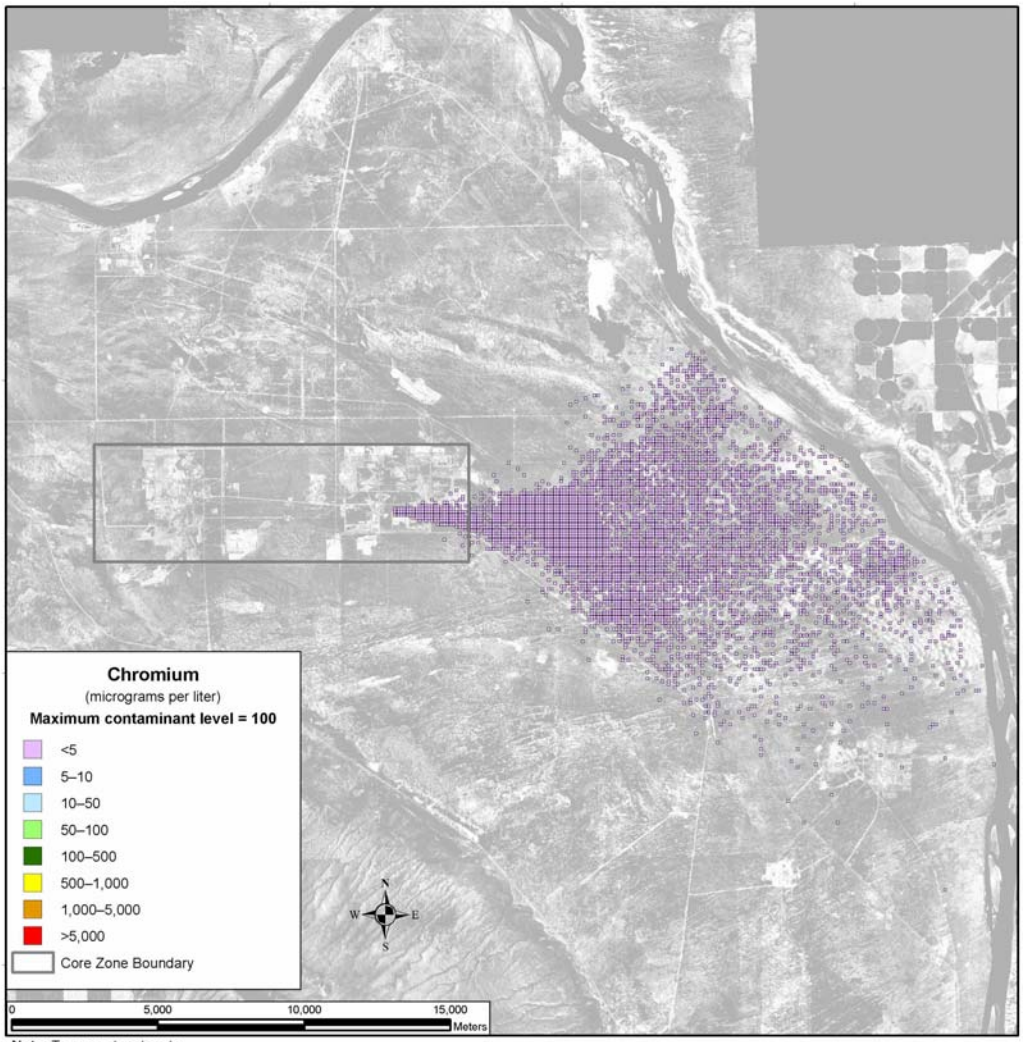
Note: To convert meters to feet, multiply by 3.281

Figure 5–577. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



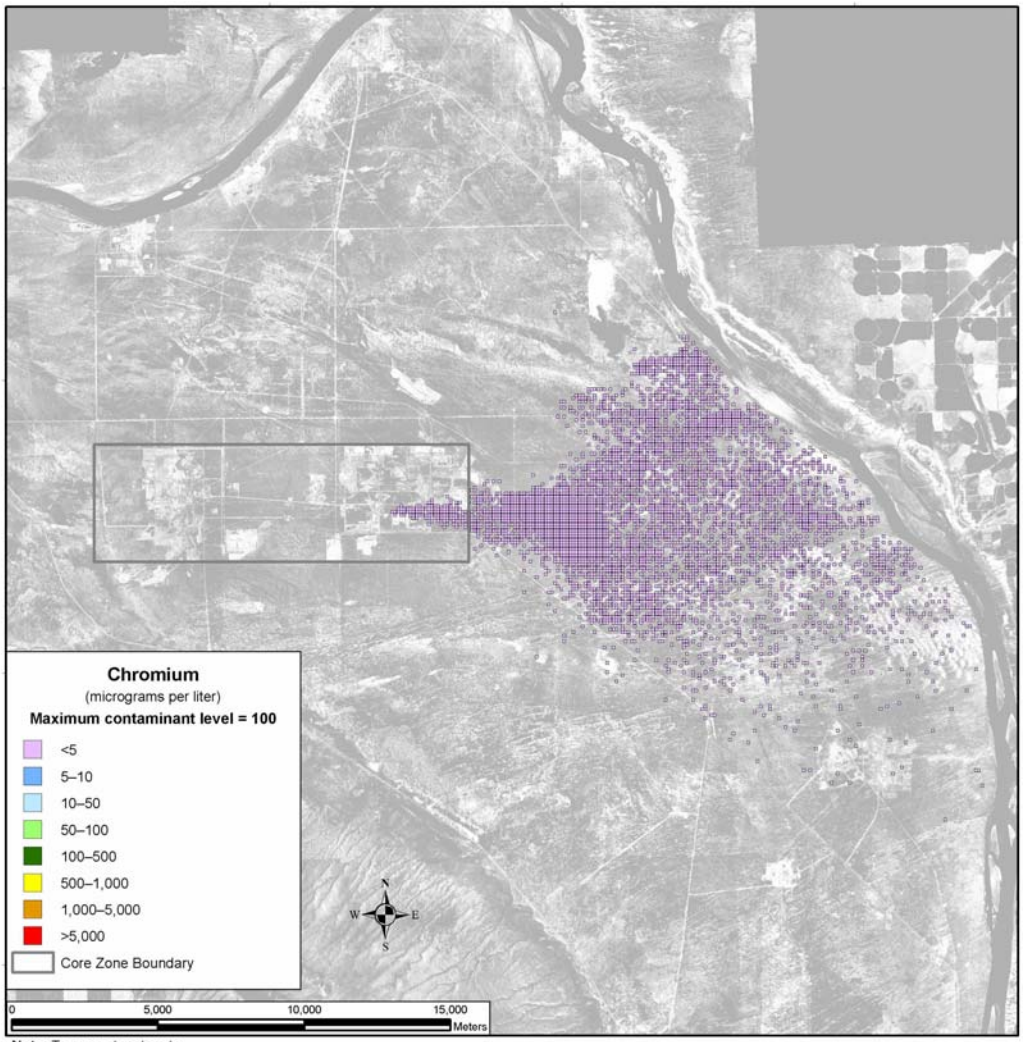
Note: To convert meters to feet, multiply by 3.281

Figure 5–578. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



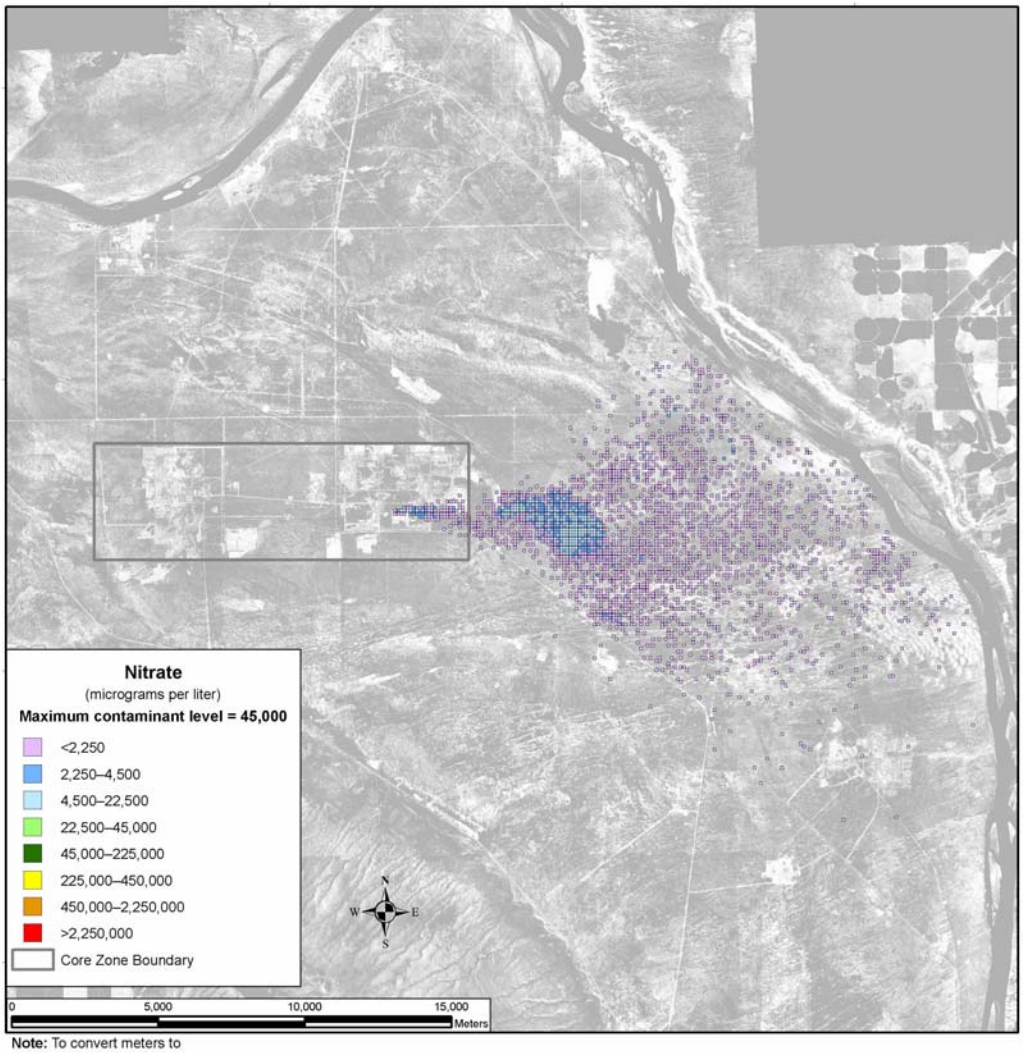
Note: To convert meters to feet, multiply by 3.281

Figure 5–579. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



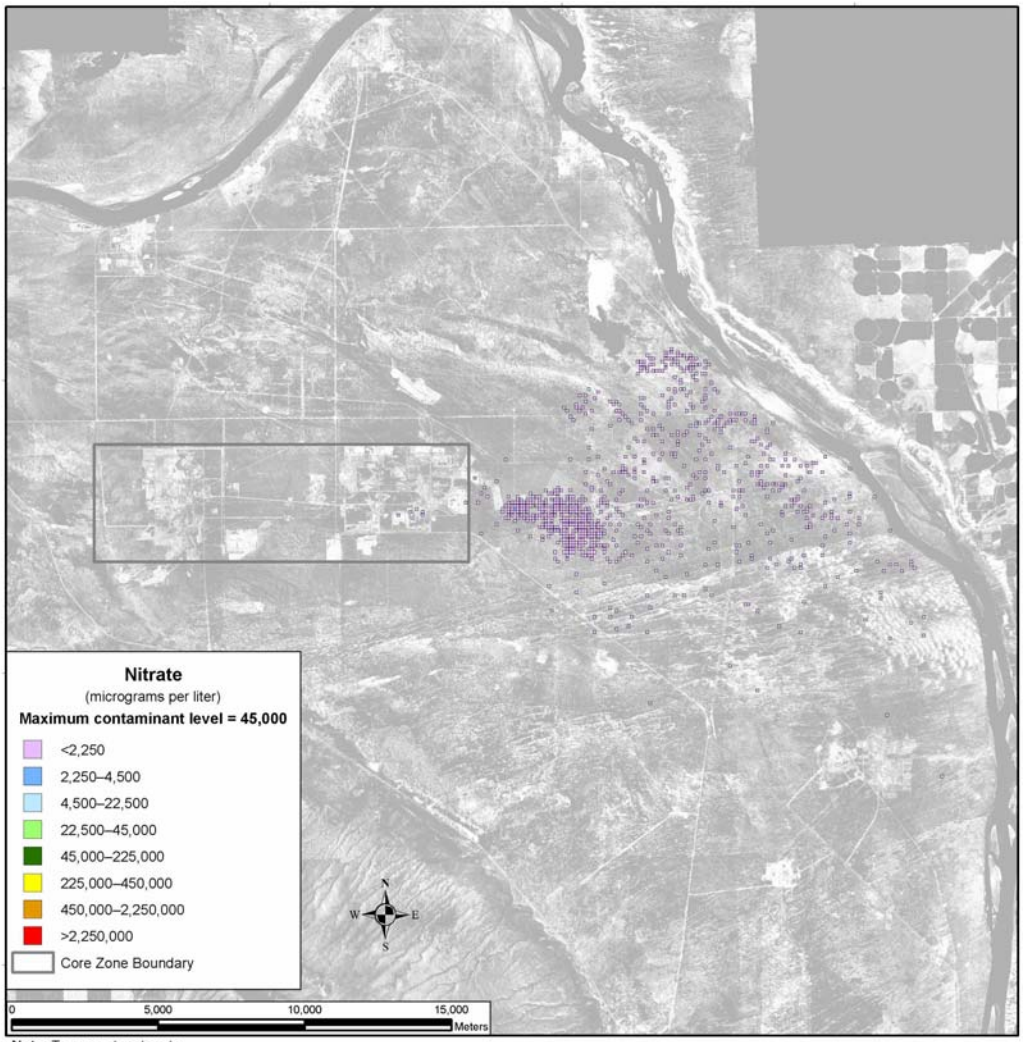
Note: To convert meters to feet, multiply by 3.281

Figure 5–580. Waste Management Alternative 2, 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 5–581. Waste Management Alternative 2, 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 5–582. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

Under Waste Management Alternative 2, Disposal Group 2, Subgroup 2-A, in general, the predominant contributor is the iodine-129 inventory at IDF-East that is available for release to the environment at the start of the post-disposal period. The technetium-99, chromium, and nitrate releases do not exceed benchmark concentrations during the period of analysis except in small, isolated areas (pockets). The release data show declining but significant concentrations through the end of this analysis period (CY 11,885).

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

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, includes Tank Closure Alternative 6B, Base Case; FFTF Decommissioning Alternative 2 or 3; and onsite- and offsite-generated waste. Waste would be converted to IHLW and ILAW glass. IHLW would be stored on site, while ILAW glass would be managed on site as high-level radioactive waste (HLW) pending disposition.

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

- The disposal period starts with the onset of disposal operations for IDF-East and the RPPDF in CY 2009 and continues through CY 2100, when the disposal facilities will be operationally closed. During this disposal period, the materials in these permitted, operational facilities are assumed to be unavailable 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 the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, IDF-East 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 2, Disposal Group 2, Subgroup 2-B, Base Case. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case is focused on the following COPC drivers:

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

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

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

ANALYSIS OF RELEASE AND MASS BALANCE

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

200-East Area Integrated Disposal Facility

Figure 5–583 shows the release to the vadose zone for the radiological risk drivers and Figure 5–584, the chemical hazard drivers. For all seven types of sources, the inventories in the waste forms are a major factor in the quantities released to the vadose zone. The predominant source of technetium-99 in the vadose zone is offsite-generated waste (77 percent), followed by tank closure secondary waste (19 percent), and ETF-generated secondary waste (4 percent). The sources of the iodine-129 release are offsite-generated waste (85 percent) and ETF-generated secondary waste (14 percent). The chromium release is from the tank closure secondary waste (86 percent), waste management secondary waste and onsite-generated waste (8 percent), with some from offsite-generated waste (4 percent) and ETF-generated secondary waste (2 percent). All of the nitrate released is from ETF-generated secondary waste. There is no acetonitrile from any of the waste forms in IDF-East.

Figure 5–585 shows the release to groundwater for the radiological risk drivers and Figure 5–586, 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. Most of the vadose zone technetium-99 (89 percent), iodine-129 (91 percent), chromium (>99 percent), and nitrate (>99 percent) is released to groundwater during the period of analysis.

Figure 5–587 shows the release to the Columbia River for the radiological risk drivers and Figure 5–588, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most of the technetium-99 (97 percent), iodine-129 (97 percent), chromium (97 percent), and nitrate (>99 percent) in the groundwater is released to the Columbia River over the period of analysis.

Overall, most of the technetium-99 (86 percent), iodine-129 (89 percent), chromium (96 percent), and nitrate (98 percent) from the vadose zone is released to the Columbia River. These releases are identical to those of Waste Management Alternative 2, Disposal Group 2-B, Option Case, for these COPCs.

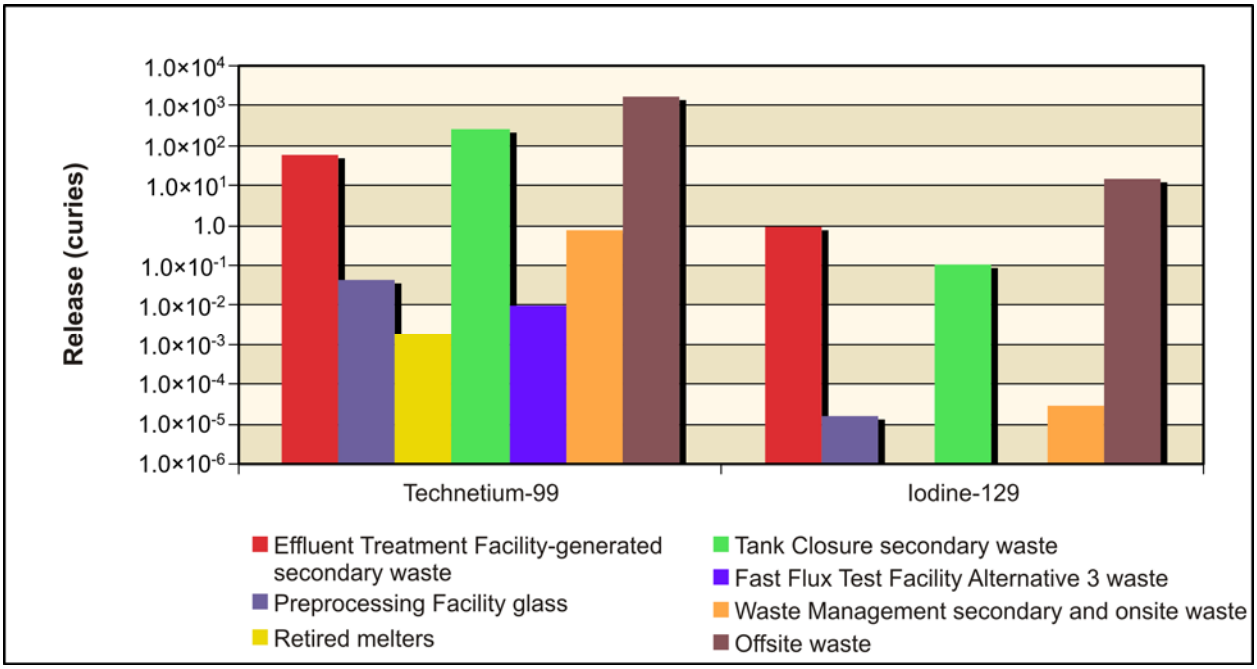


Figure 5–583. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

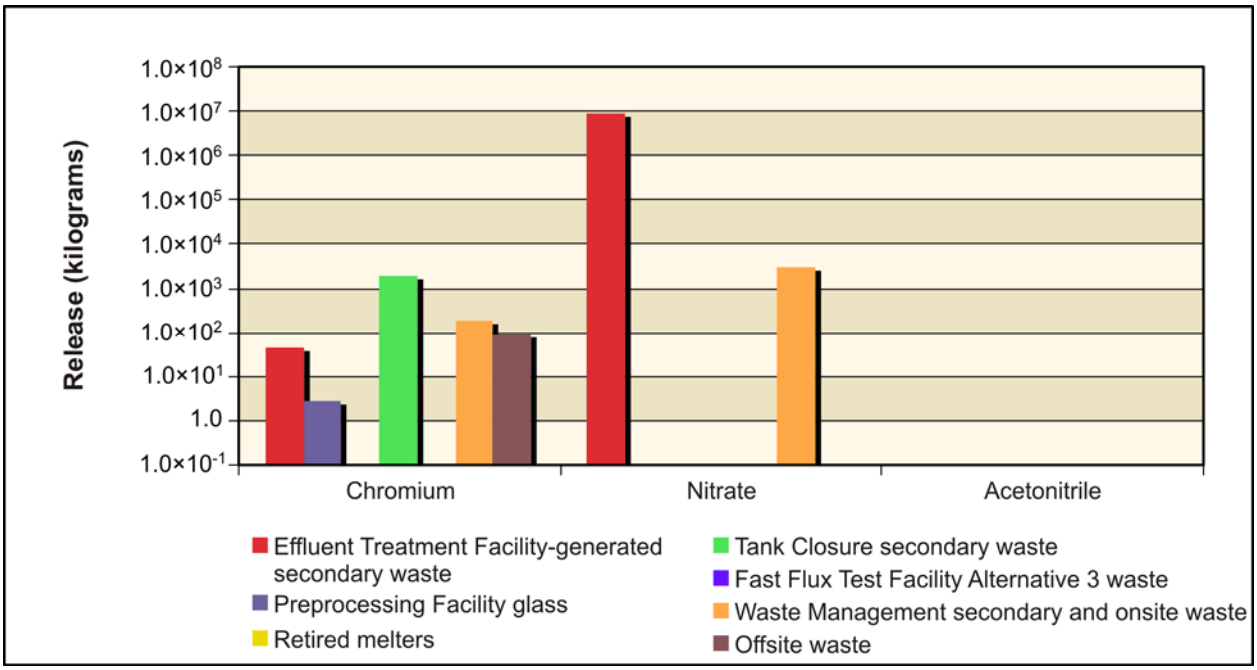


Figure 5–584. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

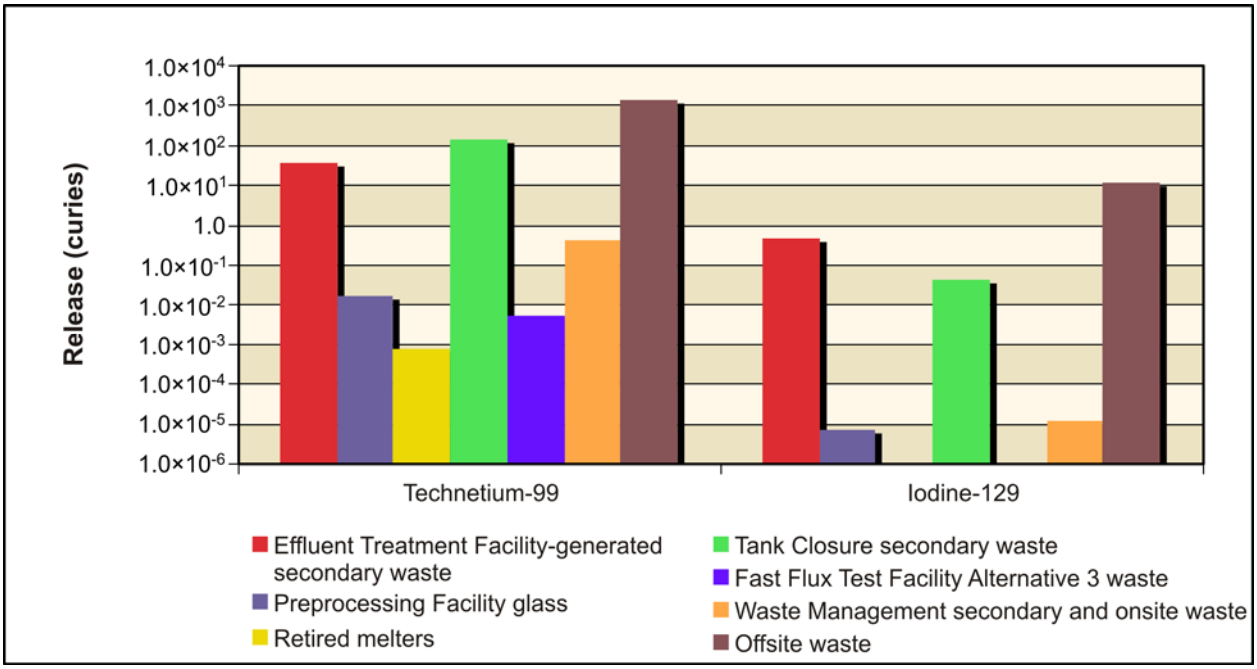


Figure 5–585. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

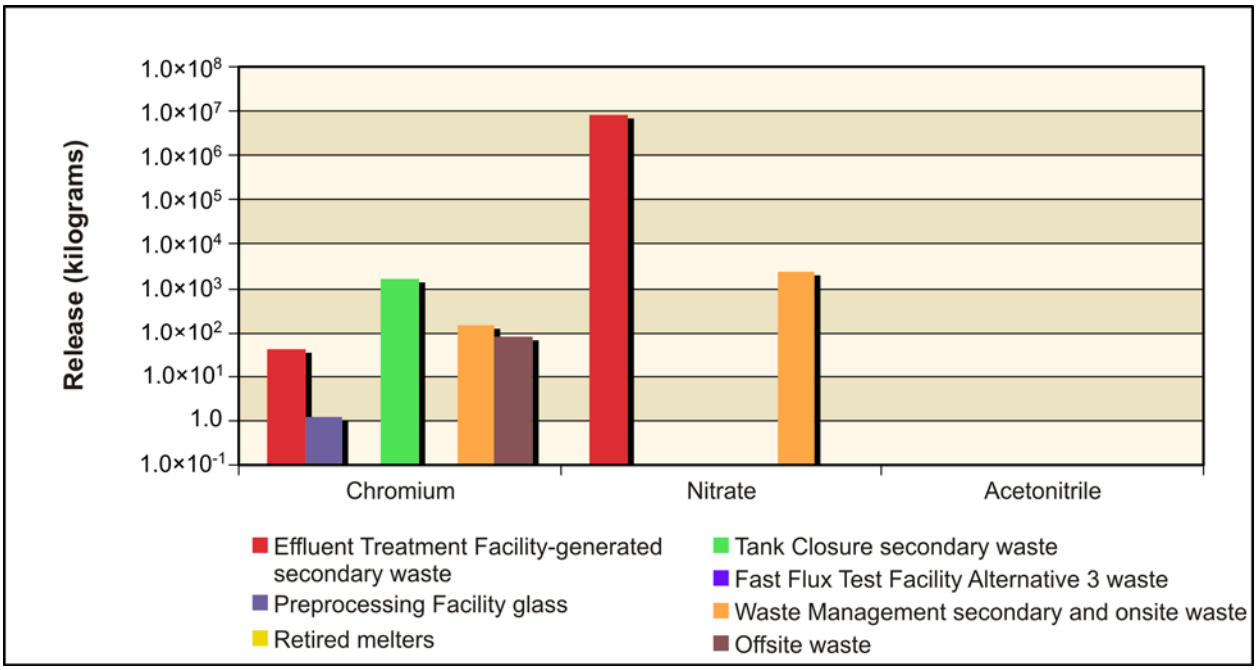


Figure 5–586. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

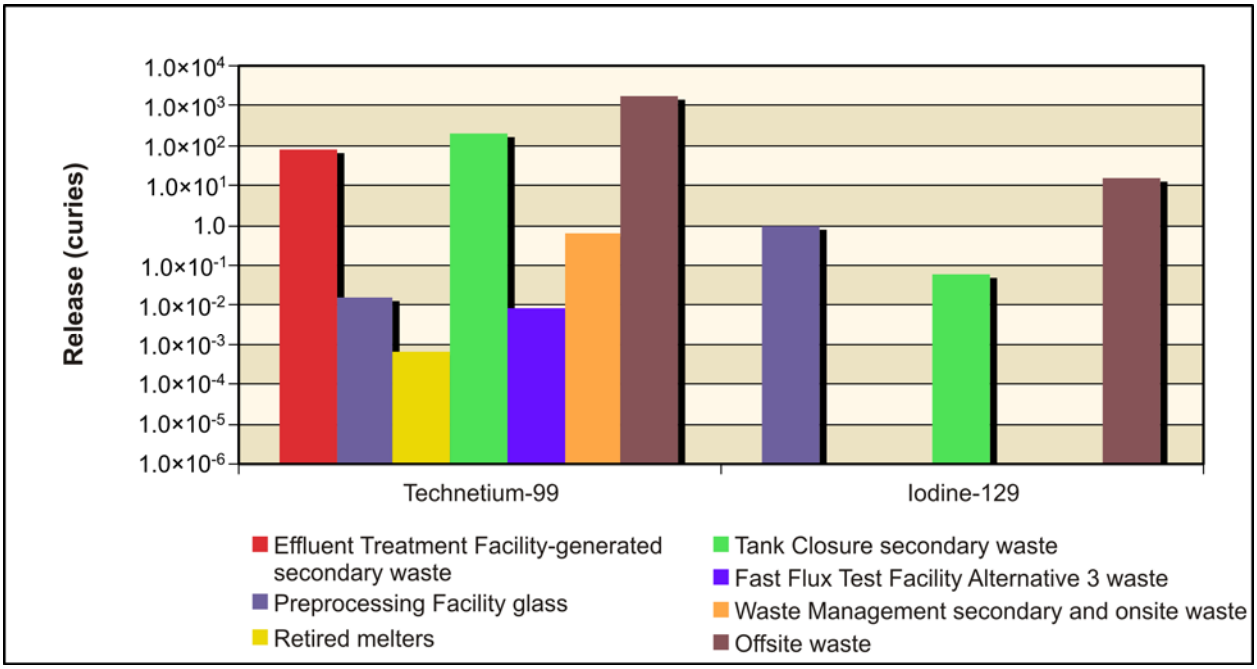


Figure 5–587. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

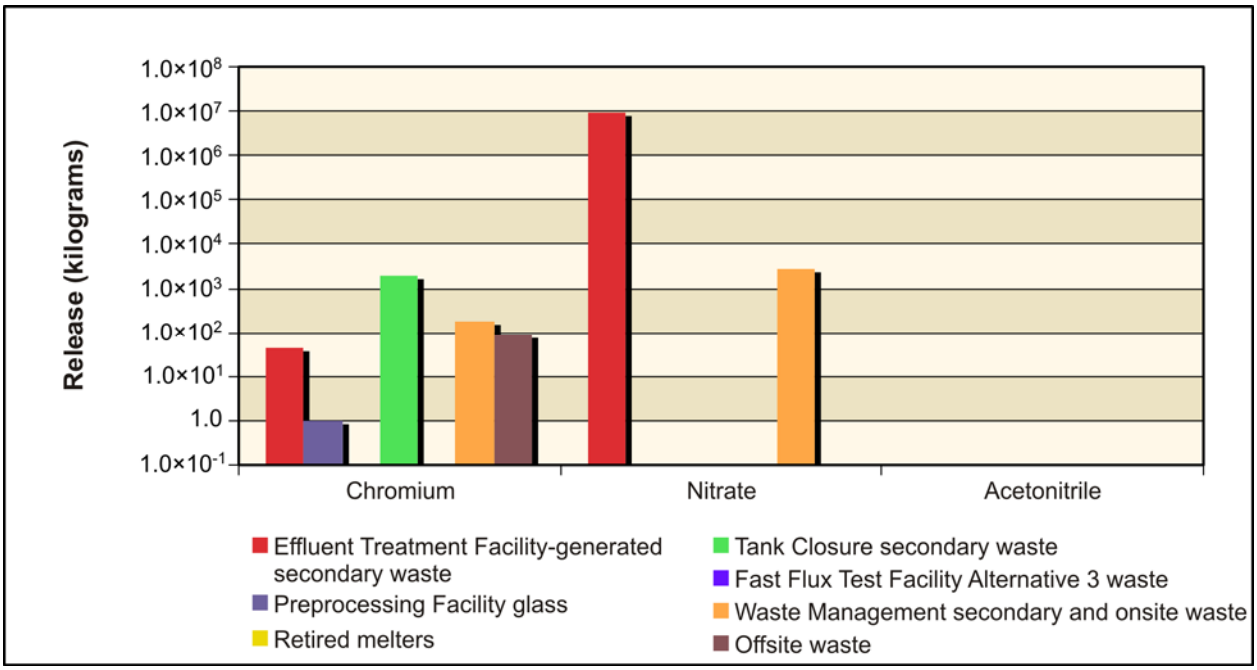


Figure 5–588. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–589 shows the release to the vadose zone for the radiological risk drivers and Figure 5–590, 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 predominant releases from the RPPDF are technetium-99 and iodine-129, with technetium-99 being the predominant radionuclide released. The chemical releases from the RPPDF include nitrate (largest), chromium, and acetonitrile (smallest).

Figure 5–591 shows the release to groundwater for the radiological risk drivers and Figure 5–592, 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 technetium-99, iodine-129, chromium, nitrate, and acetonitrile, the amount released to groundwater is essentially equal to the amount released to the vadose zone.

Figure 5–593 shows the release to the Columbia River for the radiological risk drivers and Figure 5–594, 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, nitrate, and acetonitrile, the amount released to the Columbia River is essentially equal to the amount released to groundwater.

Overall, about 96 percent of the radionuclides and chemicals released by the RPPDF to the vadose zone are released to the Columbia River during the period of analysis. Identical results were observed for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case.

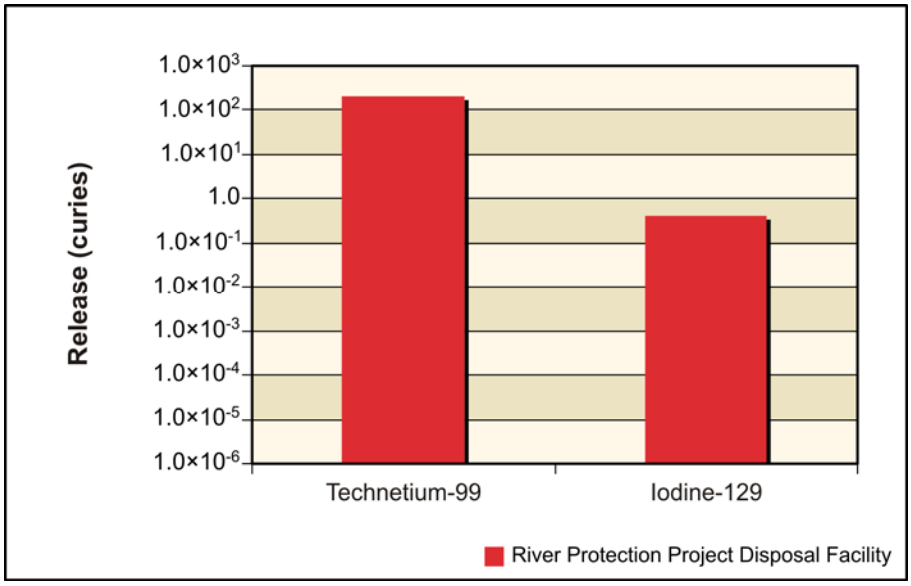


Figure 5–589. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

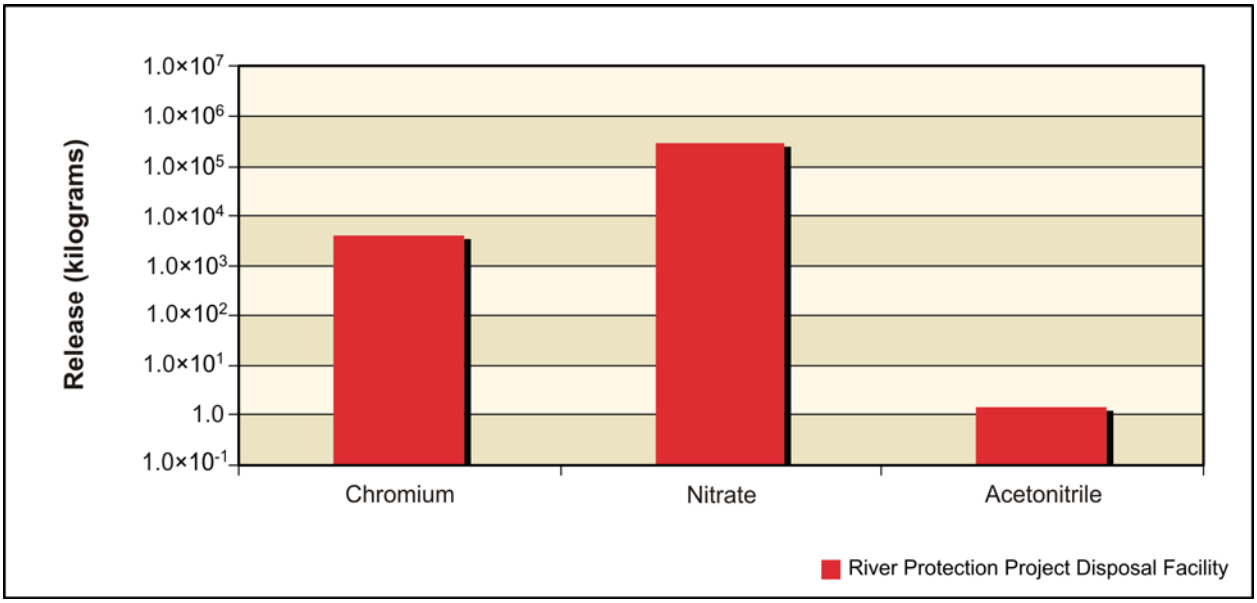


Figure 5–590. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

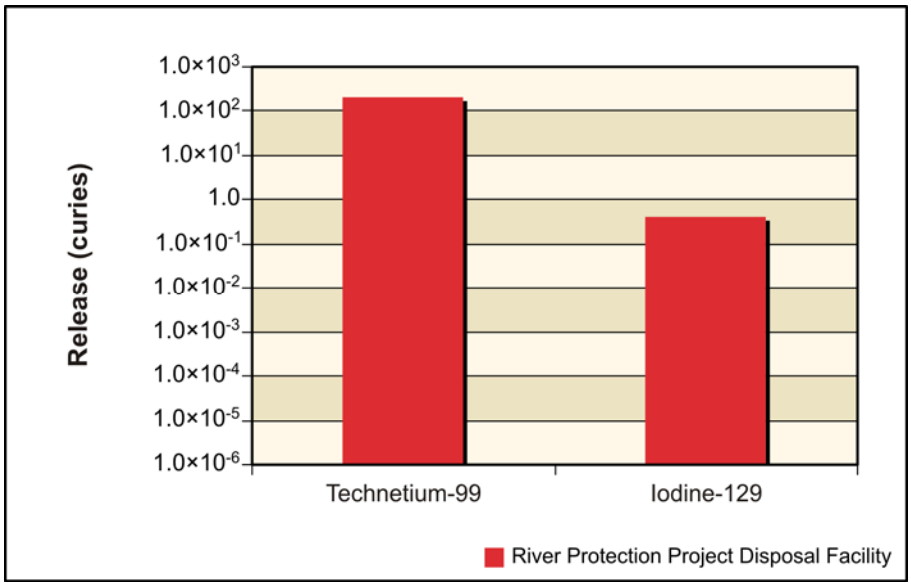


Figure 5–591. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

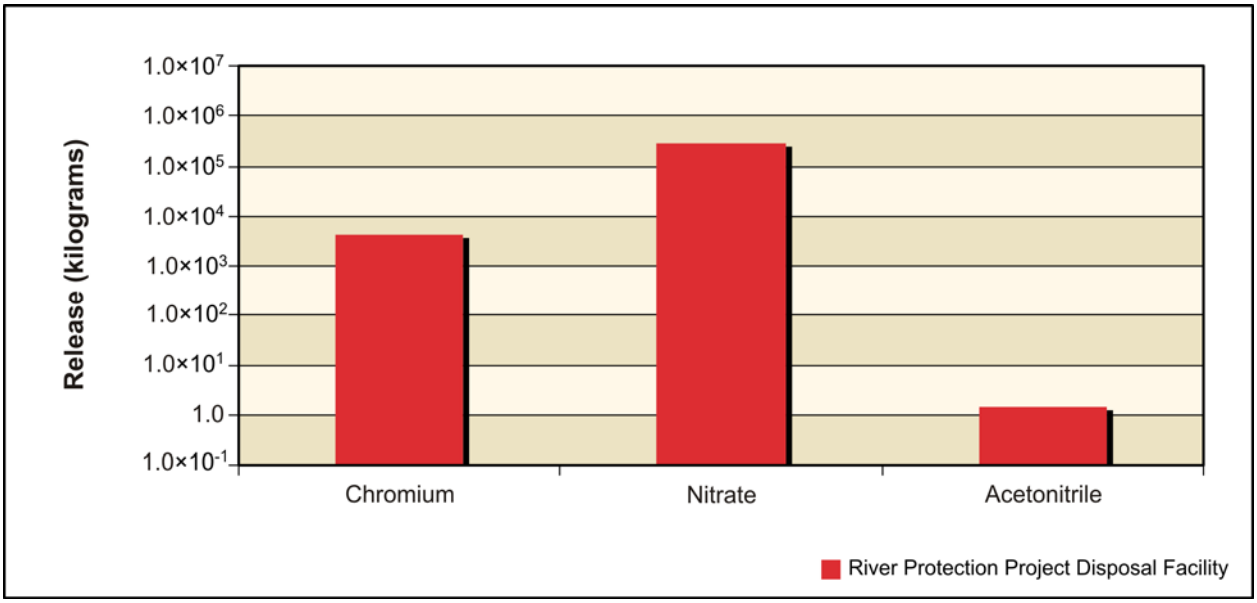


Figure 5–592. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

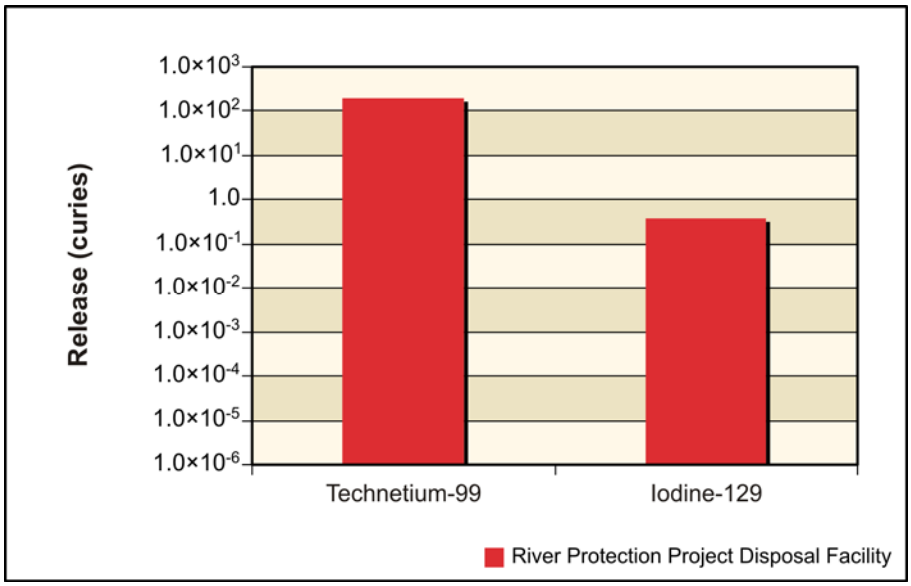


Figure 5–593. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

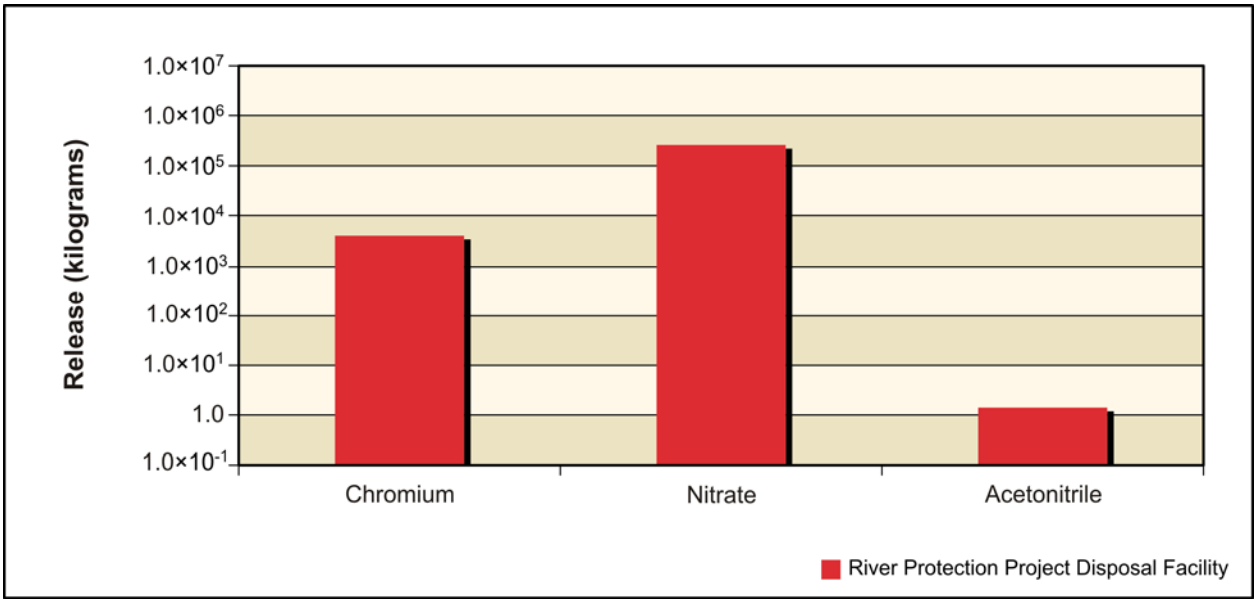


Figure 5–594. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration of each radionuclide and chemical is also shown. The concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. 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. Table 5–85 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River nearshore.

Table 5–85. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**2,890**	283	**1,140**	703	900
	(8580)	(3889)	(8365)	(8477)	
Iodine-129	**24**	0.5	**10**	**6**	1
	(9058)	(4089)	(9188)	(9652)	
Chemical in micrograms per liter					
Chromium	3	6	11	2	100
	(8281)	(3868)	(11232)	(5035)	
Nitrate	16,600	353	5,750	3,310	45,000
	(8162)	(3996)	(8245)	(7837)	

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

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figures 5–595 through 5–598 show concentration versus time for technetium-99, iodine-129, nitrate, and chromium, respectively. The releases of technetium-99 from IDF-East and the RPPDF do not exceed the benchmark concentrations at the Core Zone Boundary or the Columbia River nearshore (see Figure 5–595). The technetium-99 concentrations at both boundaries remain fairly constant for most of the analysis period and then decrease into CY 11,940.

Figure 5–596 shows iodine-129 exceeding benchmark concentrations starting about CY 5940 and continuing through CY 11,940 for both the Core Zone Boundary and the Columbia River nearshore. Figures 5–597 and 5–598 show that the nitrate and chromium releases do not reach the benchmark concentrations over the period of analysis. The nitrate and chromium concentrations at the Core Zone Boundary and the Columbia River nearshore are always at least one order of magnitude lower than their benchmark concentrations.

Figure 5–599 shows concentration versus time for total uranium. Uranium-238 has no detectable release to the environment. Total uranium concentrations, while very low, continue to increase during the period of analysis and beyond. The total uranium concentration never approaches closer than six orders of magnitude to the benchmark concentration during the period of analysis (through CY 11,940).

