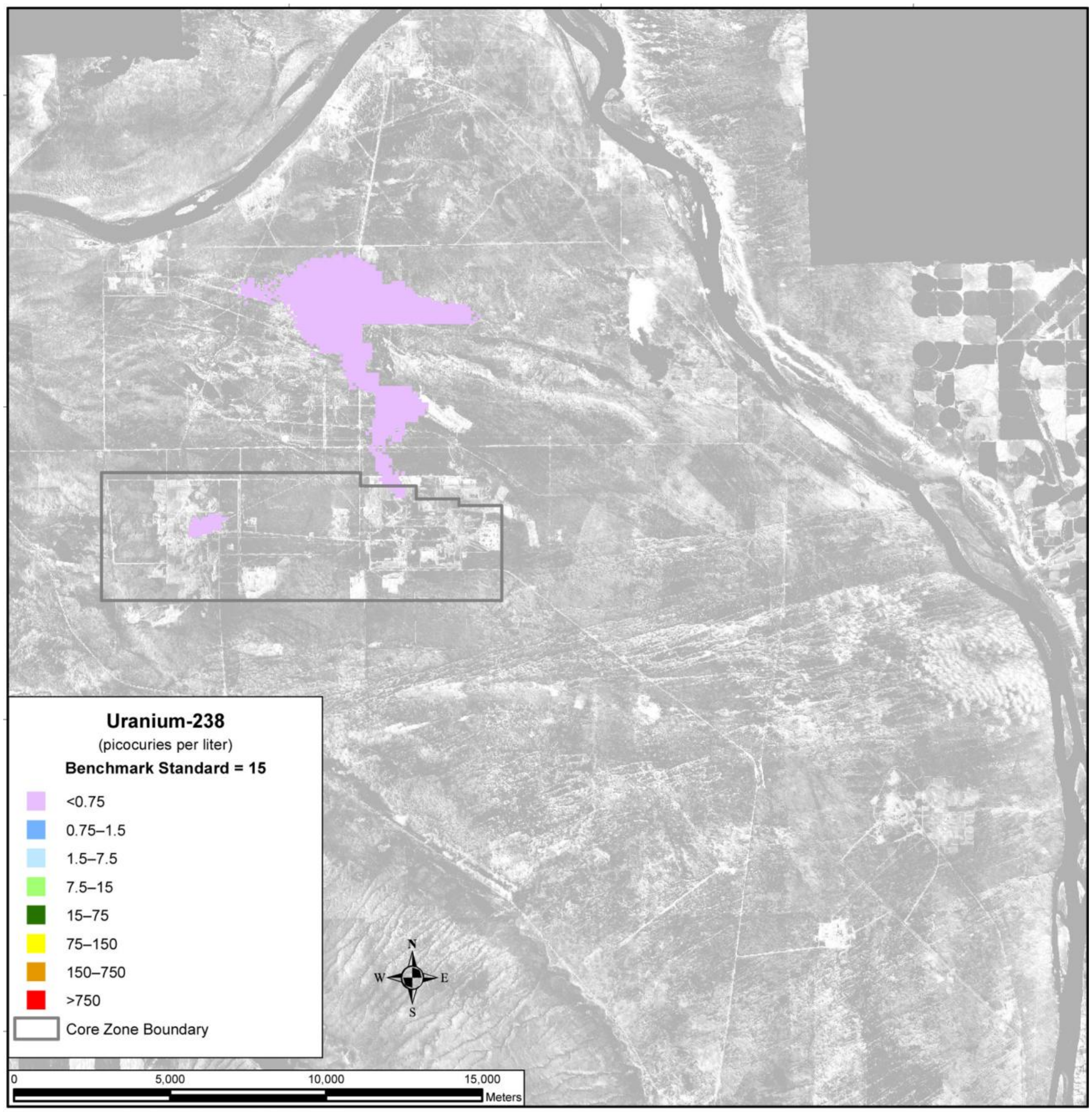