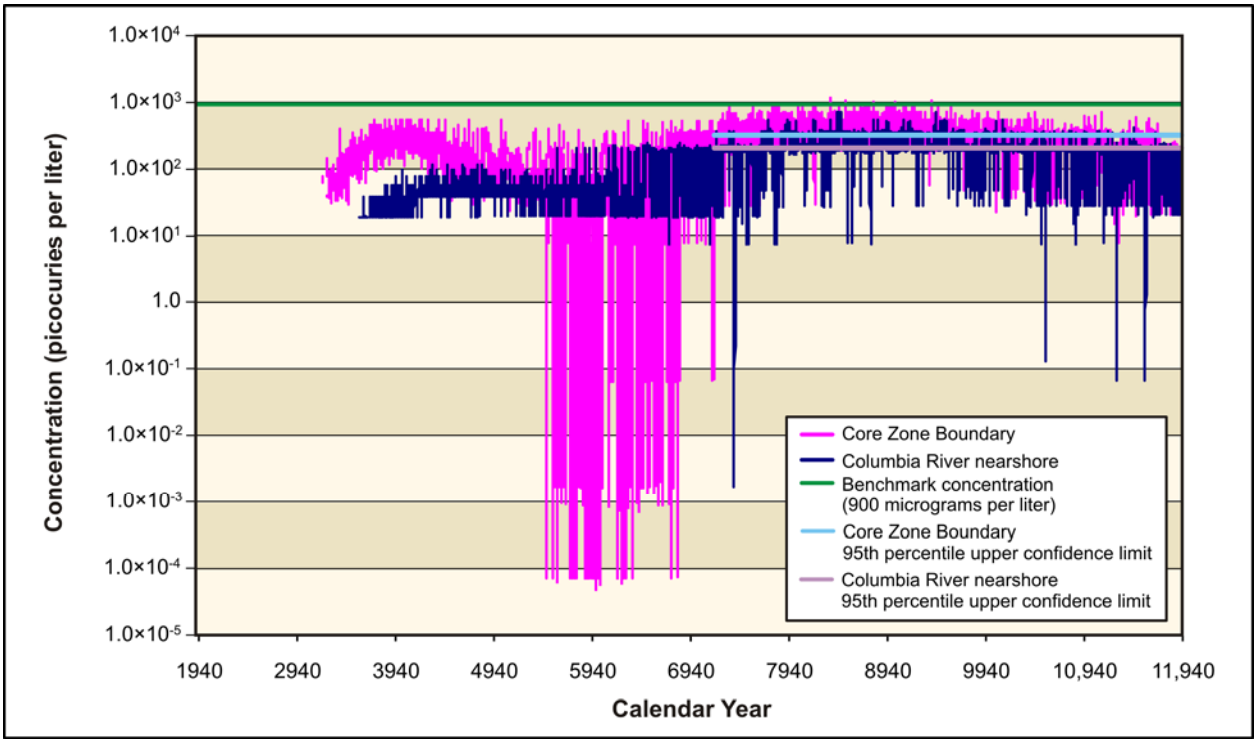


Figure 5–595. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Technetium-99 Concentration Versus Time

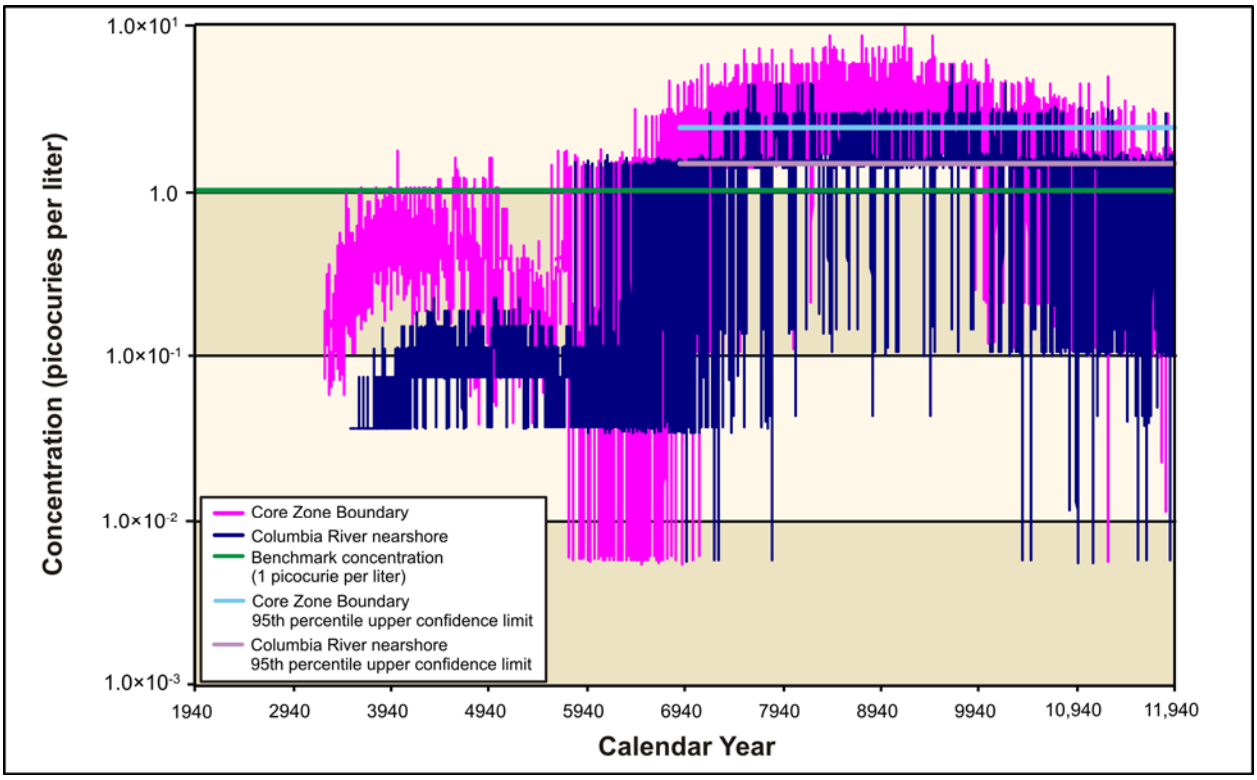


Figure 5–596. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Iodine-129 Concentration Versus Time

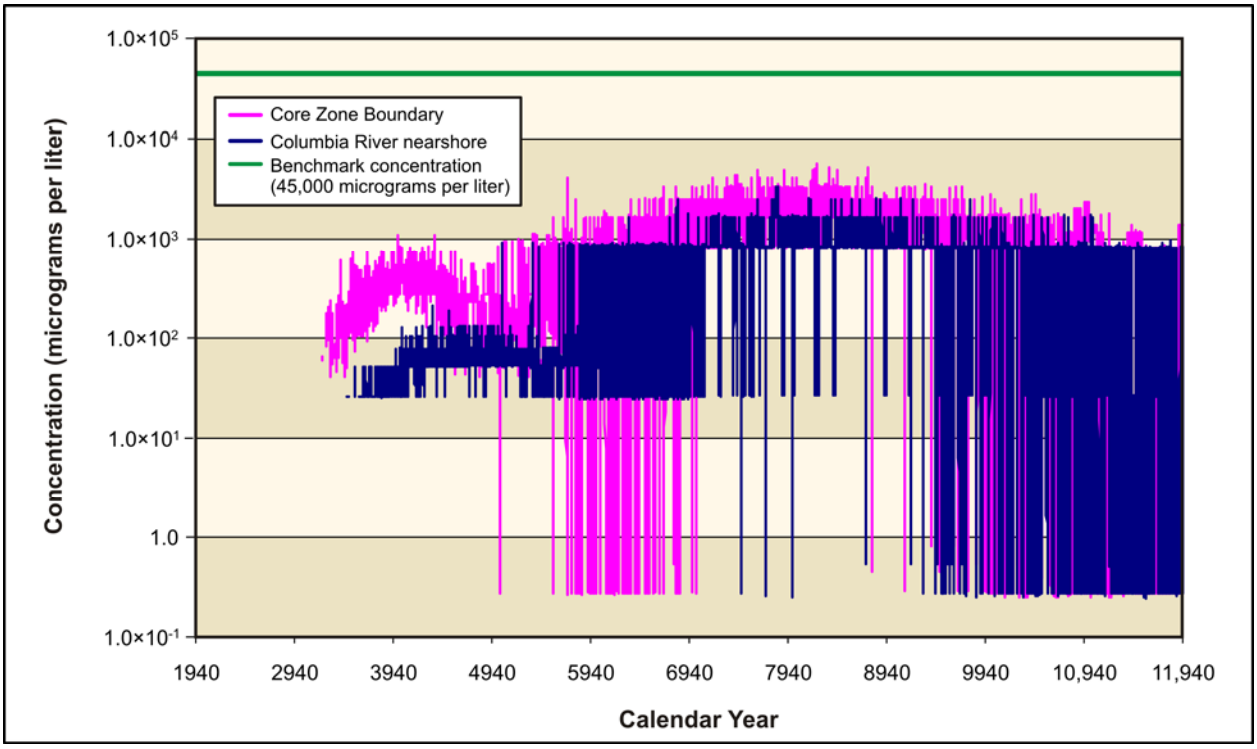


Figure 5–597. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Nitrate Concentration Versus Time

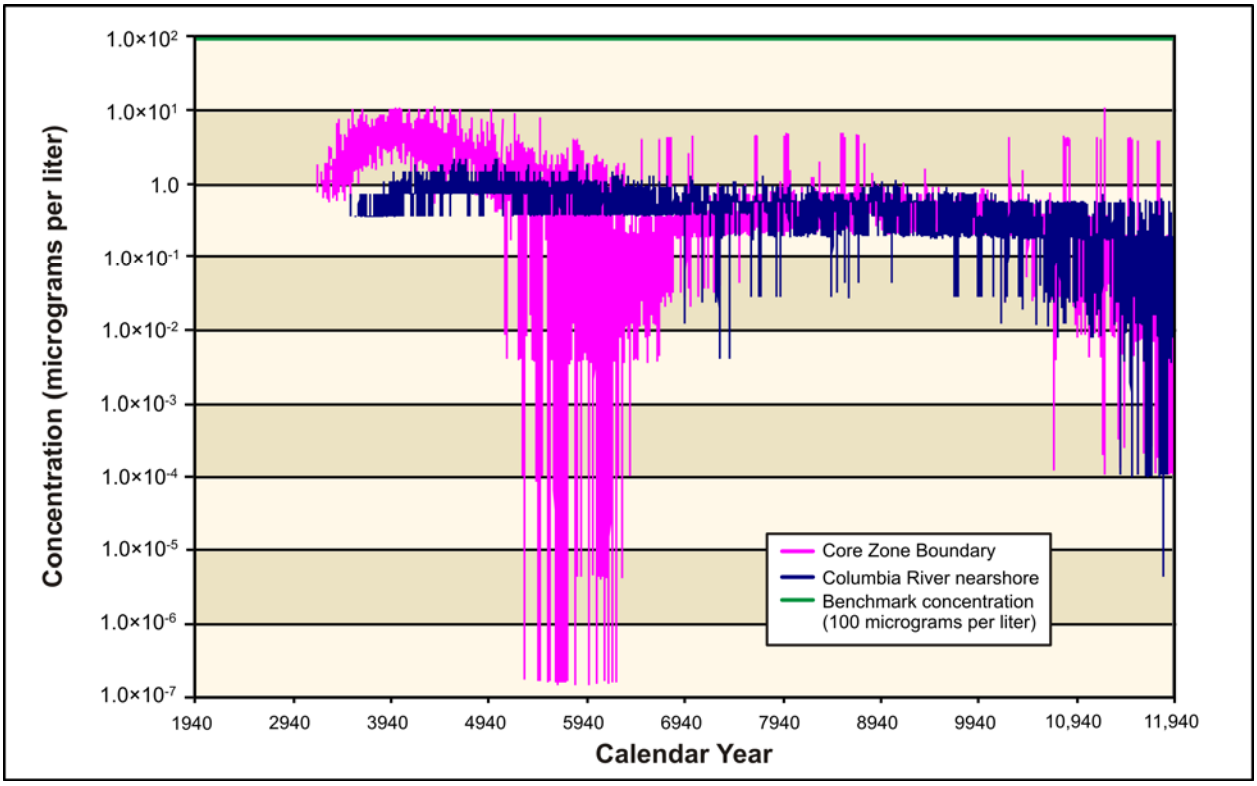


Figure 5–598. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Chromium Concentration Versus Time

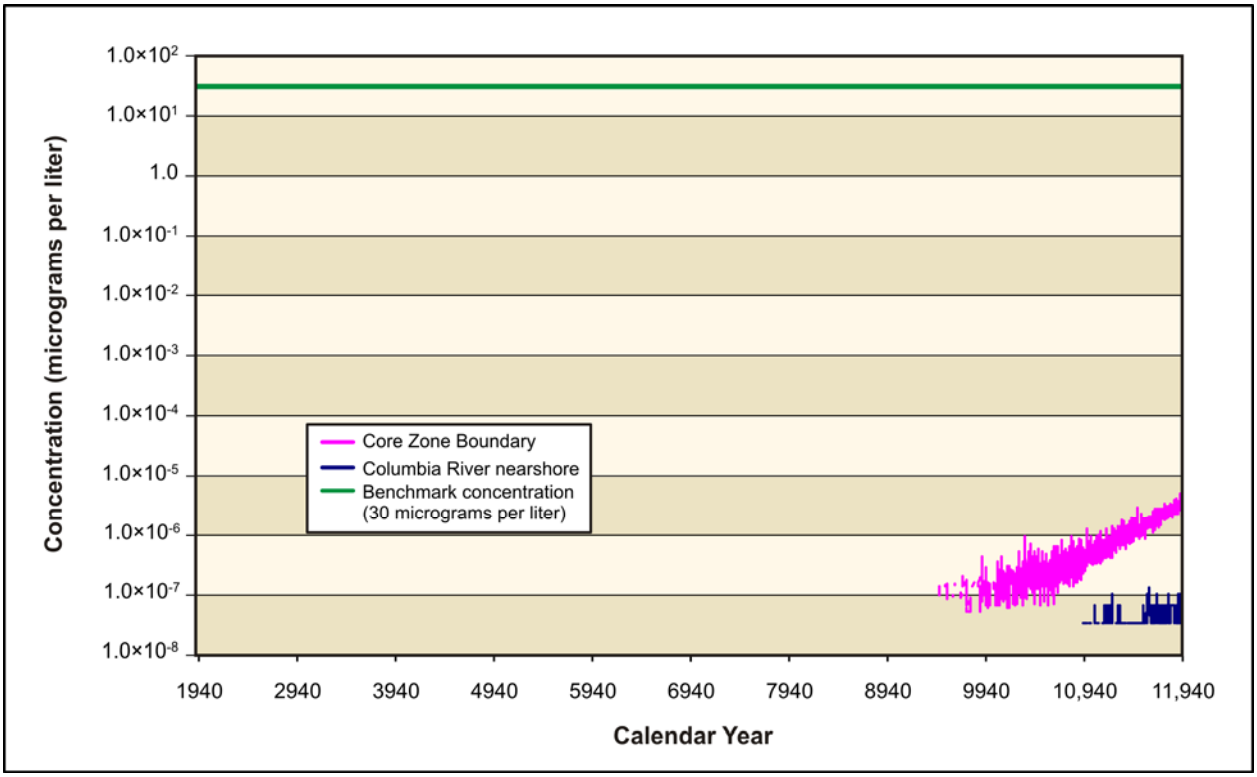


Figure 5–599. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, 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.

Figures 5–600 through 5–611 show concentration distributions at CYs 3890, 7140, and 11,885 for technetium-99, iodine-129, nitrate, and chromium. Figure 5–612 shows the concentration distribution for total uranium at CY 11,885. These groundwater releases from IDF-East that extend from the east of the Core Zone Boundary to the Columbia River and from the RPPDF north from the Core Zone Boundary to the Columbia River. The releases from the RPPDF remain in a fairly narrow area until about halfway to the Columbia River nearshore, where the plume spreads out and continues to the shoreline. The IDF-East plume is contained in a narrow area until it reaches about one-third of the distance to the Columbia River nearshore, where it spreads out and continues to the shoreline.

Figure 5–600 (CY 3890) shows that the technetium-99 release from the RPPDF exceeds the benchmark concentrations in small areas north of the Core Zone Boundary. Figure 5–601 (CY 7140) shows that the RPPDF technetium-99 distribution has nearly dissipated, but that areas of higher technetium-99 concentration remain. This figure also shows that the release from IDF-East extends from the release site to the Columbia River. By CY 11,885 (see Figure 5–602), the RPPDF-released technetium-99 has nearly

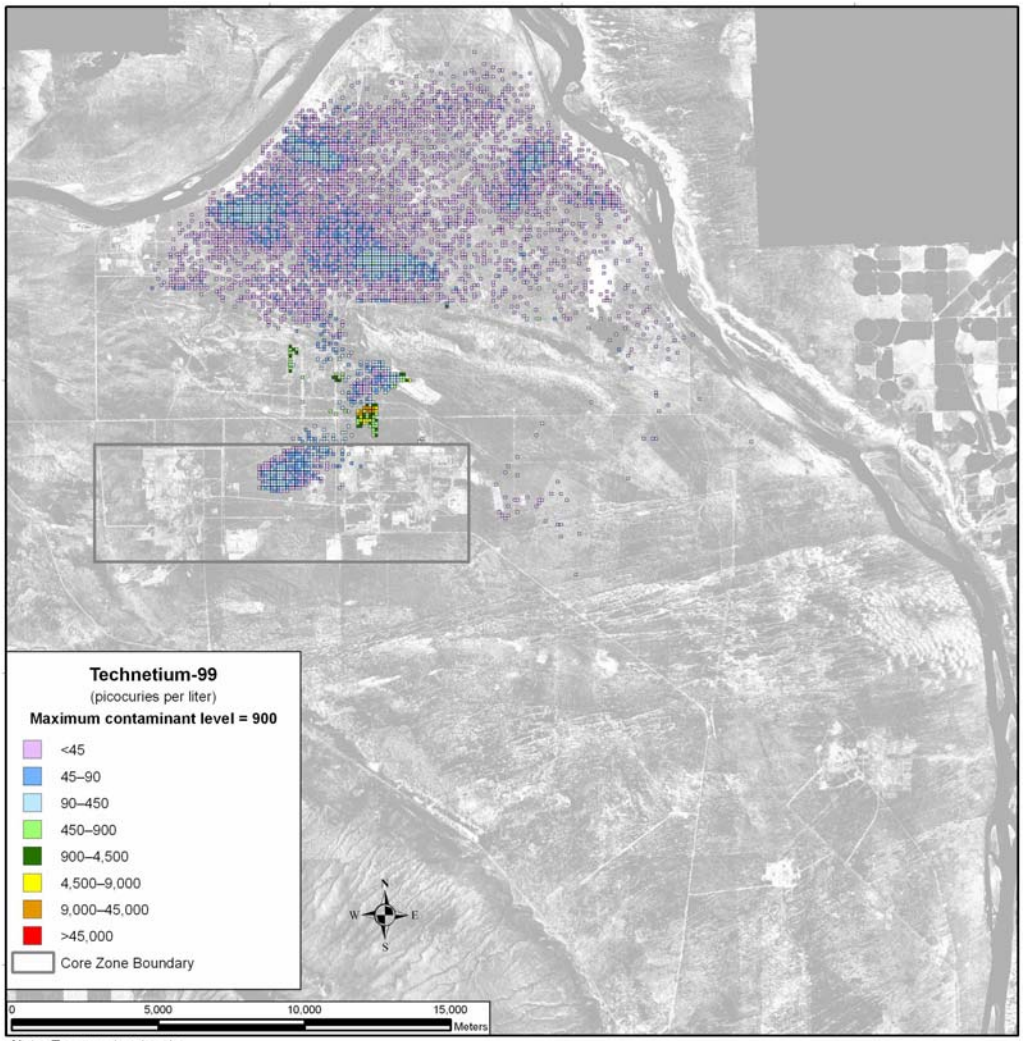
dissipated, with the exception of a small, isolated area of high concentration. The IDF-East technetium-99 release has increased significantly, and the concentration in groundwater continues in a widely distributed plume through CY 11,885. Those concentrations, however, remain below the benchmark concentration.

Figures 5–603 through 5–605 show similar concentration distribution for iodine-129, the RPPDF plume extending north from the Core Zone Boundary and the IDF-East plume extending east. Figure 5–603 shows an RPPDF plume at CY 3890 and but no IDF-East plume, the IDF-East release having occurred in later years. Figure 5–604 shows a dissipated RPPDF iodine-129 distribution and a significant IDF-East plume extending from the release site to the Columbia River. There is an area east of the Core Zone Boundary in which the iodine-129 concentration exceeds the benchmark concentration. Figure 5–605 (CY 11,885) shows almost no RPPDF iodine-129 but a small area (pocket) of high-concentration iodine-129 remains. This indicates that the IDF-East iodine-129 release to the Columbia River continues through CY 11,885, and that in smaller areas the concentrations approach or exceed the benchmark concentration.

Figures 5–606 through 5–608 show chromium releases from the RPPDF and IDF-East that produce plume maps (time, space, and concentration) similar to those of the technetium-99 and iodine-129 releases. These also show a delayed (relative to the RPPDF release) release of chromium from IDF-East. However, areas of higher nitrate concentrations from both releases do not exceed benchmark concentrations. A small area of higher nitrate concentration from the RPPDF nitrate release appears to be maintained through CY 11,885.

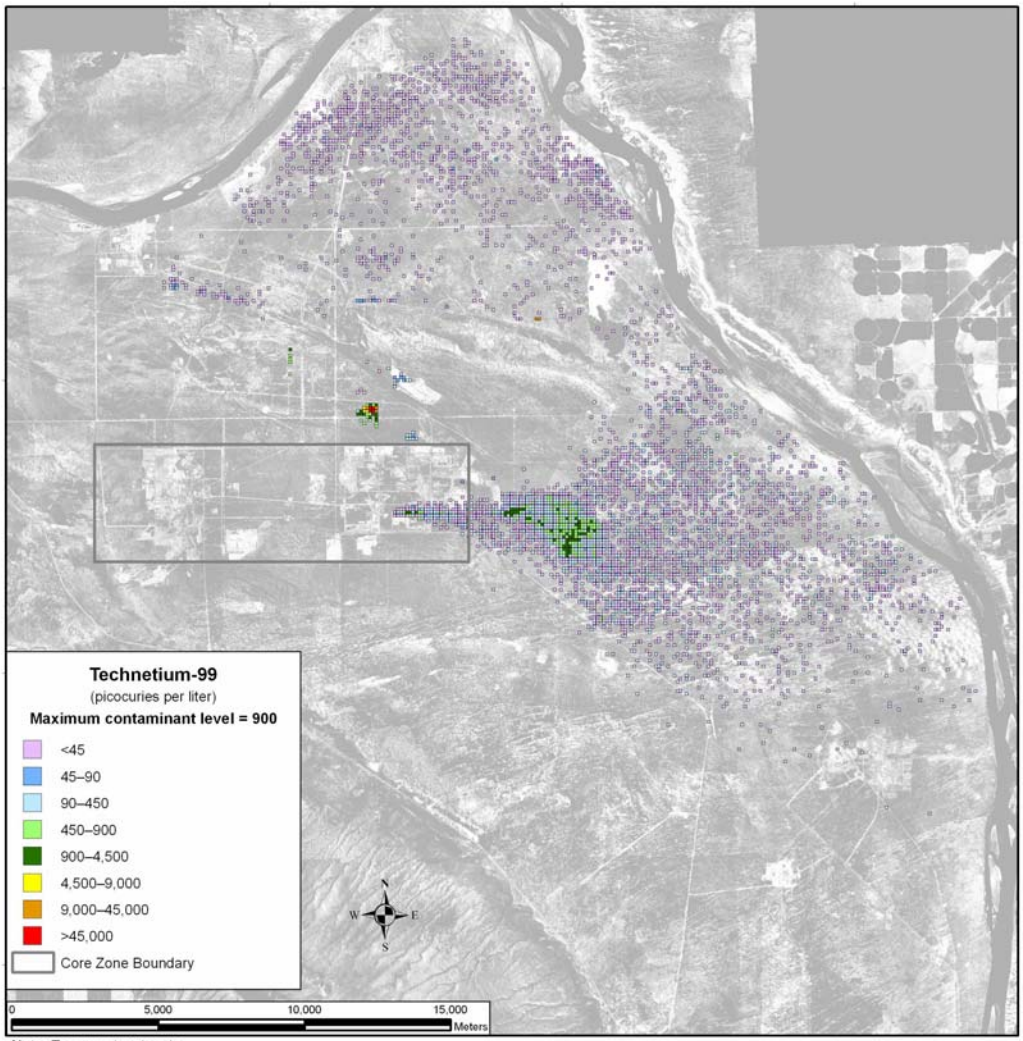
The nitrate release shown in Figures 5–609 through 5–611 is nearly identical to the chromium release (time and space ranges). The IDF-East nitrate release never reaches the benchmark concentration. In CY 7140, the RPPDF shows a small area in which a high nitrate concentration is maintained, but this appears to dissipate by CY 11,885.

Figure 5–612 shows the concentration distribution for total uranium released from the RPPDF for CY 11,885. The released total uranium produces a fairly even distribution between the release source and the Columbia River nearshore. As total uranium is not as mobile as the other COPCs, the total uranium release results in a fairly homogeneous distribution between the release source and the Columbia River. The concentration is consistently well below the benchmark concentration and there are no areas of higher levels, as were observed for other COPCs. The distribution and consistency of the CY 11,885 total uranium distribution would indicate that the released total uranium plume will remain well past CY 11,885.



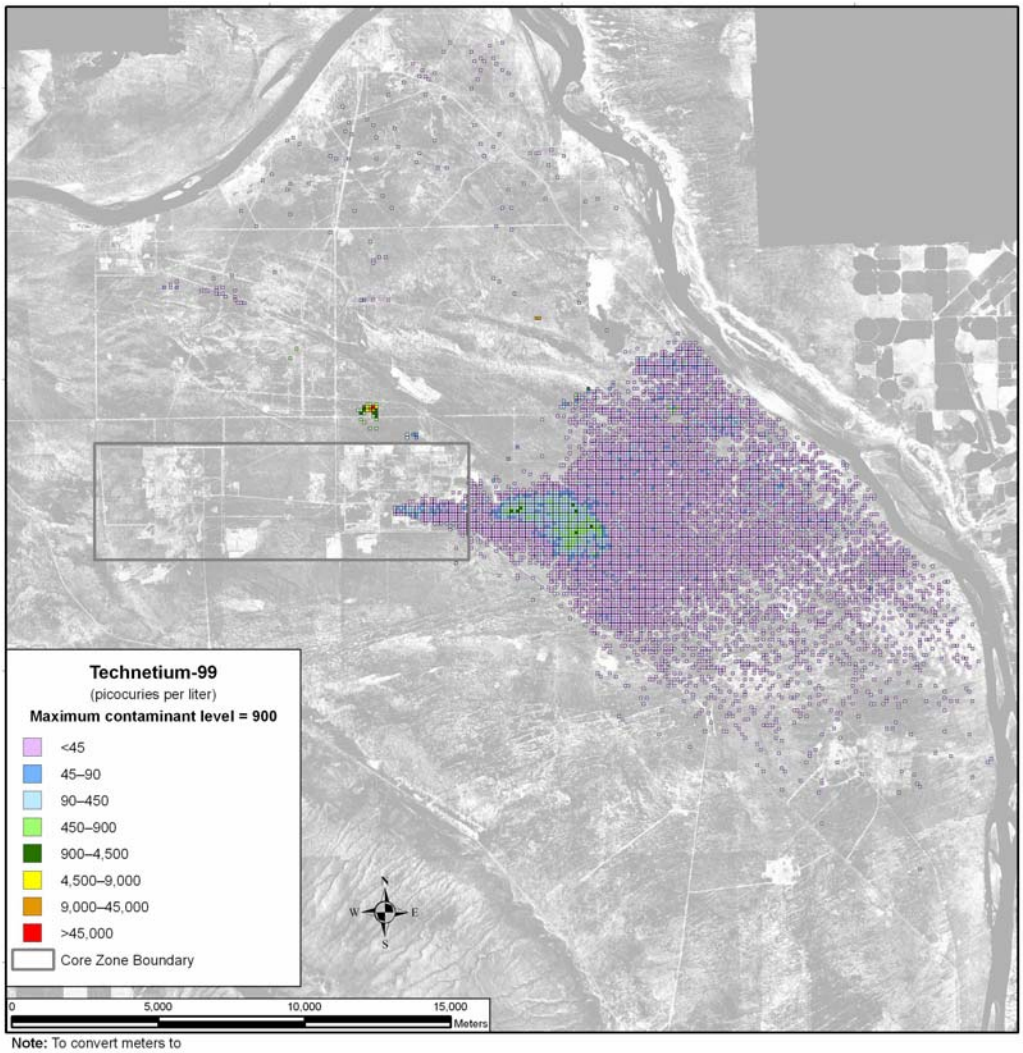
Note: To convert meters to feet, multiply by 3.281

Figure 5–600. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



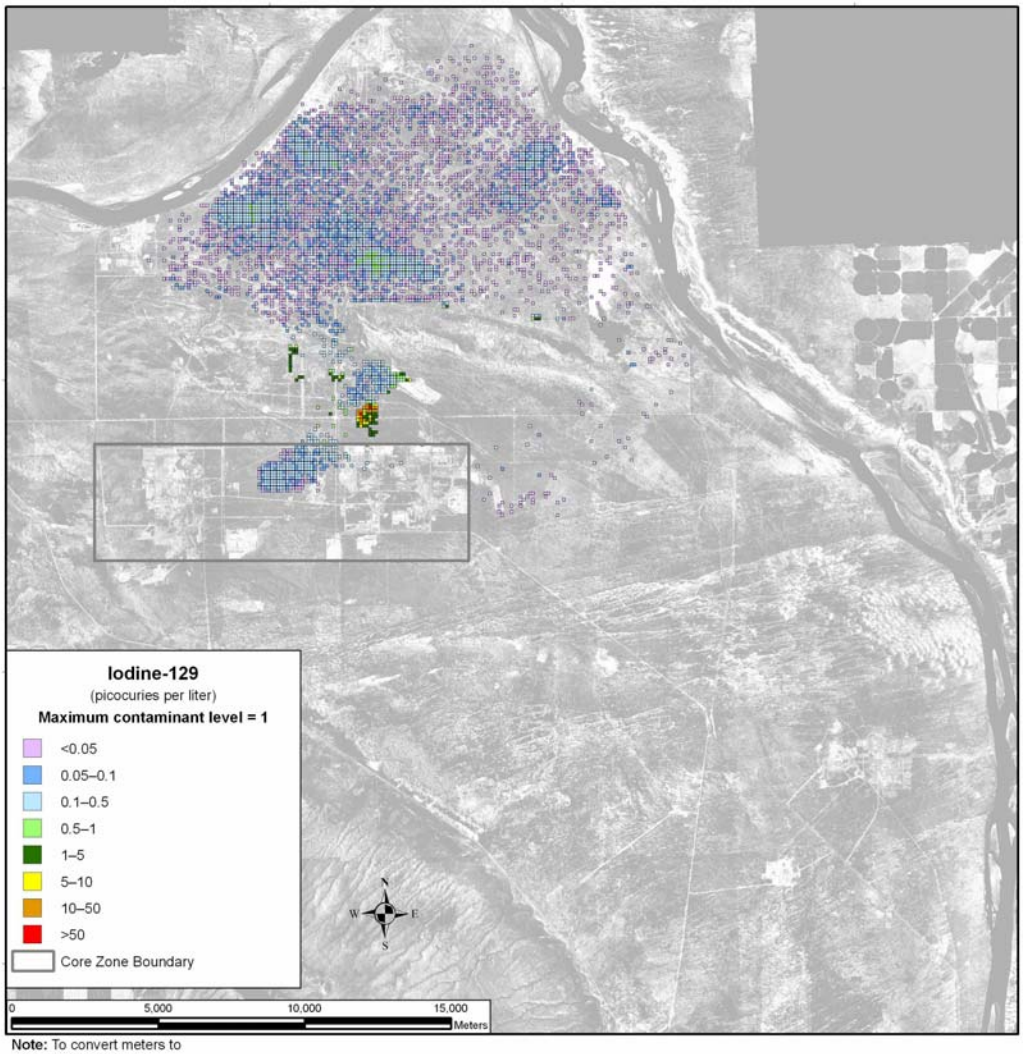
Note: To convert meters to feet, multiply by 3.281

Figure 5–601. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



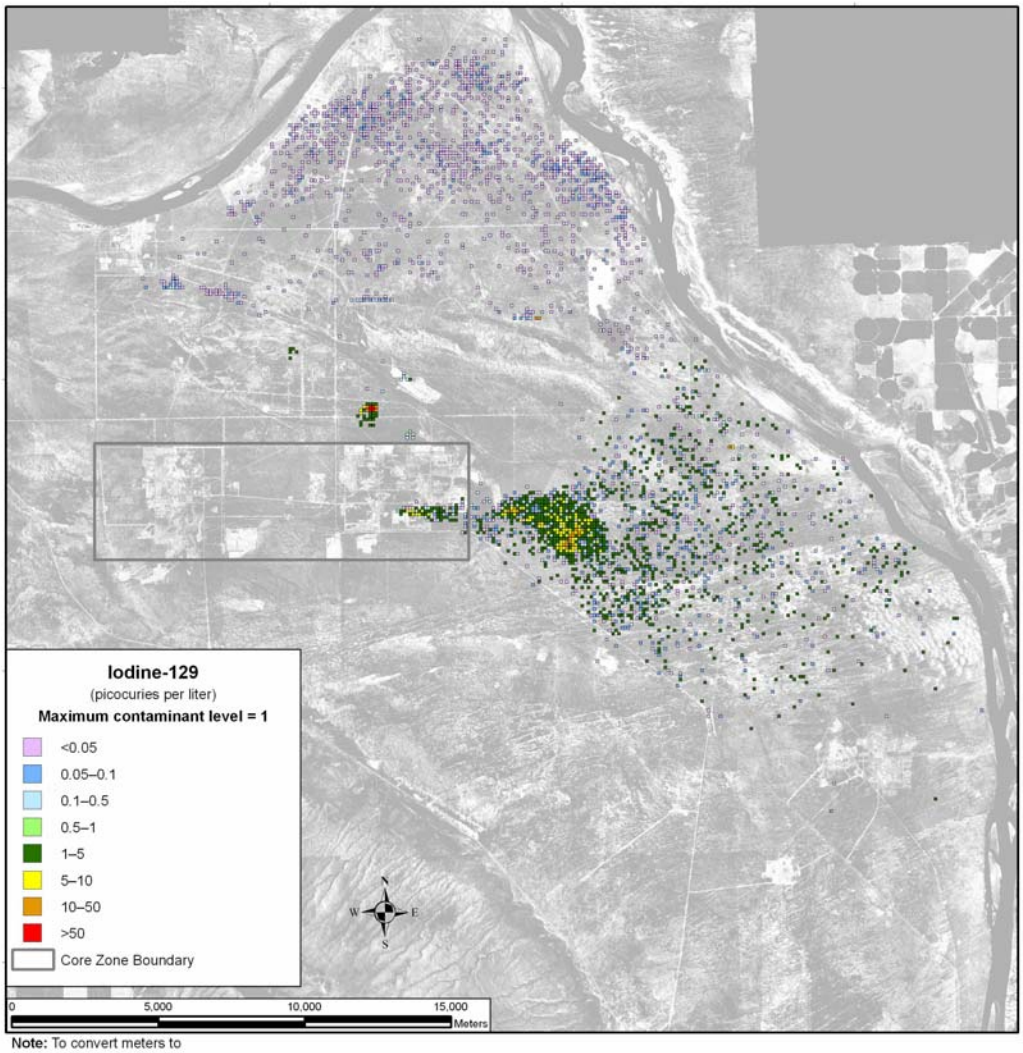
Note: To convert meters to feet, multiply by 3.281

Figure 5–602. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



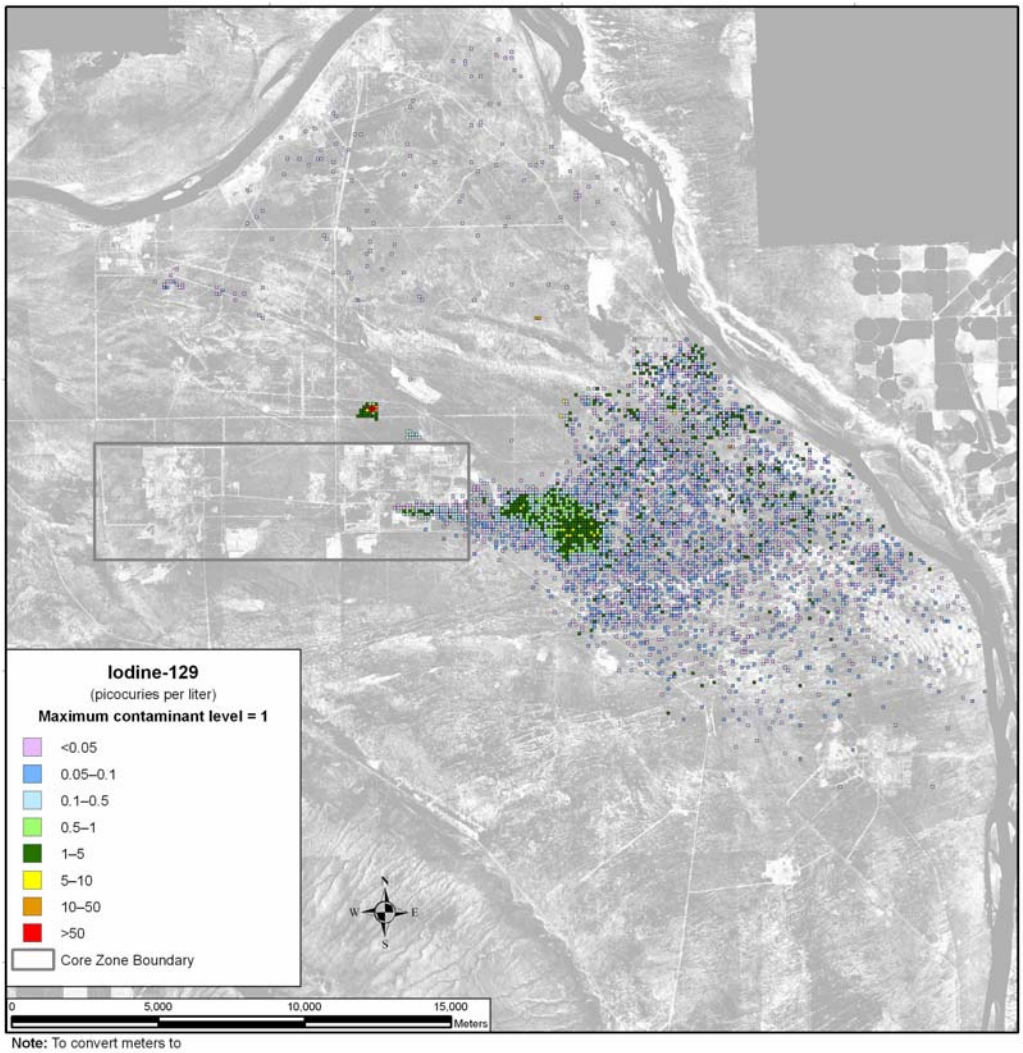
Note: To convert meters to feet, multiply by 3.281

Figure 5–603. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



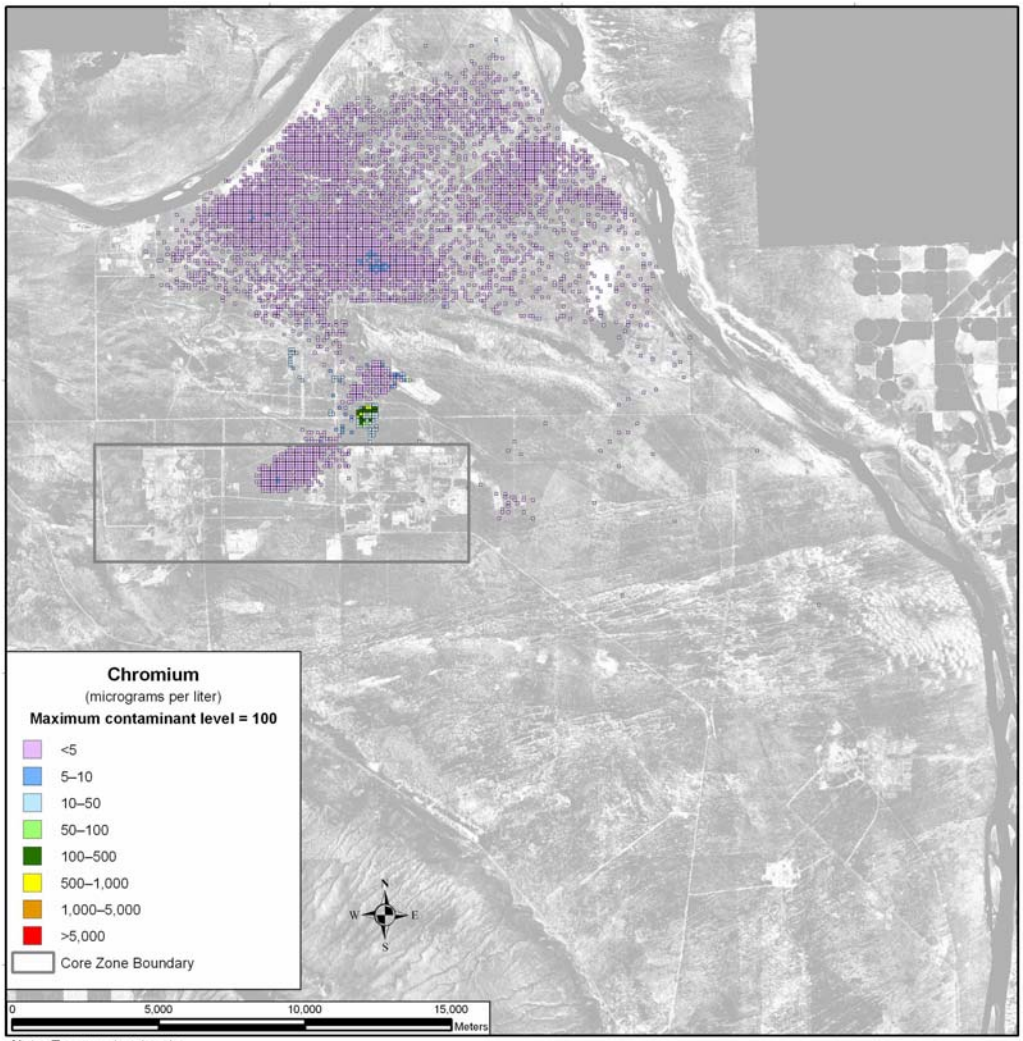
Note: To convert meters to feet, multiply by 3.281

Figure 5–604. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



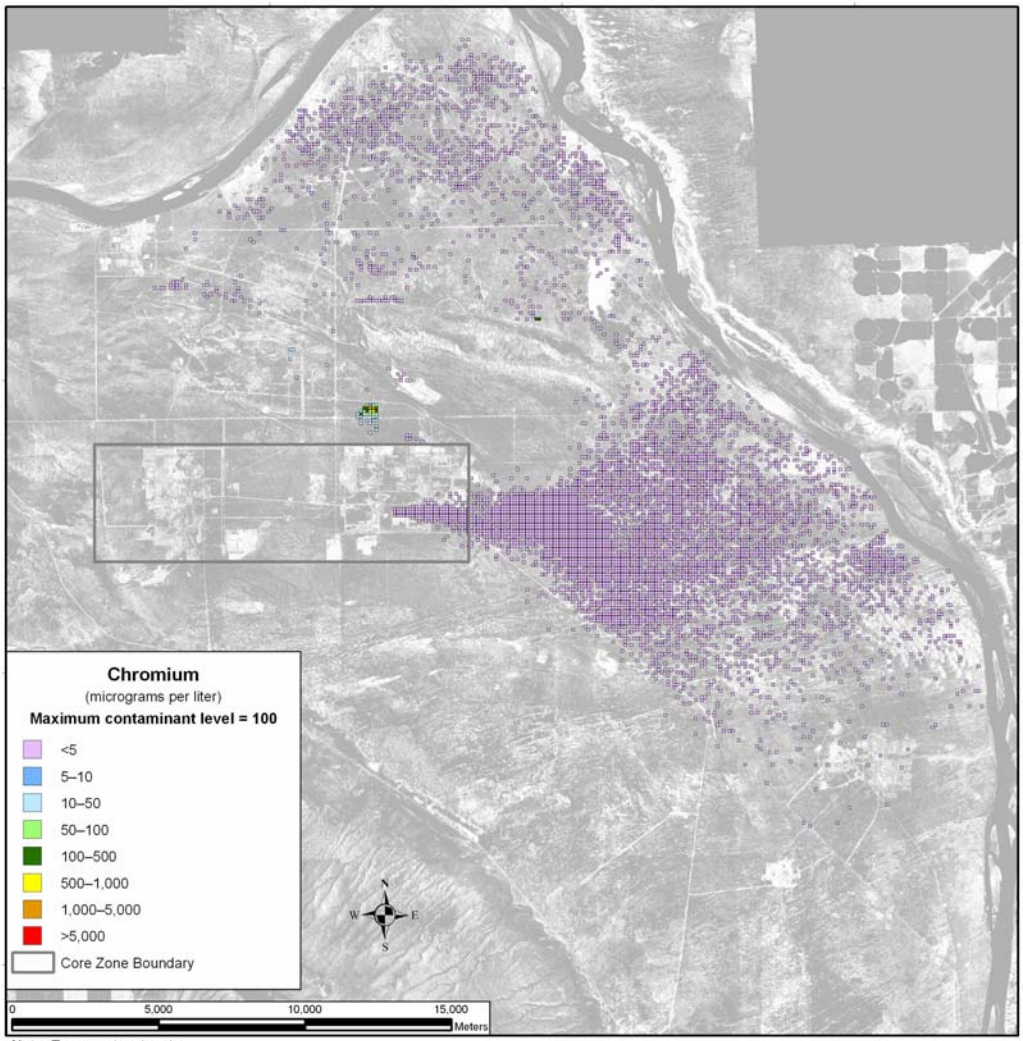
Note: To convert meters to feet, multiply by 3.281

Figure 5–605. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



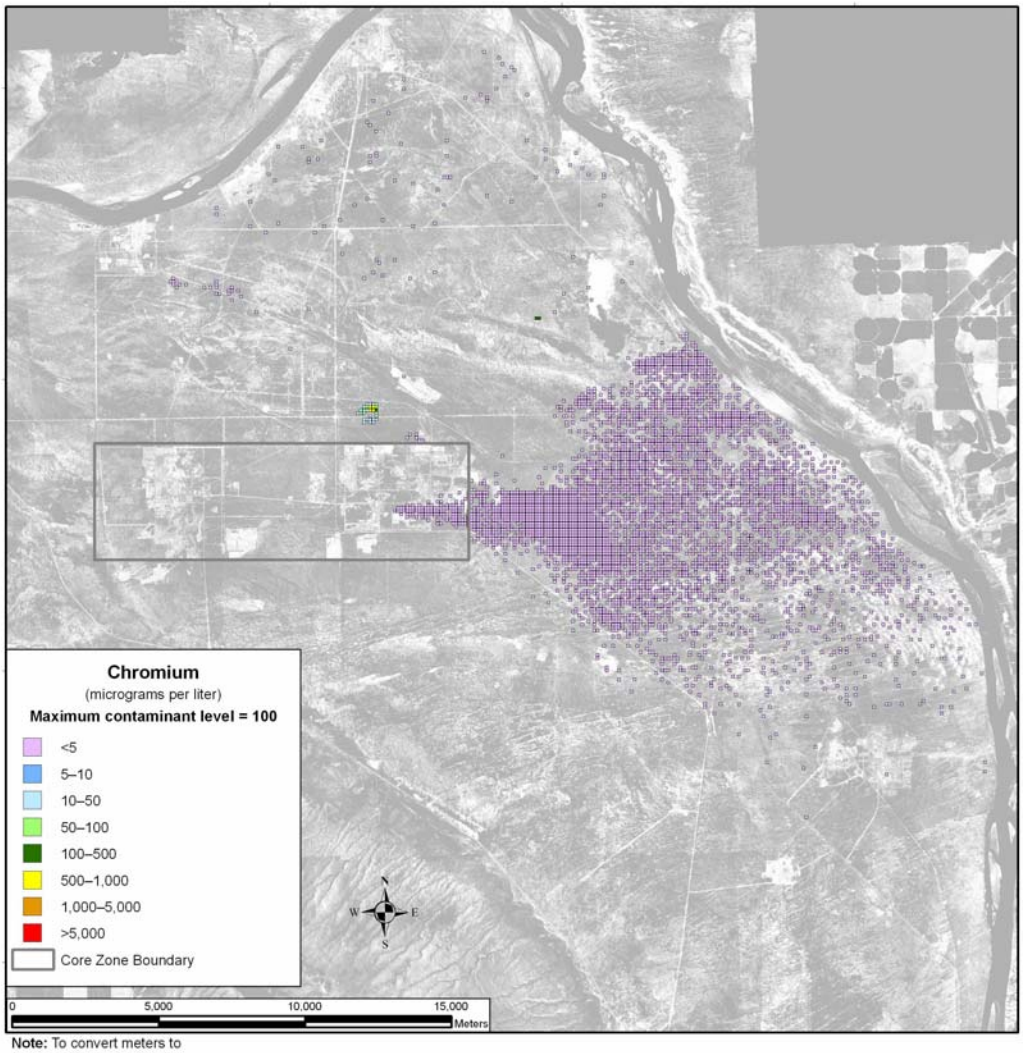
Note: To convert meters to feet, multiply by 3.281

Figure 5–606. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



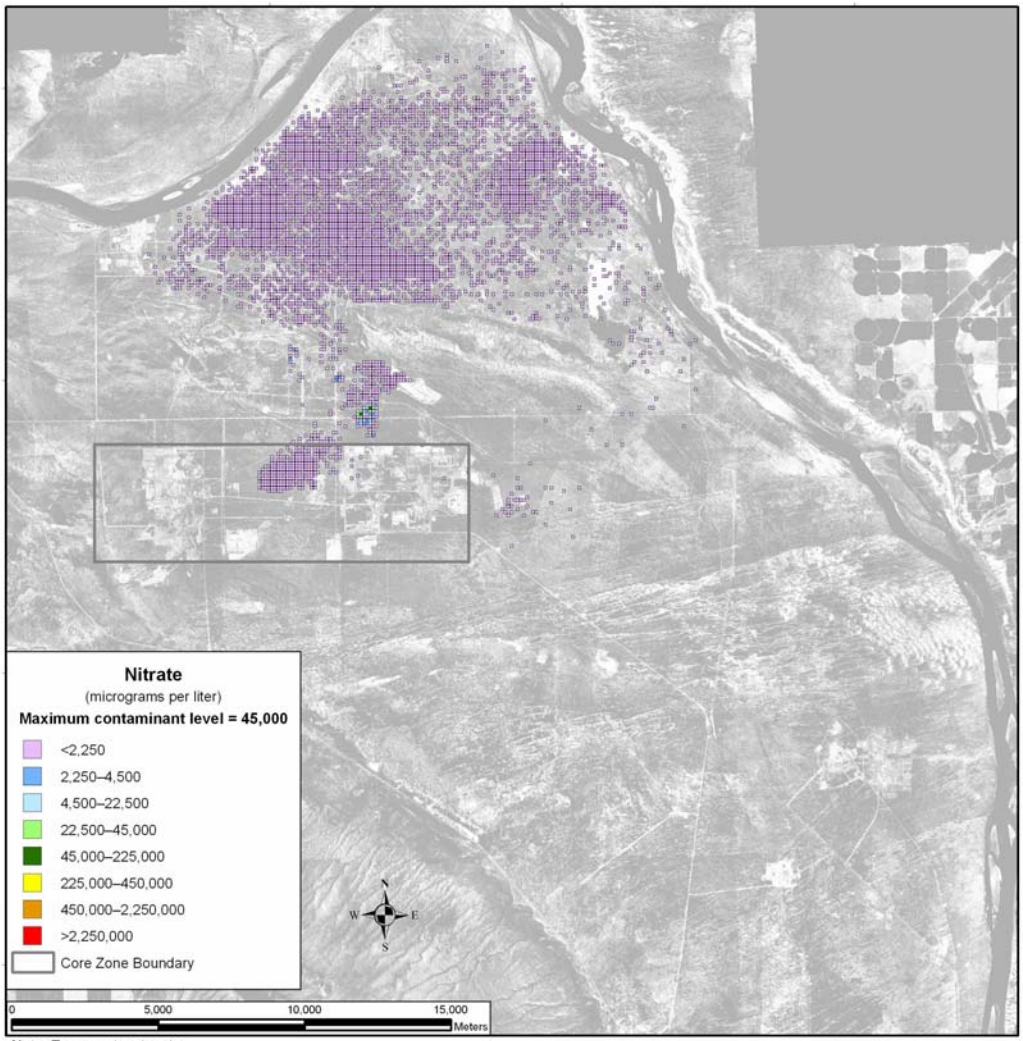
Note: To convert meters to feet, multiply by 3.281

Figure 5–607. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



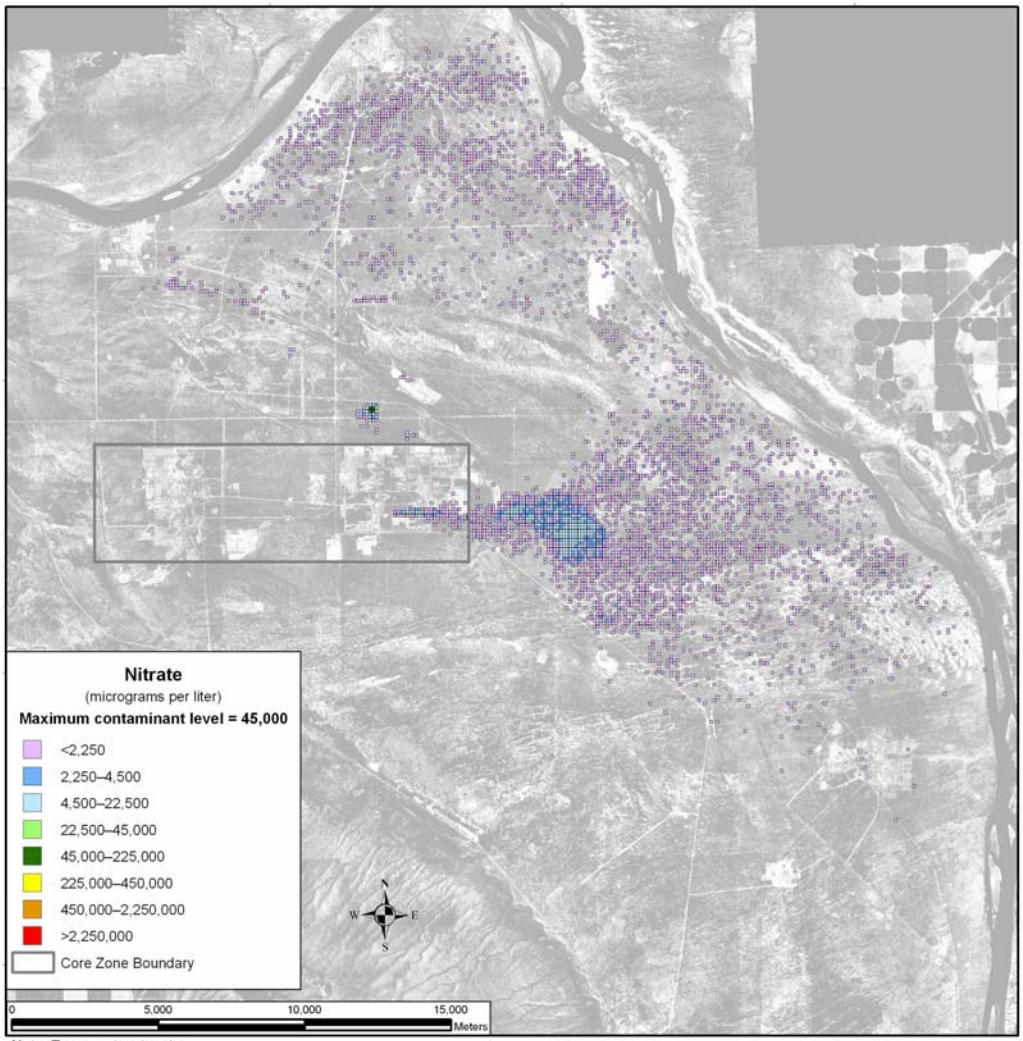
Note: To convert meters to feet, multiply by 3.281

Figure 5–608. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



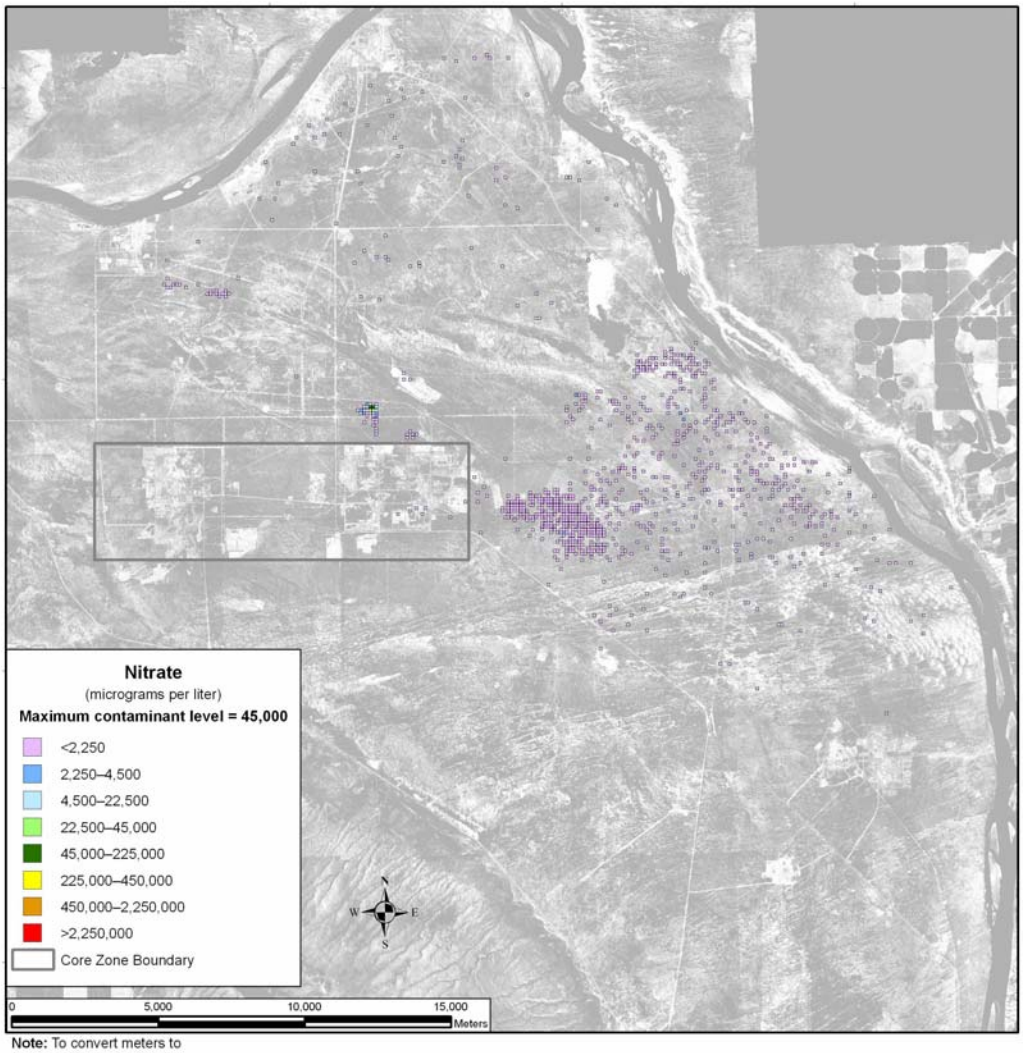
Note: To convert meters to feet, multiply by 3.281

Figure 5–609. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



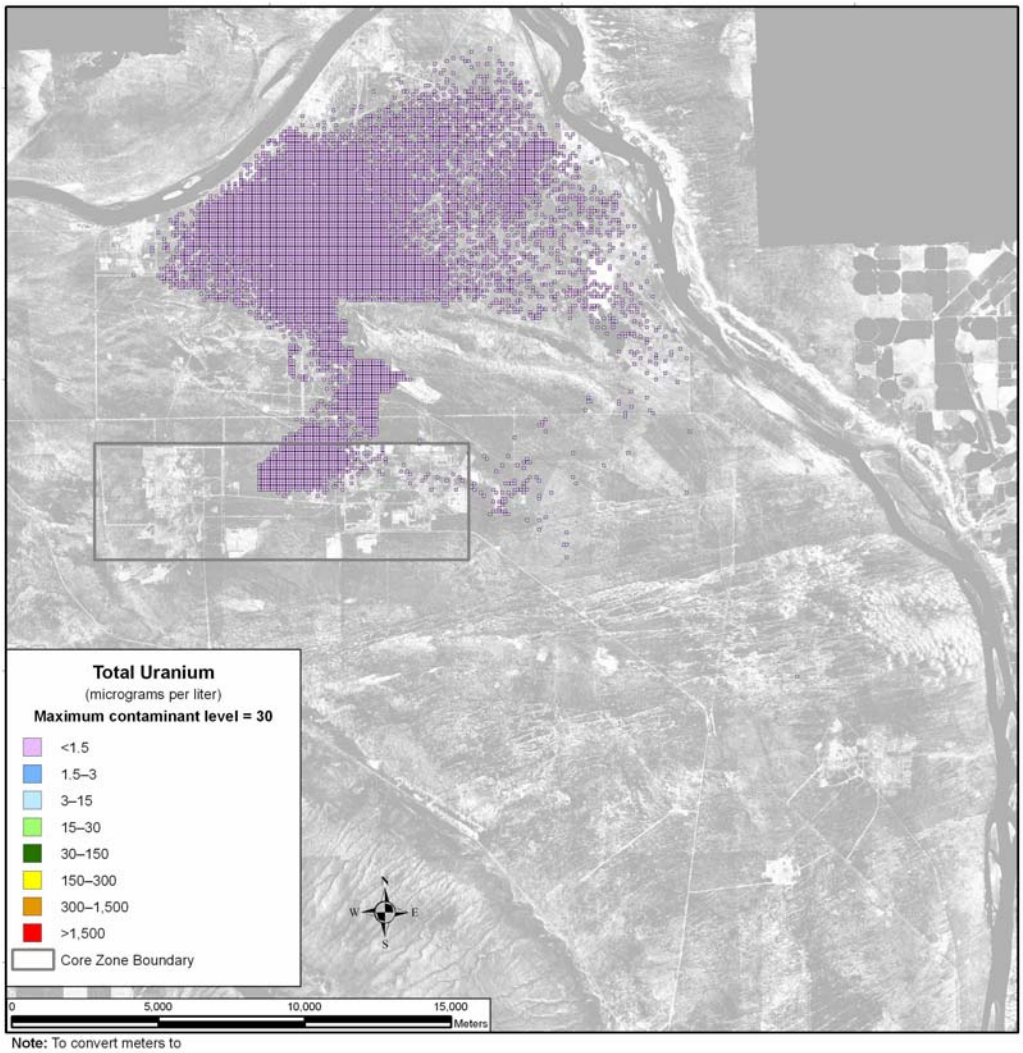
Note: To convert meters to feet, multiply by 3.281

Figure 5–610. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–611. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–612. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, released iodine-129 is the major source of this risk. The analysis indicates that the concentrations of the COPCs at these points decrease to levels significantly below the benchmark concentrations through CY 11,885.

As for the conservative tracers, there are small, isolated areas near the outer Core Zone Boundary in which high concentrations appear not to dissipate; they remain high through the end of the period of analysis. The release of total uranium appears fairly homogeneous between the release source and the Columbia River nearshore. Although the concentration in this plume is well below the benchmark, total uranium remains in the environment and trends shows an increasing concentration through the end of this analysis period (CY 11,885).

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

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, includes Tank Closure Alternative 6B, Option Case; FFTF Decommissioning Alternative 2 or 3; and onsite- and offsite-generated waste. Summaries of the actions and timelines for Waste Management Alternative 2 are provided in Chapter 2, Section 2.5.

For the long-term groundwater impact analysis, two major periods have been identified for Waste Management Alternative 2, Disposal Group 1, Subgroup 1-E:

- The disposal period starts with the onset of disposal operations for IDF-East and the RPPDF in CY 2009 and continues through CY 2100. During this disposal period, the materials in these permitted, operational facilities are assumed to be unavailable 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 the RPPDF become available for release to the environment. For the purpose of analyzing long-term groundwater impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, IDF-East 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 2, Disposal Group 2, Subgroup 2-B, Option Case. Full results are tabulated in Appendices M, N, and O. This discussion of long-term impacts associated with Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, is focused on the following COPC drivers:

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

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

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

ANALYSIS OF RELEASE AND MASS BALANCE

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

200-East Area Integrated Disposal Facility

IDF-East has seven subtotals plotted representing releases from ETF-generated secondary waste, Preprocessing Facility (PPF) glass, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, waste management secondary and onsite-generated waste, and offsite-generated waste.

Figure 5–613 shows the release to the vadose zone for the radiological risk drivers and Figure 5–614, chemical hazard drivers. The inventories in the waste forms are a major factor in the quantities released to the vadose zone. The predominant source of technetium-99 in the vadose zone is offsite-generated waste (77 percent), followed by tank closure secondary waste (19 percent), and ETF-generated secondary waste (4 percent). The sources of the iodine-129 release are offsite-generated waste (85 percent) and ETF-generated secondary waste (14 percent). The chromium release is from the tank closure secondary waste (85 percent), waste management secondary and onsite-generated waste (8 percent) offsite-generated waste (4 percent), ETF-generated secondary waste (2 percent), and PPF glass (1 percent). All of the nitrate released is from ETF-generated secondary waste. There is no acetonitrile from any of the waste forms in IDF-East.

Figure 5–615 shows the release to groundwater for the radiological risk drivers and Figure 5–616, 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 vadose zone technetium-99 (89 percent), iodine-129 (91 percent) and all of the chromium and nitrate are released to groundwater during the period of analysis.

Figure 5–617 shows the release to the Columbia River for the radiological risk drivers and Figure 5–618, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. Most of the groundwater technetium-99 (97 percent), iodine-129 (97 percent), chromium (97 percent), and nitrate (>99 percent) are released to the Columbia River over the period of analysis.

Overall, most of the vadose zone technetium-99 (86 percent), iodine-129 (89 percent), chromium (96 percent), and nitrate (98 percent) from IDF-East is released to the Columbia River. These releases are identical to those for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

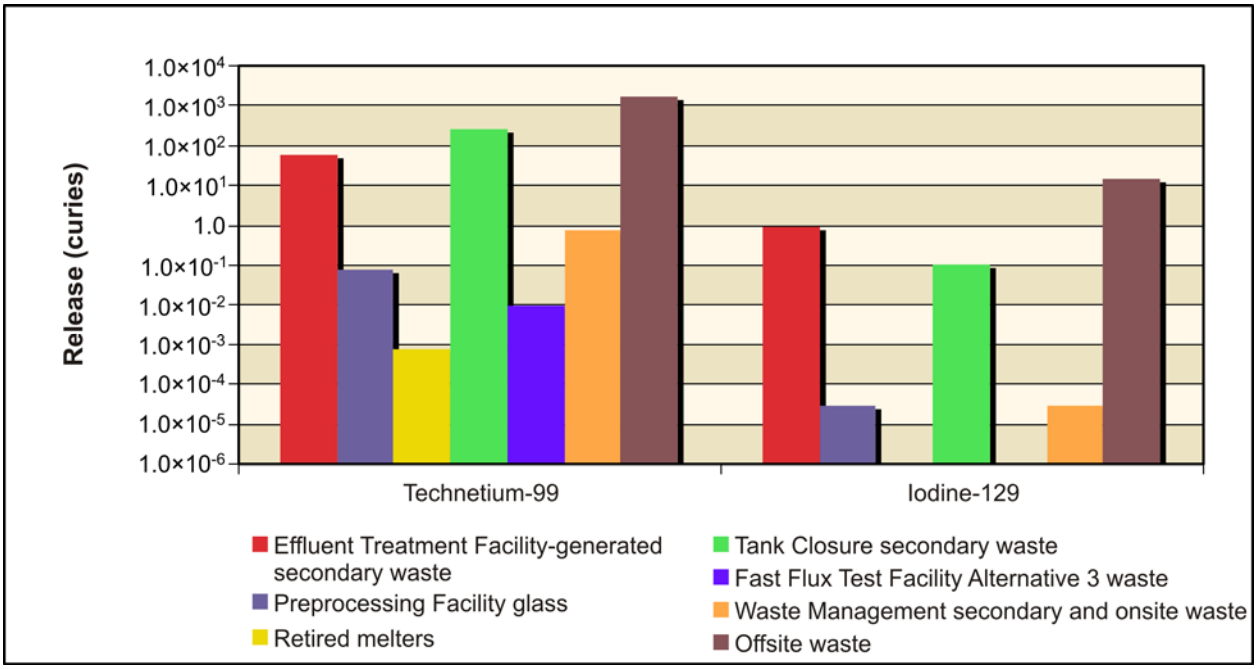


Figure 5–613. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

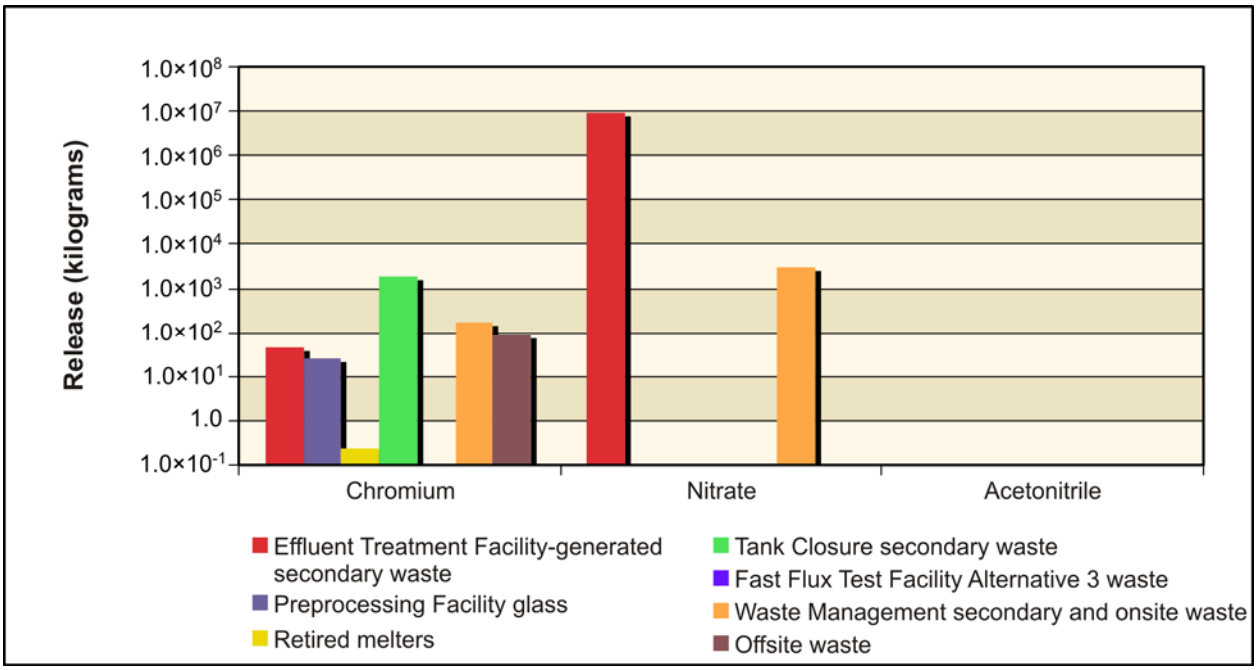


Figure 5–614. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

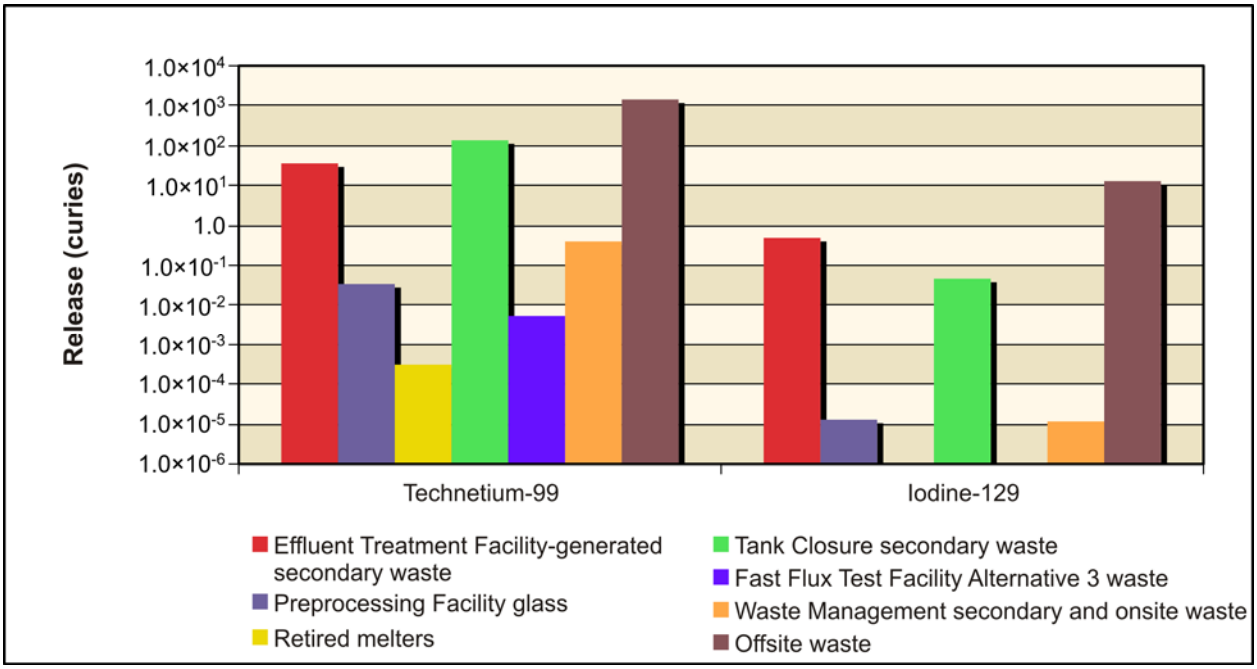


Figure 5–615. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

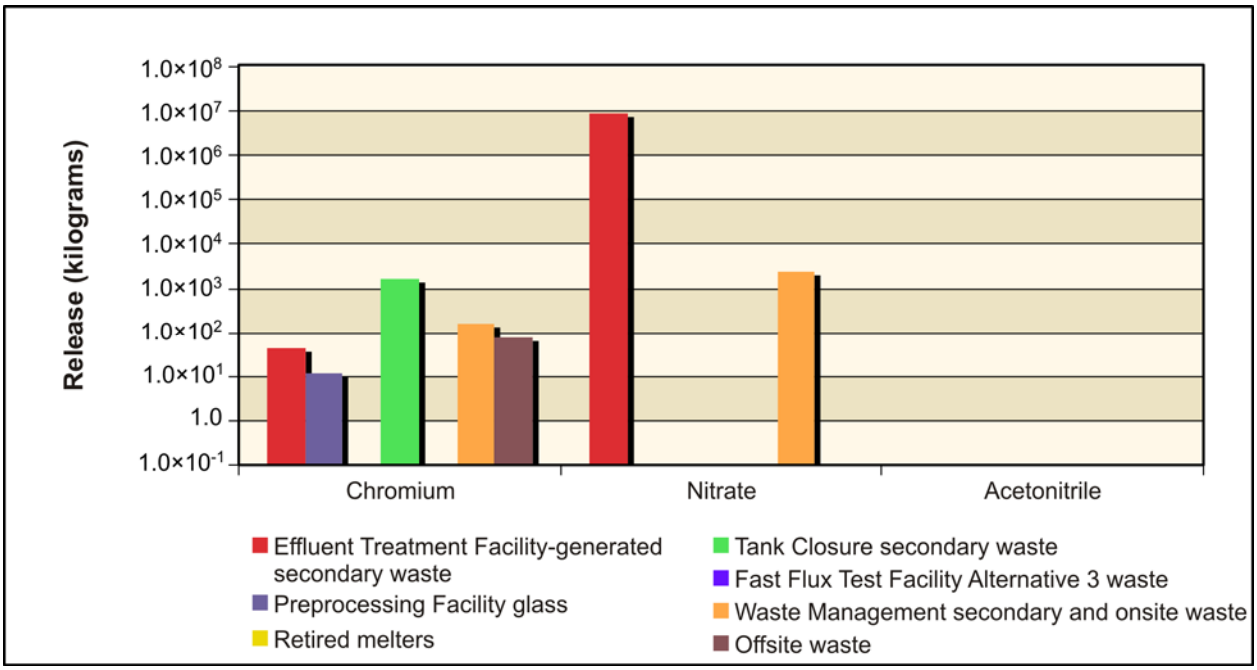


Figure 5–616. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

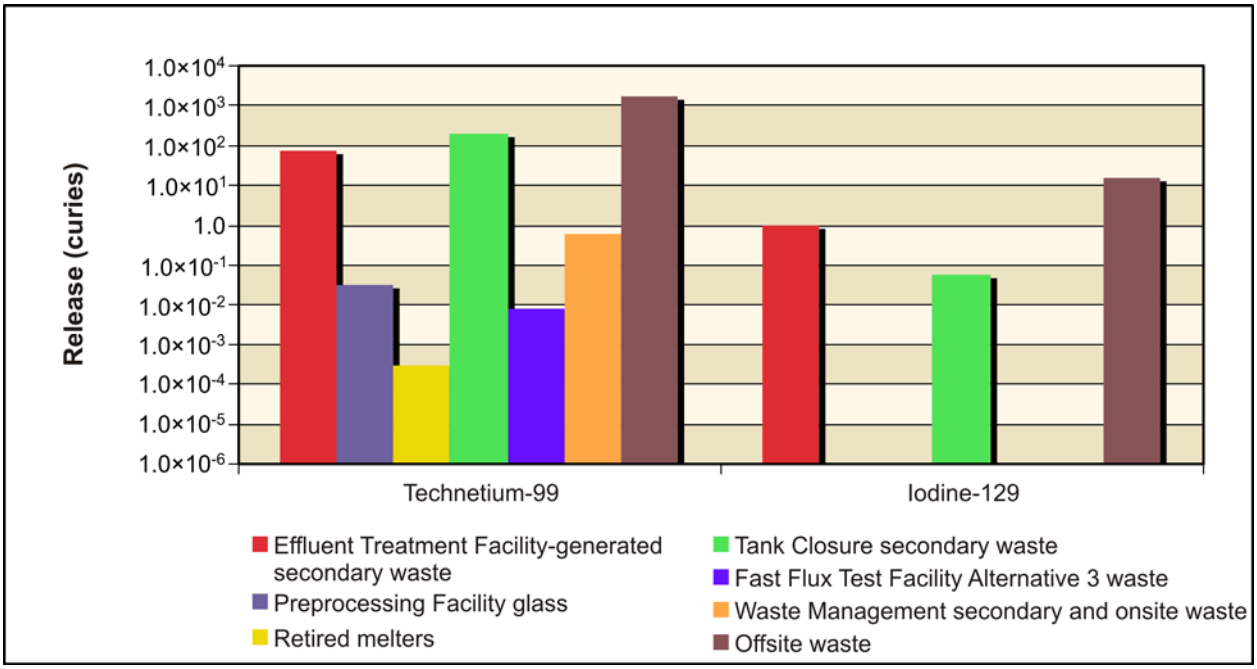


Figure 5–617. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

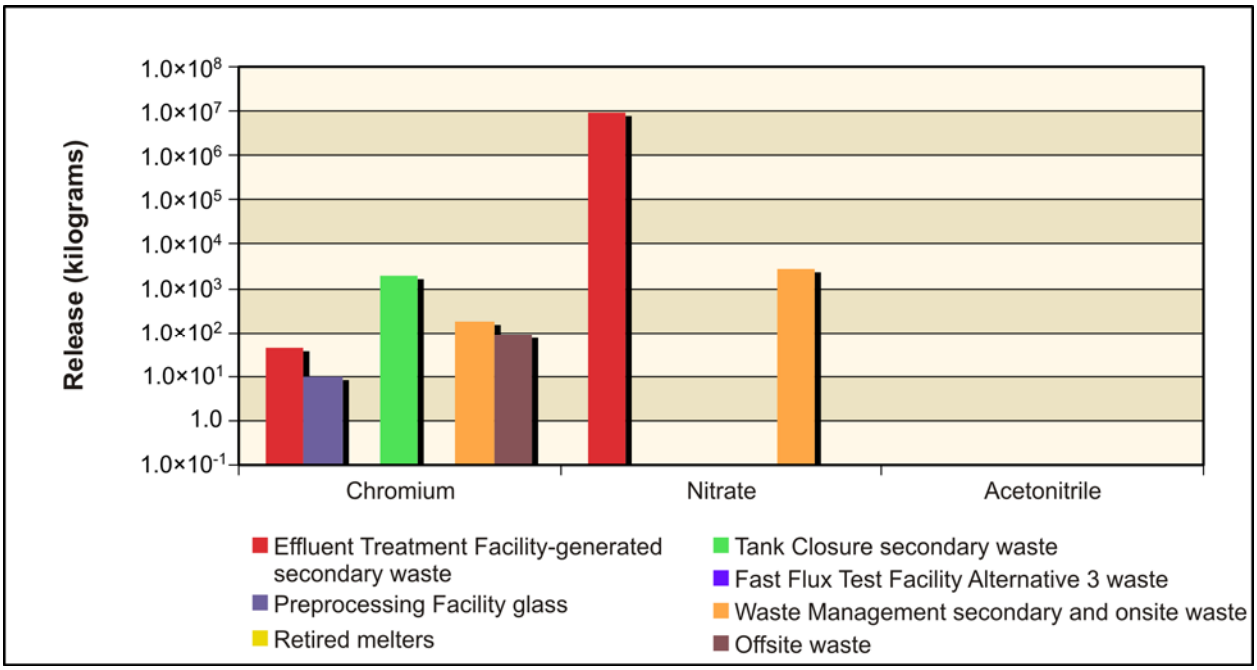


Figure 5–618. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–619 shows the release to the vadose zone for the radiological risk drivers and Figure 5–620, 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 predominant releases from the RPPDF are technetium-99 and iodine-129, with technetium-99 being the predominant radionuclide released. The chemical releases from the RPPDF include nitrate (largest), chromium, and acetonitrile (smallest).

Figure 5–621 shows the release to groundwater for the radiological risk drivers and Figure 5–622, the chemical hazard drivers. In addition to the 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. All of the RPPDF vadose zone technetium-99, iodine-129, chromium, nitrate, and acetonitrile is released to groundwater.

Figure 5–623 shows the release to the Columbia River for the radiological risk drivers and Figure 5–624, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. All of the RPPDF groundwater iodine-129, technetium-99, chromium, nitrate, and acetonitrile, is released to the Columbia River.

Overall, about 95 percent of the RPPDF vadose zone radionuclides and chemicals are released to the Columbia River during the period of analysis. This release is almost identical to that identified for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

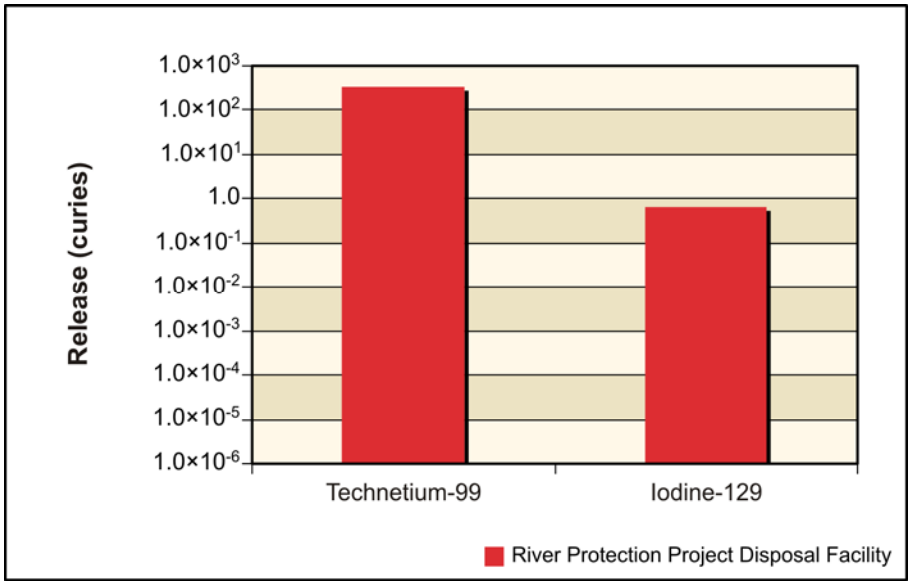


Figure 5–619. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

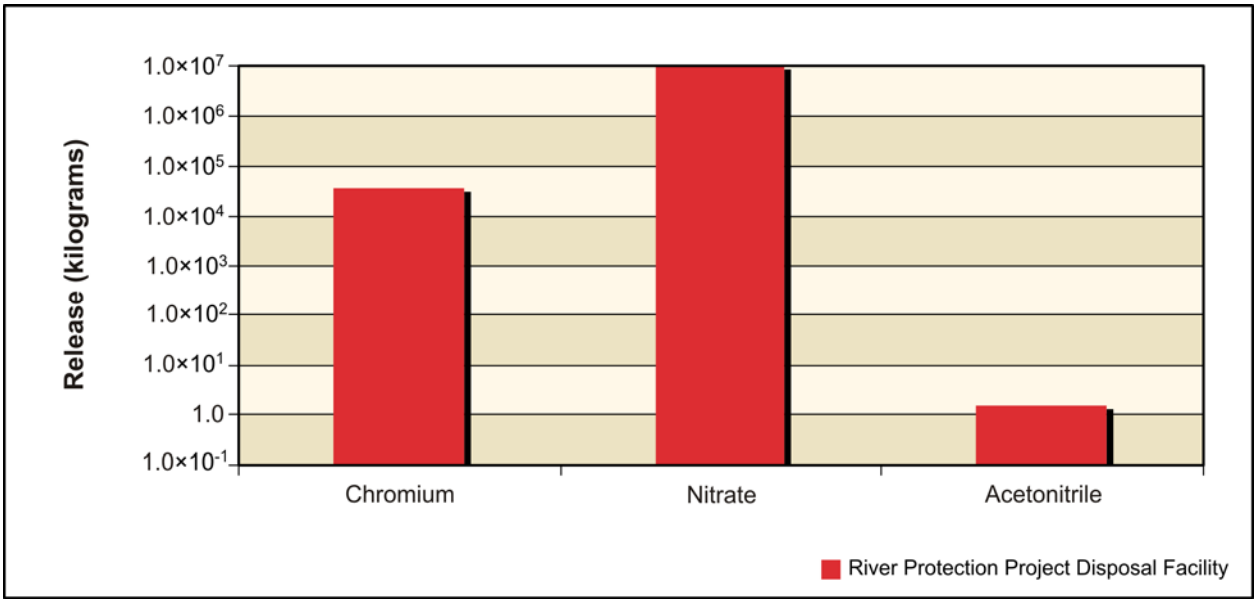


Figure 5–620. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

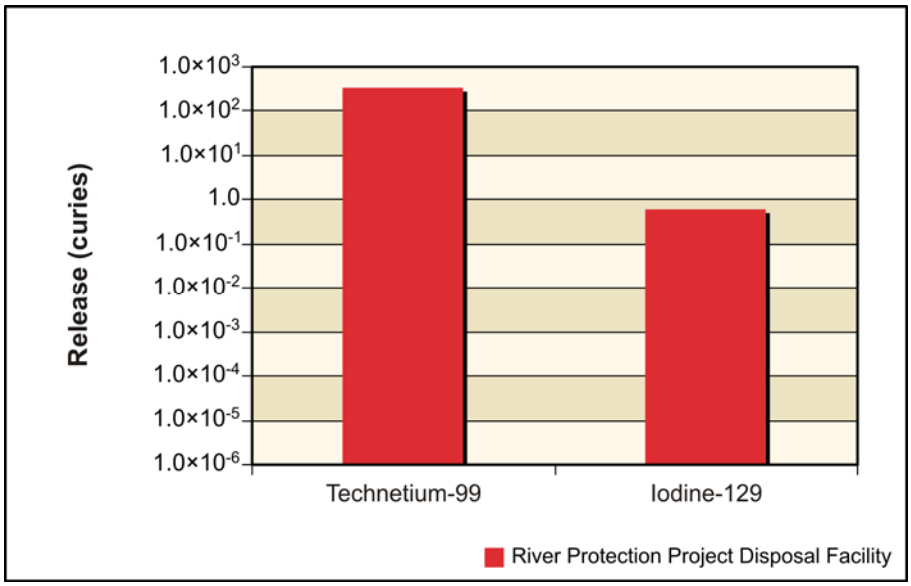


Figure 5–621. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

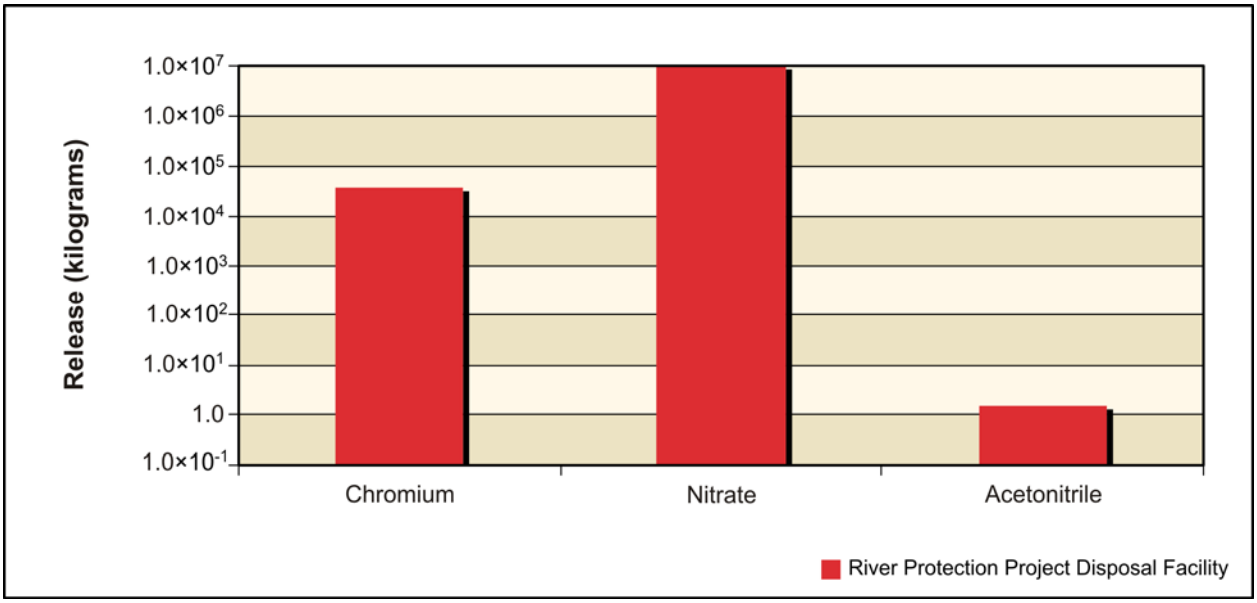


Figure 5–622. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

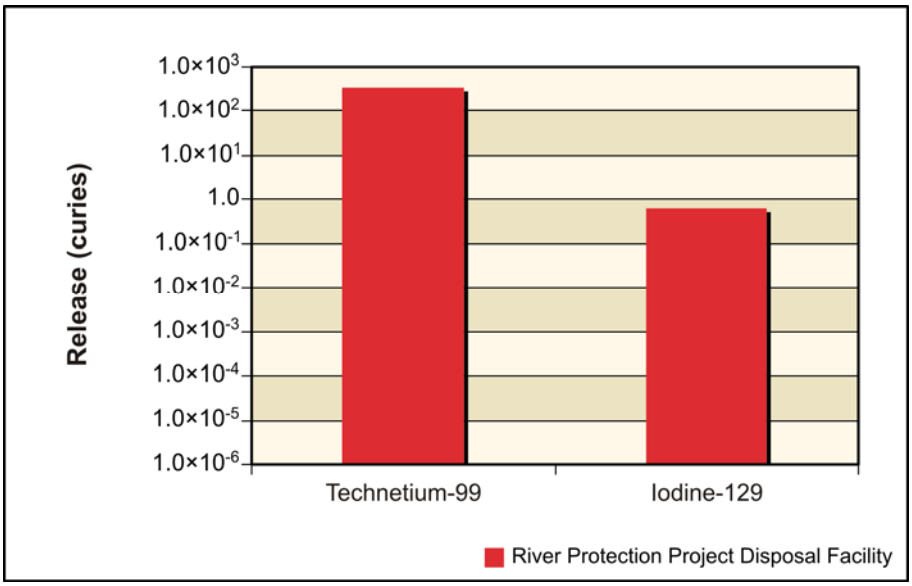


Figure 5–623. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

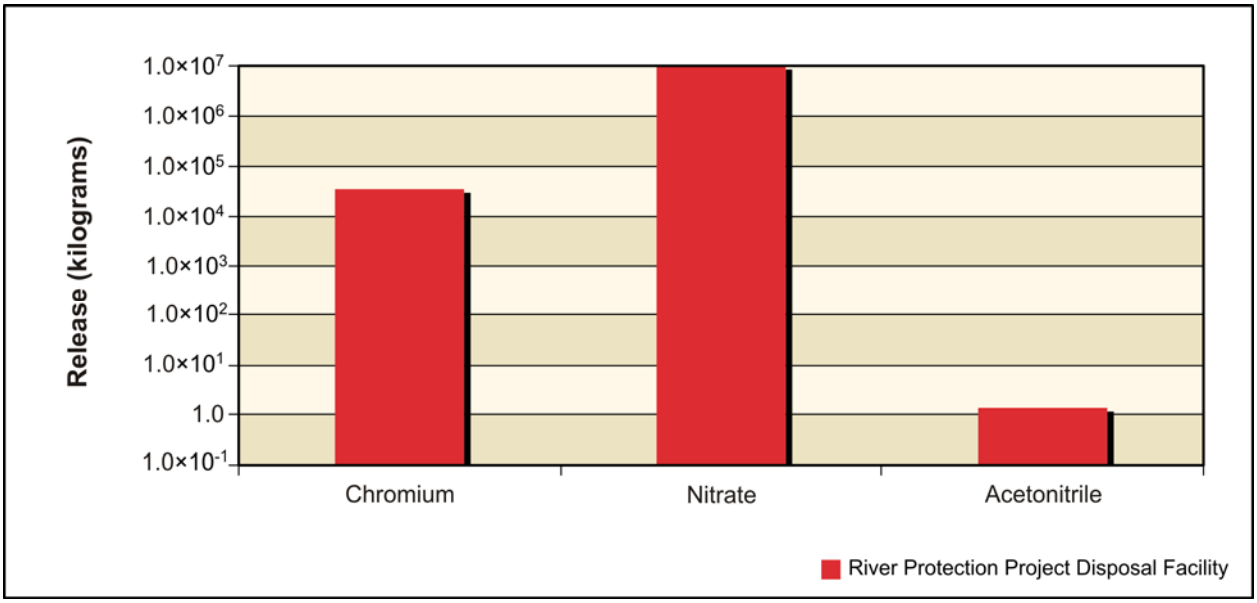


Figure 5–624. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, in terms of groundwater concentration versus time at the Core Zone Boundary, and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter. The benchmark concentration of each radionuclide and chemical is also shown. The concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations. 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. Table 5–86 lists the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary and Columbia River nearshore.

Table 5–86. Waste Management Alternative 2, Disposal Group 2, Subgroup 2B, Option Case, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**2,890** (8580)	340 (4213)	**1,350** (4466)	717 (8477)	900
Iodine-129	**24** (9058)	0.6 (4176)	**10** (9188)	**6** (9652)	1
Chemical in micrograms per liter					
Chromium	3 (8281)	33 (4118)	97 (10533)	17 (5522)	100
Nitrate	16,600 (8162)	9,070 (3962)	28,400 (9305)	5,700 (4618)	45,000

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

Figures 5–625 through 5–628 show concentration versus time for technetium-99, iodine-129, nitrate, and chromium, respectively. With the exception of nitrate, the concentrations versus time are essentially identical to those for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

The concentration of technetium-99 (see Figure 5–625) is below the benchmark at the Core Zone Boundary and the Columbia River nearshore. The technetium-99 concentrations remains fairly constant for most of the analysis period and then decreases through CY 11,940, staying within about one order of magnitude from the benchmark. Figure 5–626 shows iodine-129 exceeding benchmark concentrations starting at about CY 5940 and continuing through CY 11,940 at both the Core Zone Boundary and the Columbia River nearshore. This concentration peaks during the last one-third of the analysis period and then declines, reaching the benchmark concentration at about CY 11,940.

Nitrate concentrations at the Core Zone Boundary and Columbia River nearshore peak near the start of the analysis period (see Figure 5–627). Both concentrations then decrease through CY 11,885, always at least one order of magnitude below the benchmark concentration. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, shows a similar nitrate release, but with a peak about three-quarters of the way through the analysis period and then a decline to the benchmark concentration at about CY 11,885.

Figure 5–628 shows that the chromium concentrations at the Core Zone Boundary and the Columbia River nearshore always remain just below the benchmark concentration. In Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, the chromium is below the benchmark by at least one order of magnitude.