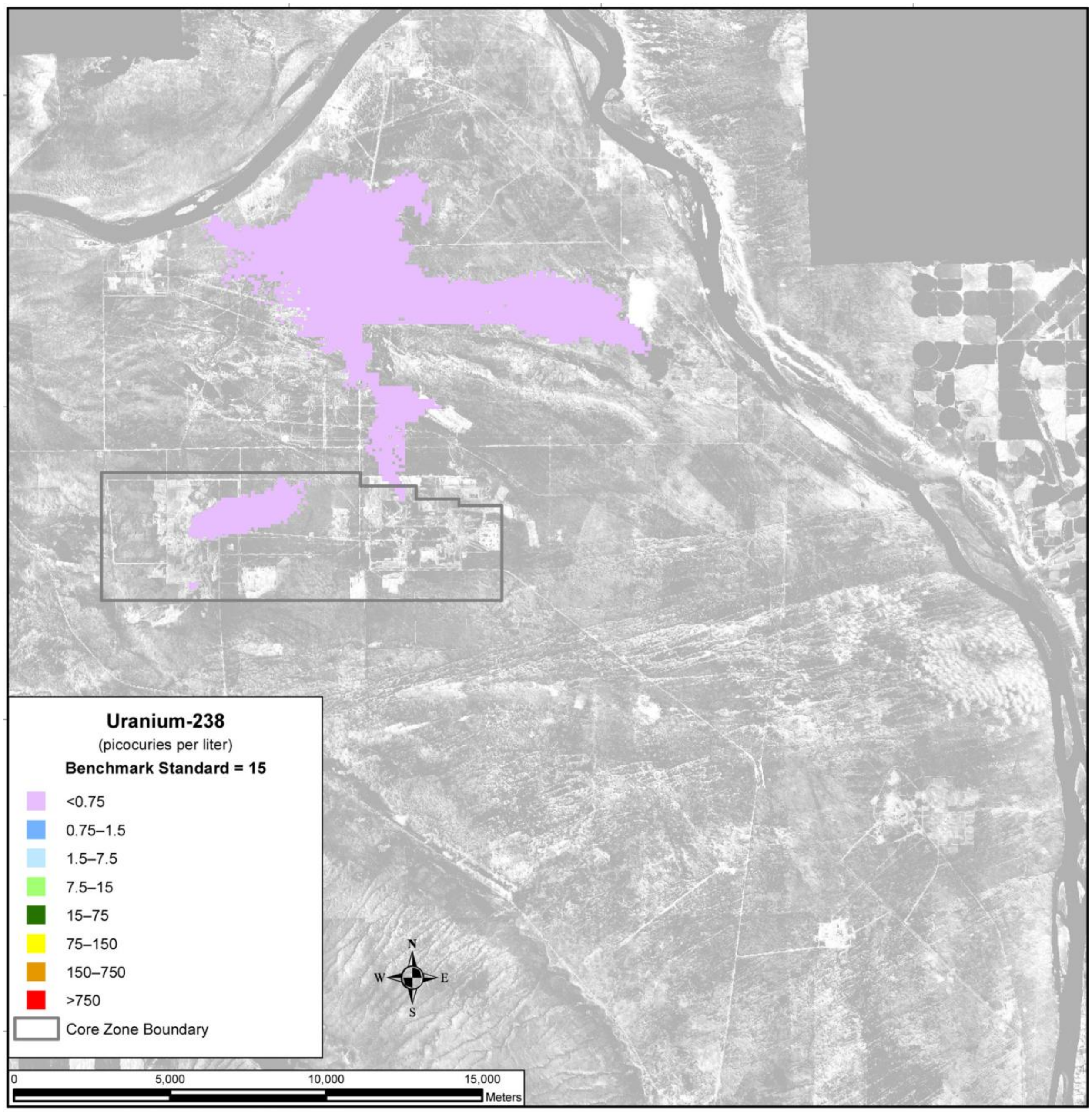


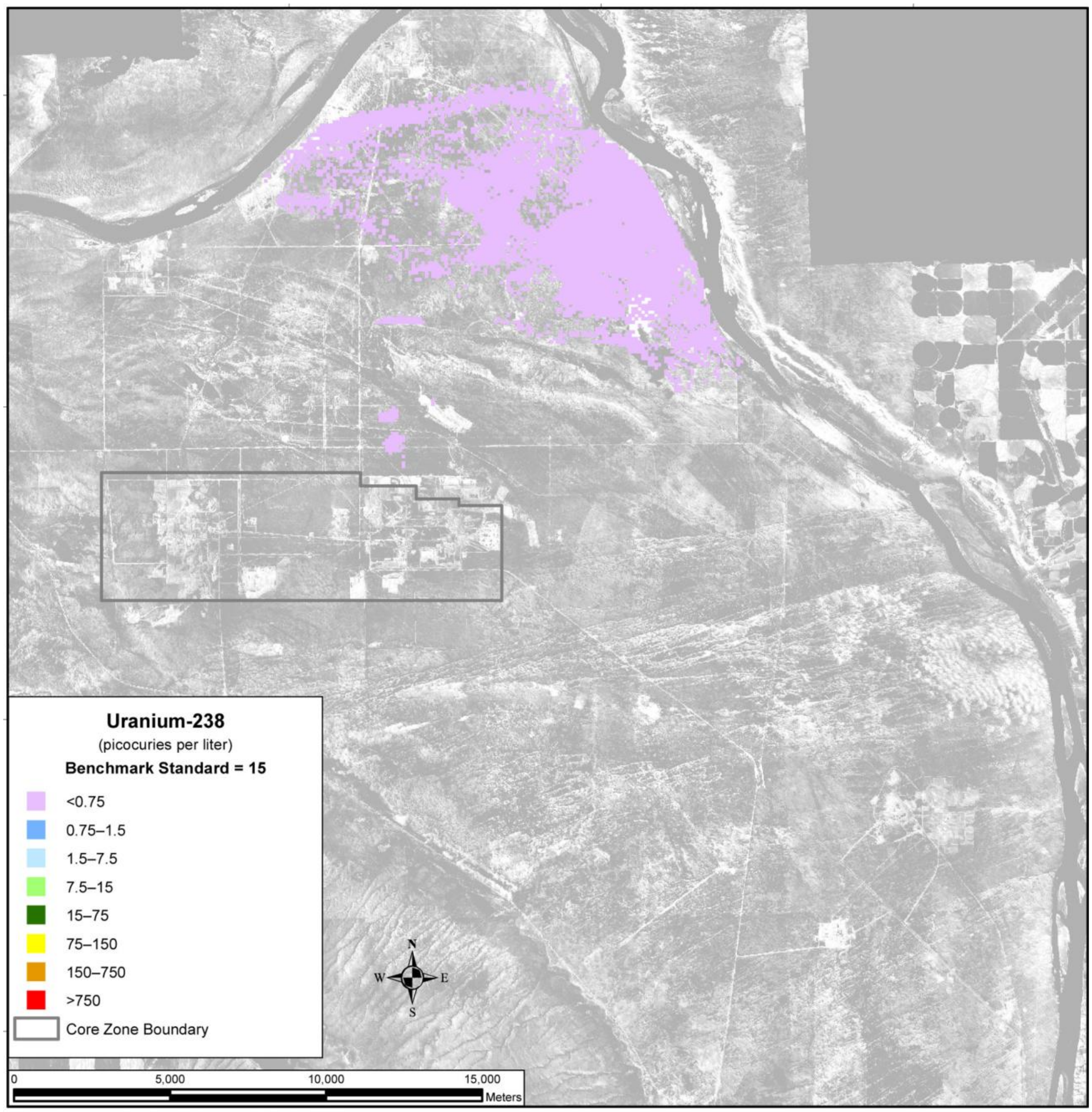
Note: To convert meters to feet, multiply by 3.281.