Figure 5–629 shows concentration versus time for total uranium. Uranium-238 has no detectable release to the environment. Total uranium concentrations, while very low, continue to increase during the period of analysis and beyond. The total uranium concentrations remain at least six orders of magnitude below the benchmark concentration throughout the analysis period (through CY 11,940). These release concentrations are basically identical to those for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

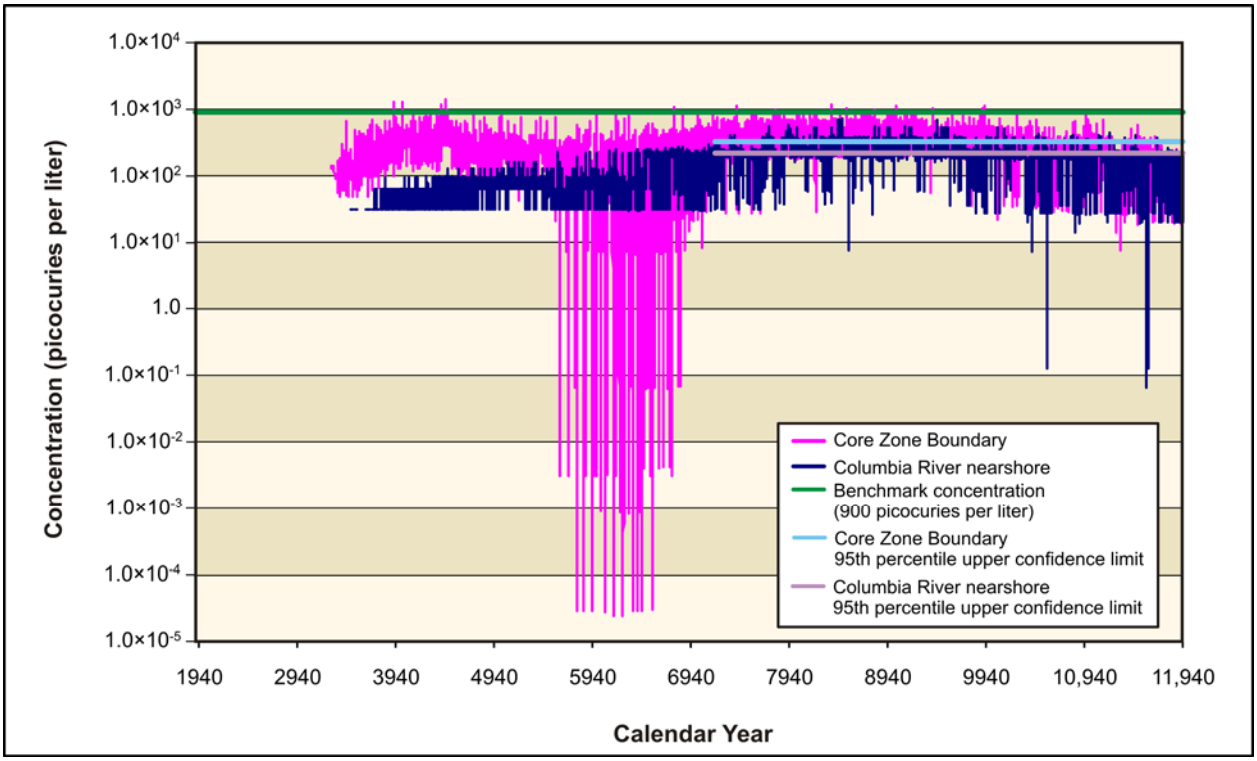


Figure 5–625. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Technetium-99 Concentration Versus Time

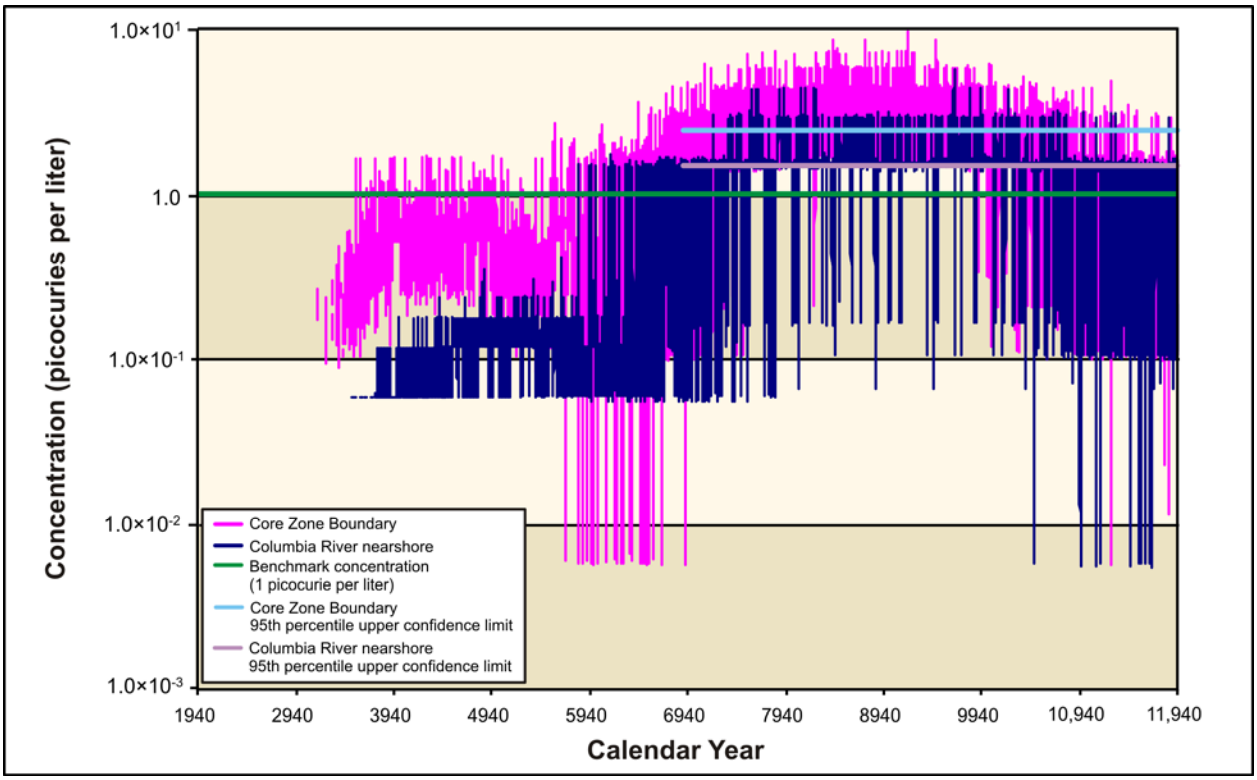


Figure 5–626. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Iodine-129 Concentration Versus Time

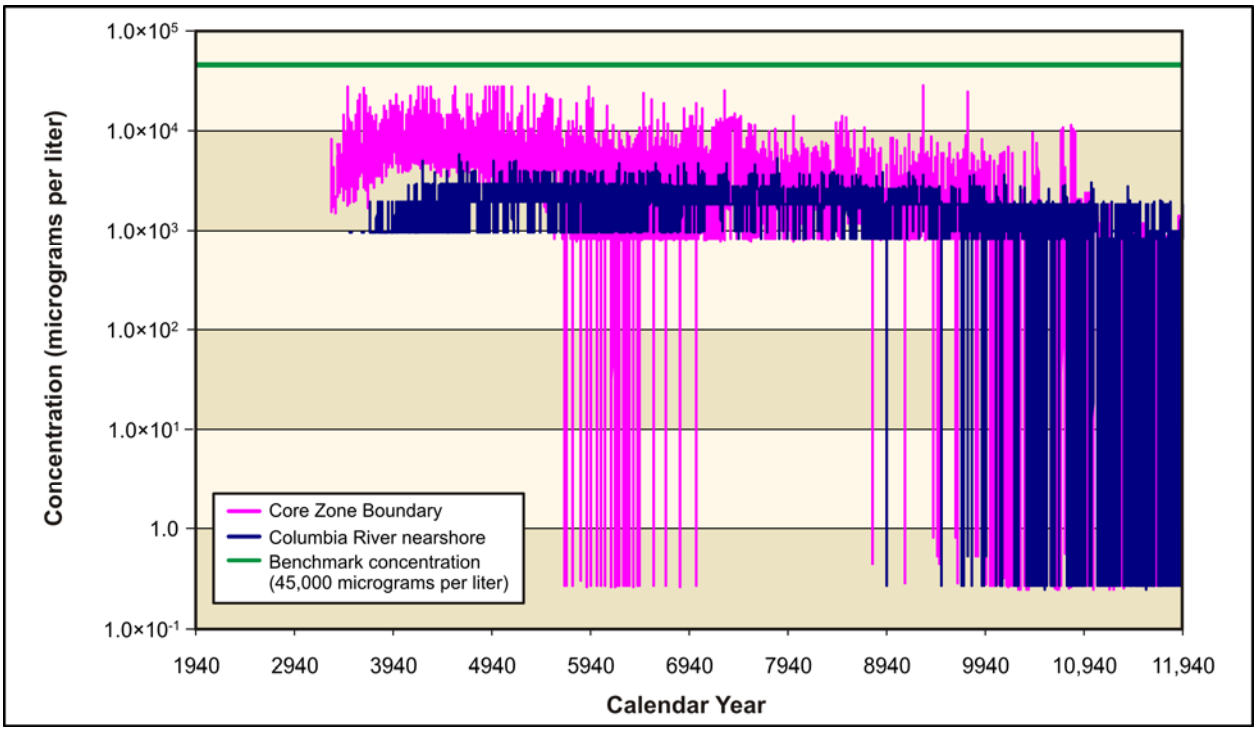


Figure 5–627. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Nitrate Concentration Versus Time

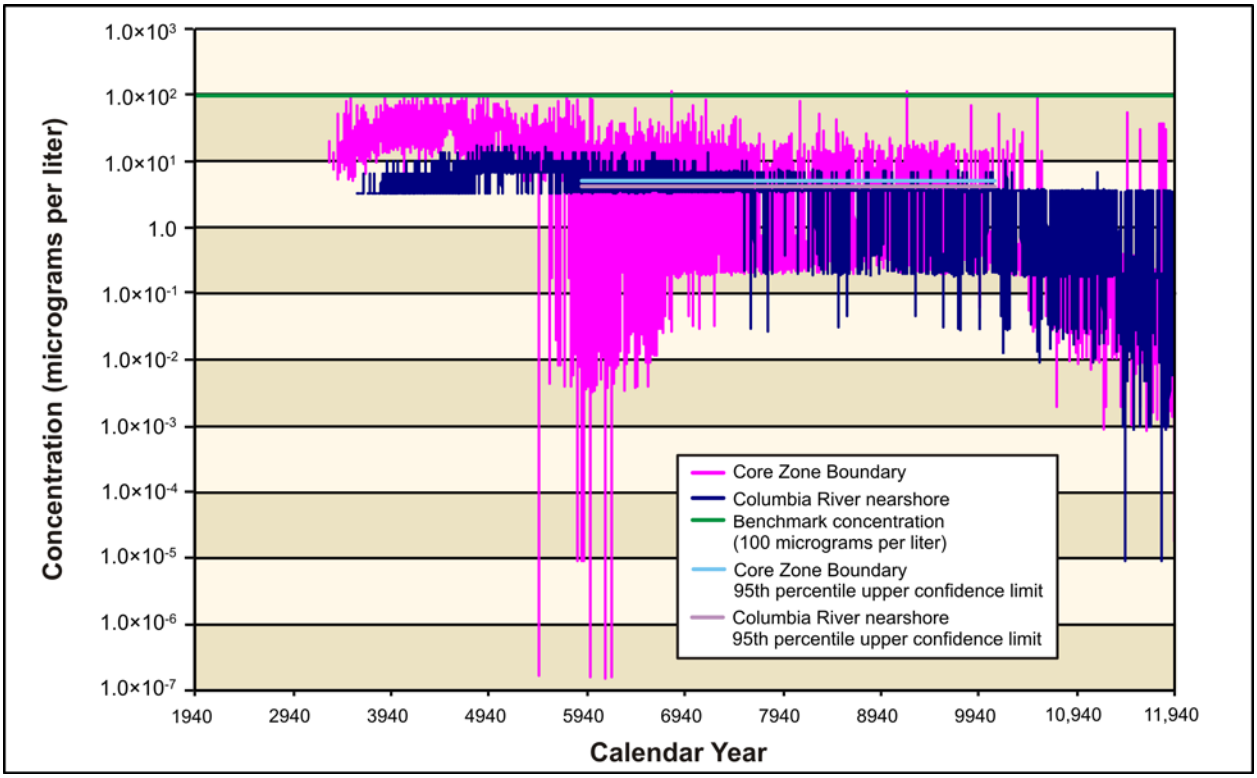


Figure 5–628. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Chromium Concentration Versus Time

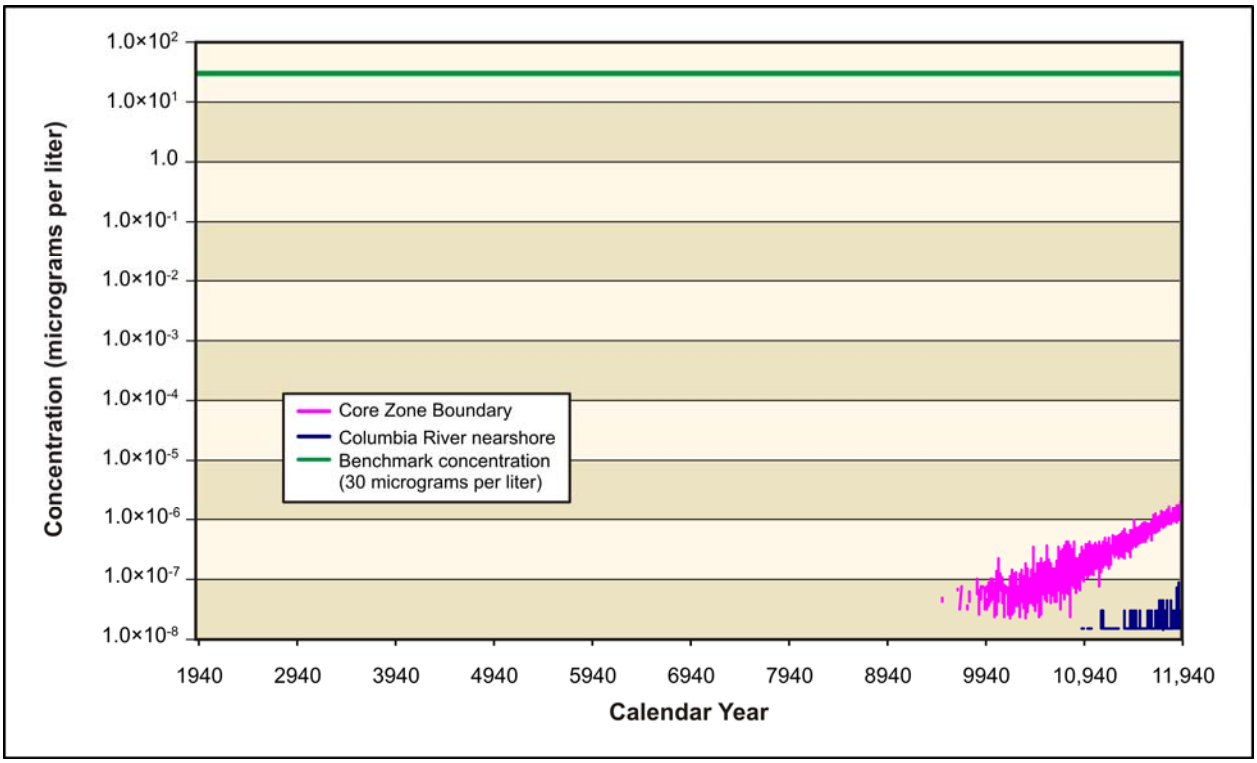


Figure 5–629. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Total Uranium Concentration Versus Time

ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, 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.

Figures 5–630 through 5–641 show concentration distributions at CYs 3890, 7140, and 11,885 for technetium-99, iodine-129, nitrate, and chromium. Figure 5–642 shows the concentration distribution of total uranium at CY 11,885. These data show that groundwater releases extend from IDF-East east to the Columbia River and from the RPPDF north to the Columbia River. The RPPDF release remains in a fairly narrow channel until about halfway to the Columbia River, where it spreads out. The IDF-East release is also contained in a narrow area until it reaches one-third the distance to the Columbia River, where it begins to spread.

Figure 5–630 (CY 3890) shows a technetium-99 releases from the RPPDF that exceeds the benchmark concentrations in small areas just outside the Core Zone Boundary. Figure 5–631 (CY 7140) shows a nearly dissipated RPPDF technetium-99 distribution, as well as several very small areas in which the concentration exceeds the benchmark. It also shows several areas in which the technetium-99 released from IDF-East approaches and potentially exceeds the technetium-99 benchmark concentration. By CY 11,885 (see Figure 5–632), the technetium-99 from the RPPDF is nearly dissipated, though there

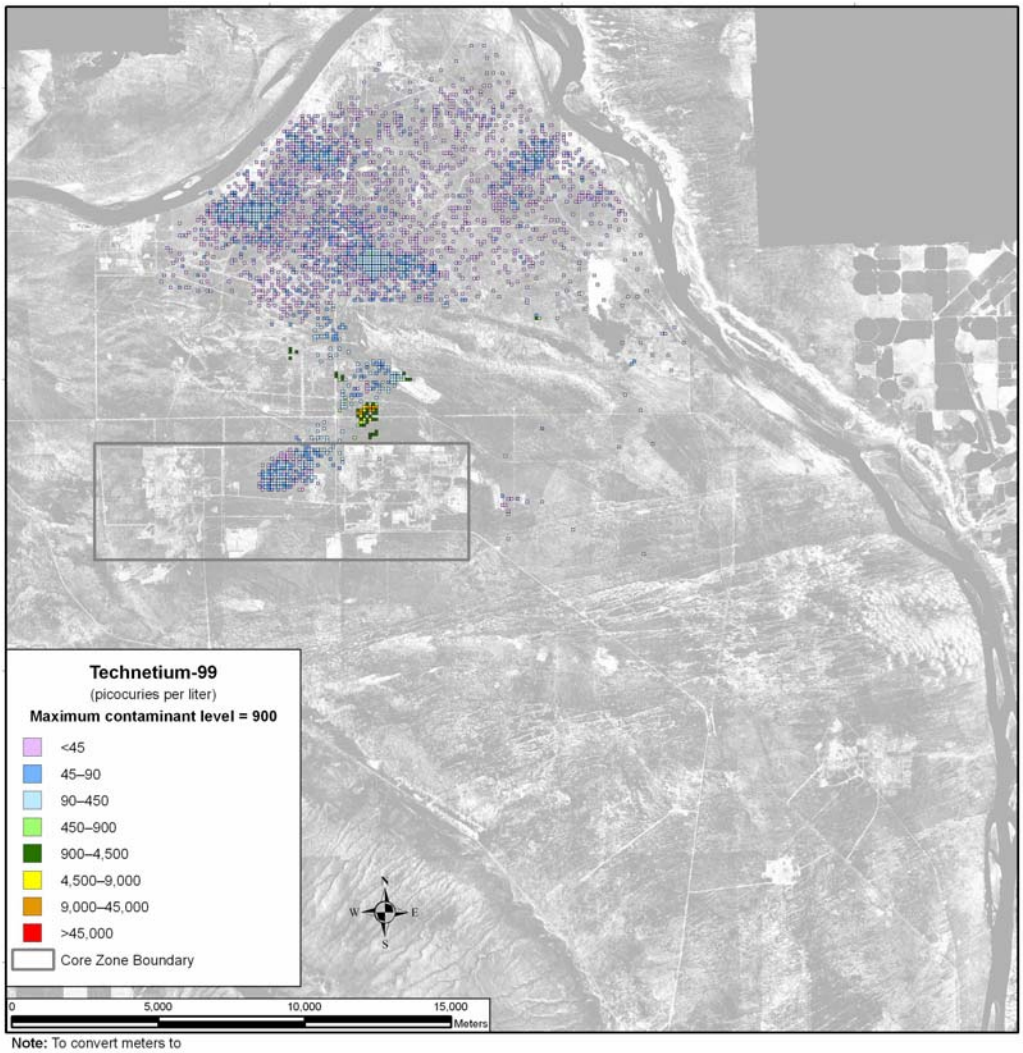
remains a small, isolated area of high concentration. The IDF-East technetium-99 release continues through CY 11,882, but most of the concentrations remain below the benchmark.

Figures 5–633 through 5–635 show similar concentration distributions of iodine-129 from the RPPDF and IDF-East, the RPPDF plume extending to the north from the Core Zone and the IDF-East plume to the east. Figure 5–633 shows an RPPDF plume at CY 3890 and but no IDF-East plume; it only becomes visible later. Figure 5–634 shows the dissipation of the RPPDF iodine-129 plume and a significant IDF-East plume. A small area (pocket) of high-concentration RPPDF iodine-129 remains and an area of IDF-East iodine-129 in concentrations higher than the benchmark has developed to the east of the Core Zone Boundary. Figure 5–635 (CY 11,885) shows a nearly dissipated RPPDF iodine-129 plume and the small higher-concentration area. It also shows an expanded IDF-East iodine-129 distribution and an area in which the iodine-129 exceeds the benchmark concentration. The spatial distributions of technetium-99 and iodine-129 over the analysis period are nearly identical to those of Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

Figures 5–636 through 5–638 show plume maps (time, space, and concentration) for nitrate releases from the RPPDF and IDF-East that are similar to those for technetium-99 and iodine-129 releases. In isolated areas north of the Core Zone Boundary, the RPPDF-released nitrate concentrations exceed the benchmark concentrations, a circumstance not observed in Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, nitrate releases. There is also a small area of high nitrate concentration from the RPPDF release that appears to continue through CY 11,885.

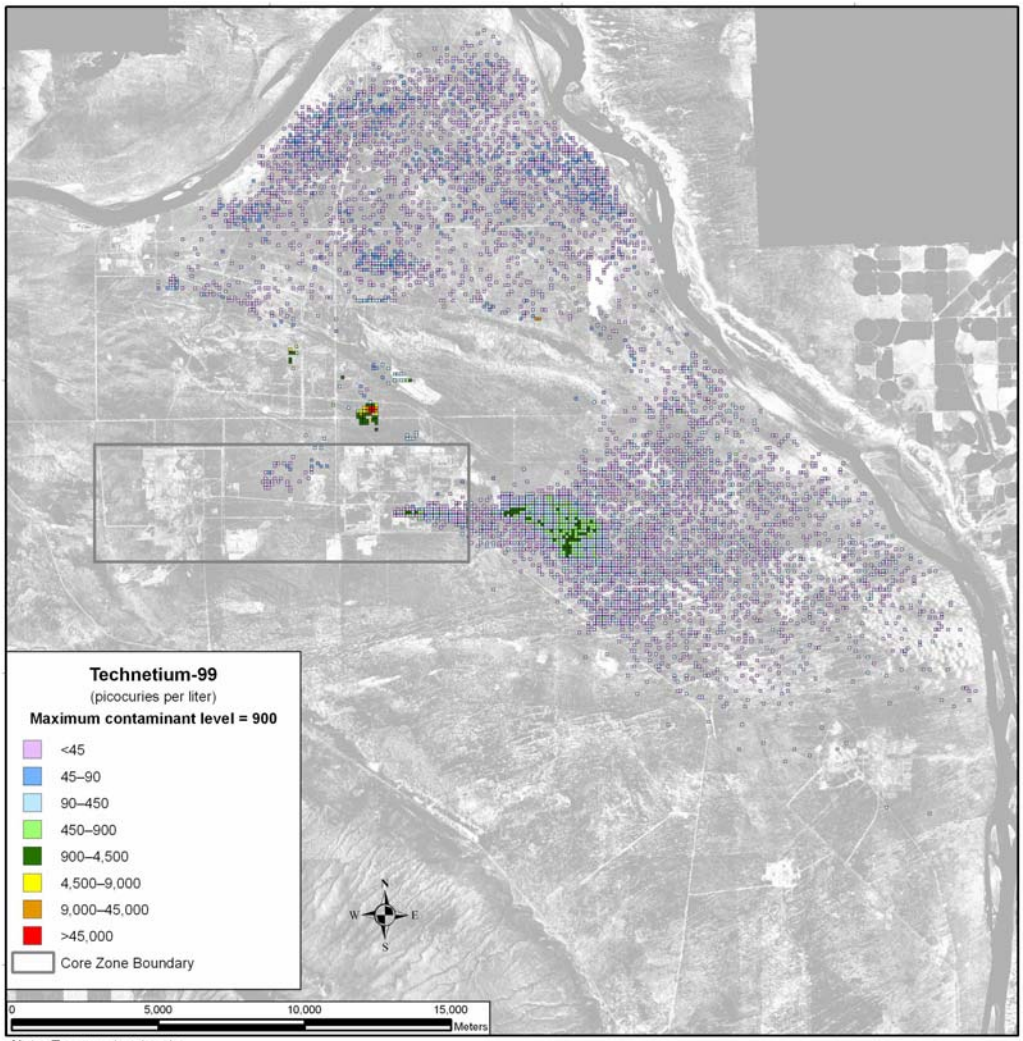
The chromium release shown in Figures 5–639 through 5–641 is nearly identical to the nitrate release in time and spatial ranges. The RPPDF release distribution includes a small area in which the chromium concentration exceeds the benchmark through CY 11,885. The IDF-East chromium release never reaches the benchmark, but the distribution continues through CY 11,885. In Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case, the nitrate high-concentration areas dissipate more rapidly and are below the benchmark concentration by CY 11,885.

Figure 5–642 shows the concentration distribution for total uranium released from the RPPDF for CY 11,885. The released total uranium produces a fairly homogeneous distribution between the release source and the Columbia River nearshore. The distribution concentration is consistently below the benchmark concentration. The retardation of total uranium yields a fairly consistent distribution between the point of release and the Columbia River. This indicates that the total uranium distribution will remain past CY 11,885. Identical results were observed for Waste Management Alternative 2, Disposal Group 2 Subgroup 2-B, Base Case.



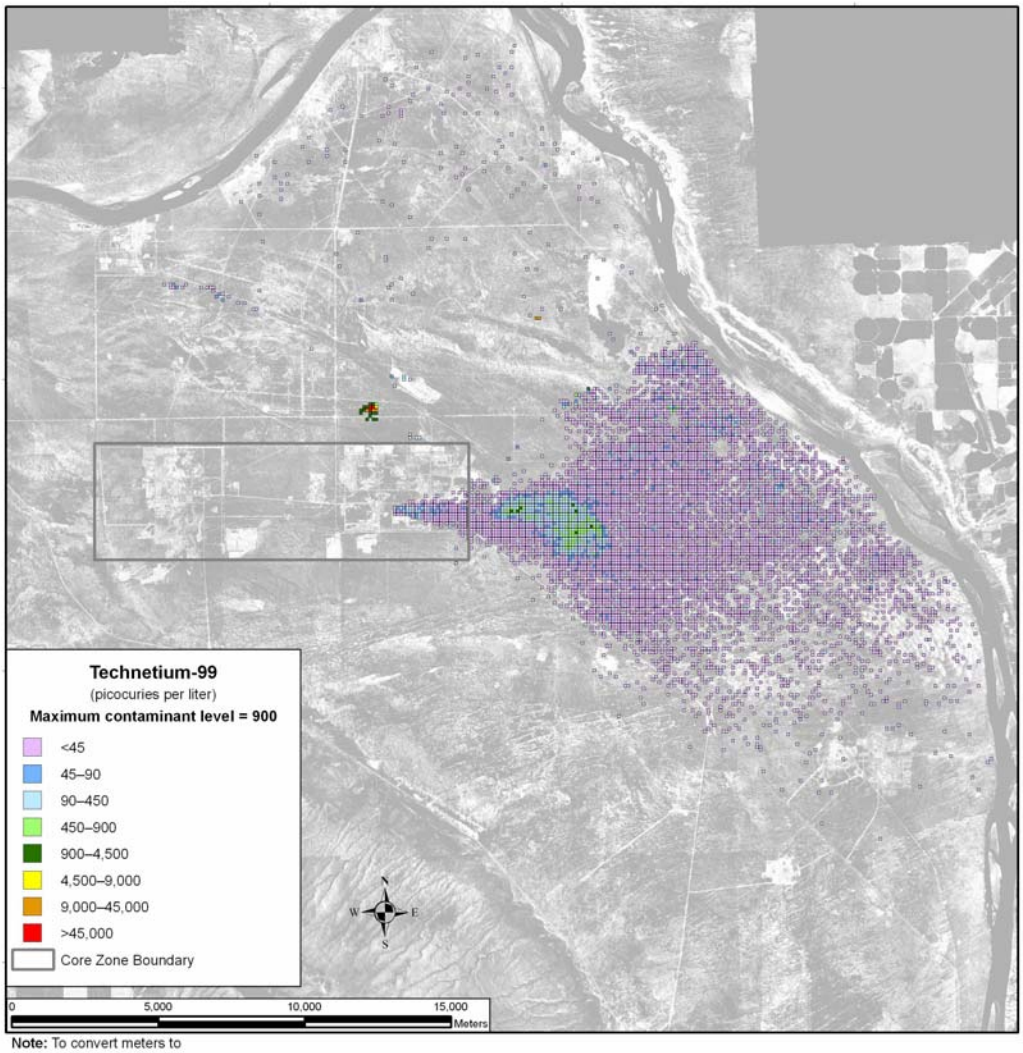
Note: To convert meters to feet, multiply by 3.281

Figure 5–630. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



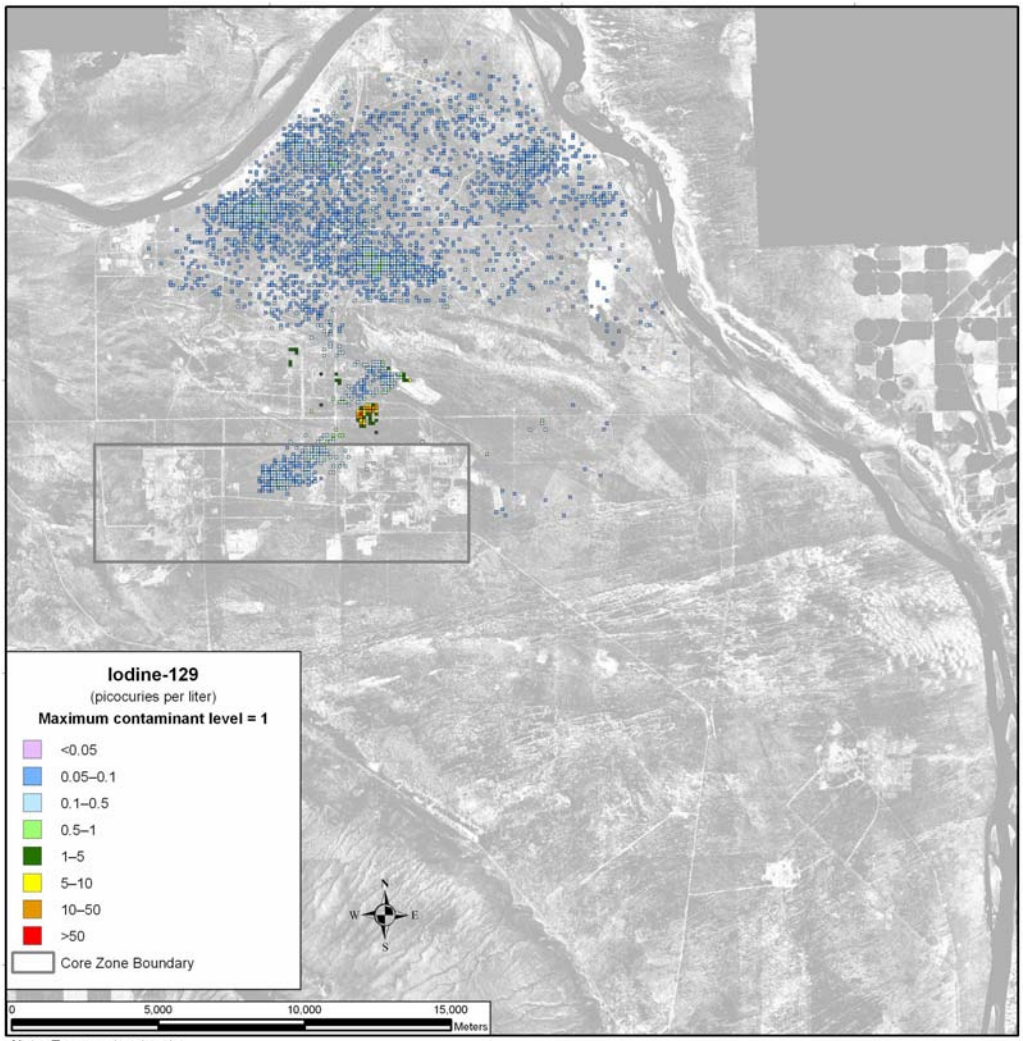
Note: To convert meters to feet, multiply by 3.281

Figure 5–631. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



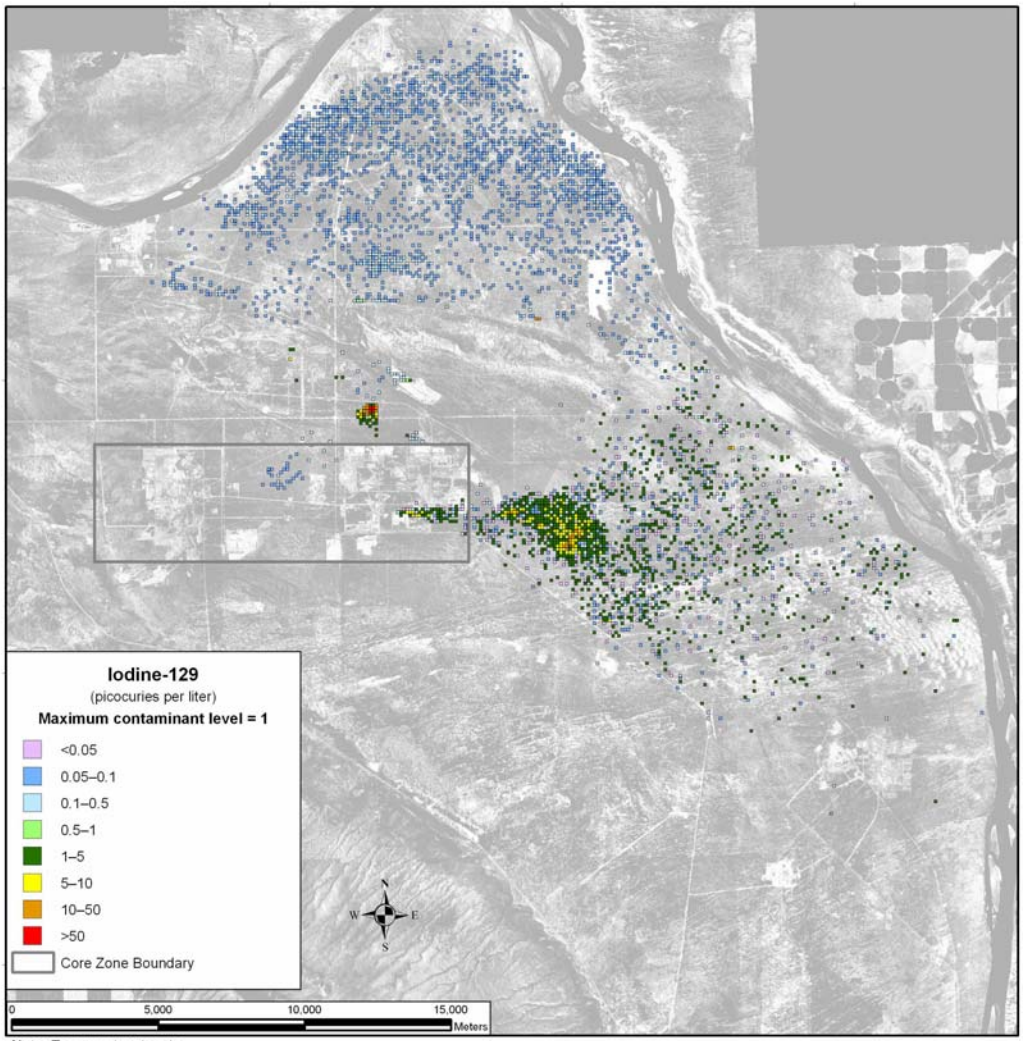
Note: To convert meters to feet, multiply by 3.281

Figure 5–632. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



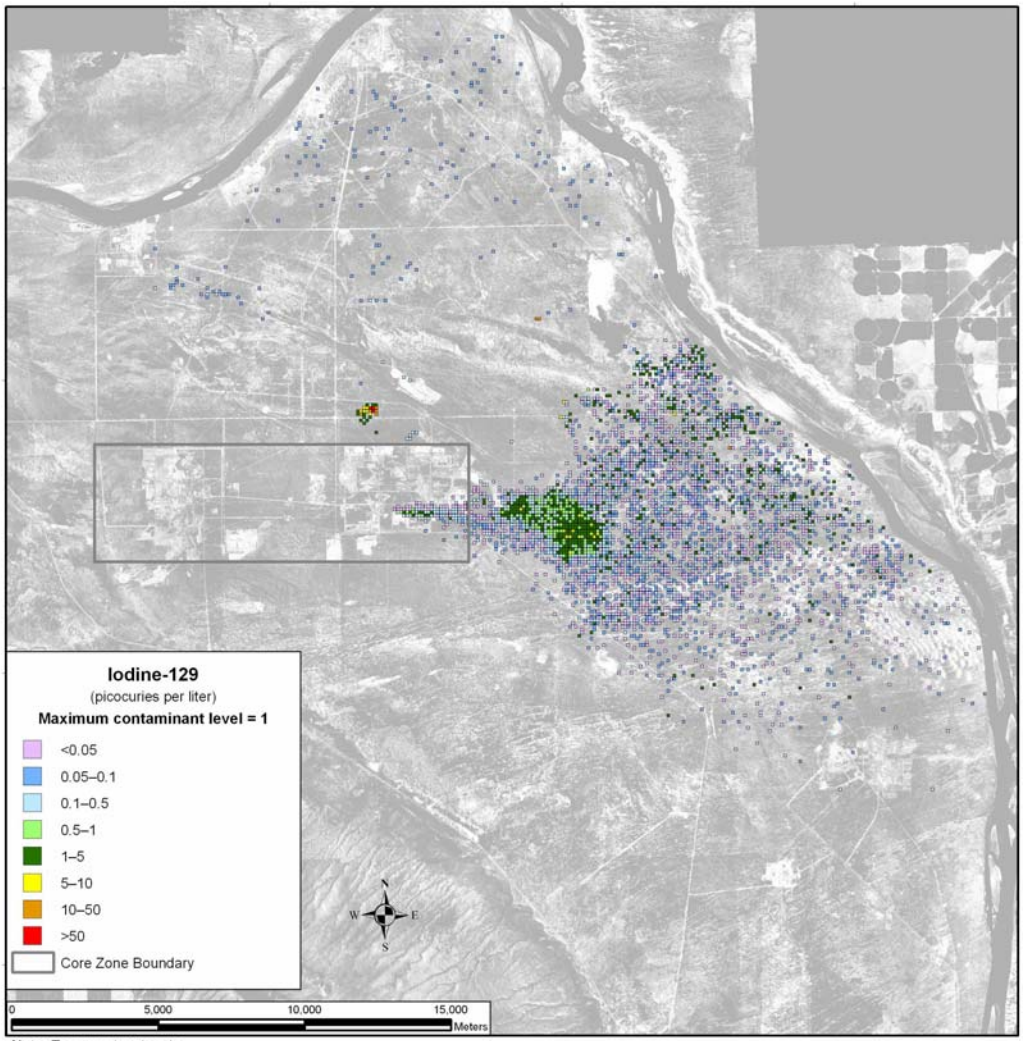
Note: To convert meters to feet, multiply by 3.281

Figure 5–633. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



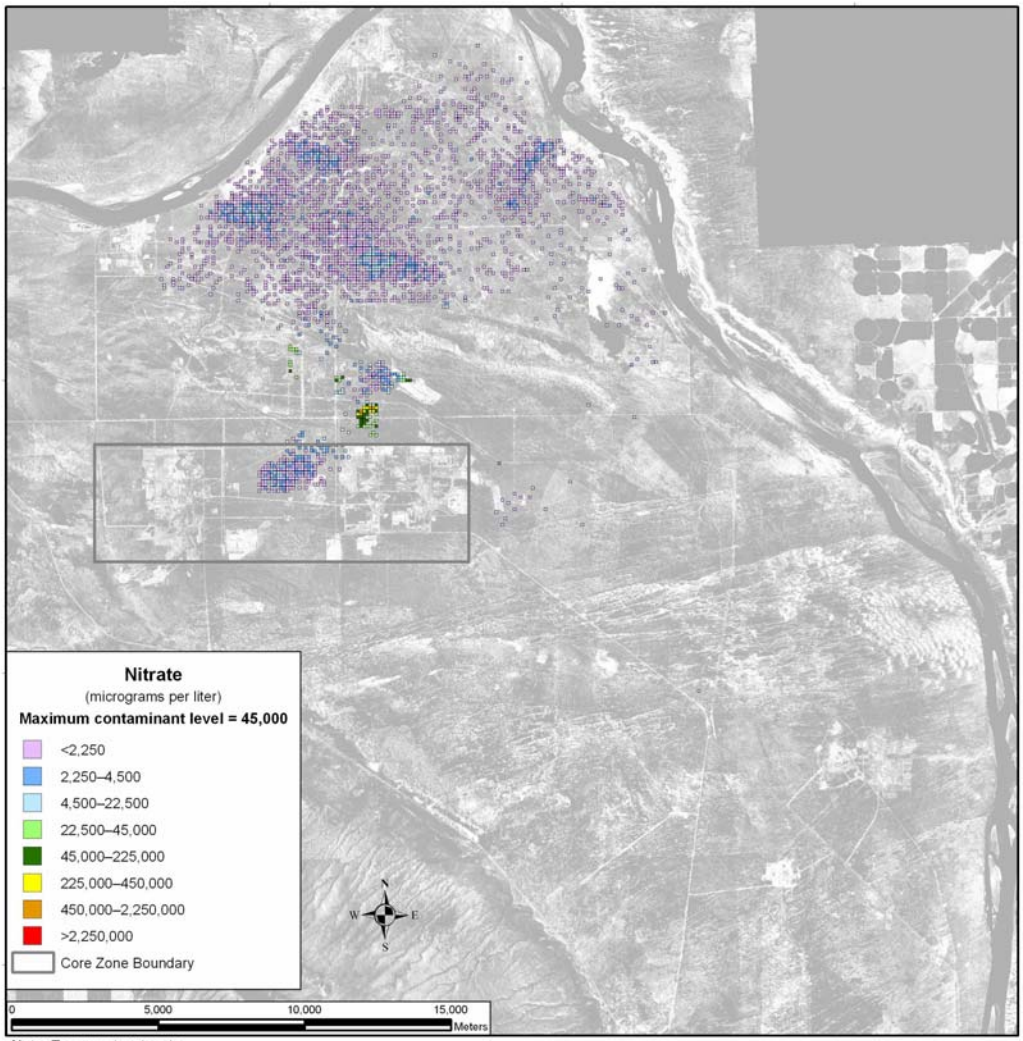
Note: To convert meters to feet, multiply by 3.281

Figure 5–634. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



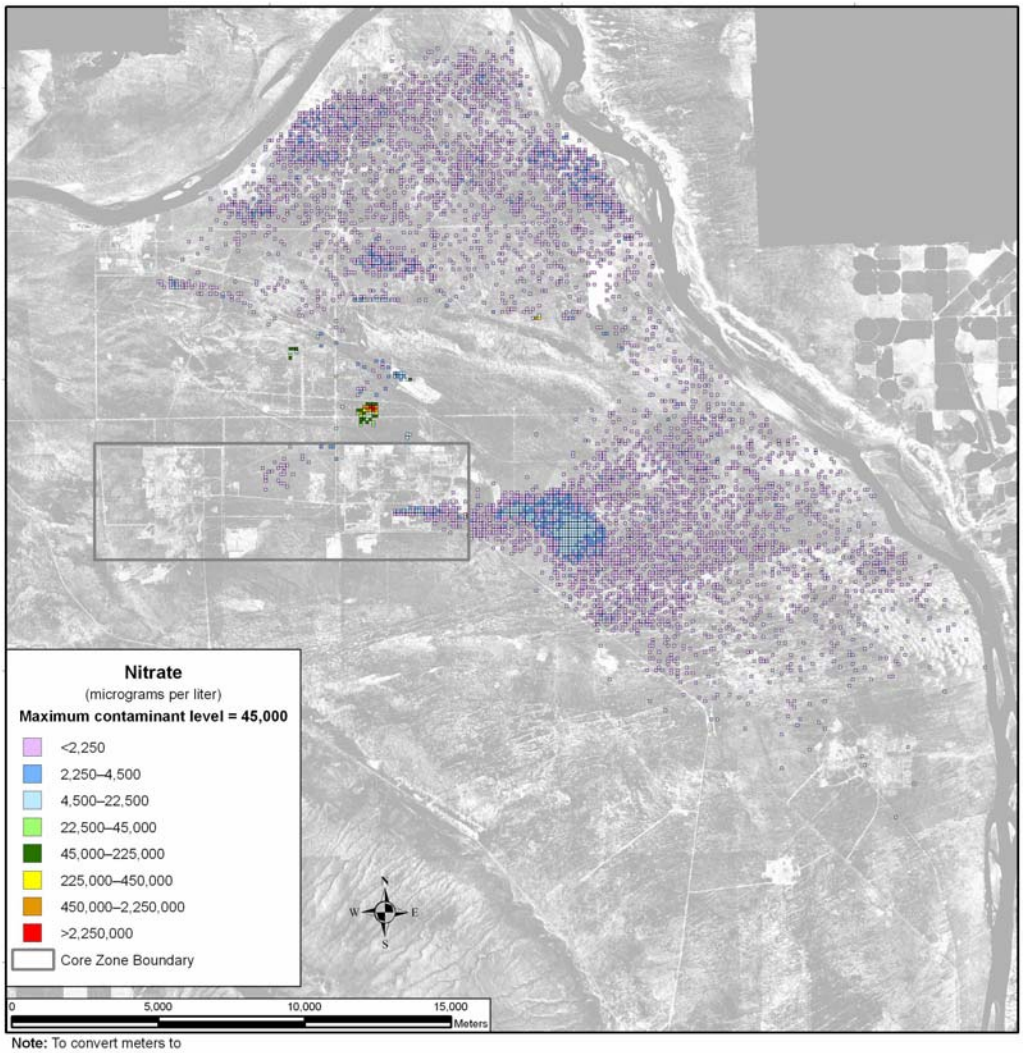
Note: To convert meters to feet, multiply by 3.281

Figure 5–635. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



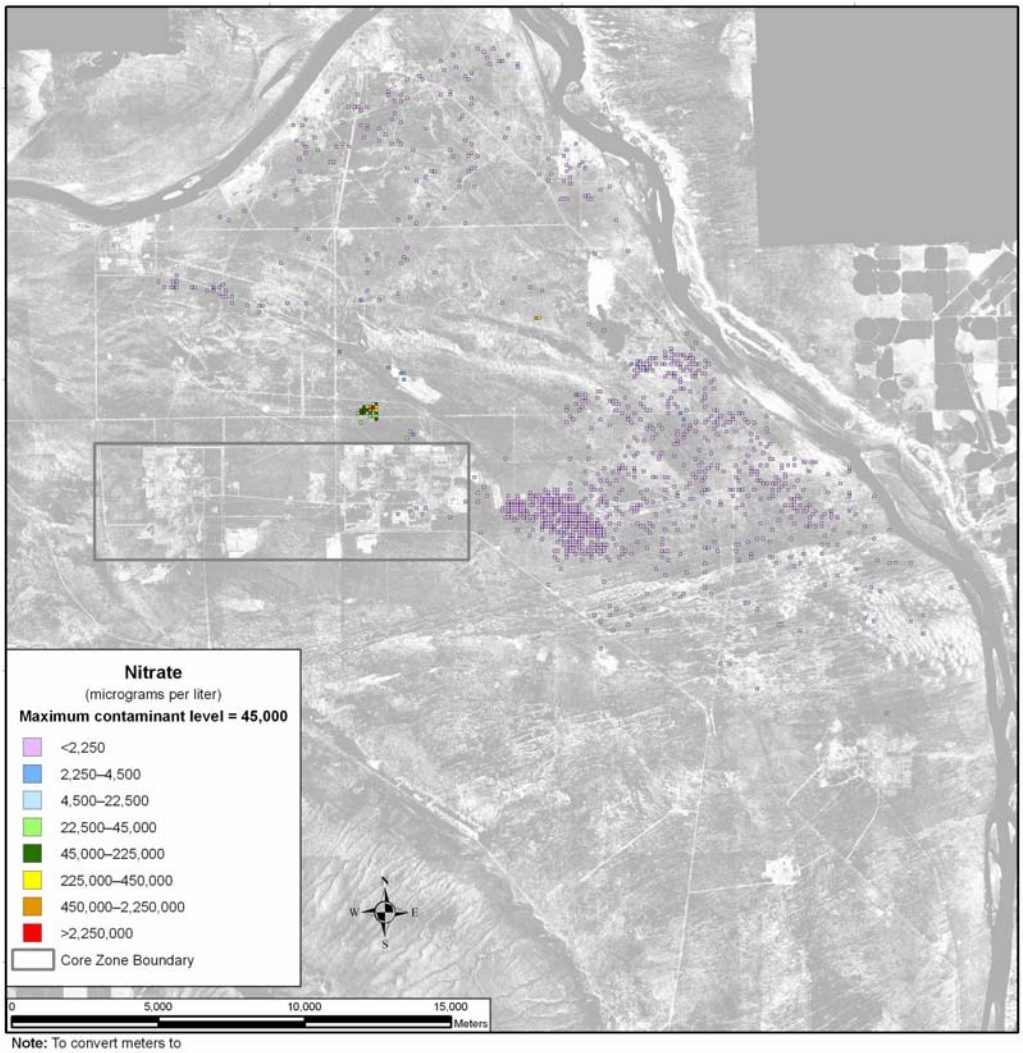
Note: To convert meters to feet, multiply by 3.281

Figure 5–636. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



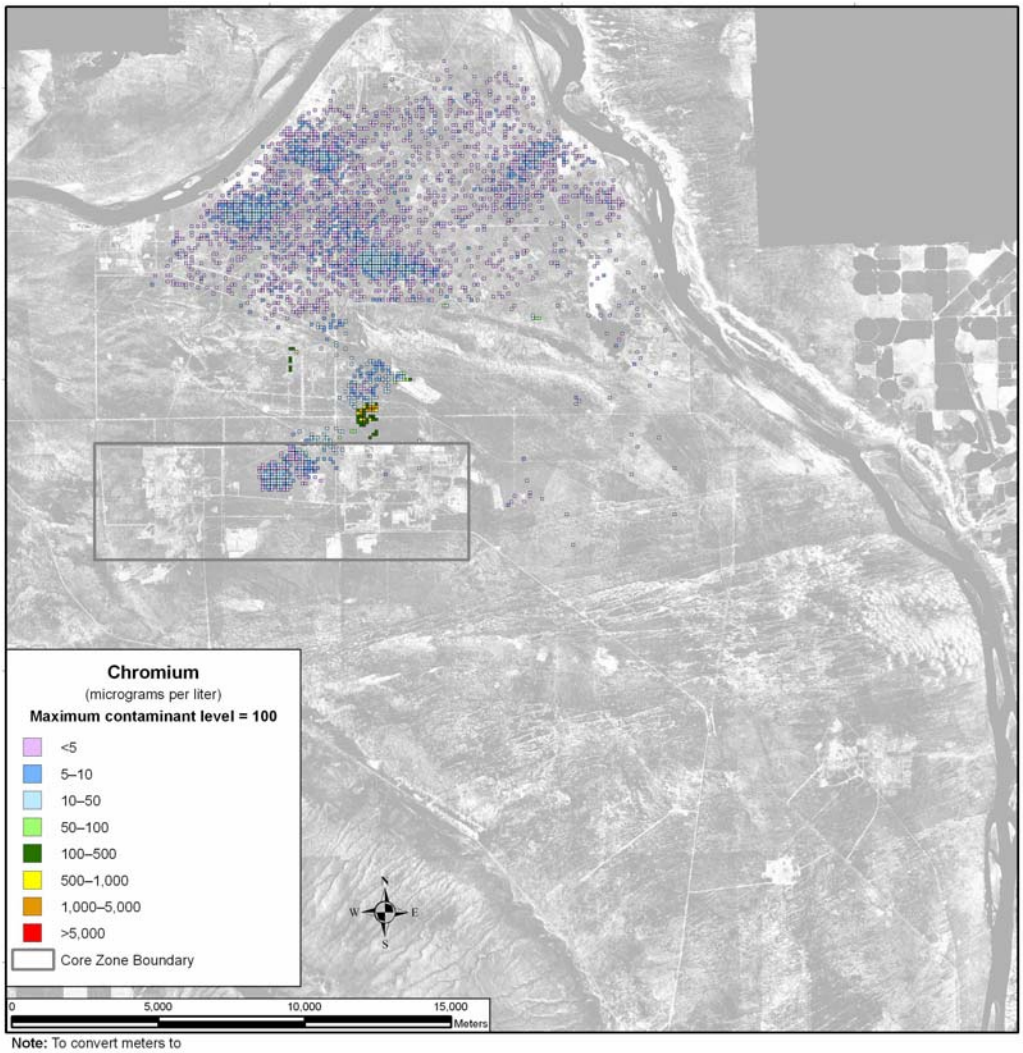
Note: To convert meters to feet, multiply by 3.281

Figure 5–637. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



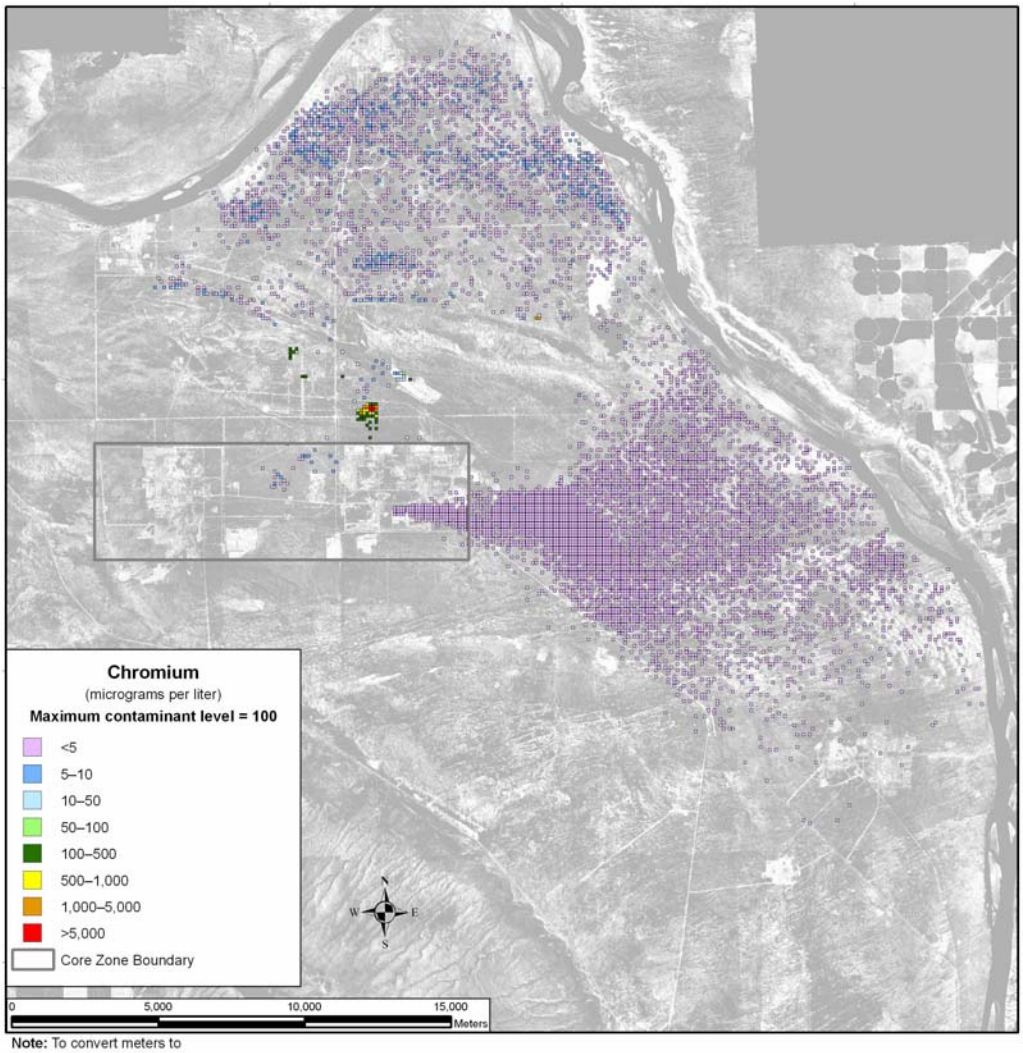
Note: To convert meters to feet, multiply by 3.281

Figure 5–638. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885



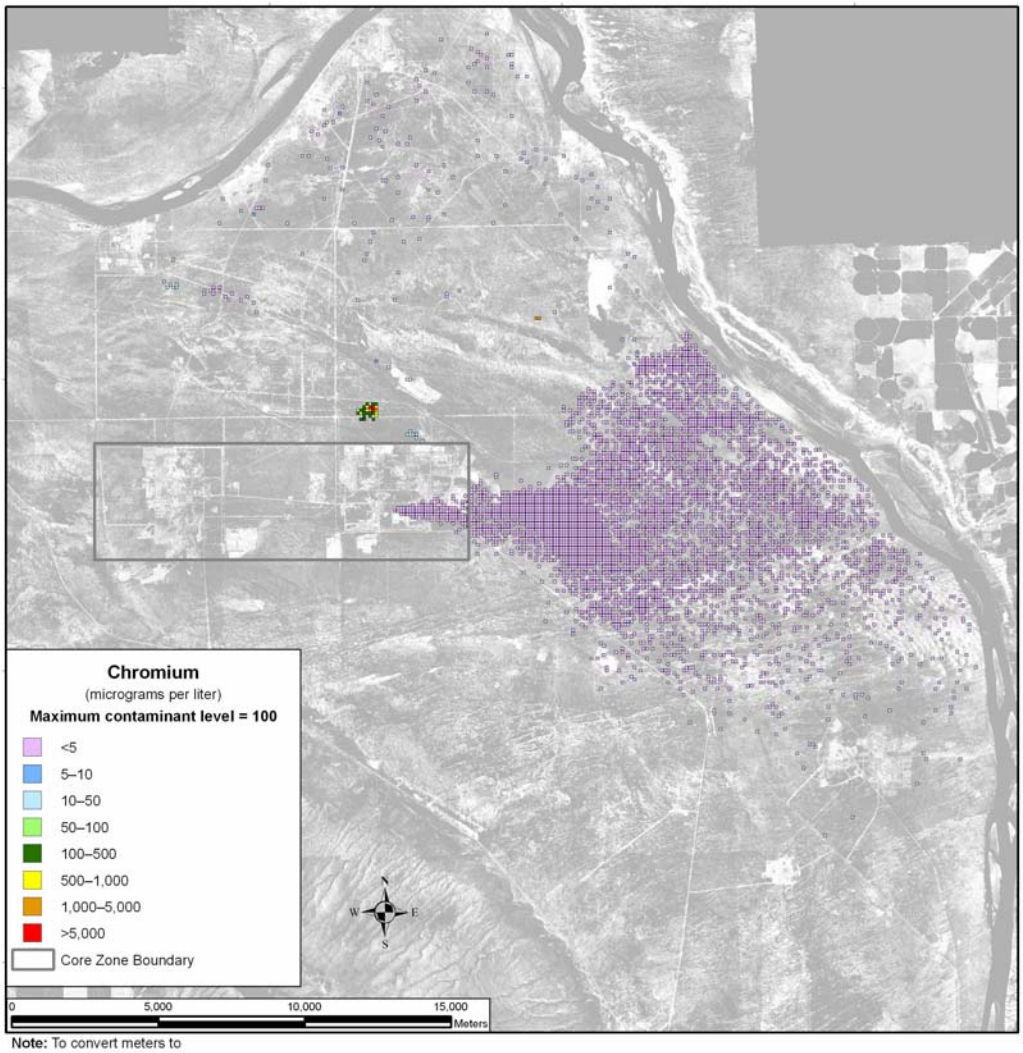
Note: To convert meters to feet, multiply by 3.281

Figure 5–639. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



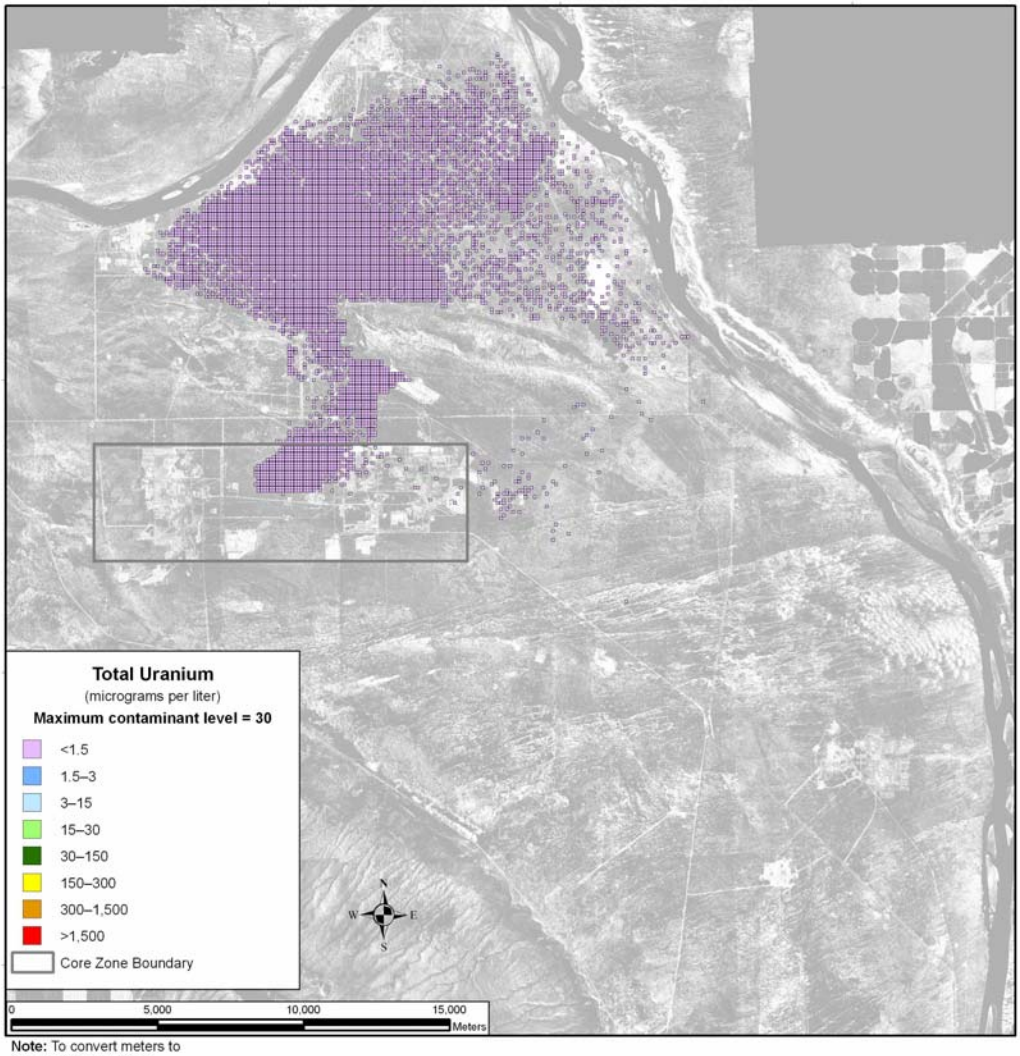
Note: To convert meters to feet, multiply by 3.281

Figure 5–640. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281

Figure 5–641. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–642. Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Option Case, in general, the analysis indicates that the concentrations of the COPCs at Core Zone Boundary and the Columbia River nearshore decrease to levels significantly below the benchmark concentrations.

In small, isolated areas near the outer Core Zone Boundary, there are high concentrations of the conservative tracers that remain high (i.e., they appear not to dissipate) through the end of the period of analysis. A fairly homogeneous plume of released uranium lies between the release source and the Columbia River nearshore. Although the concentrations of total uranium are both two orders of magnitude lower than the benchmark concentrations during this analysis period, the trend appears to show a continuing increase through the end of that period.

Except for isolated areas with nitrate and chromium, the spatial and time distributions are nearly identical to those for Waste Management Alternative 2, Disposal Group 2, Subgroup 2-B, Base Case.

5.3.1.2.3 Disposal Group 3

Disposal Group 3 is characterized by an operational completion date of CY 2165 for both IDF-East and the RPPDF. In Disposal Group 3, IDF-East has a large capacity (425,000 cubic meters [556,000 cubic yards]) and the RPPDF an even larger capacity (8,370,000 cubic meters [10,900,000 cubic yards]). These capacities are designed to meet the waste generation volumes associated with Tank Closure Alternative 6A, Base and Option Cases; FFTF Decommissioning Alternative 2 or 3; and onsite- and offsite-generated waste.

ACTIONS AND TIMEFRAMES INFLUENCING GROUNDWATER IMPACTS

Disposal Group 3 covers Tank Closure Alternative 6A, Base and Option Cases; FFTF Decommissioning Alternative 2 or 3; and onsite- and offsite-generated waste. For both the Base and Option Cases, waste will be converted to IHLW and PPF glass. IHLW would be stored on site, while PPF glass would be disposed of at IDF-East.

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

- The disposal period starts with the onset of disposal operations in IDF-East and the RPPDF in CY 2009 and continues through CY 2165 when these facilities will be operationally closed. During the disposal period, the materials in these permitted, operational facilities are unavailable for release to the environment.

- The post-disposal period starts in CY 2166 and continues through the 10,000-year period of analysis until CY 11,940. At the start of this period, materials in the facilities become available for release to the environment. For purposes of analyzing long-term groundwater impacts of Waste Management Alternative 3, Disposal Group 3, IDF-East and RPPDF are assumed to be covered by a barrier limiting infiltration during the first 500 years of the post-disposal period.

COPC DRIVERS

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

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

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

The COPC drivers that are discussed in detail in this section (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. Total uranium was added to the list because it begins to appear toward the end of the period of analysis. Total uranium is long-lived or stable, but is not as mobile as the other COPC drivers; it moves about seven times more slowly than groundwater. Acetonitrile was added because of its appearance in the RPPDF. 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 Alternative 2, Disposal Group 3, Base and Option Cases, in terms of the total amount released to the vadose zone, groundwater, and the Columbia River. Releases of radionuclides are totaled in curies; chemicals, in kilograms. Both are totaled over the 10,000-year period of analysis. Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over eight orders of magnitude.

200-East Area Integrated Disposal Facility

Seven subtotals are plotted for IDF-East representing releases from ETF-generated secondary waste, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, offsite-generated waste, steam reforming waste, retired melters, and waste management secondary and onsite-generated waste. Figure 5–643 shows the release to the vadose zone at IDF-East in the Base Case for the radiological risk drivers and Figure 5–644, the chemical hazard drivers. Technetium-99 is significantly released to the vadose zone from each on the subtotaled sources, with offsite-generated waste and tank closure secondary waste contributing the most. Iodine-129 has significant releases from five of the subtotaled sources, with offsite-generated waste and ETF-generated secondary waste contributing the most. Chromium has six significant sources, with ETF-generated secondary waste and tank closure secondary waste providing the most releases. Nitrate is only significantly released from ETF-generated secondary waste and waste management secondary waste, and onsite-generated waste.

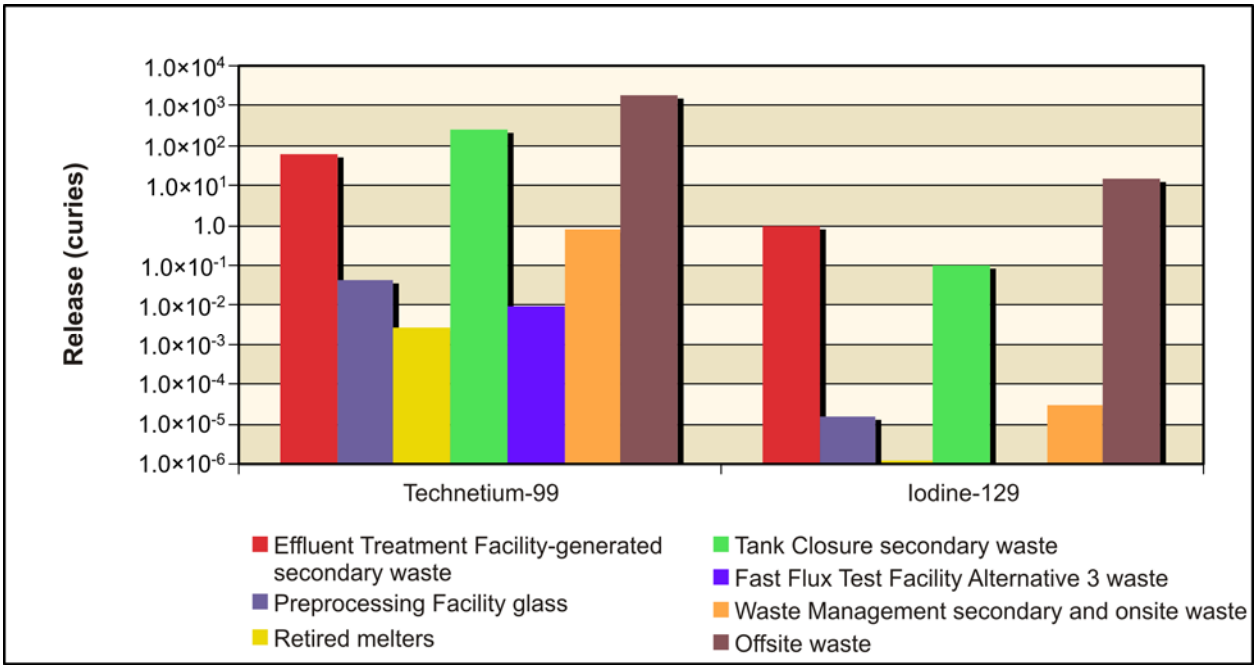


Figure 5–643. Waste Management Alternative 2, Disposal Group 3, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

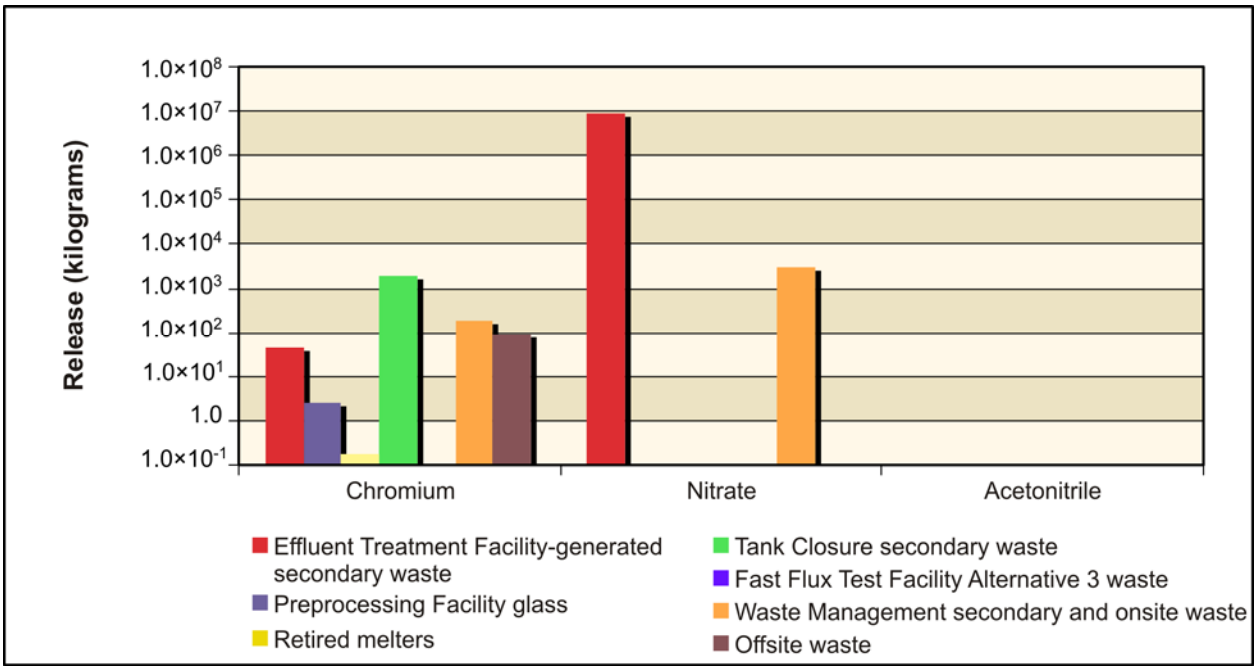


Figure 5–644. Waste Management Alternative 2, Disposal Group 3, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–645 shows the release to the vadose zone at IDF-East in the Option Case for the radiological risk drivers and Figure 5–646, the chemical hazard drivers. The radiological risk drivers and the chemical hazard drivers released to the vadose zone in the Option Case are essentially identical to those in the Base Case.

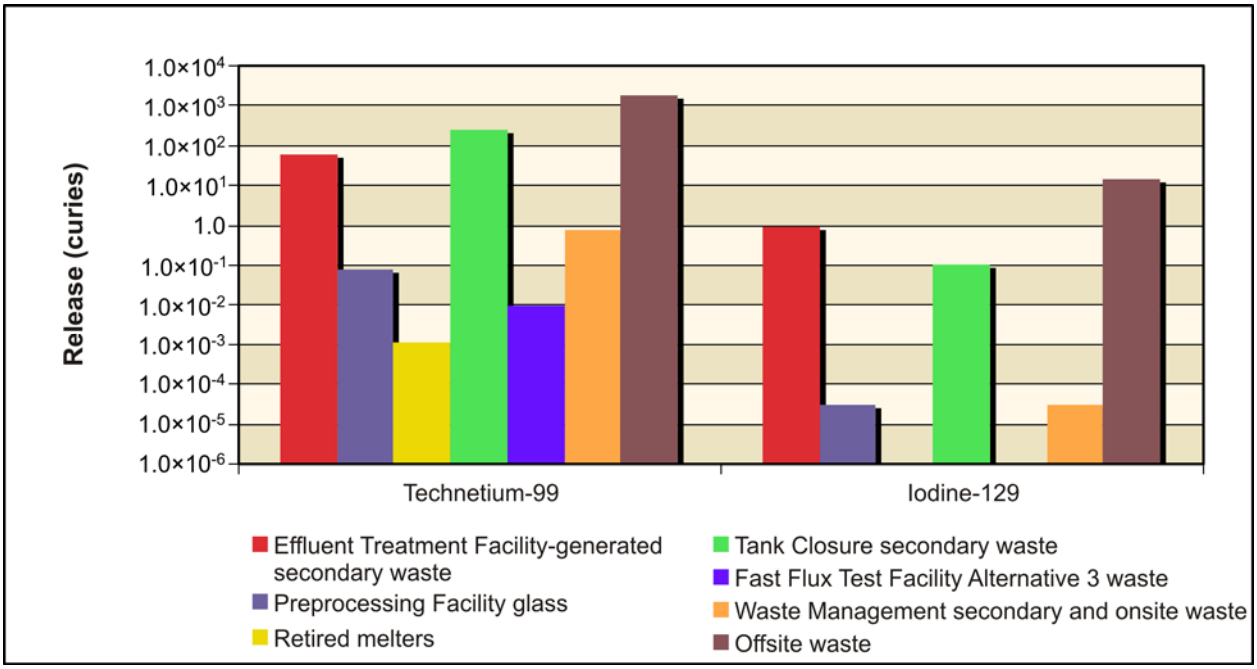


Figure 5–645. Waste Management Alternative 2, Disposal Group 3, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

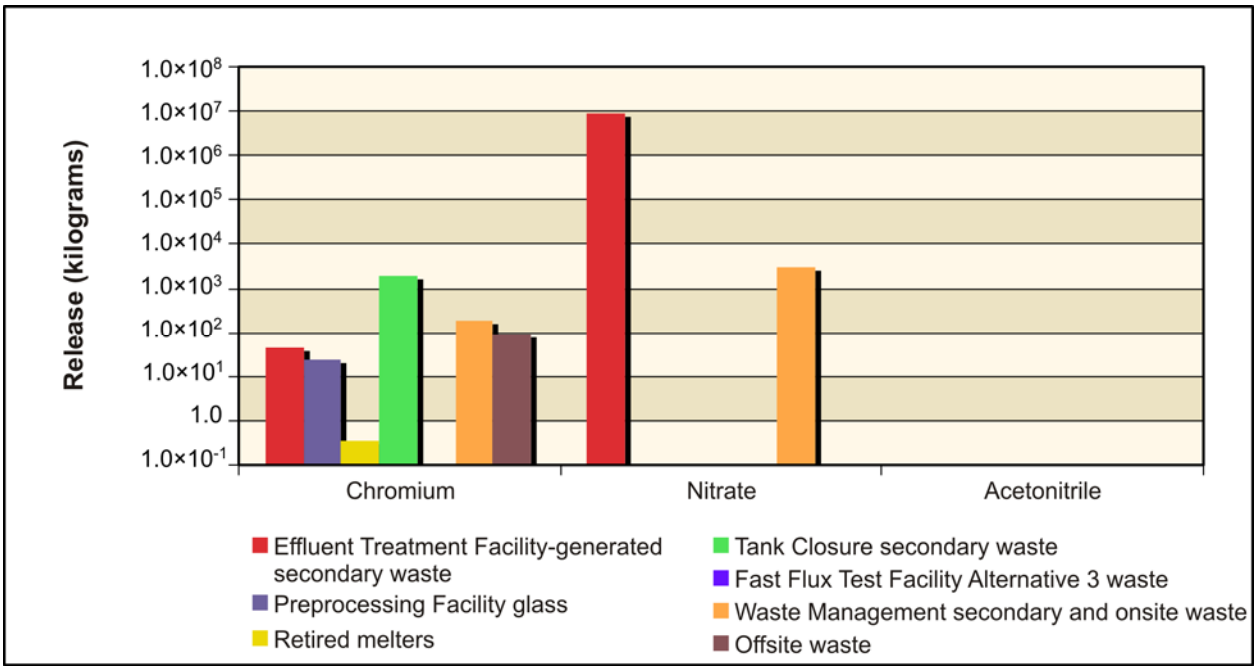


Figure 5–646. Waste Management Alternative 2, Disposal Group 3, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Vadose Zone

Figure 5–647 shows the release to groundwater at IDF-East in the Base Case for the radiological risk drivers and Figure 5–648, the chemical hazard drivers. 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 (technetium-99, iodine-129, chromium, and nitrate), the amount released to groundwater is typically equal to the amount released to the vadose zone. Ninety-five to 100 percent of the technetium-99 released to the vadose zone released from ETF-generated secondary waste and offsite-generated waste reaches groundwater. Forty to 60 percent of the technetium-99 released to the vadose zone from other sources—i.e., PPF glass, retired melters, tank closure secondary waste, FFTF Decommissioning Alternative 3 waste, and waste management secondary and onsite-generated waste—reaches groundwater. For iodine-129 from offsite-generated waste, releases to groundwater and to the vadose zone are essentially equal. Only about 40 percent of the iodine-129 released to the vadose zone—i.e., releases from ETF-generated secondary waste, PPF glass, tank closure secondary waste, and waste management secondary and onsite-generated waste—reaches groundwater. Chromium released to groundwater from ETF-generated secondary waste, tank closure secondary waste, waste management secondary and onsite-generated waste, and offsite-generated waste is essentially equal to that released to the vadose zone. About 45 percent of the chromium released from PPF glass and retired melters to the vadose zone is transferred to the groundwater. Finally, nitrate released to groundwater from ETF-generated secondary waste, waste management secondary waste, and onsite-generated waste is essentially equal to that released to the vadose zone.

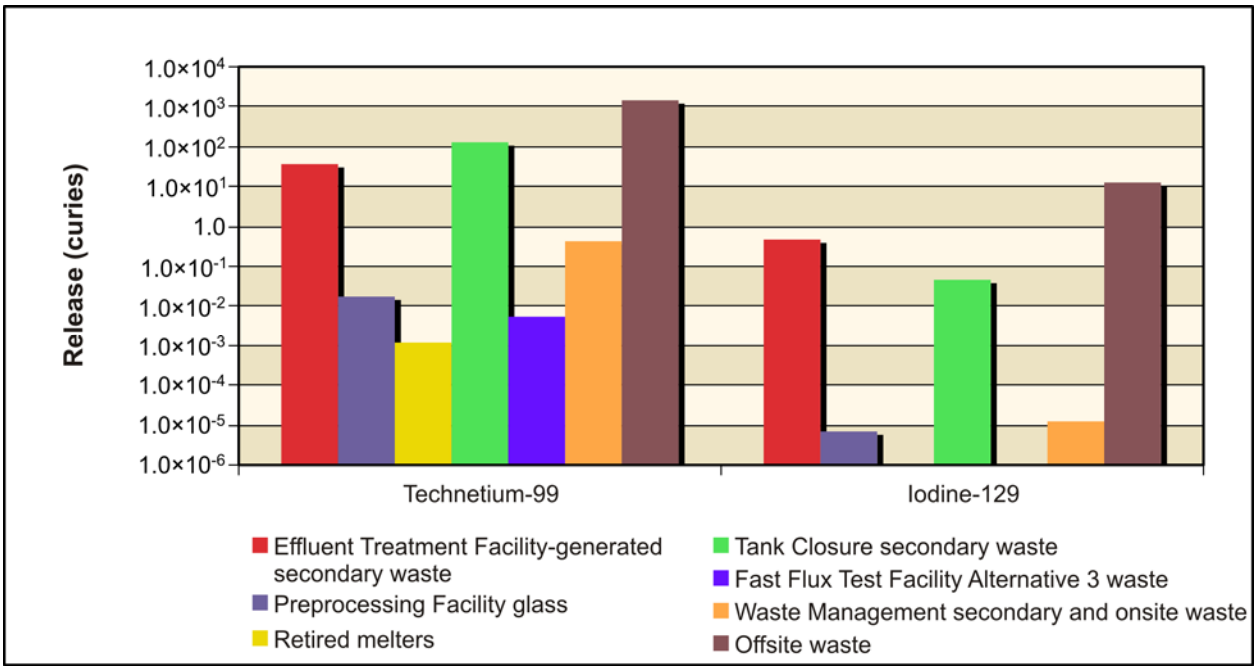


Figure 5–647. Waste Management Alternative 2, Disposal Group 3, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

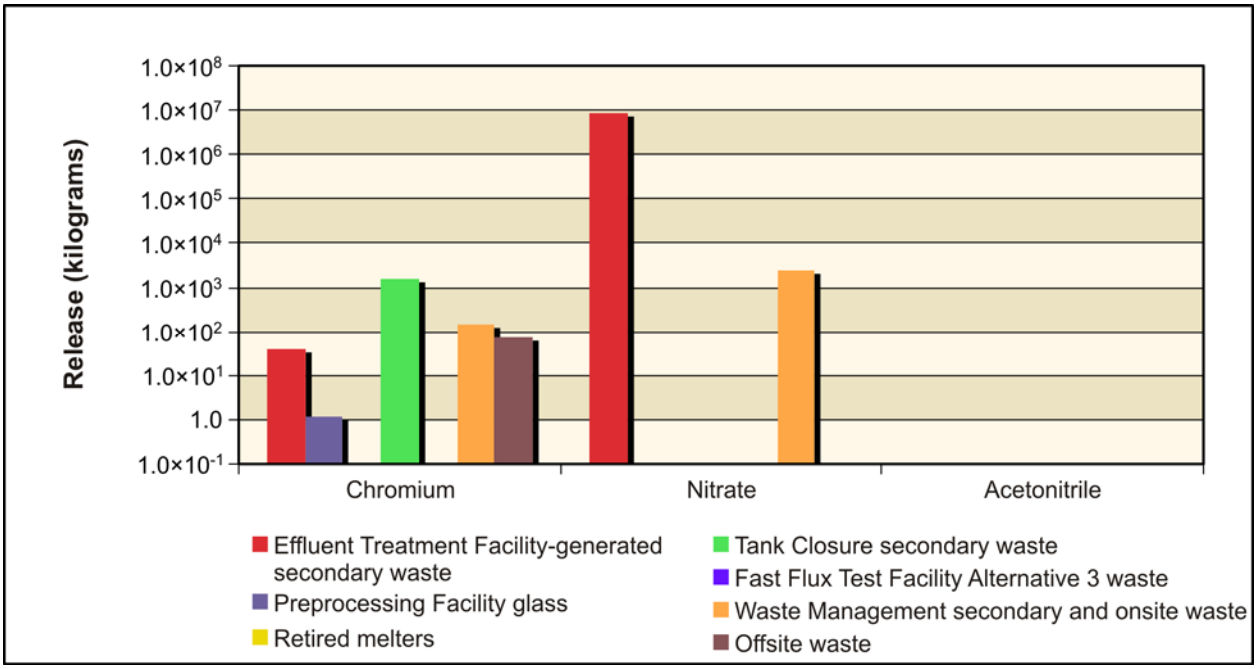


Figure 5–648. Waste Management Alternative 2, Disposal Group 3, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–649 shows the release to groundwater at IDF-East in the Option Case for the radiological risk drivers and Figure 5–650, the chemical hazard drivers. The releases of radiological risk drivers and the chemical hazard drivers to groundwater in the Option Case are essentially identical to those in the Base Case.

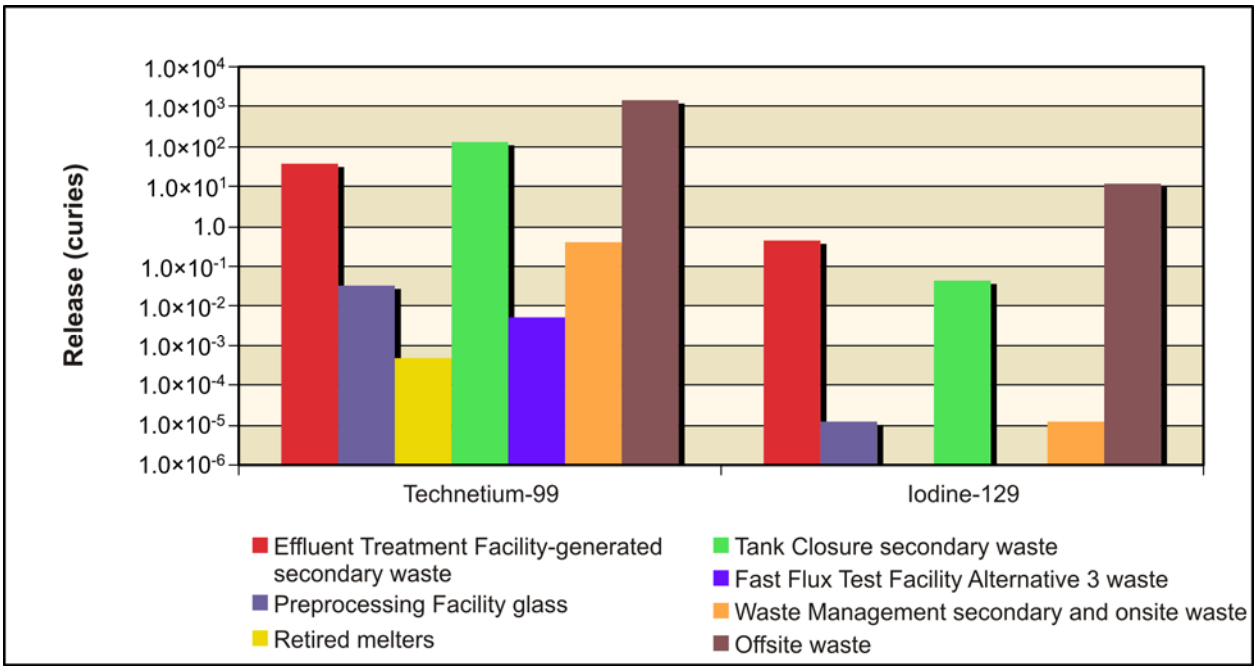


Figure 5–649. Waste Management Alternative 2, Disposal Group 3, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Groundwater

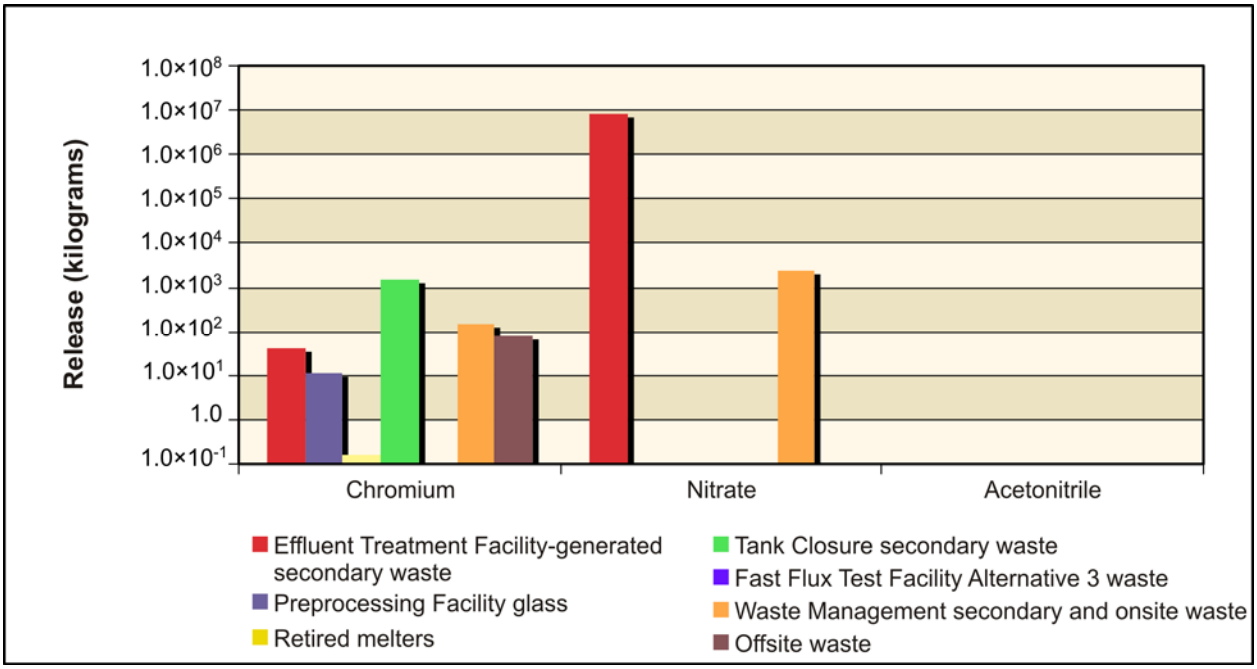


Figure 5–650. Waste Management Alternative 2, Disposal Group 3, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Groundwater

Figure 5–651 shows the release to the Columbia River at IDF-East in the Base Case for the radiological risk drivers and Figure 5–652, the chemical hazard drivers. For the conservative tracers (technetium-99, iodine-129, chromium, and nitrate), the amount released to the Columbia River is typically essentially equal to the amount released to the vadose zone. Ninety to 97 percent of the technetium-99 released to groundwater from ETF-generated secondary-waste, PPF glass, retired melters, FFTF Decommissioning Alternative 3 waste, waste management secondary and onsite-generated waste, and offsite-generated waste reaches the Columbia River. Only about 60 percent of the technetium-99 released to groundwater from the tank closure secondary waste reaches the river. Ninety to 97 percent of the iodine-129 released to groundwater from ETF-generated secondary waste and offsite-generated waste reaches the Columbia River. Only about 25 percent of the iodine-129 released from the tank closure secondary waste to groundwater is transferred to the river. Essentially none of the iodine-129 released to groundwater from PPF glass, waste management secondary waste, and onsite-generated is transferred to the river. As for chromium, 90 to 98 percent of the amount released from ETF-generated secondary waste, PPF glass, retired melters, tank closure secondary waste, waste management secondary and onsite-generated waste, and offsite-generated waste is released to the Columbia River. The amount of nitrate released to the Columbia River from ETF-generated secondary waste, waste management secondary waste, and onsite-generated waste is essentially equal to that released to the groundwater.

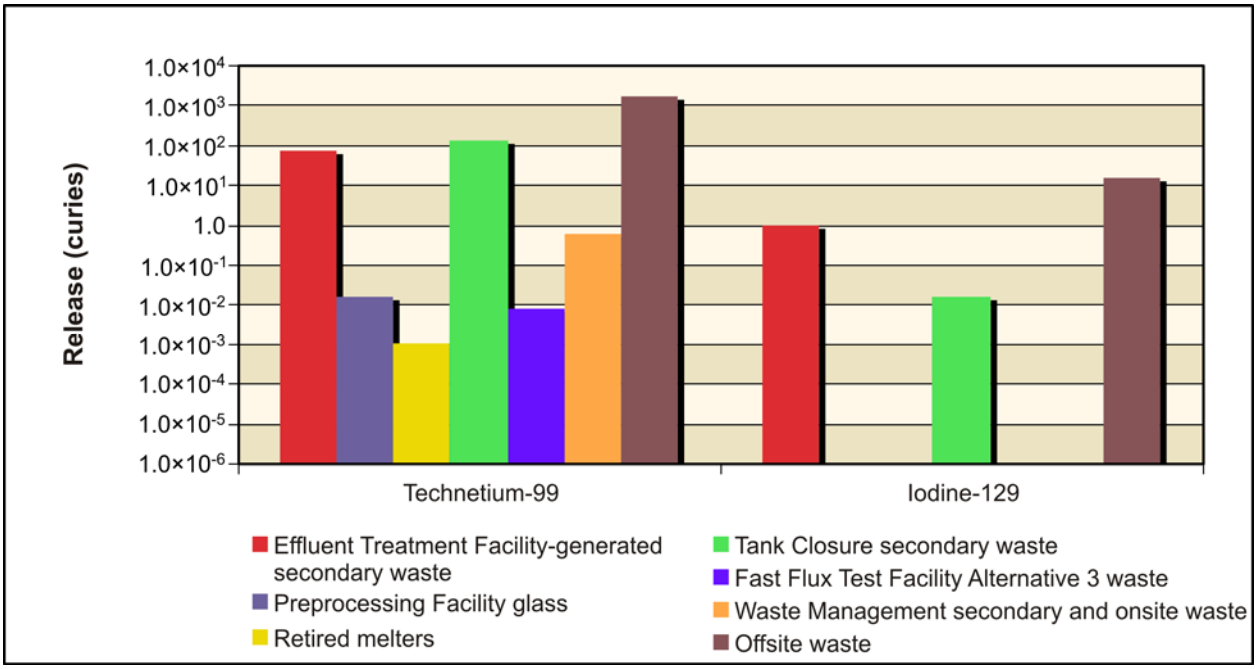


Figure 5–651. Waste Management Alternative 2, Disposal Group 3, Base Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

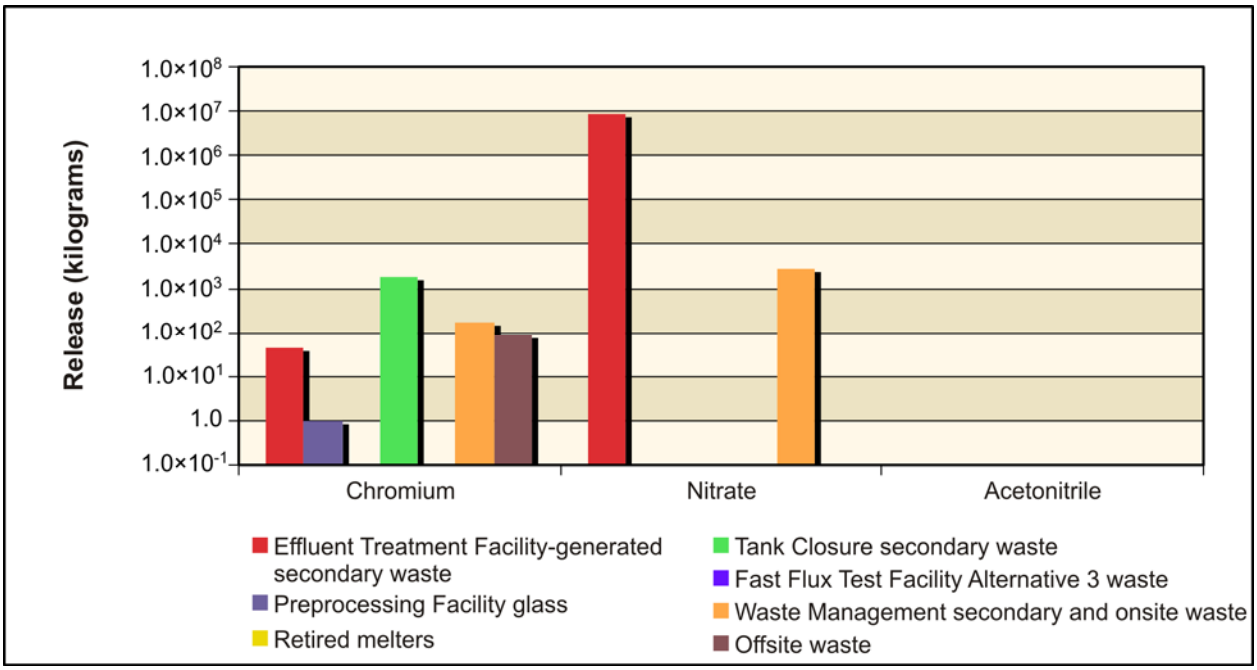


Figure 5–652. Waste Management Alternative 2, Disposal Group 3, Base Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

Figure 5–653 shows the release to the Columbia River at IDF-East in the Option Case for the radiological risk drivers and Figure 5–654, the chemical hazard drivers. For the IDF, the radiological risk drivers and the chemical hazard drivers released to the Columbia River in the Option Case are essentially identical to those in the Base Case.

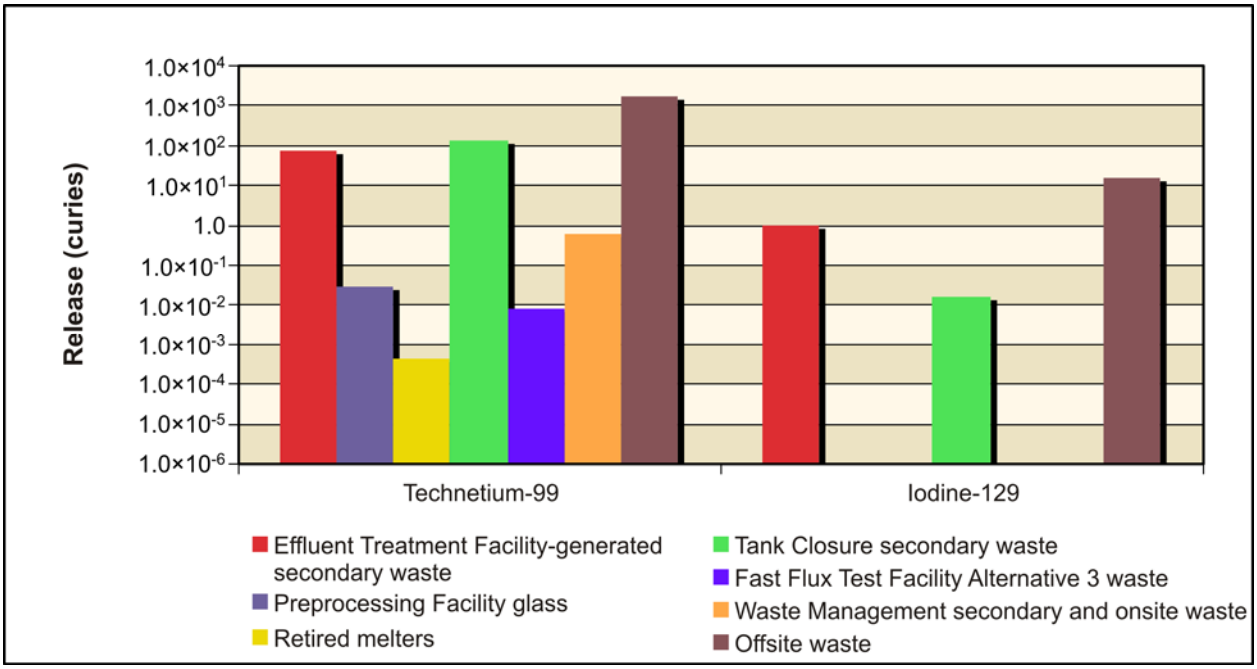


Figure 5–653. Waste Management Alternative 2, Disposal Group 3, Option Case, Radiological Releases at 200-East Area Integrated Disposal Facility to Columbia River

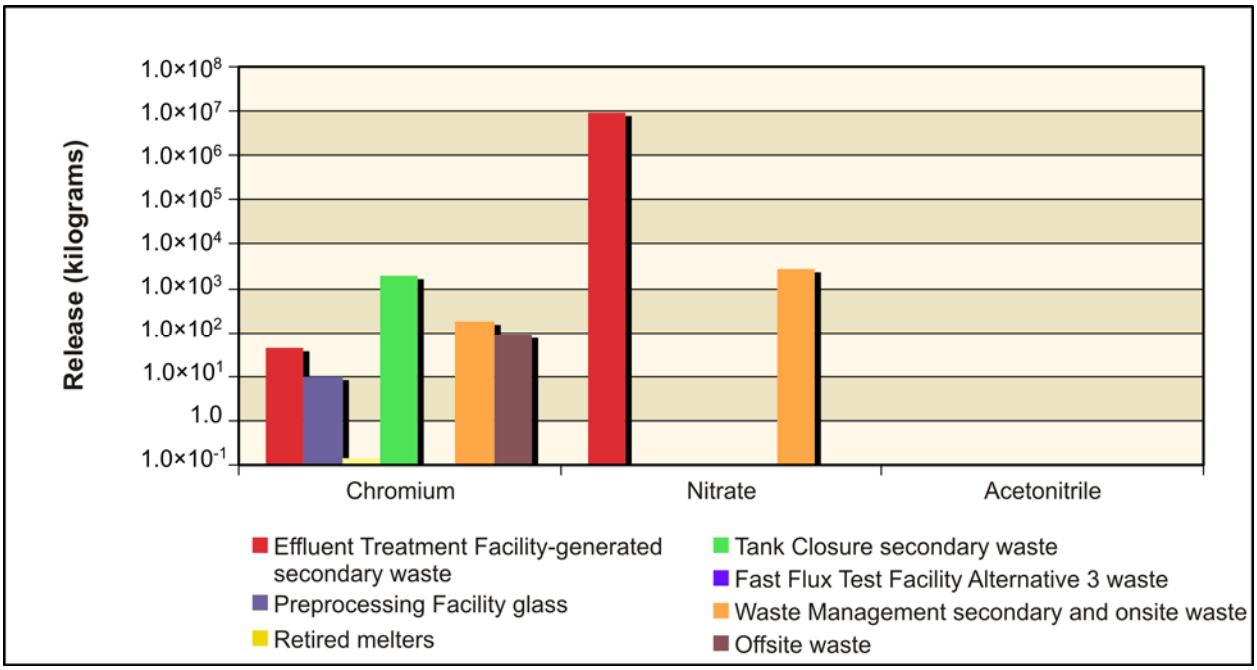


Figure 5–654. Waste Management Alternative 2, Disposal Group 3, Option Case, Chemical Releases at 200-East Area Integrated Disposal Facility to Columbia River

River Protection Project Disposal Facility

Figure 5–655 shows the release to the vadose zone at the RPPDF in the Base Case for the radiological risk drivers and Figure 5–656, the chemical hazard drivers. The only constituents significantly released to the vadose zone from the RPPDF were technetium-99, iodine-129, chromium, and nitrate.

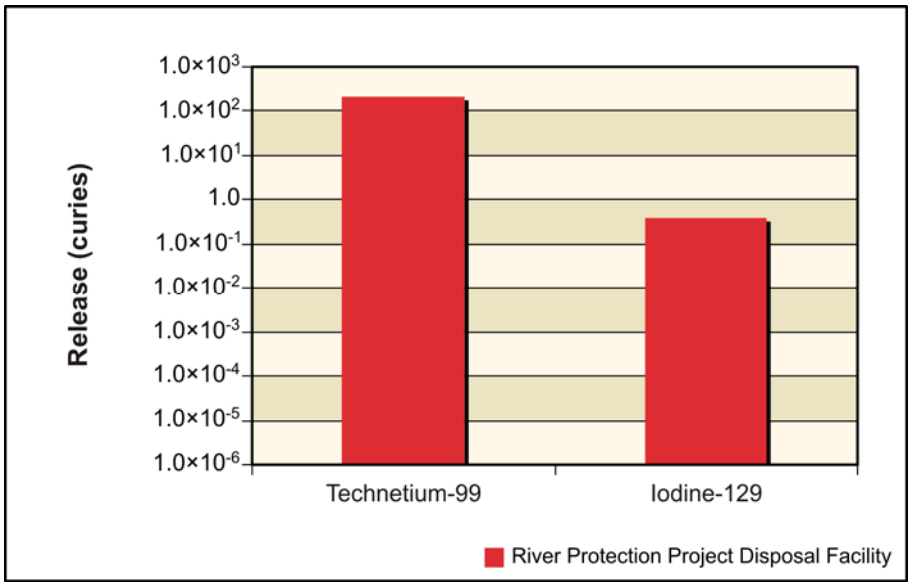


Figure 5–655. Waste Management Alternative 2, Disposal Group 3, Base Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

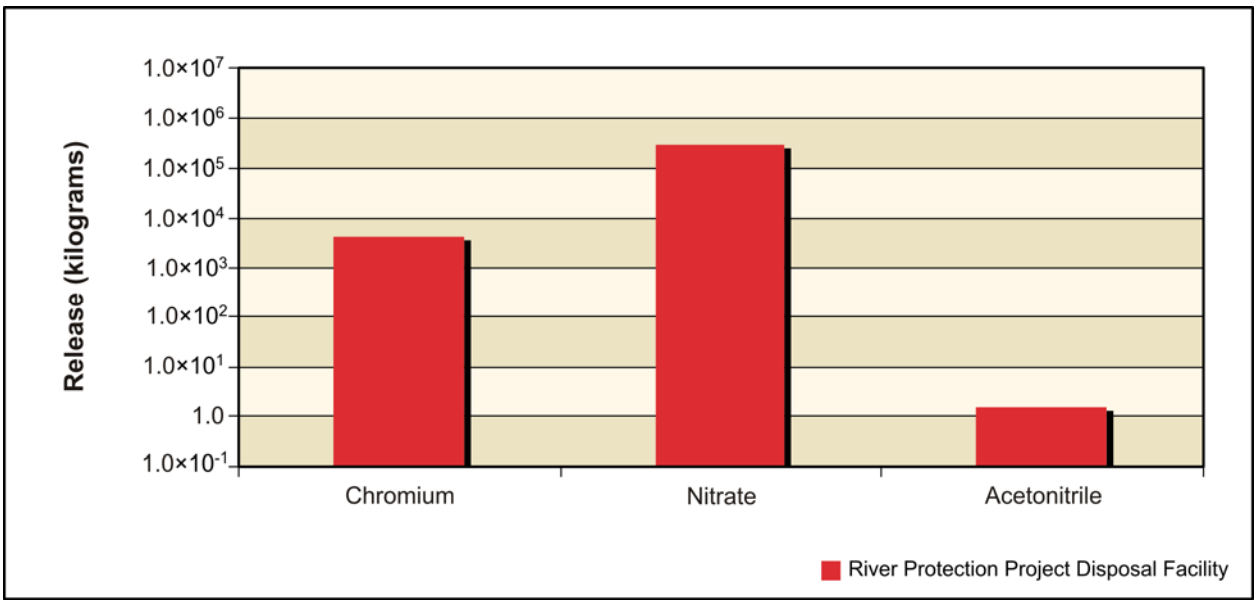


Figure 5–656. Waste Management Alternative 2, Disposal Group 3, Base Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–657 shows the release to the vadose zone for the Option Case at the RPPDF for the radiological risk drivers, and Figure 5–658, the chemical hazard drivers. For the RPPDF, the radiological risk drivers and the chemical hazard drivers for the Option Case have essentially identical releases to the vadose zone as in the Base Case.

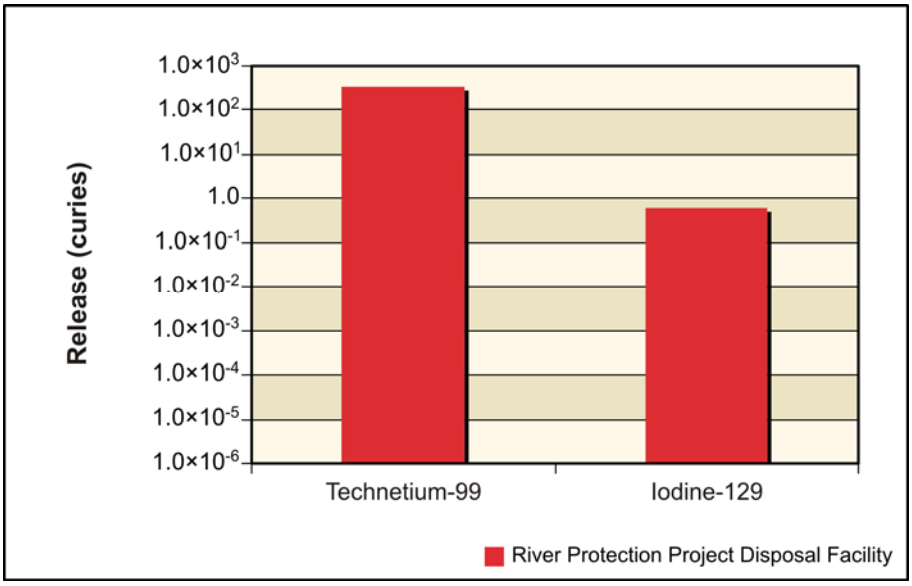


Figure 5–657. Waste Management Alternative 2, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Vadose Zone

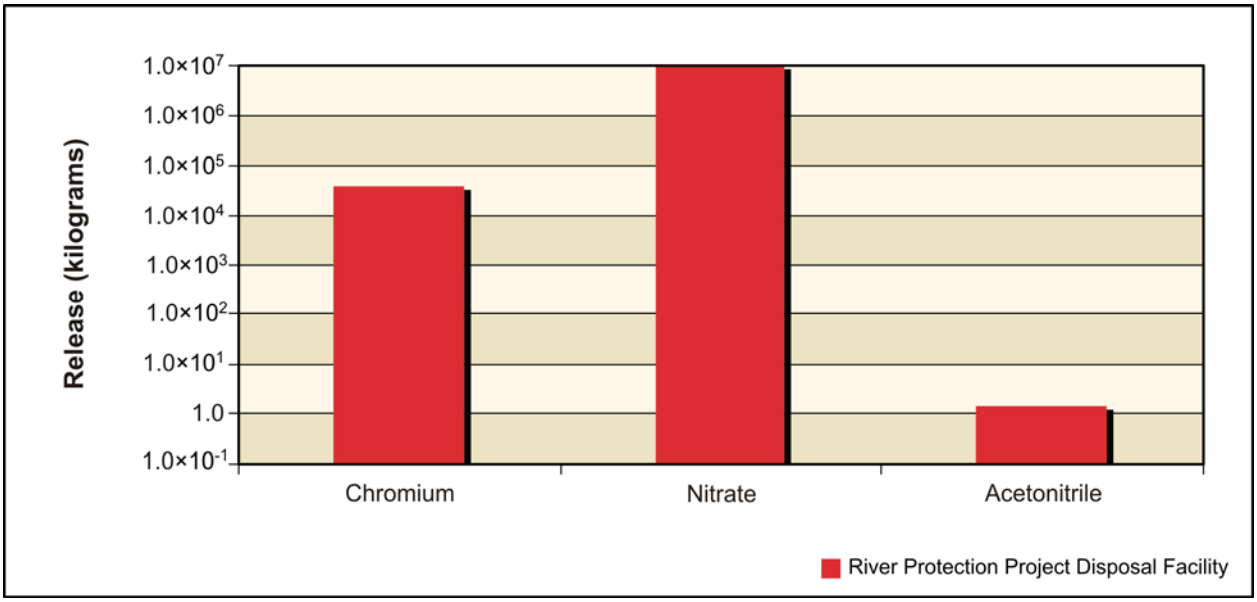


Figure 5–658. Waste Management Alternative 2, Disposal Group 3, Option Case, Chemical Releases at River Protection Project Disposal Facility to Vadose Zone

Figure 5–659 shows the release to groundwater for the Base Case at the RPPDF for the radiological risk drivers and Figure 5–660, the chemical hazard drivers. For the RPPDF, the amount released to groundwater was essentially equal to that released to the vadose zone for technetium-99, iodine-129, chromium, nitrate, and acetonitrile.

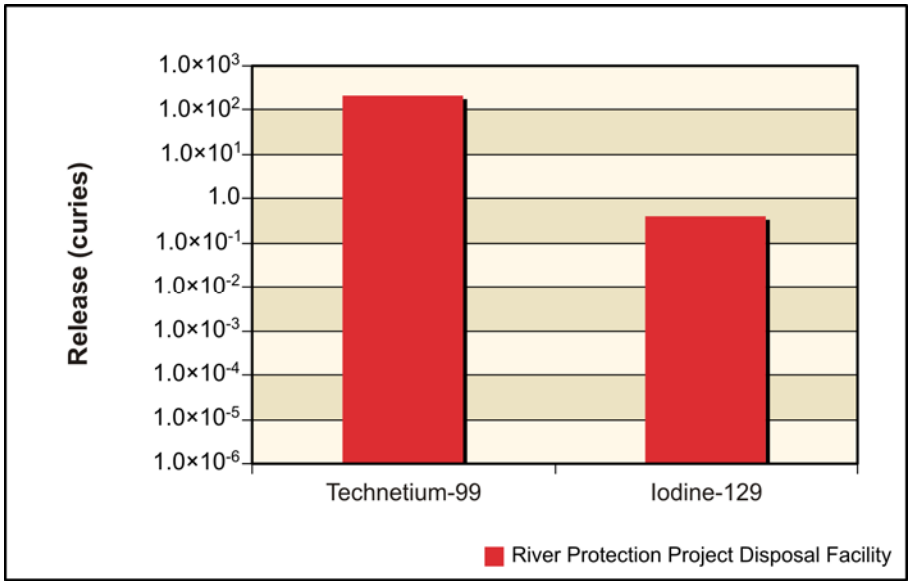


Figure 5–659. Waste Management Alternative 2, Disposal Group 3, Base Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

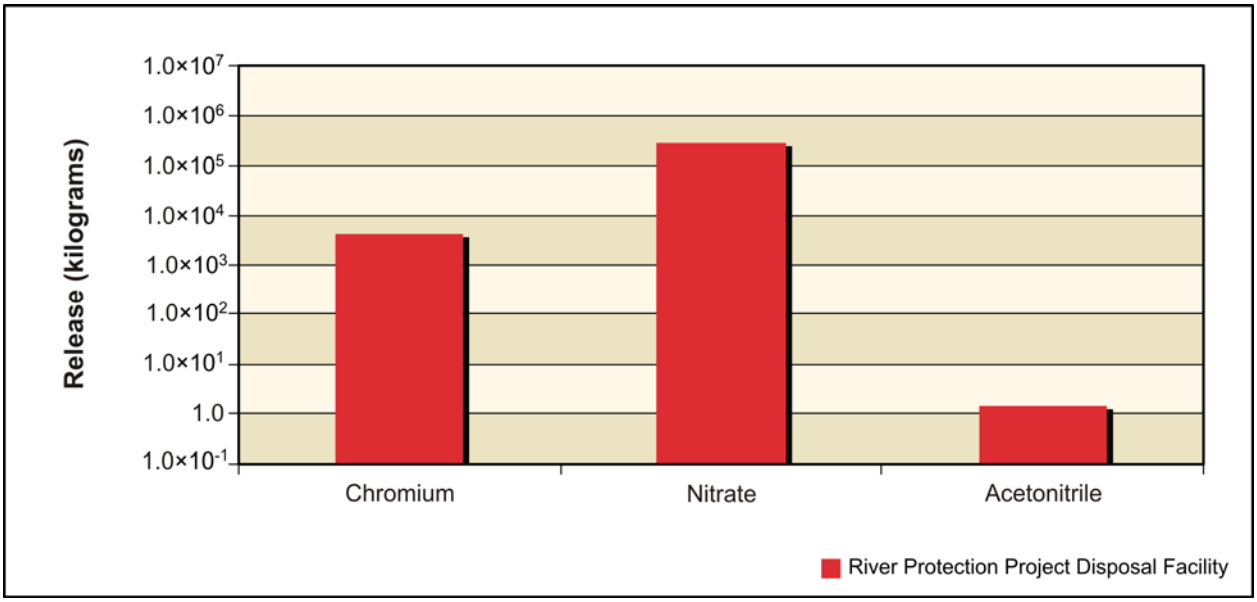


Figure 5–660. Waste Management Alternative 2, Disposal Group 3, Base Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–661 shows the release to groundwater for the Option Case at the RPPDF for the radiological risk drivers and Figure 5–662, the chemical hazard drivers. For the RPPDF, the radiological risk drivers and the chemical hazard drivers for the Option Case have essentially identical releases to the groundwater as in the Base Case.

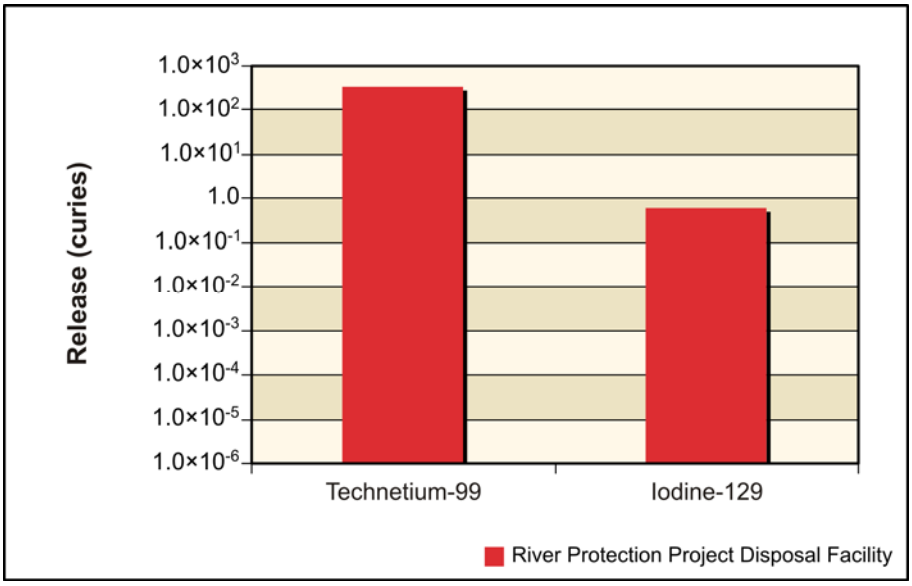


Figure 5–661. Waste Management Alternative 2, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Groundwater

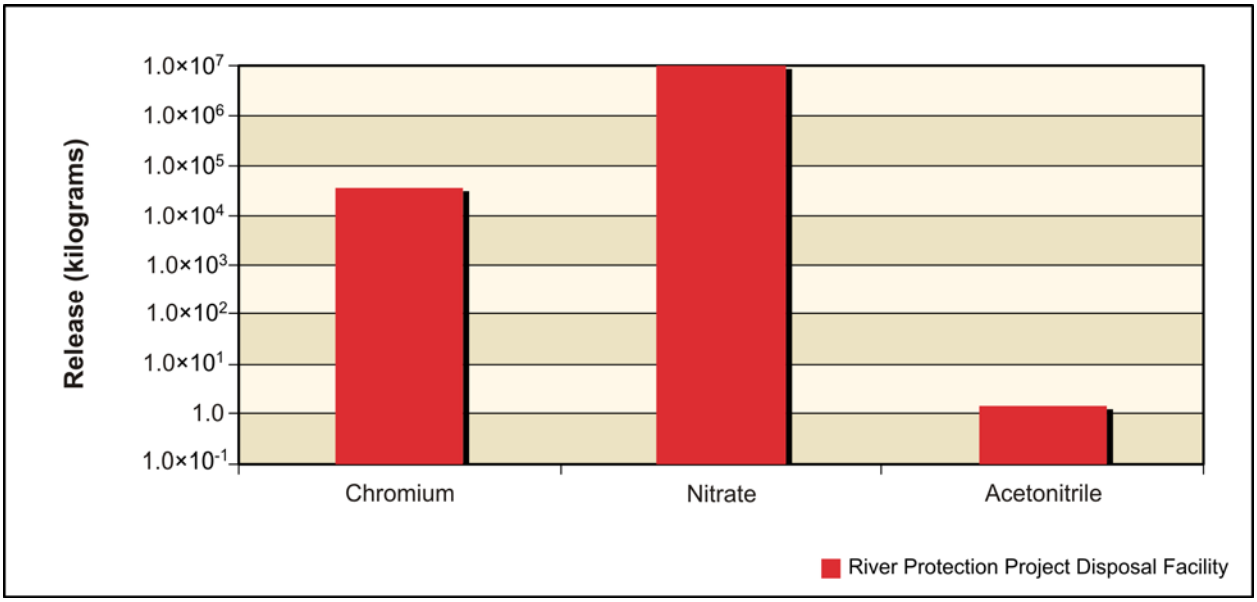


Figure 5–662. Waste Management Alternative 2, Disposal Group 3, Option Case, Chemical Releases at River Protection Project Disposal Facility to Groundwater

Figure 5–663 shows the release to the Columbia River for the Base Case at the RPPDF for the radiological risk drivers and Figure 5–664, the chemical hazard drivers. For the RPPDF, about 95 percent of the amount that was released from the groundwater reached the Columbia River for technetium-99, iodine-129, chromium, nitrate, and acetonitrile.

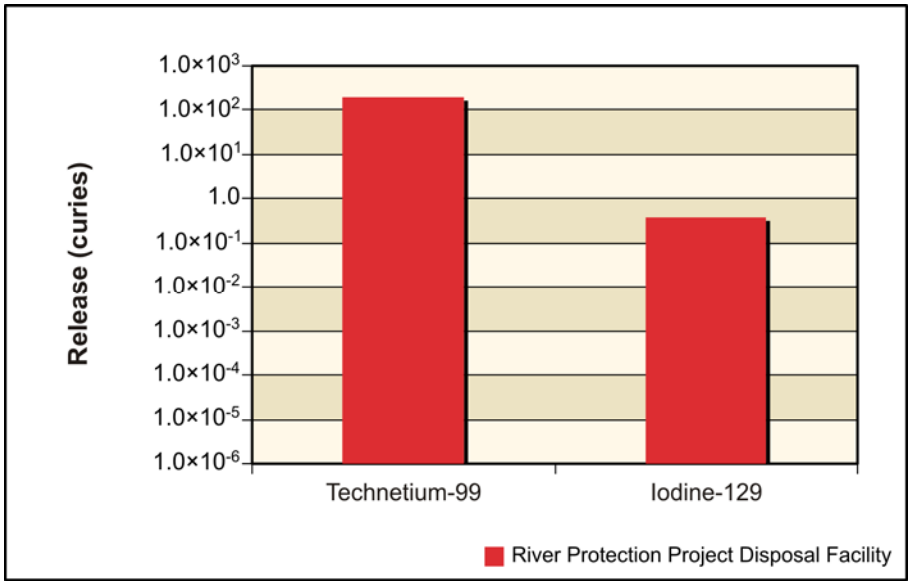


Figure 5–663. Waste Management Alternative 2, Disposal Group 3, Base Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

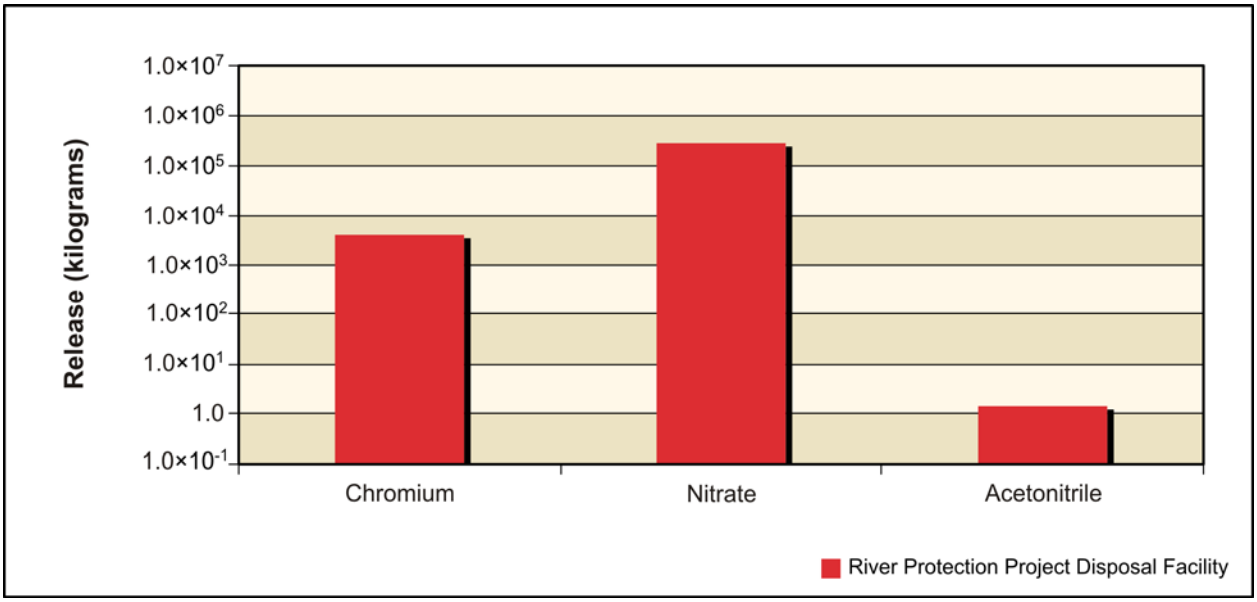


Figure 5–664. Waste Management Alternative 2, Disposal Group 3, Base Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

Figure 5–665 shows the release to the Columbia River for the Option Case at the RPPDF for the radiological risk drivers and Figure 5–666, the chemical hazard drivers. For the RPPDF, the radiological risk drivers and the chemical hazard drivers for the Option Case have essentially identical releases to the Columbia River as in the Base Case.

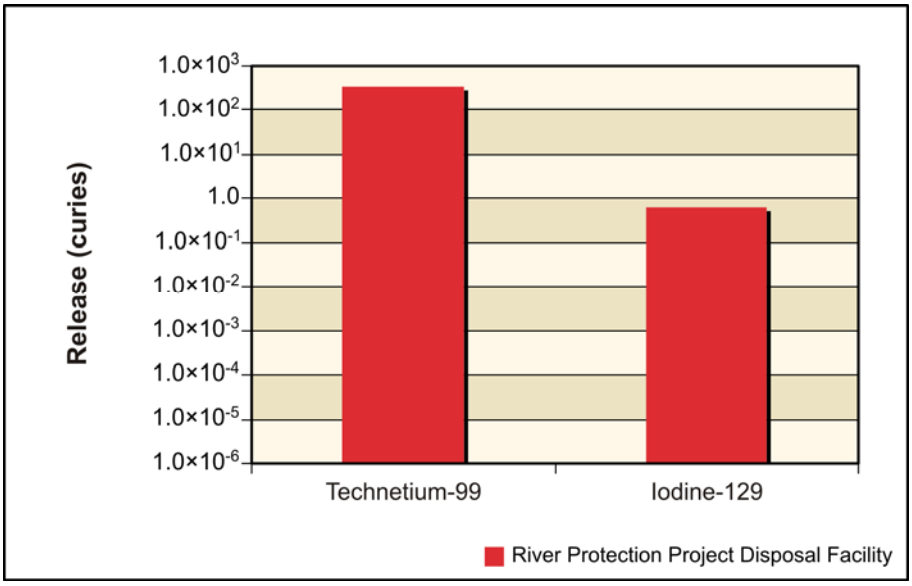


Figure 5–665. Waste Management Alternative 2, Disposal Group 3, Option Case, Radiological Releases at River Protection Project Disposal Facility to Columbia River

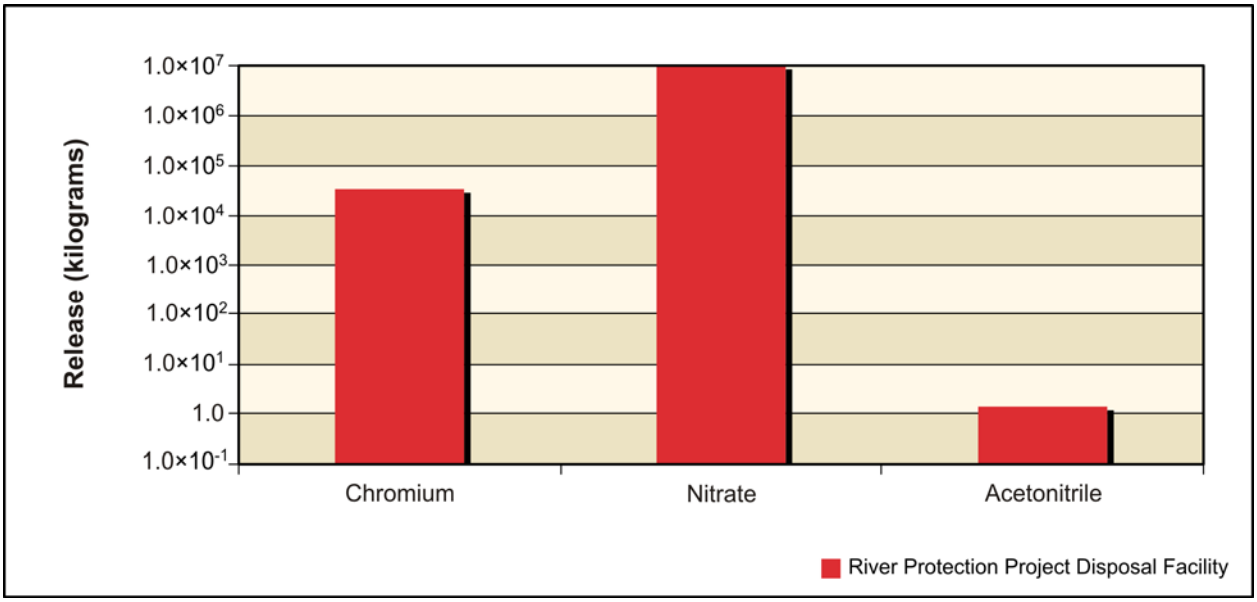


Figure 5–666. Waste Management Alternative 2, Disposal Group 3, Option Case, Chemical Releases at River Protection Project Disposal Facility to Columbia River

ANALYSIS OF CONCENTRATION VERSUS TIME

This section presents the impacts of Waste Management Alternative 2, Disposal Group 3, Base and Option Cases, 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 a few graphs. This confidence interval was calculated to show when the actual concentration over a certain time interval (95 percent of the time) is likely 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. Tables 5–87 and 5–88 list the maximum concentrations of the COPCs in the peak year at IDF-East and the RPPDF, Core Zone Boundary and Columbia River nearshore.

Table 5–87. Waste Management Alternative 2, Disposal Group 3, Base Case, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**3,040** (8646)	303 (3987)	**1,180** (8173)	848 (9284)	900
Iodine-129	**22** (8850)	0.5 (4073)	**11** (11300)	**6** (8985)	1
Chemical in micrograms per liter					
Chromium	3 (8561)	6 (4109)	11 (6384)	3 (4877)	100
Nitrate	16,600 (7367)	404 (4001)	6,550 (6859)	3,310 (7741)	45,000

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

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Table 5–88. Waste Management Alternative 2, Disposal Group 3, Option Case, Maximum COPC Concentrations in the Peak Year at IDF-East and the RPPDF, Core Zone Boundary, and Columbia River Nearshore

Contaminant	IDF-East	RPPDF	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide in picocuries per liter					
Technetium-99	**3,040** (8646)	386 (4013)	**1,180** (8173)	861 (9284)	900
Iodine-129	**22** (8850)	0.6 (4172)	**11** (11300)	**6** (8985)	1
Chemical in micrograms per liter					
Chromium	3 (8561)	36 (3878)	125 (6610)	20 (6701)	100
Nitrate	16,600 (7367)	10,300 (4544)	30,200 (4627)	5,620 (6522)	45,000

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

Key: COPC=constituent of potential concern; IDF-East=200-East Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

Figure 5–667 shows the concentration versus time plot in the Base Case for technetium-99. Releases cause the groundwater concentrations at the Core Zone Boundary and the Columbia River nearshore to approach the benchmark concentration around CY 7000 to CY 10,000. The concentrations at the Core Zone Boundary and at the Columbia River nearshore never constantly remain above the benchmark concentration throughout the period of analysis.

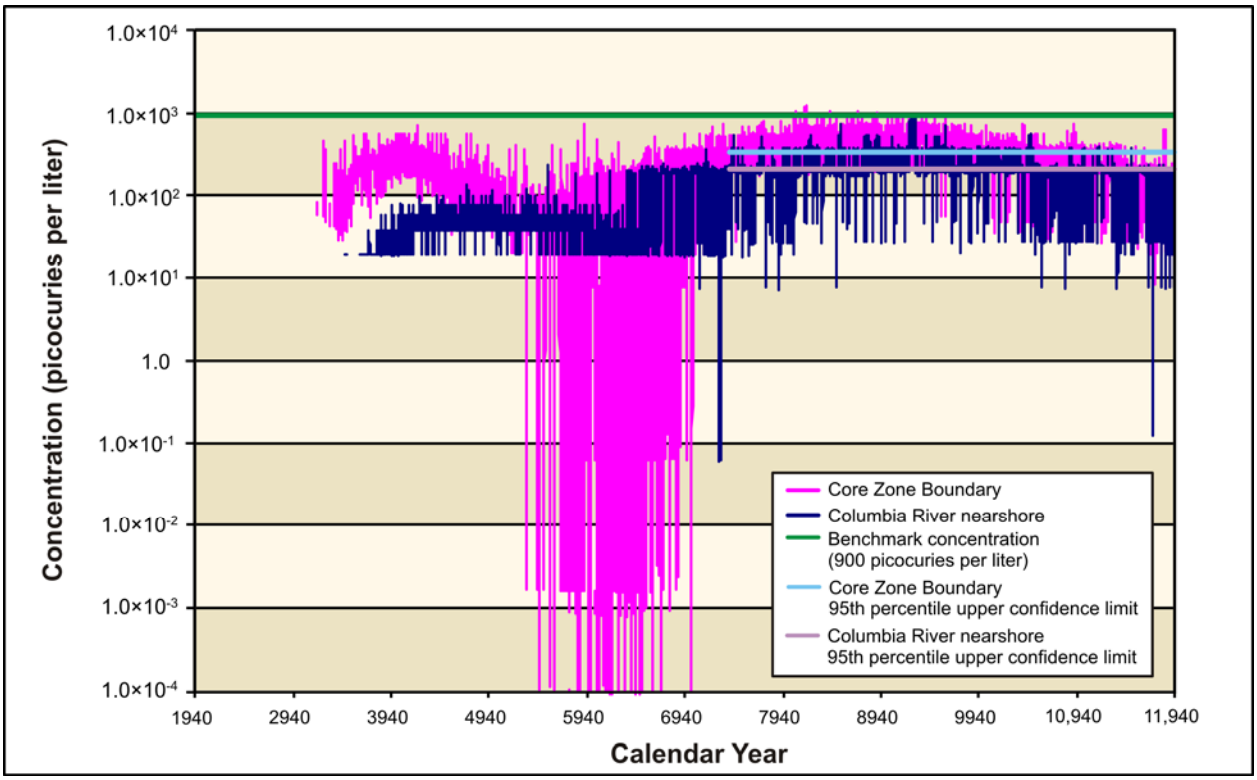


Figure 5–667. Waste Management Alternative 2, Disposal Group 3, Base Case, Technetium-99 Concentration Versus Time

Figure 5–668 shows the concentration versus time plot in the Option Case for technetium-99. The plot for technetium-99 in the Option Case is similar that in the Base Case.

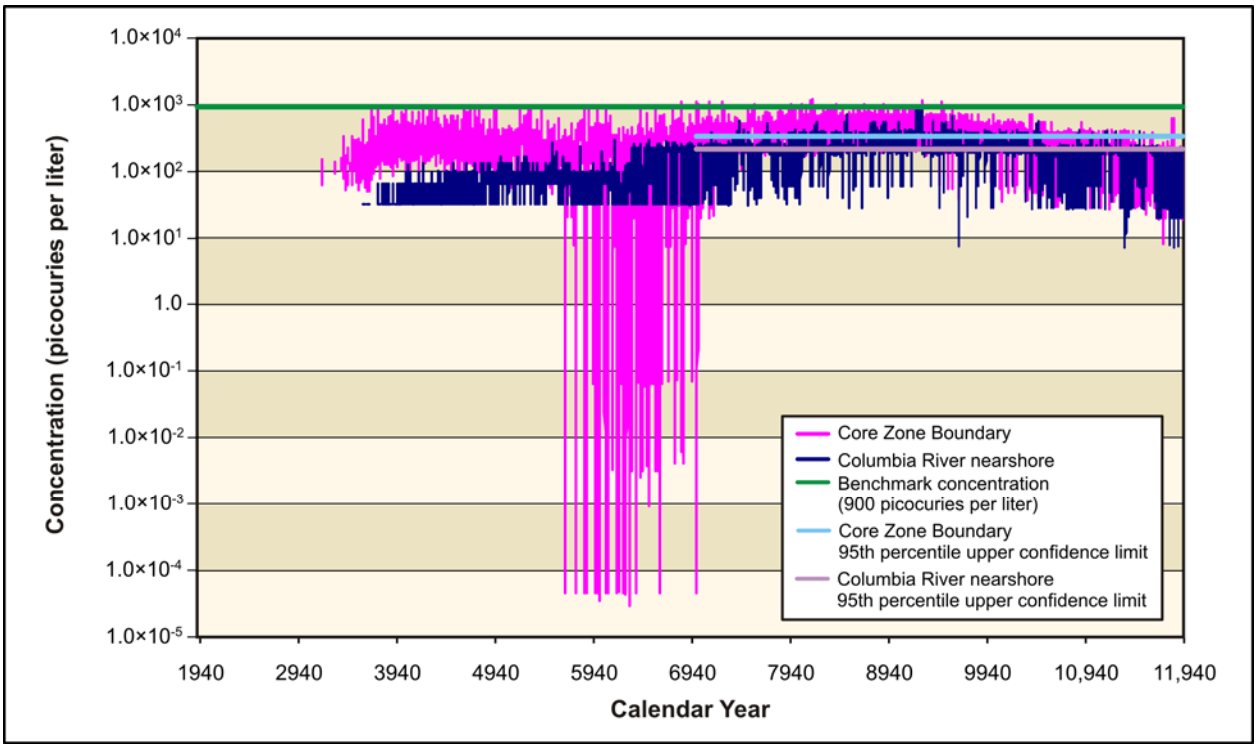


Figure 5–668. Waste Management Alternative 2, Disposal Group 3, Option Case, Technetium-99 Concentration Versus Time

The concentration versus time plot for iodine-129 in the Base Case shows a pattern similar to that of technetium-99, except that iodine-129 concentrations at the Core Zone Boundary and at the Columbia River nearshore exceed the benchmark from about CY 6000 until the end of the period of analysis. Exceedances peaked at around one order of magnitude above the benchmark concentration (see Figure 5–669).

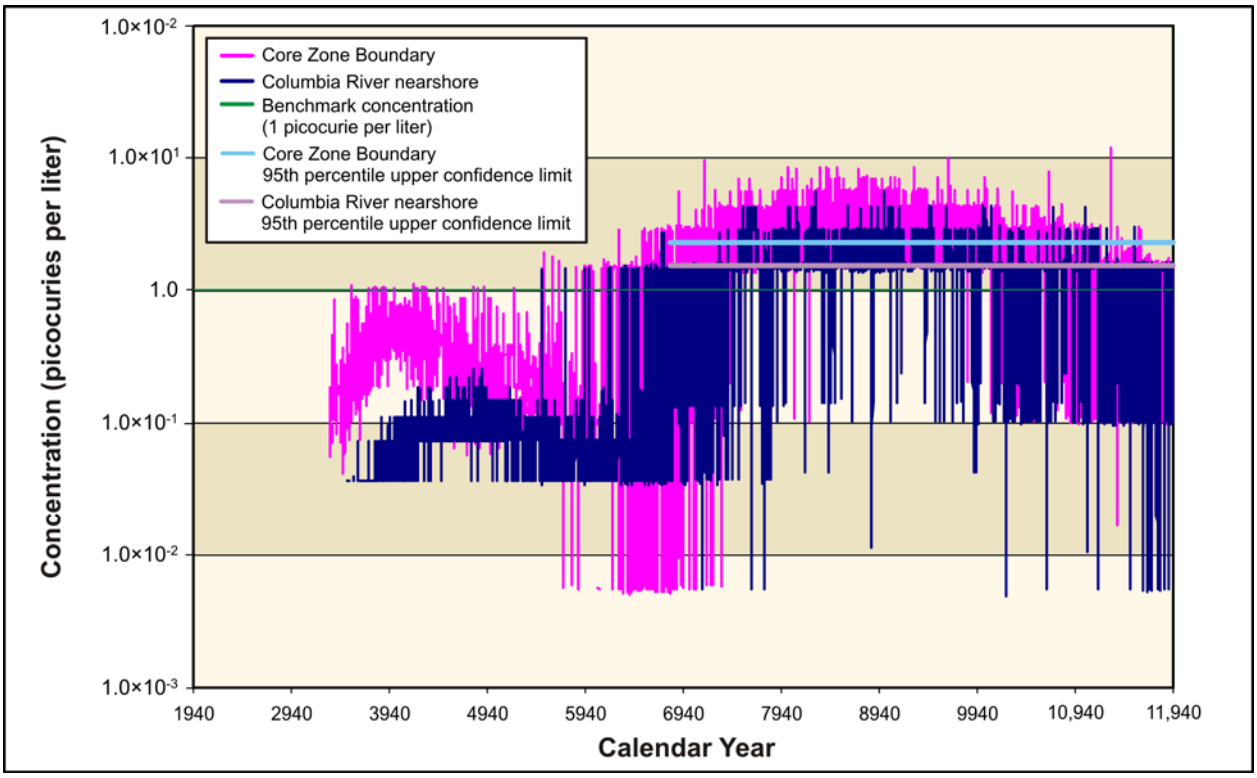


Figure 5–669. Waste Management Alternative 2, Disposal Group 3, Base Case, Iodine-129 Concentration Versus Time

The plot of iodine-129 concentration versus time in the Option Case is similar to that in the Base Case (see Figure 5–670).

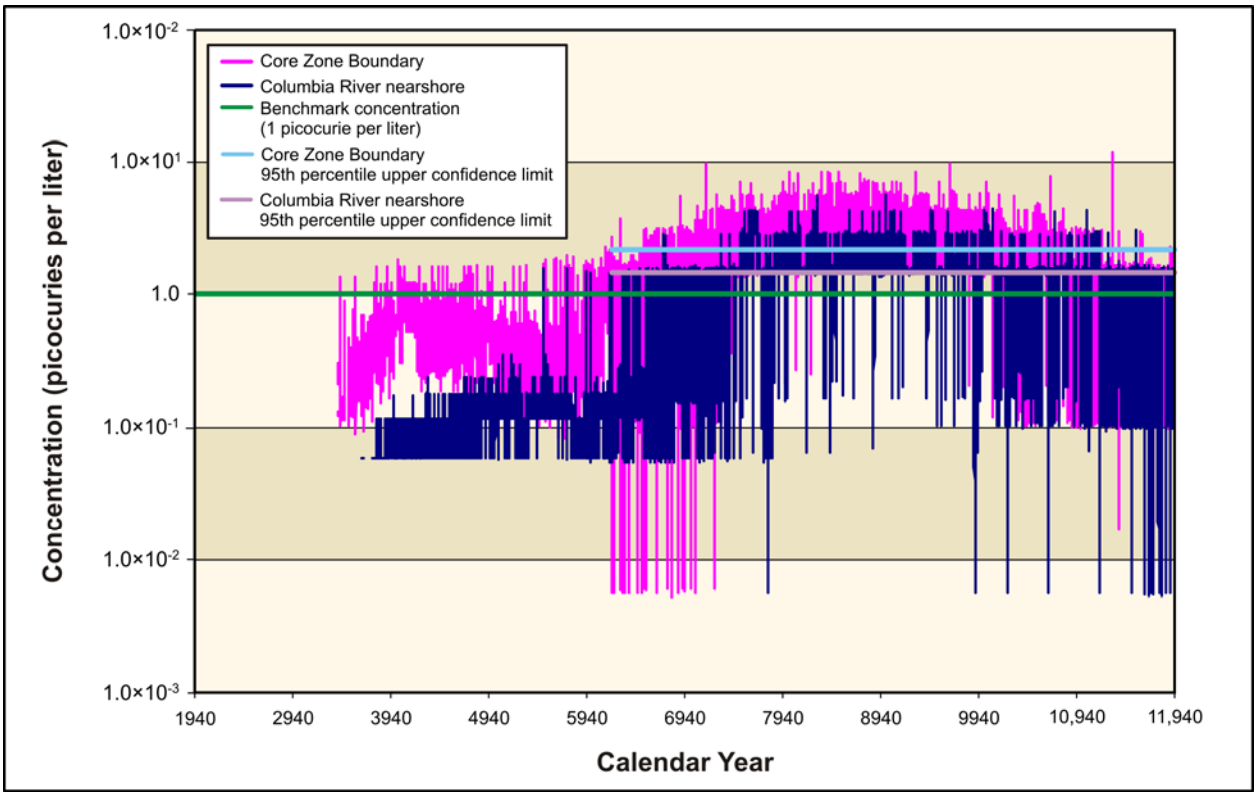


Figure 5–670. Waste Management Alternative 2, Disposal Group 3, Option Case, Iodine-129 Concentration Versus Time

Figure 5–671 shows the plot of concentration versus time for chromium in the Base Case. The concentrations at the Core Zone Boundary approach but do not exceed the benchmark from about CY 3800 to CY 5800. The concentrations at the Columbia River nearshore remained about two orders of magnitude below the benchmark.

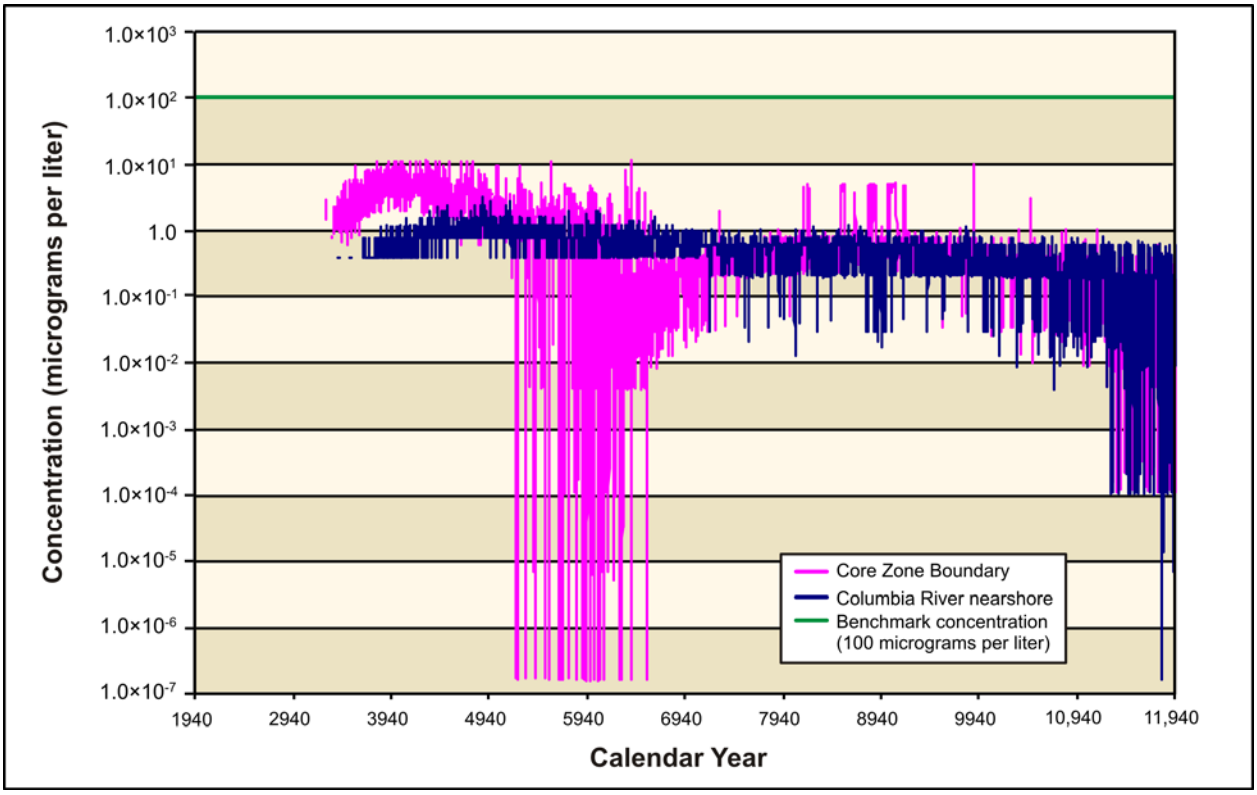


Figure 5–671. Waste Management Alternative 2, Disposal Group 3, Base Case, Chromium Concentration Versus Time

Figure 5–672 shows the plot of concentration versus time plot for chromium in the Option Case. The concentrations at the Core Zone Boundary and the Columbia River nearshore remain about one to two orders of magnitude below the benchmark.

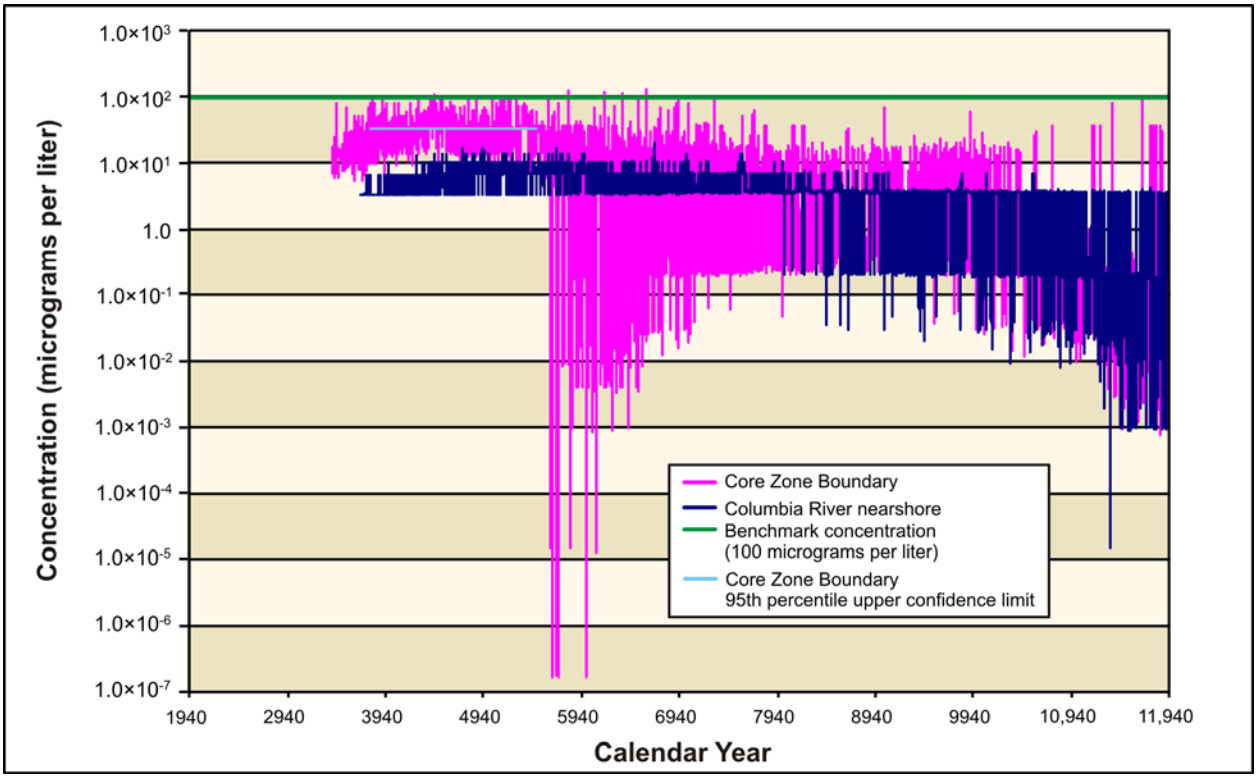


Figure 5–672. Waste Management Alternative 2, Disposal Group 3, Option Case, Chromium Concentration Versus Time

Figure 5–673 shows the plot of concentration versus time for nitrate in the Base Case. The concentrations at the Core Zone Boundary and the Columbia River nearshore both peak at around CY 8000. Even at the peak concentration levels, nitrate concentrations still remain about one order of magnitude below the benchmark.

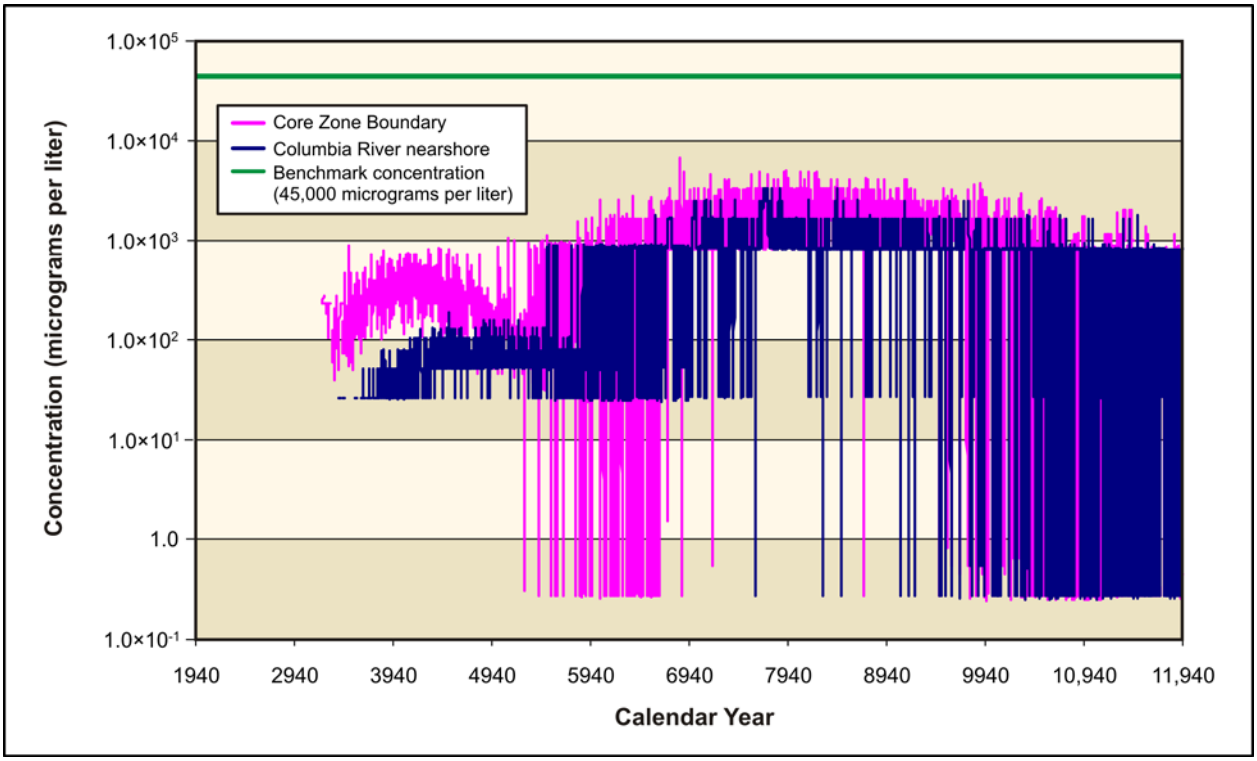


Figure 5–673. Waste Management Alternative 2, Disposal Group 3, Base Case, Nitrate Concentration Versus Time

Figure 5–674 shows the concentration versus time plot in the Option Case for nitrate. The concentrations at the Core Zone Boundary peak at around CY 4800 but remain about one-half order of magnitude below the benchmark concentration. Concentrations from the Columbia River nearshore remain fairly steady at around one order of magnitude below the benchmark.

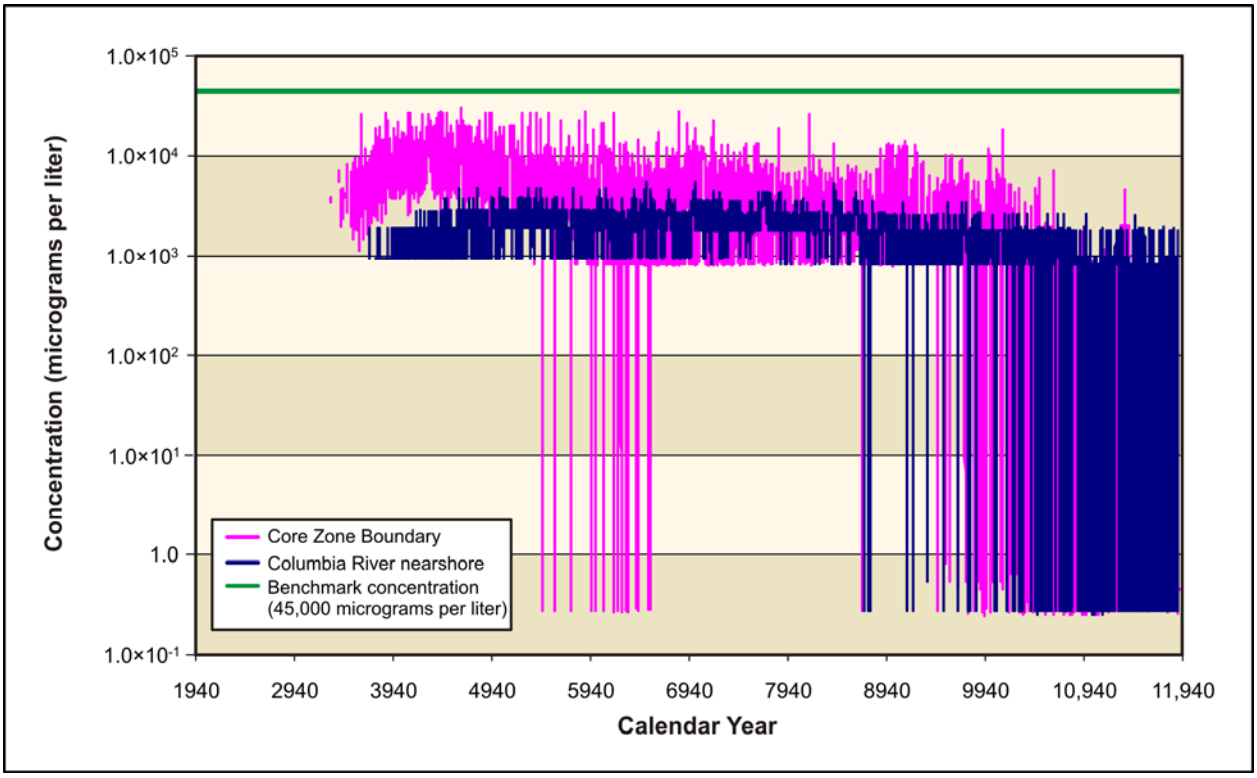


Figure 5–674. Waste Management Alternative 2, Disposal Group 3, Option Case, Nitrate Concentration Versus Time

Figure 5–675 shows the plot of concentration versus time for total uranium in the Base Case. It is not until around CY 9500 that concentrations begin to appear on the graph. The concentrations at the Core Zone Boundary and the Columbia River nearshore both remain about seven to nine orders of magnitude below the benchmark.

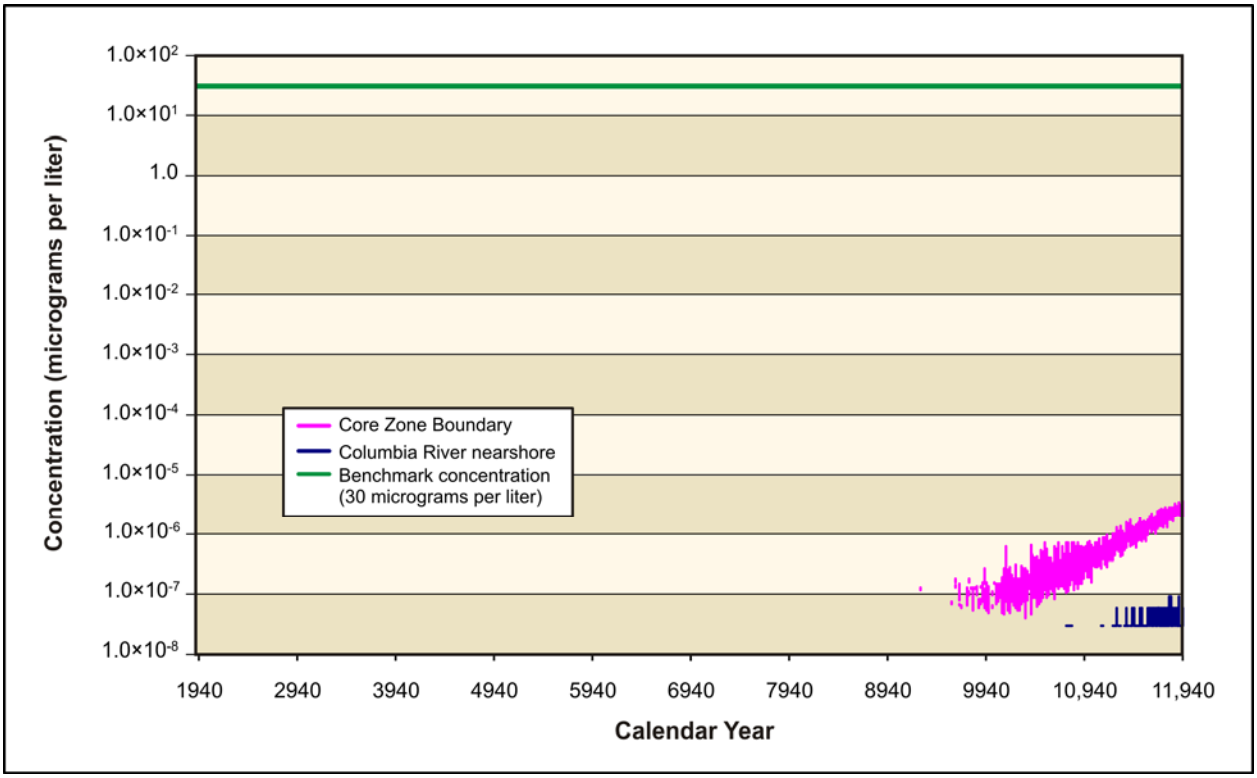


Figure 5–675. Waste Management Alternative 2, Disposal Group 3, Base Case, Total Uranium Concentration Versus Time

The plot of total uranium's concentration versus time in the Option Case is similar to that in the Base Case (see Figure 5–676).

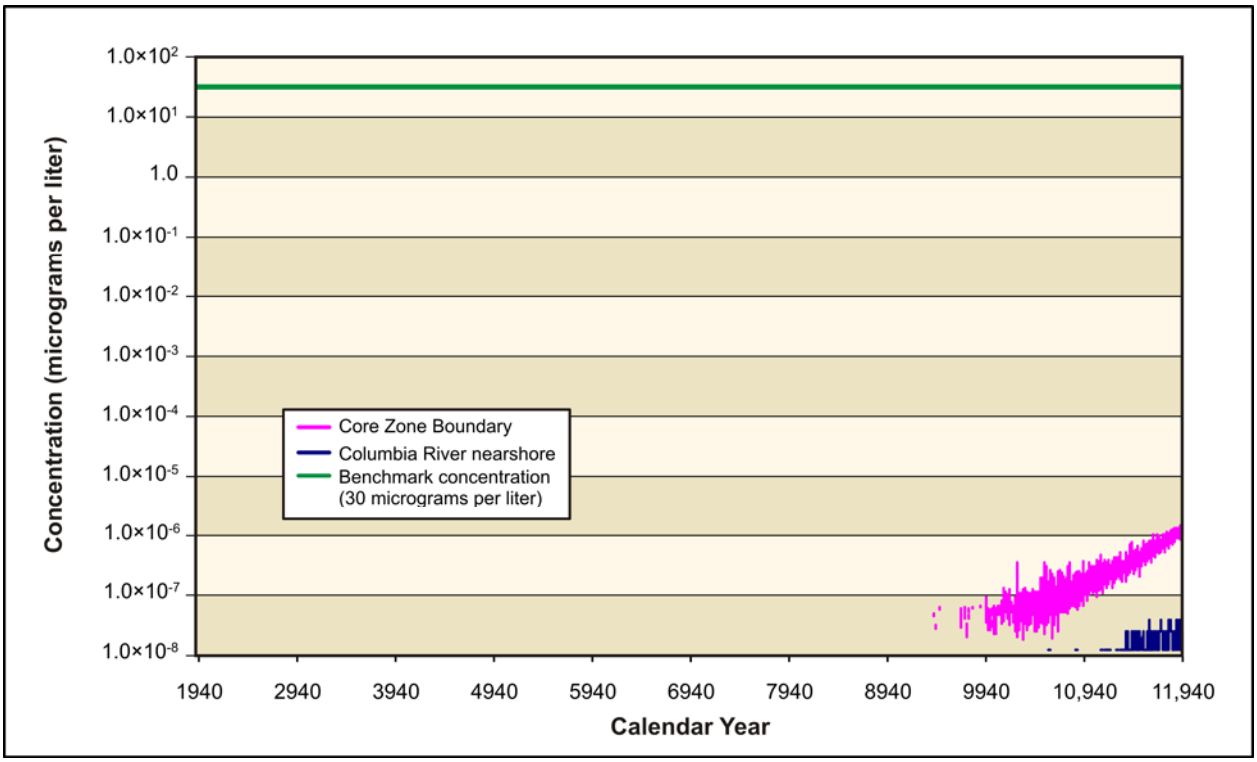


Figure 5–676. Waste Management Alternative 2, Disposal Group 3, Option Case, Total Uranium Concentration Versus Time

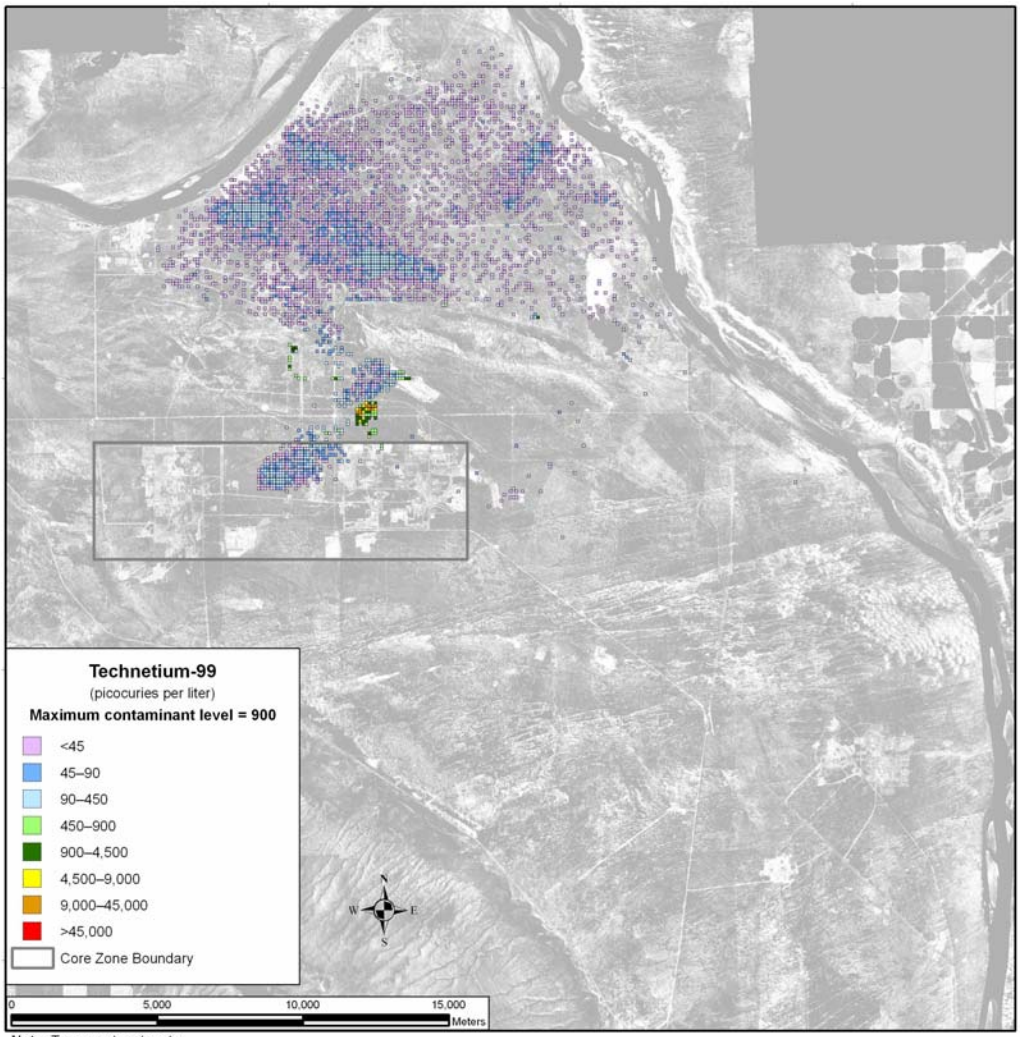
ANALYSIS OF SPATIAL DISTRIBUTION OF CONCENTRATION

This section presents the impacts of Waste Management Alternative 2, Disposal Group 3, 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 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 that vary over three orders of magnitude.

Figure 5–677 shows the spatial distribution of groundwater concentration for technetium-99 in the Base Case during CY 3890. Releases from the RPPDF create a plume extending northerly through Gable Gap toward the Columbia River. Peak concentrations in this plume exceed the benchmark by about 10 to 50 times, although most of the plume is below the benchmark. By CY 7140, releases from the IDF create a new plume extending easterly toward the Columbia River (see Figure 5–678). Peak concentrations in this plume exceed the benchmark by five times. By the end of the period of analysis (CY 11,885), the plume created by the RPPDF has mostly dissipated, while the IDF plume persists, most of it below the benchmark (see Figure 5–679). Iodine-129 shows a similar spatial distribution over time but with slightly more intense peak concentrations (see Figures 5–680 through 5–682). Chromium and nitrate also show a similar spatial distribution over time, but with less intense areas of peak concentration (see Figures 5–683 through 5–685 and Figures 5–686 through 5–688).

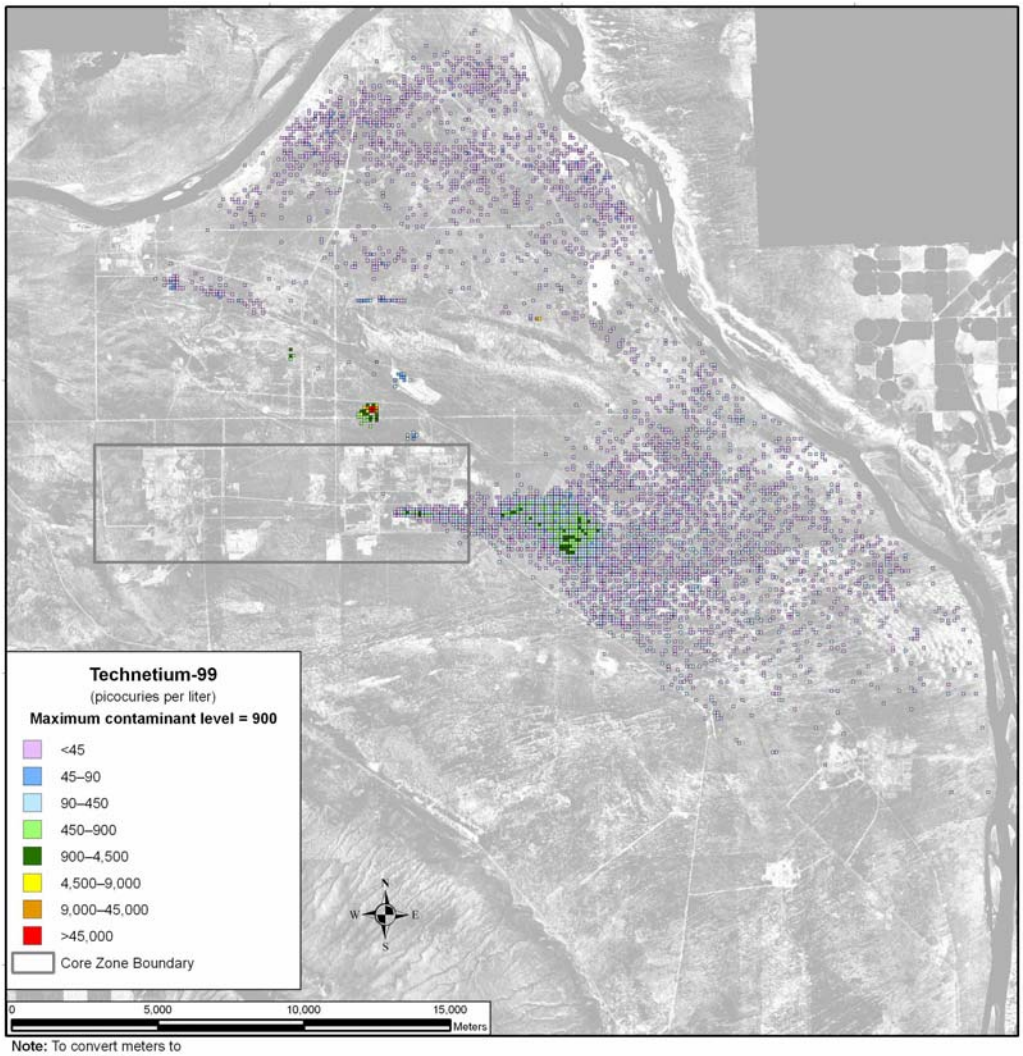
The spatial distributions of the conservative tracers in the Option Case are essentially identical to those in the Base Case (see Figures 5–689 through 5–700).

Total uranium is not as mobile as those radionuclides 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 5–701 shows the distribution of total uranium during CY 11,885 for the Base Case. A plume that is less than one-twentieth of the benchmark has been released from the RPPDF and is extending northerly through Gable Gap toward the Columbia River. Because of the slow nature of uranium's pore water velocity, most of the uranium releases are expected after the period of analysis. The spatial distribution of total uranium in the Option Case is essentially identical to that of the Base Case (see Figure 5-702).



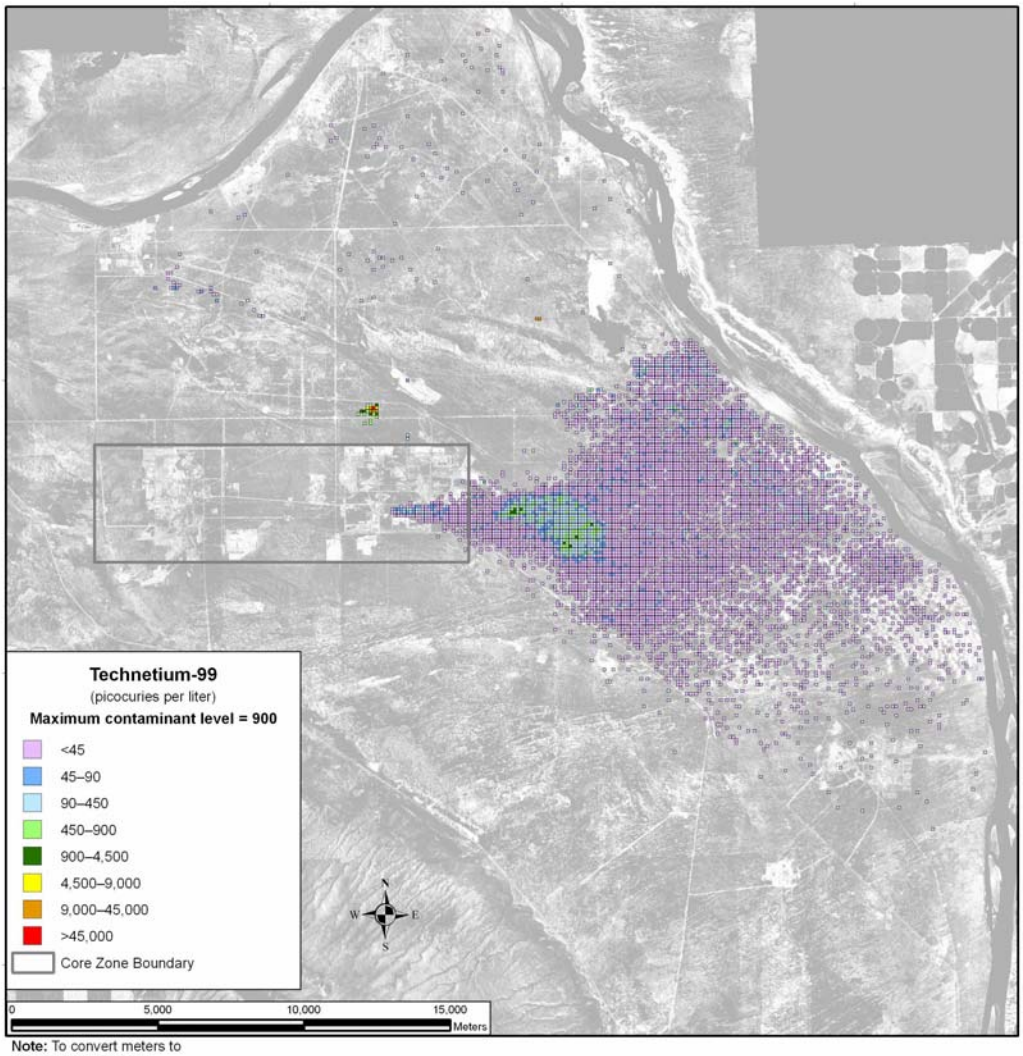
Note: To convert meters to feet, multiply by 3.281

Figure 5–677. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



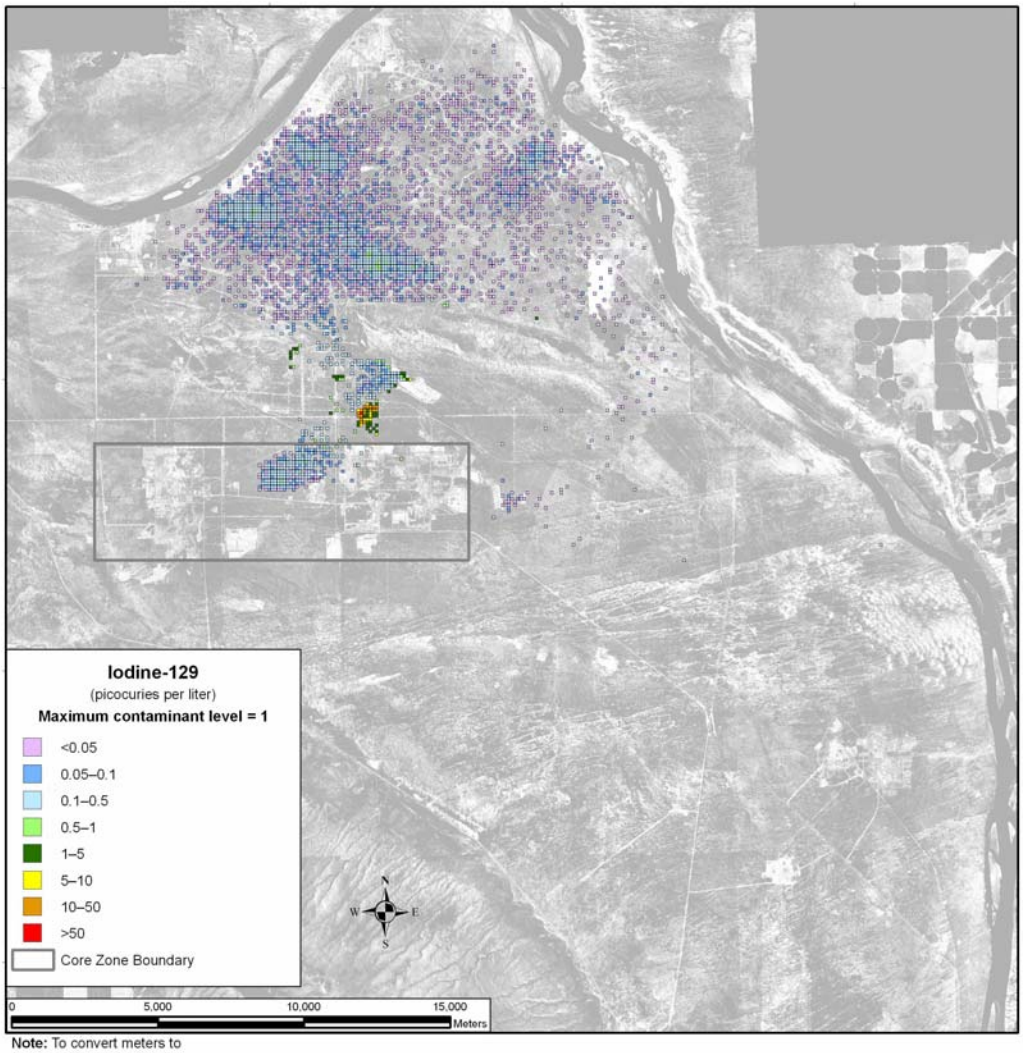
Note: To convert meters to feet, multiply by 3.281

Figure 5–678. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



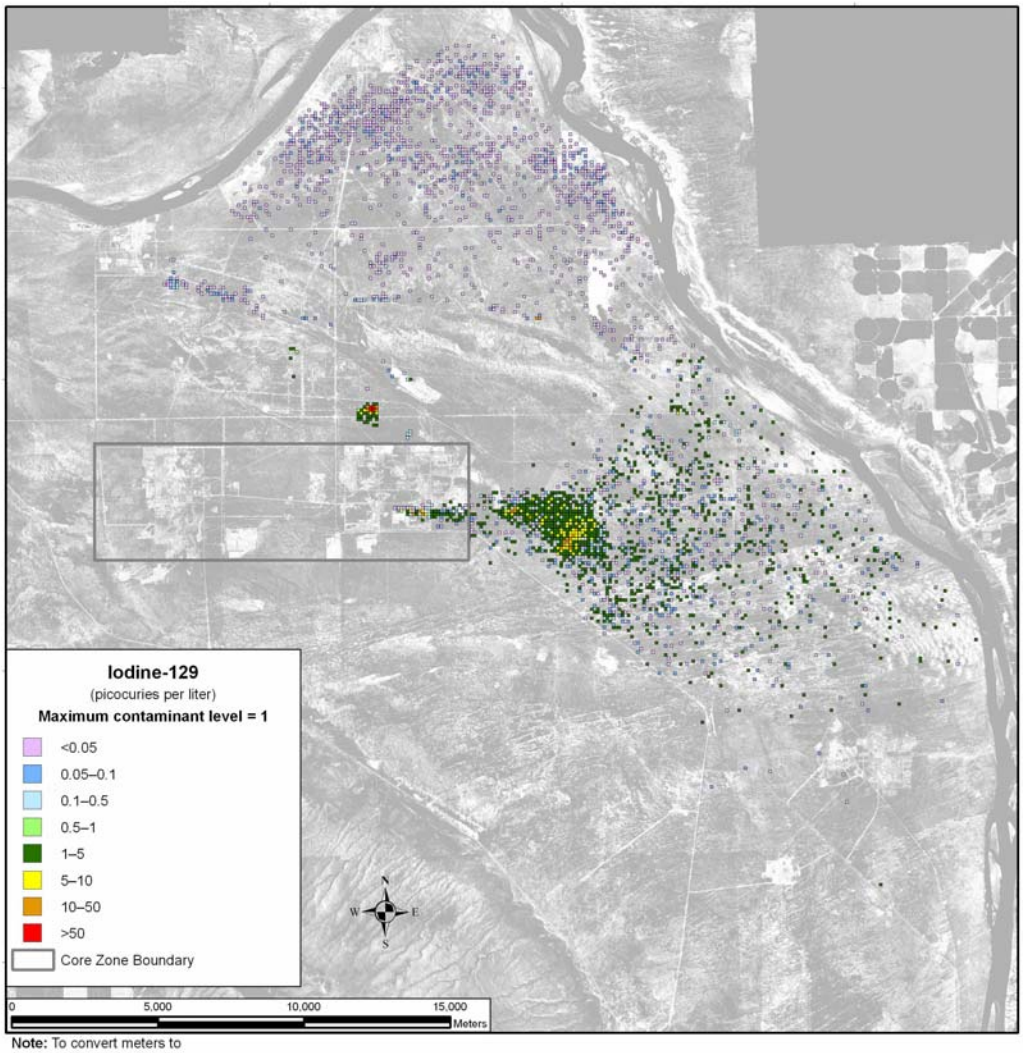
Note: To convert meters to feet, multiply by 3.281

Figure 5–679. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



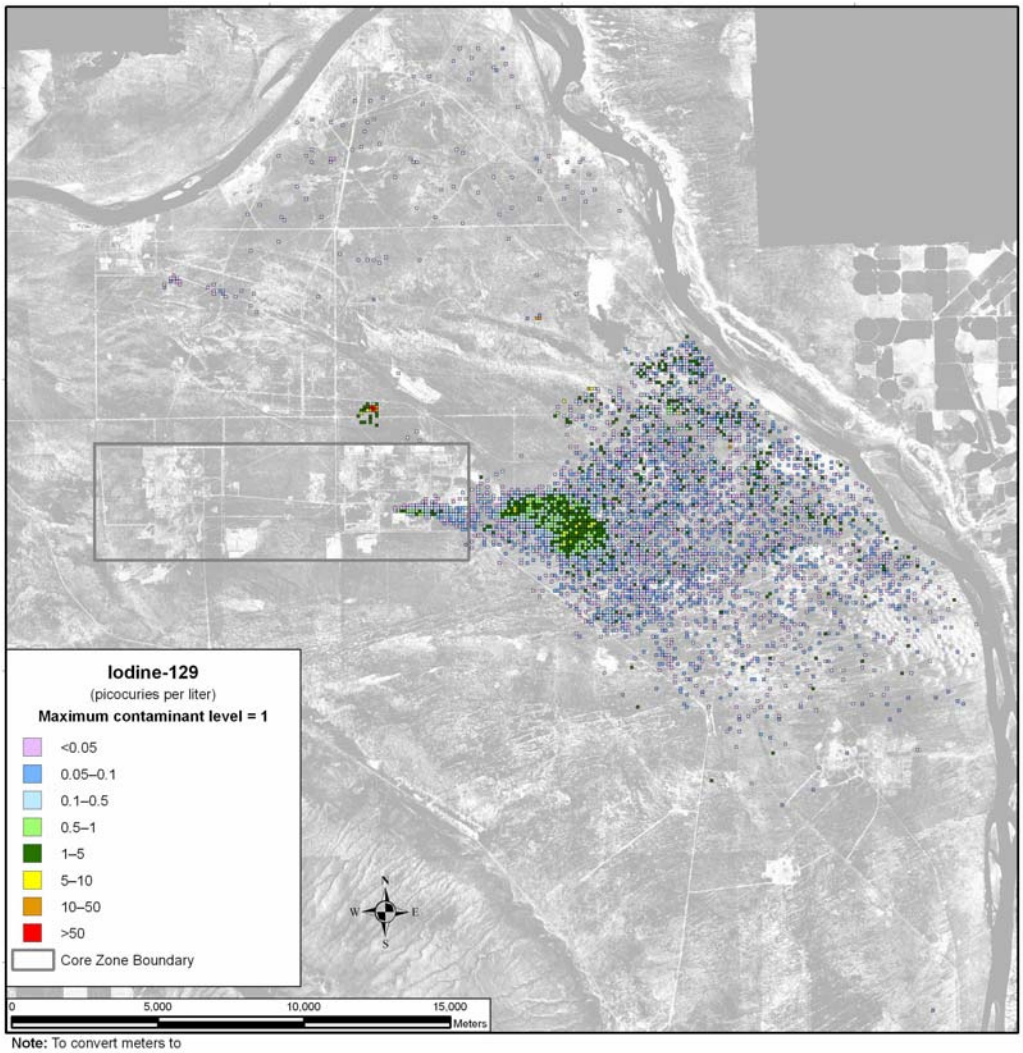
Note: To convert meters to feet, multiply by 3.281

Figure 5–680. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



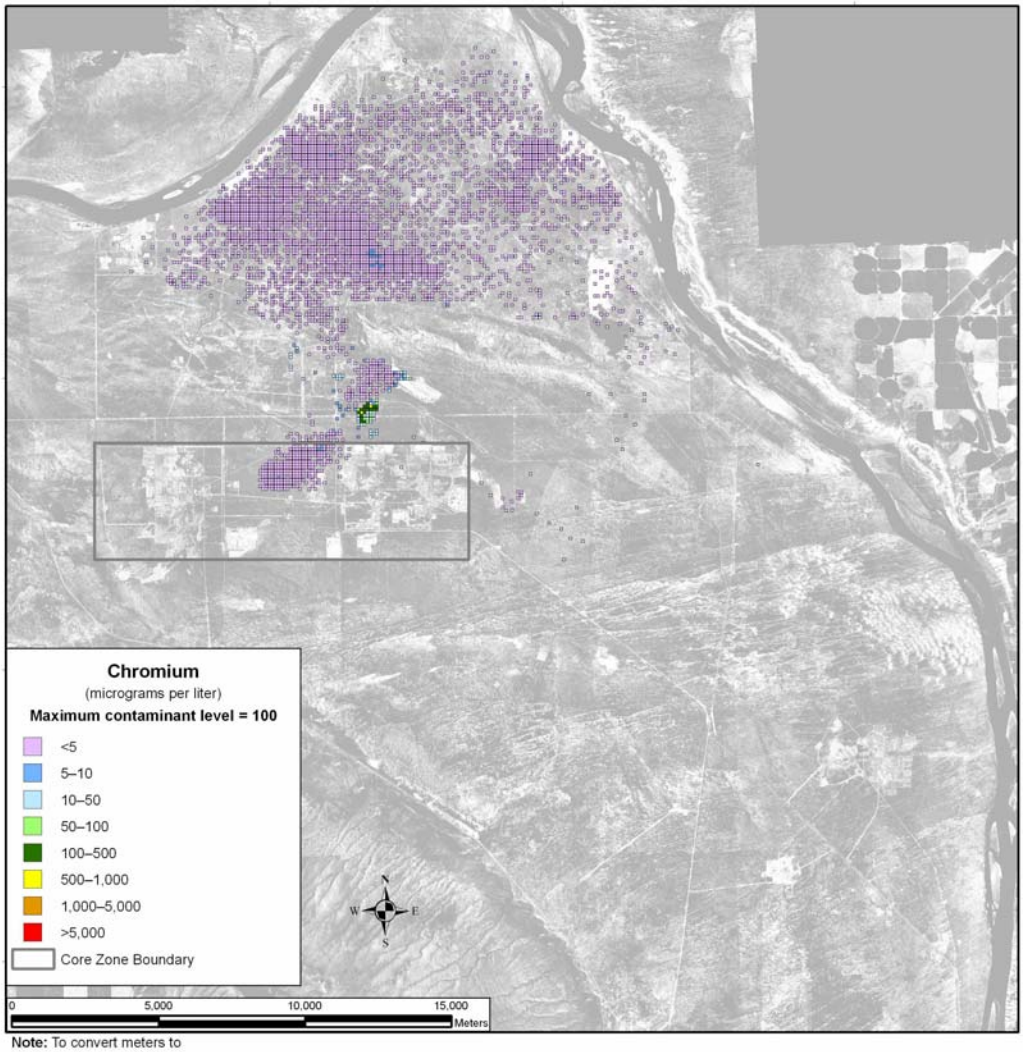
Note: To convert meters to feet, multiply by 3.281

Figure 5–681. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



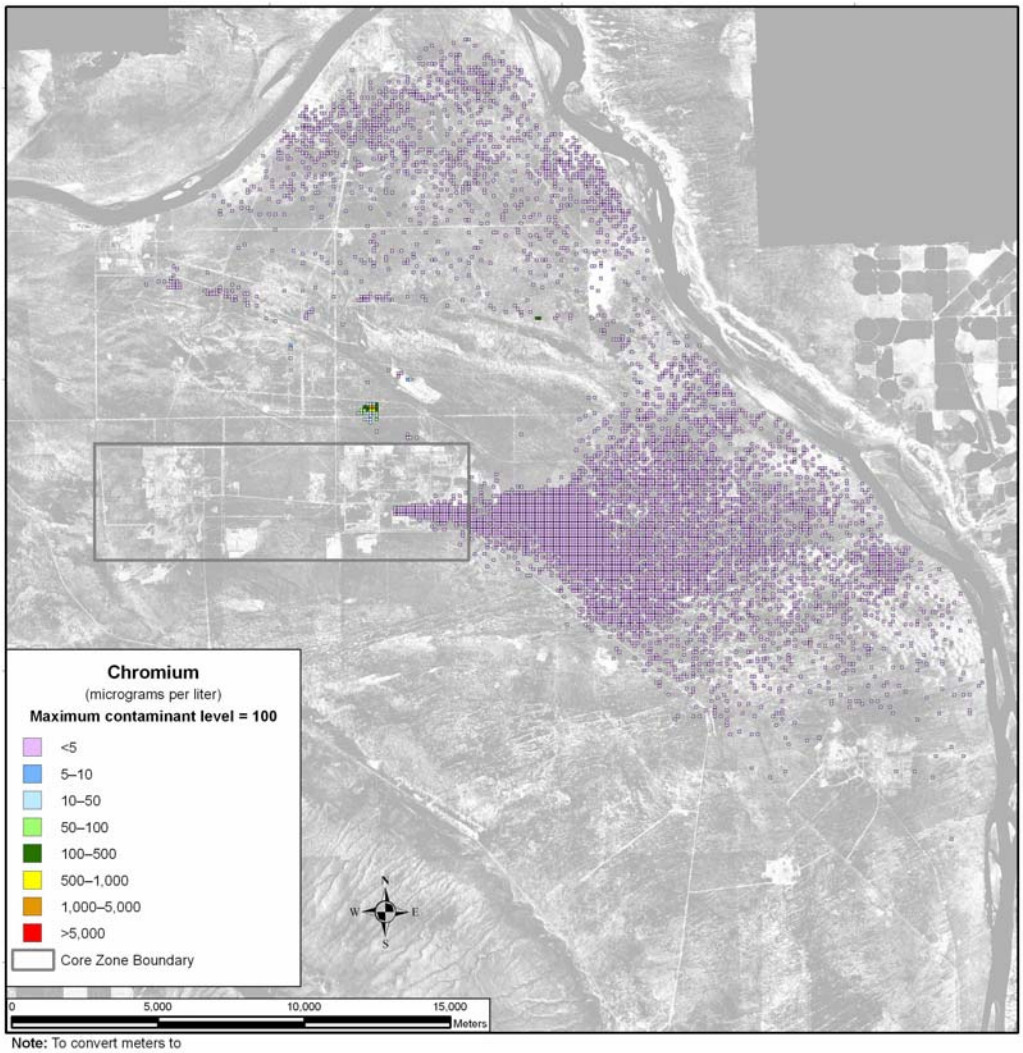
Note: To convert meters to feet, multiply by 3.281

Figure 5–682. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



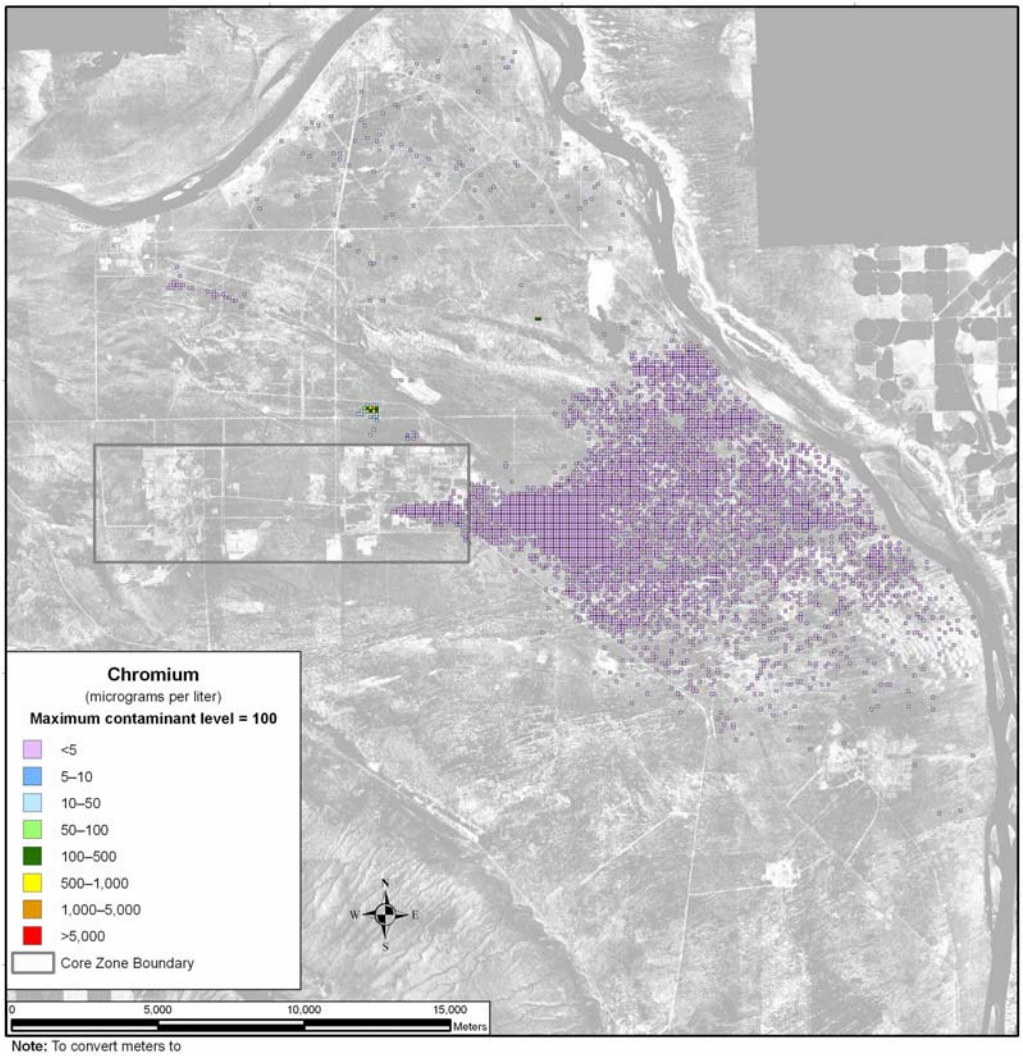
Note: To convert meters to feet, multiply by 3.281

Figure 5–683. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



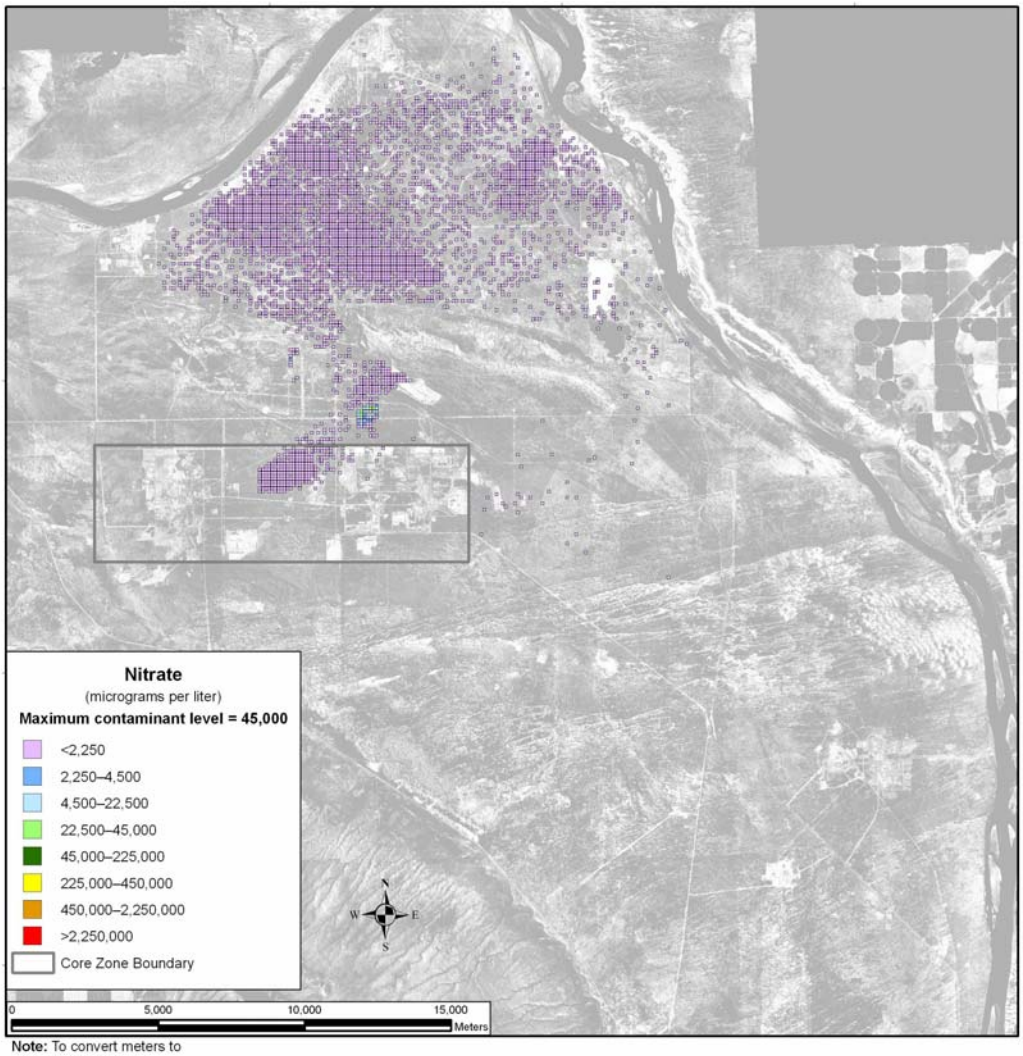
Note: To convert meters to feet, multiply by 3.281

Figure 5–684. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



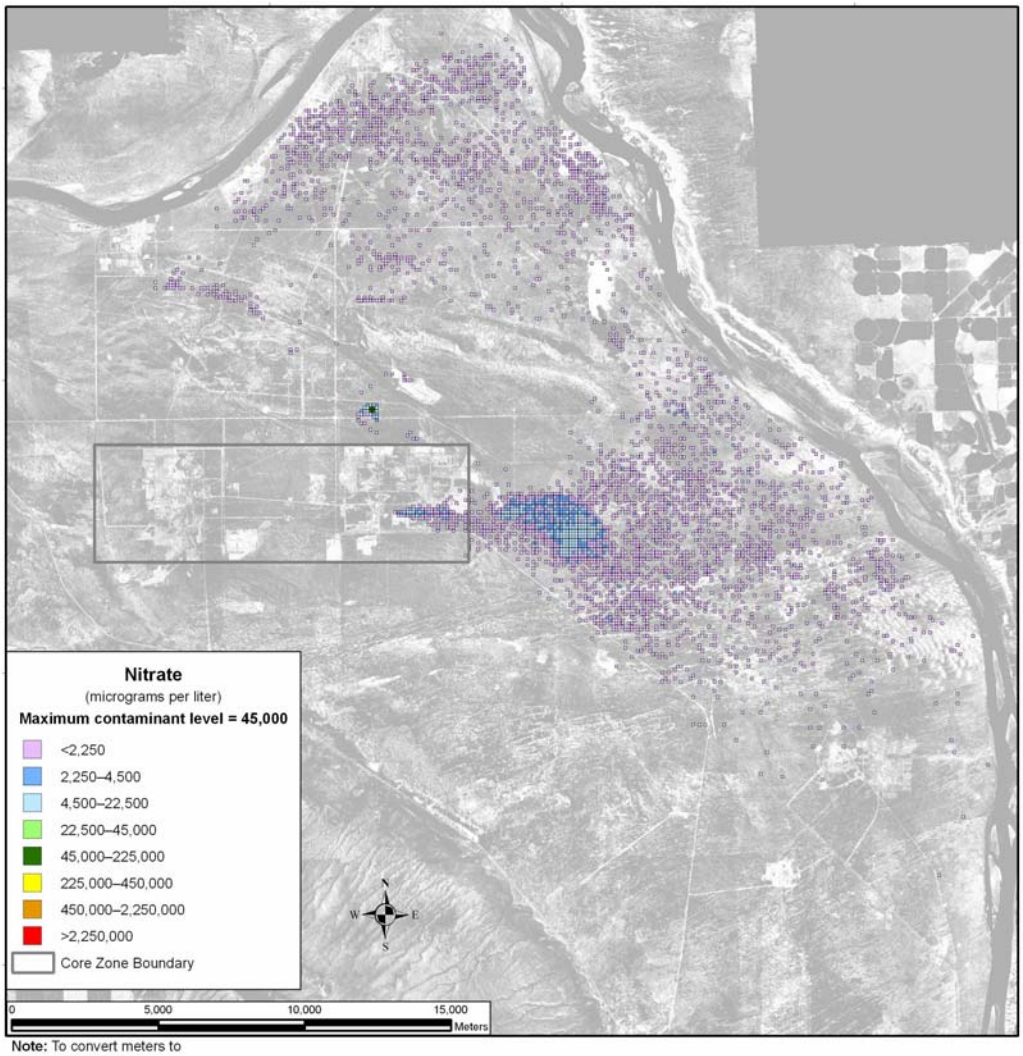
Note: To convert meters to feet, multiply by 3.281

Figure 5–685. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



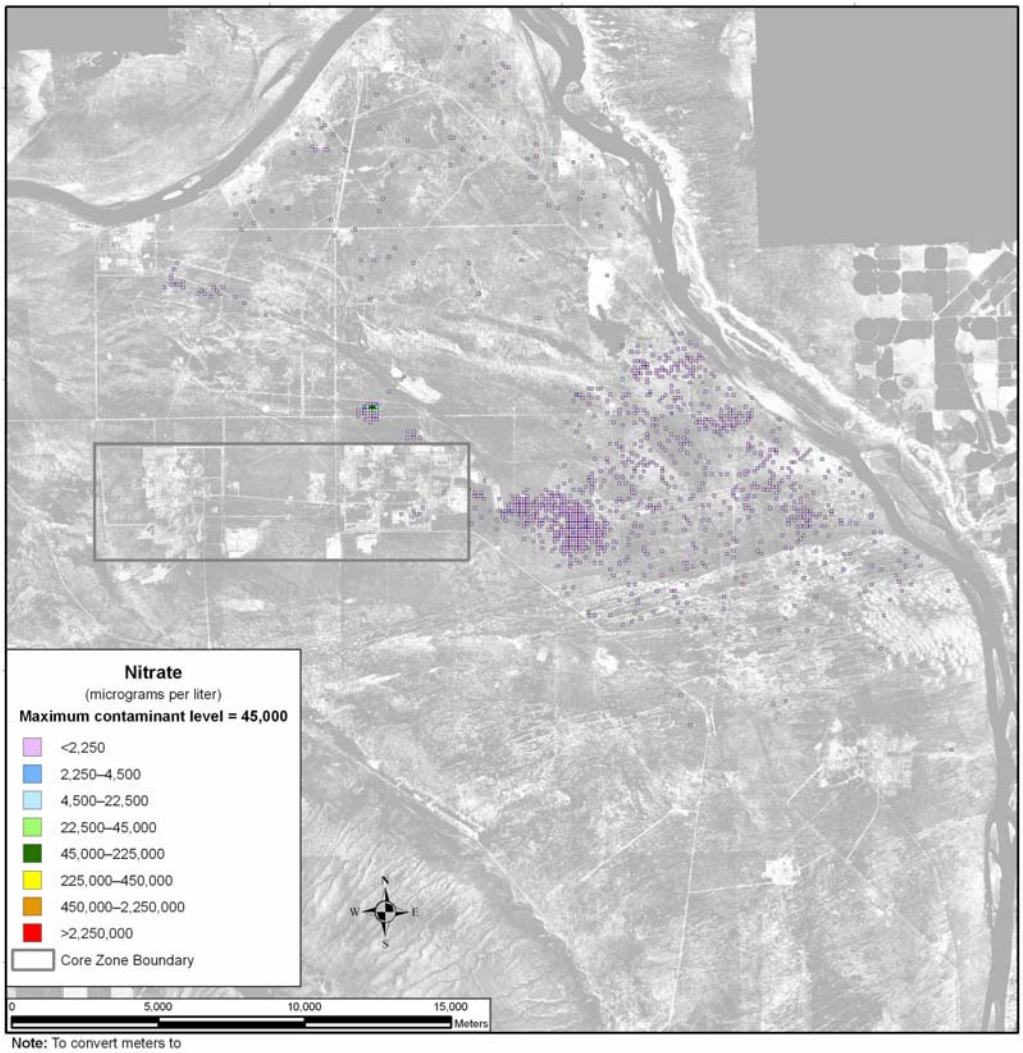
Note: To convert meters to feet, multiply by 3.281

Figure 5–686. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



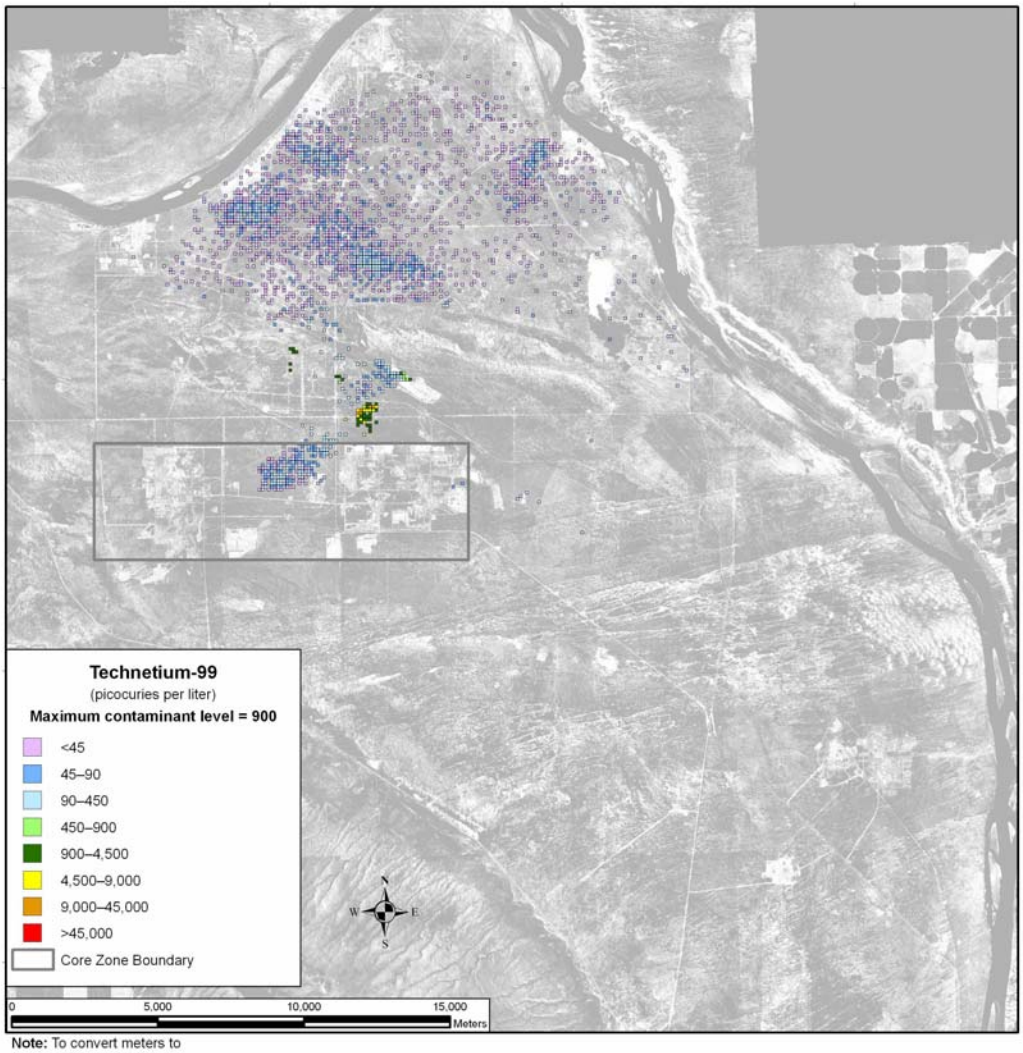
Note: To convert meters to feet, multiply by 3.281

Figure 5–687. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



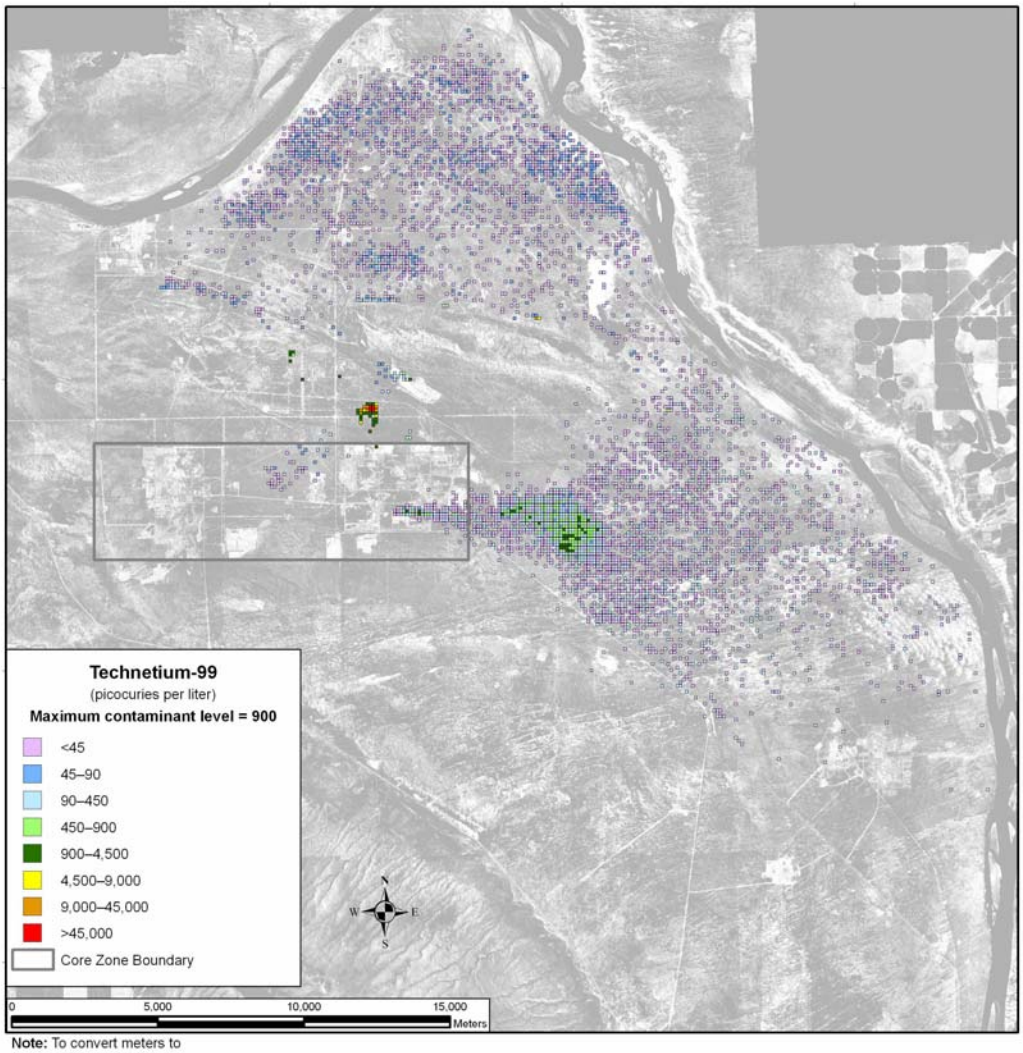
Note: To convert meters to feet, multiply by 3.281

Figure 5–688. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885



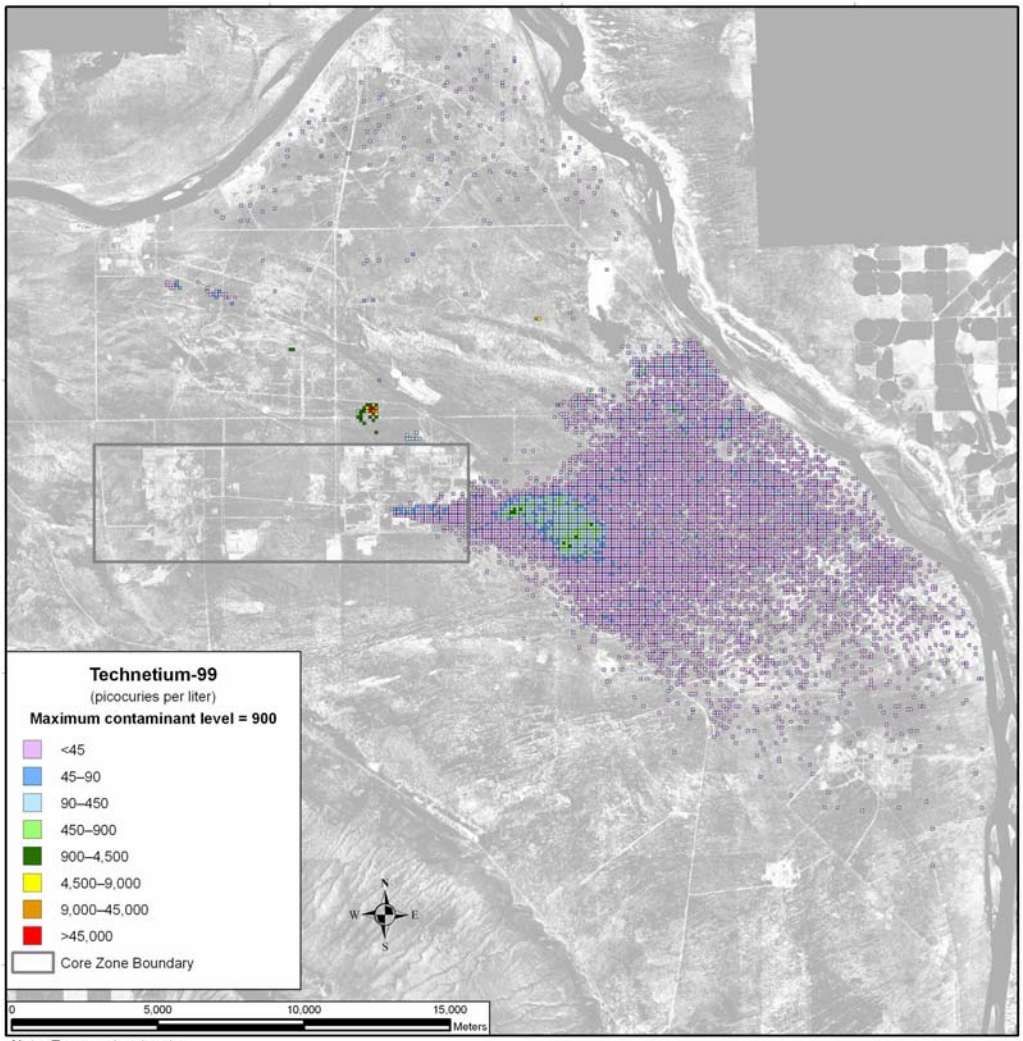
Note: To convert meters to feet, multiply by 3.281

Figure 5–689. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 3890



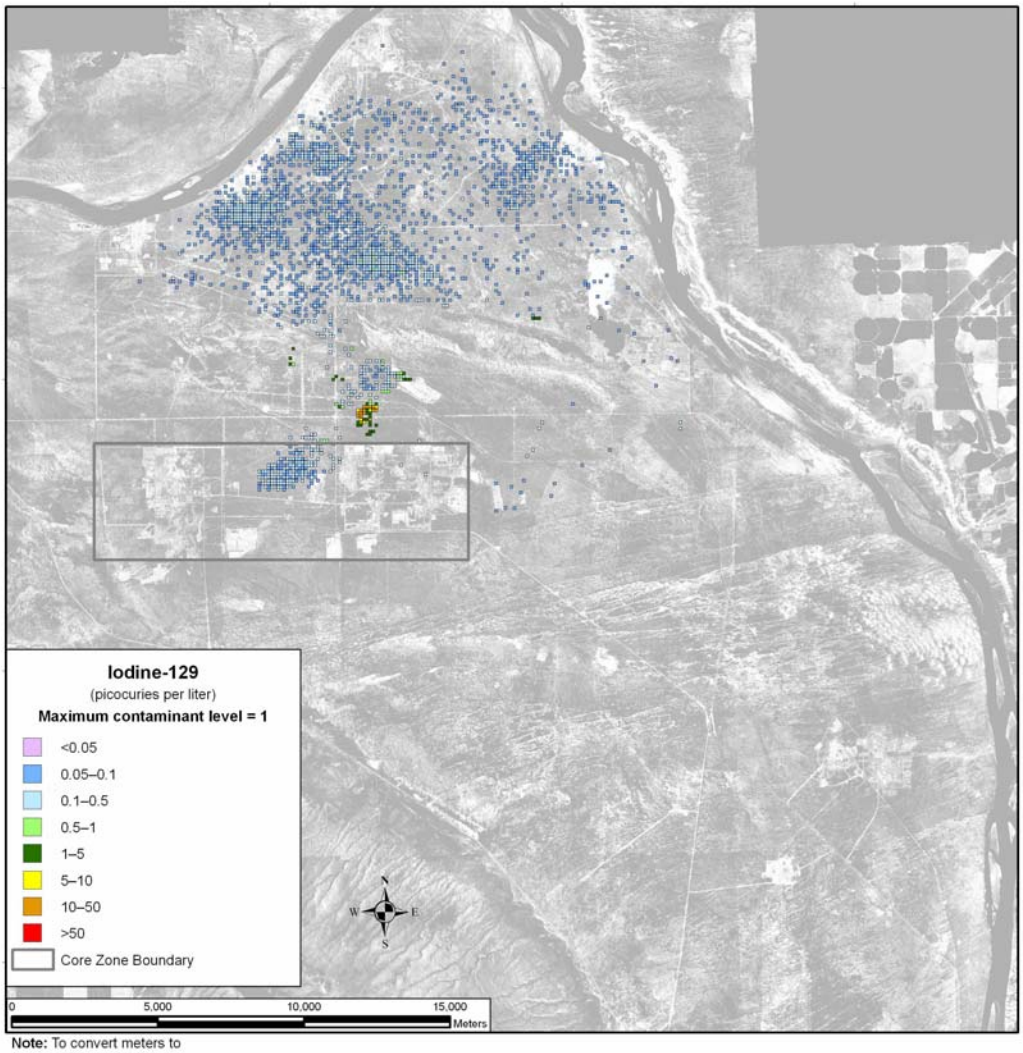
Note: To convert meters to feet, multiply by 3.281

Figure 5–690. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 7140



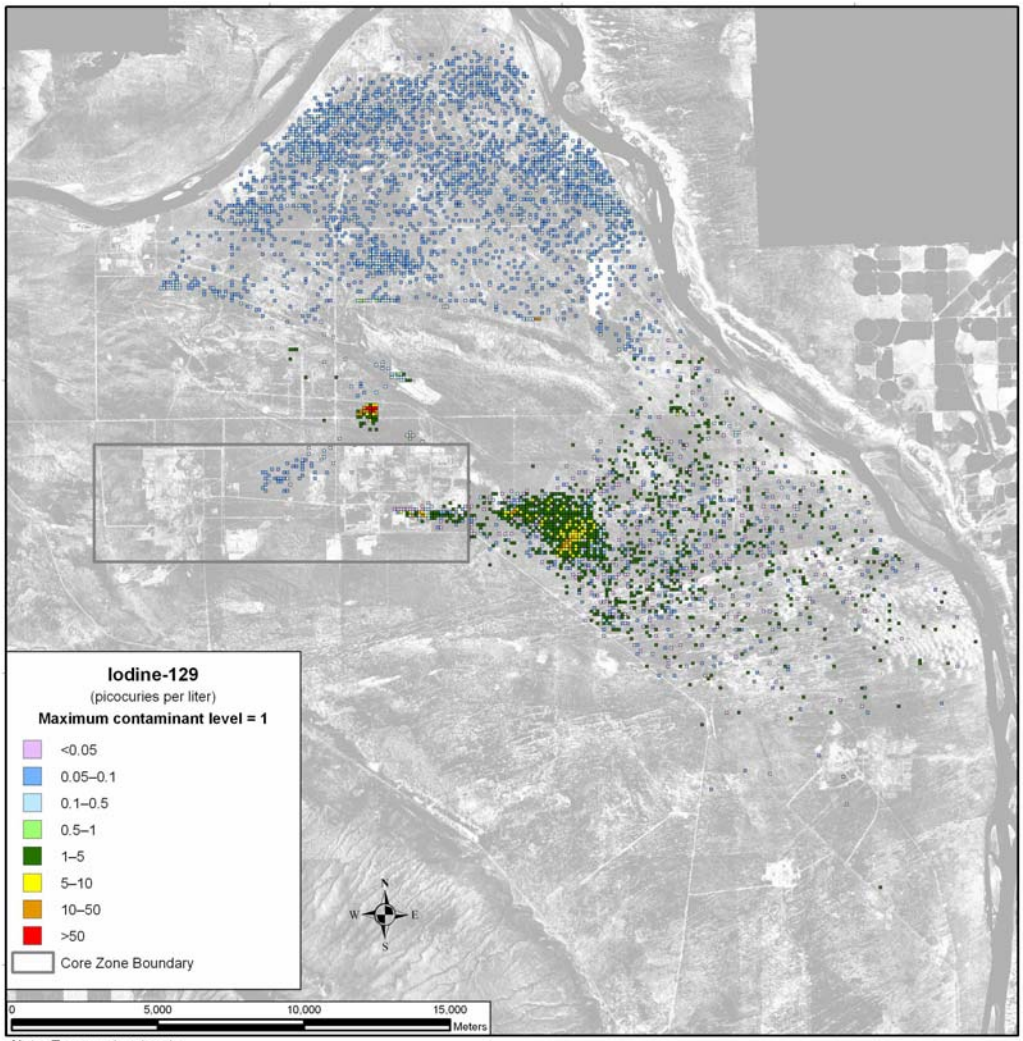
Note: To convert meters to feet, multiply by 3.281

Figure 5–691. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration During Calendar Year 11,885



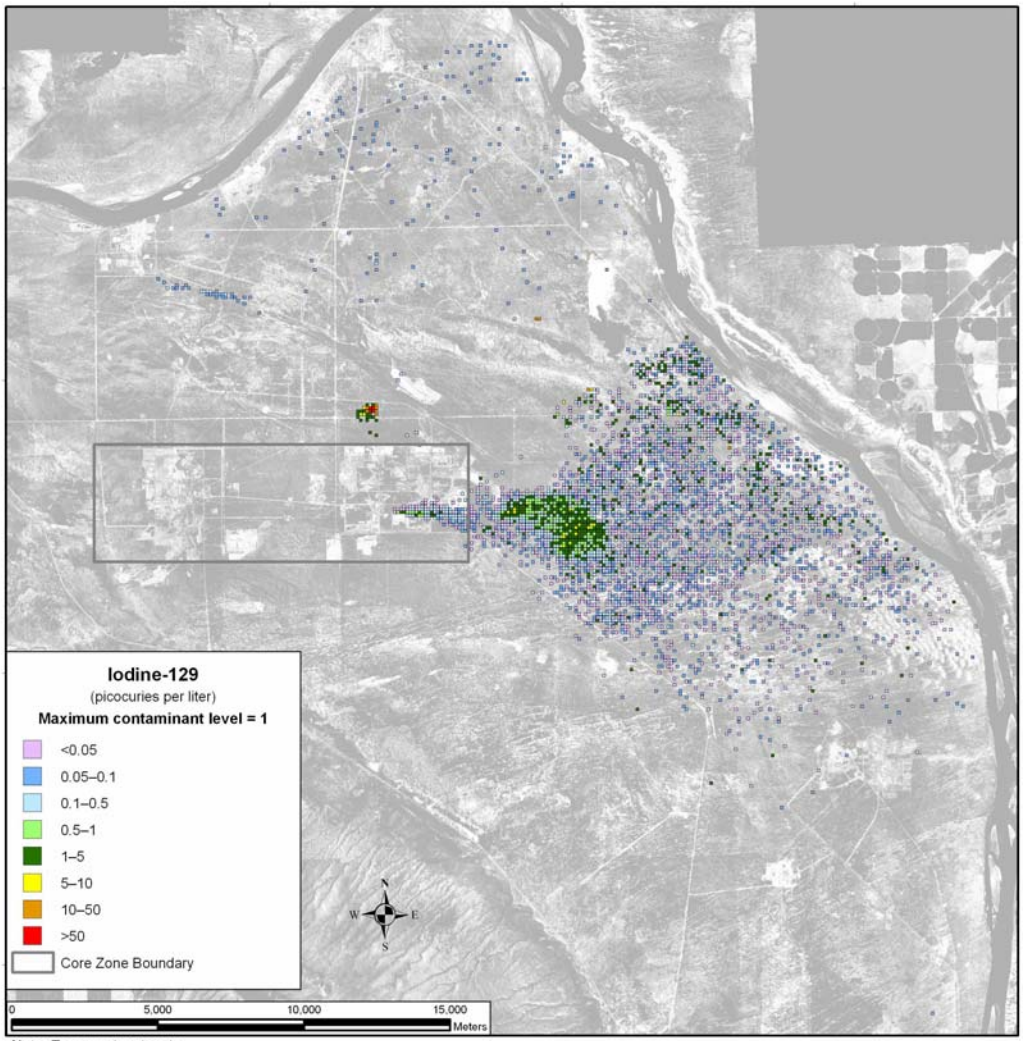
Note: To convert meters to feet, multiply by 3.281

Figure 5–692. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 3890



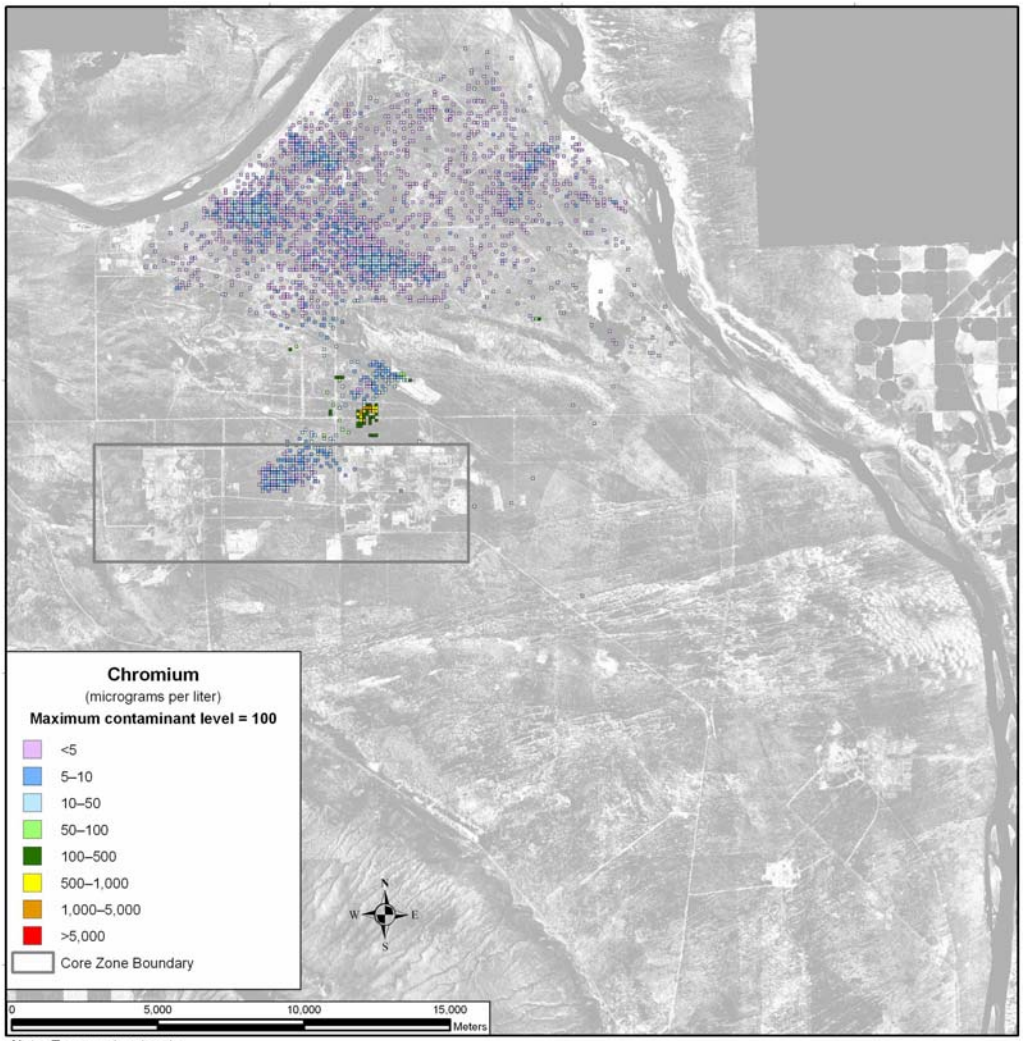
Note: To convert meters to feet, multiply by 3.281

Figure 5–693. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 7140



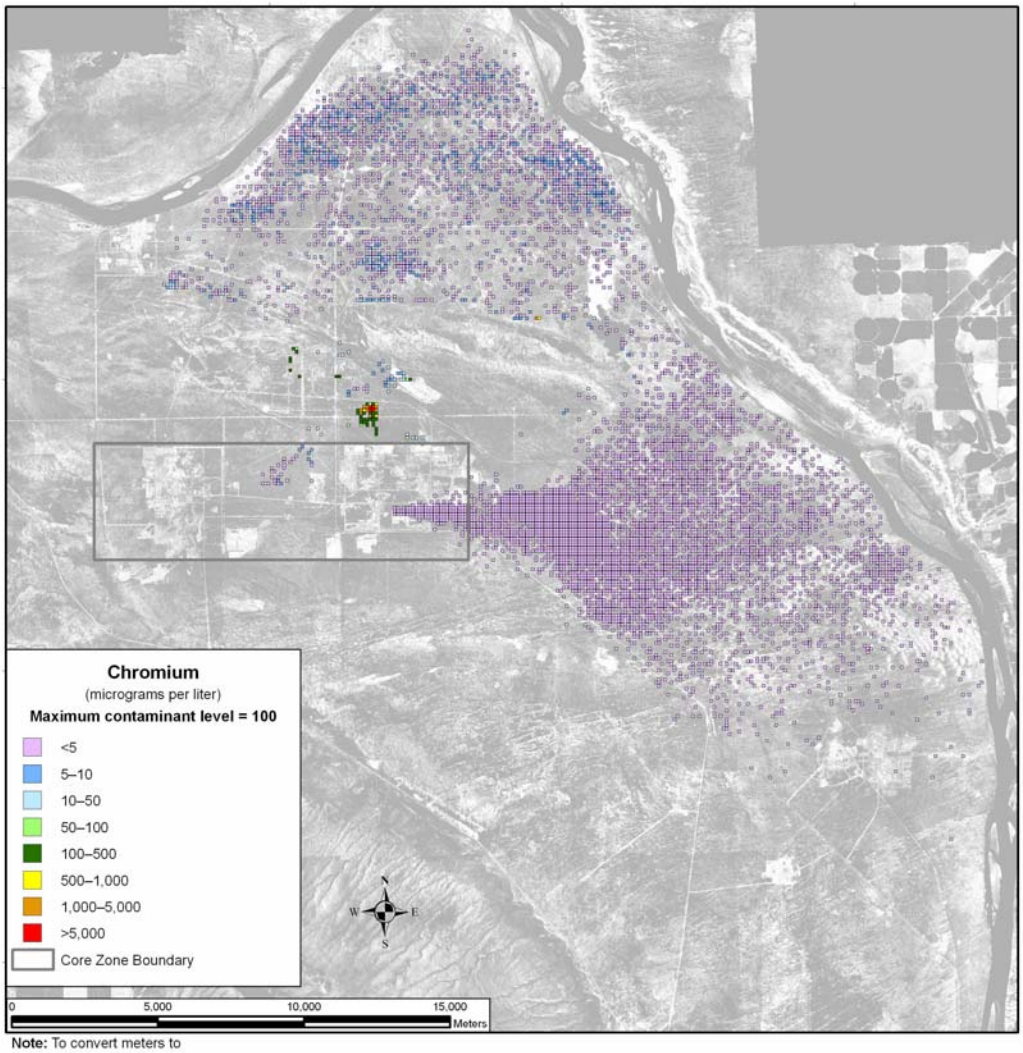
Note: To convert meters to feet, multiply by 3.281

Figure 5–694. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration During Calendar Year 11,885



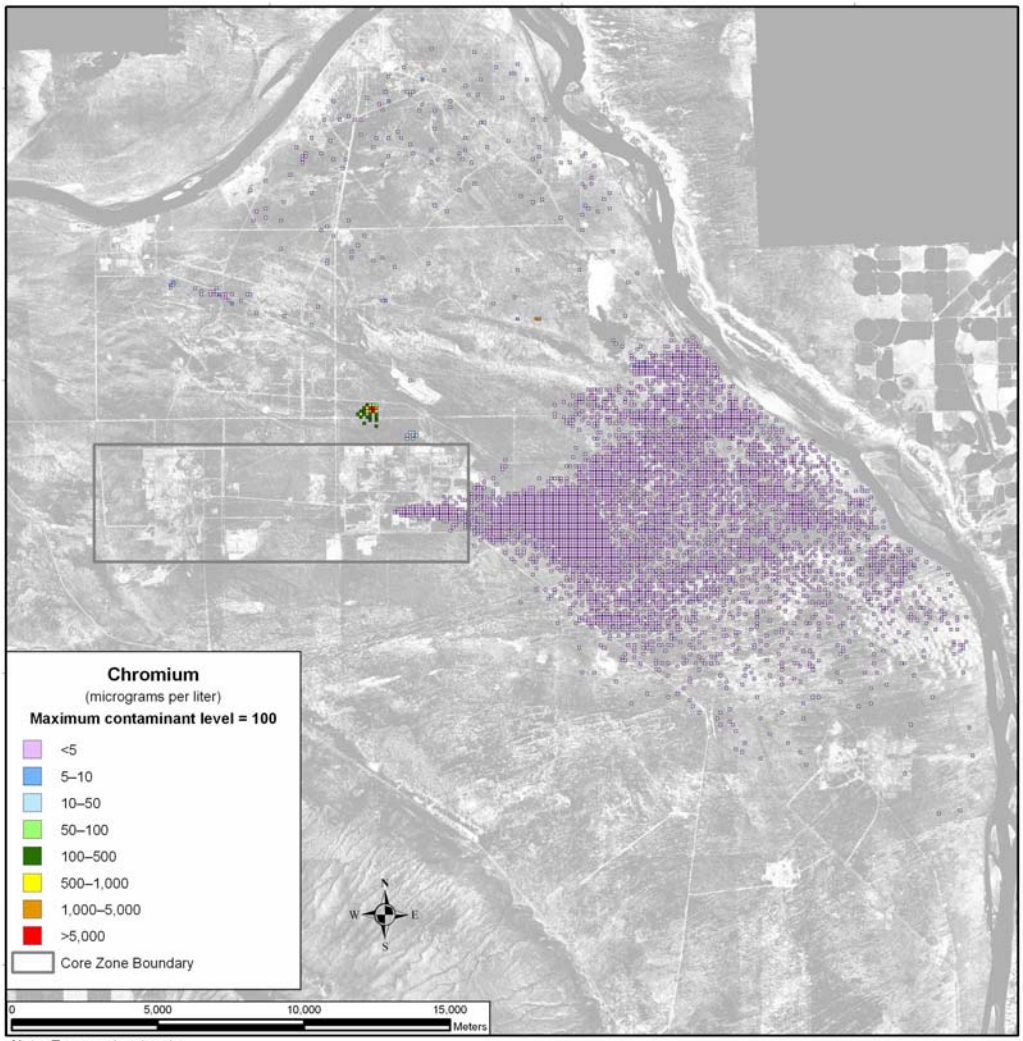
Note: To convert meters to feet, multiply by 3.281

Figure 5–695. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 3890



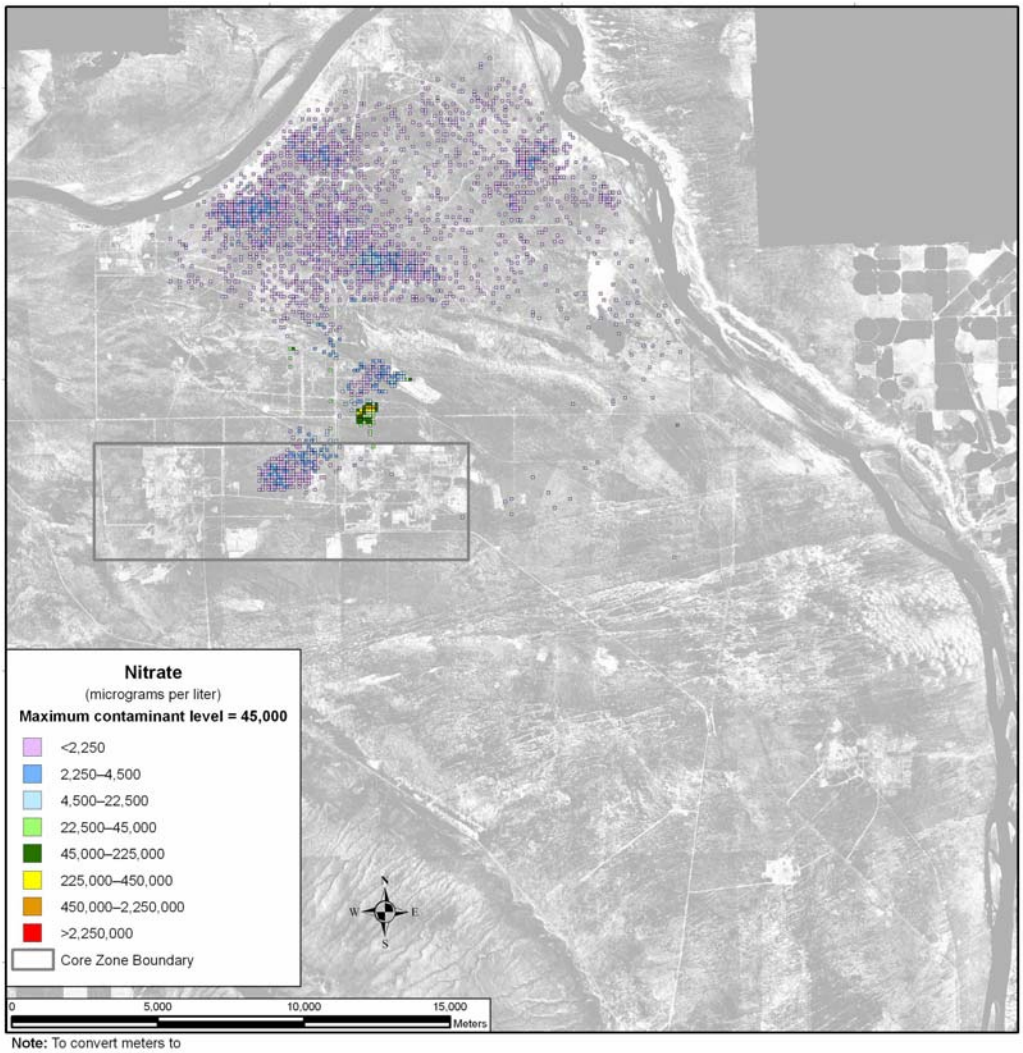
Note: To convert meters to feet, multiply by 3.281

Figure 5–696. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 7140



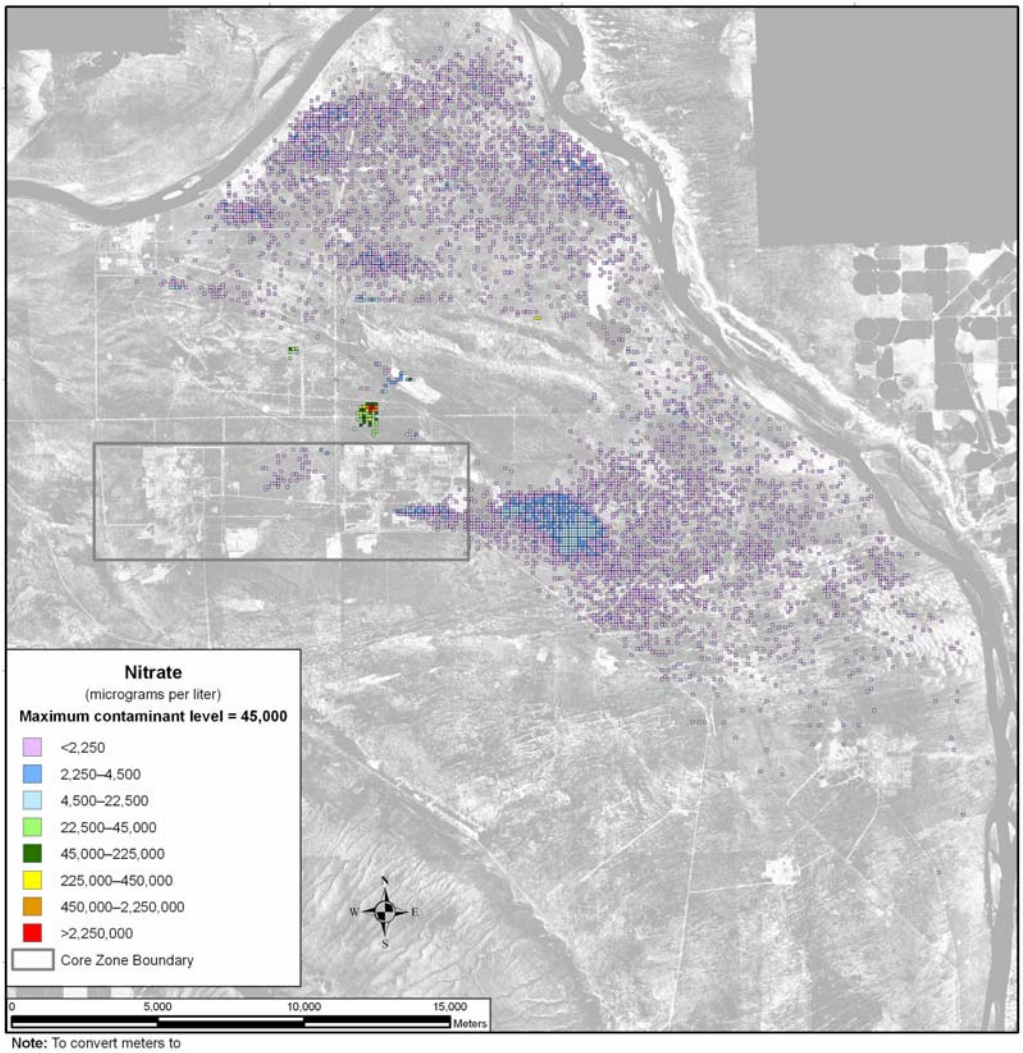
Note: To convert meters to feet, multiply by 3.281

Figure 5–697. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Chromium Concentration During Calendar Year 11,885



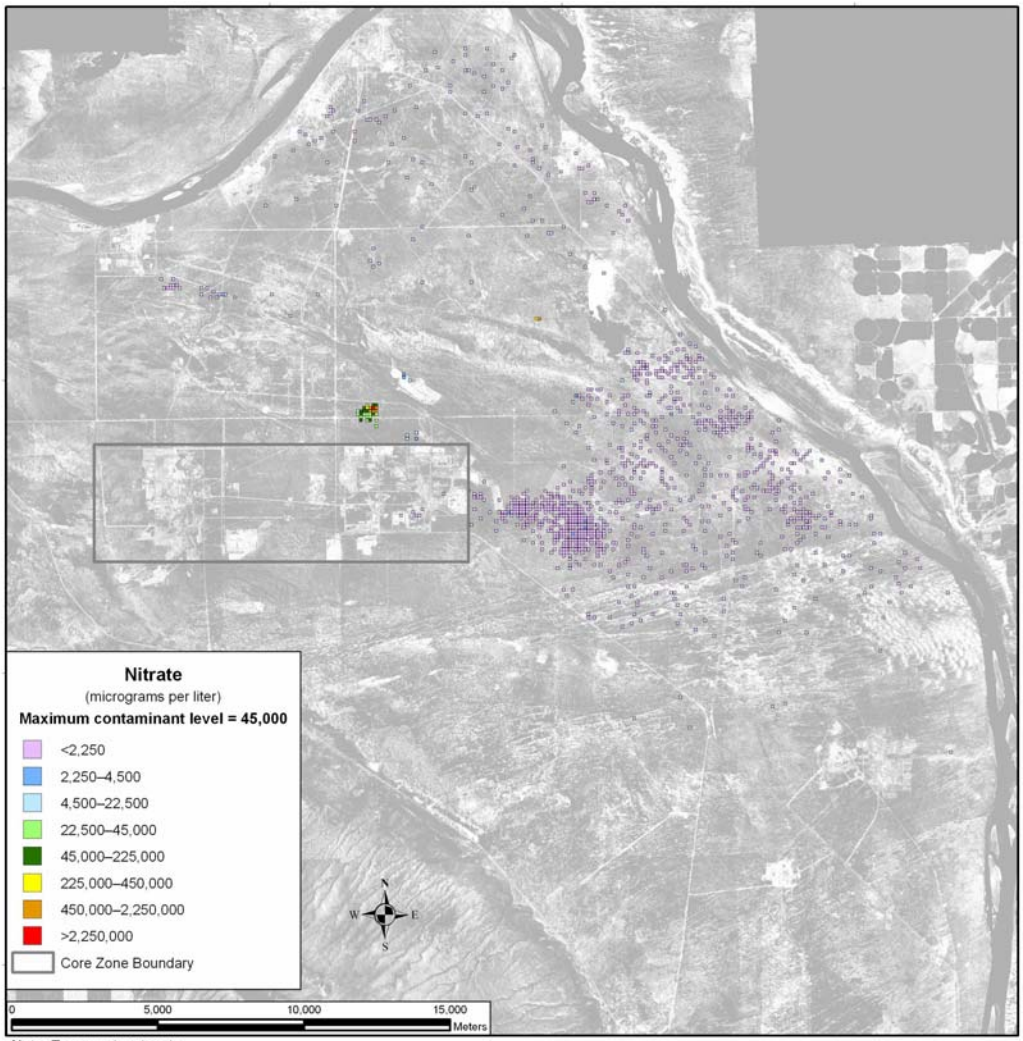
Note: To convert meters to feet, multiply by 3.281

Figure 5–698. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 3890



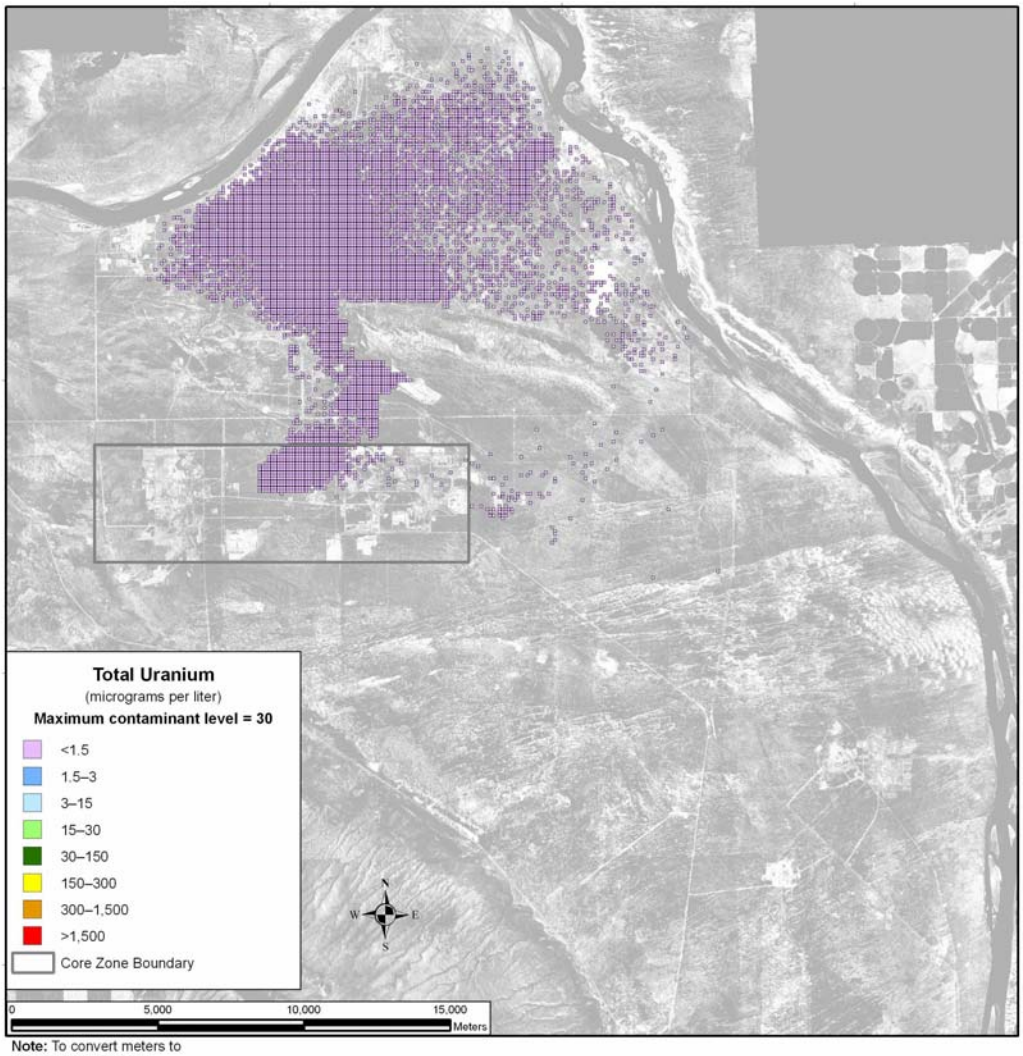
Note: To convert meters to feet, multiply by 3.281

Figure 5–699. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 7140



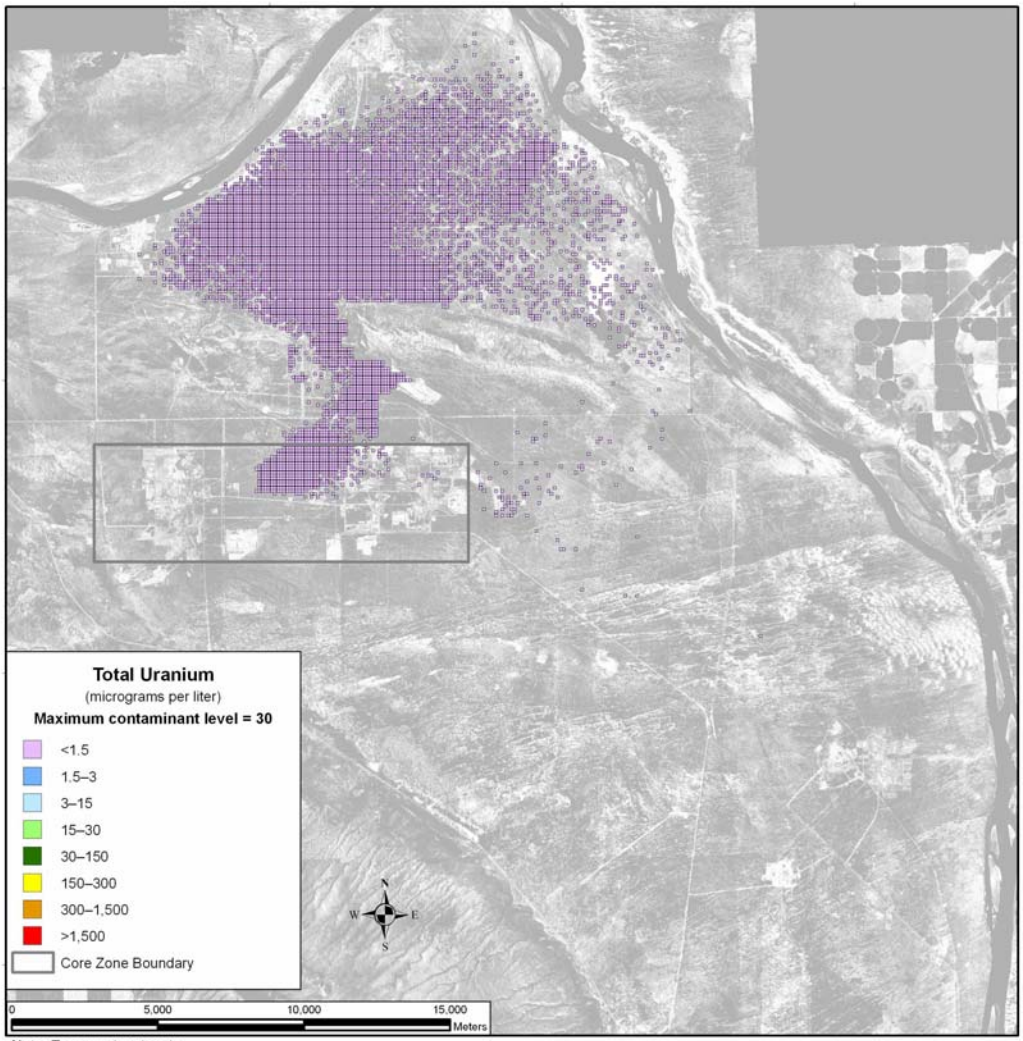
Note: To convert meters to feet, multiply by 3.281

Figure 5–700. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Nitrate Concentration During Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–701. Waste Management Alternative 2, Disposal Group 3, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885



Note: To convert meters to feet, multiply by 3.281

Figure 5–702. Waste Management Alternative 2, Disposal Group 3, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration During Calendar Year 11,885

SUMMARY OF IMPACTS

For technetium-99 in the Base Case, releases cause the groundwater concentrations at the Core Zone Boundary and at the Columbia River nearshore to approach the benchmark concentration around CY 7000 to CY 10,000. The concentrations at the Core Zone Boundary and the Columbia River nearshore never consistently remain above the benchmark throughout the period of analysis.

The behavior of technetium-99 in the Option Case is similar to that in the Base Case.

Iodine-129 concentrations in the Base Case at the Core Zone Boundary and the Columbia River nearshore exceed the benchmark from about CY 6000 until the end of the period of analysis. Peak exceedances were approximately one order of magnitude above the benchmark concentration.

Iodine-129 concentrations in the Option Case show a pattern similar to that in the Base Case.

Concentrations of chromium at the Core Zone Boundary in the Base Case approach the benchmark from about CY 3800 to CY 5800. During that time, there are no significant benchmark exceedances. The concentrations from the Columbia River nearshore remained about one order of magnitude below the benchmark.

The concentrations over time in the Option Case for chromium at the Core Zone Boundary and from the Columbia River nearshore remain just below the benchmark.

For the Base Case, nitrate concentrations at the Core Zone Boundary and from the Columbia River nearshore peak at around CY 8000. Even at the concentrations peak, nitrate levels still remain about one order of magnitude below the benchmark level.

In the Option Case, the concentrations over time for nitrate at the Core Zone Boundary peaked around CY 4800 but remain about one order of magnitude below the benchmark. Concentrations from the Columbia River nearshore remained fairly steady at around one order of magnitude below the benchmark.

For the Base Case, total uranium concentrations begin to register on the graph at CY 9500. The concentrations at the Core Zone Boundary and from the Columbia River nearshore both remain about seven to eight orders of magnitude below the benchmark level.

Total uranium concentrations in the Option Case behave similarly.