Figure 5–252. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 2010



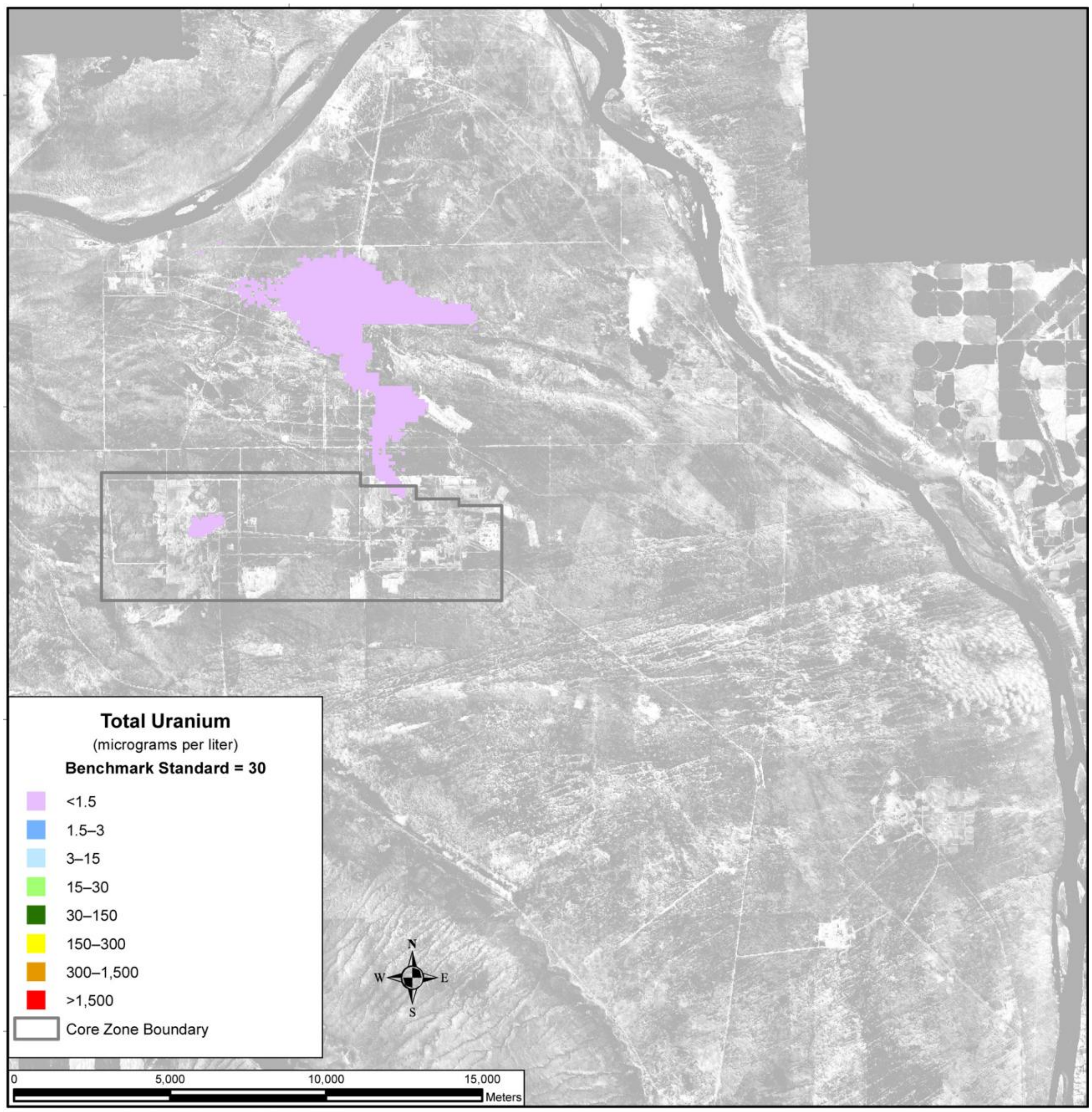
Note: To convert meters to feet, multiply by 3.281.

Figure 5–253. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 2135



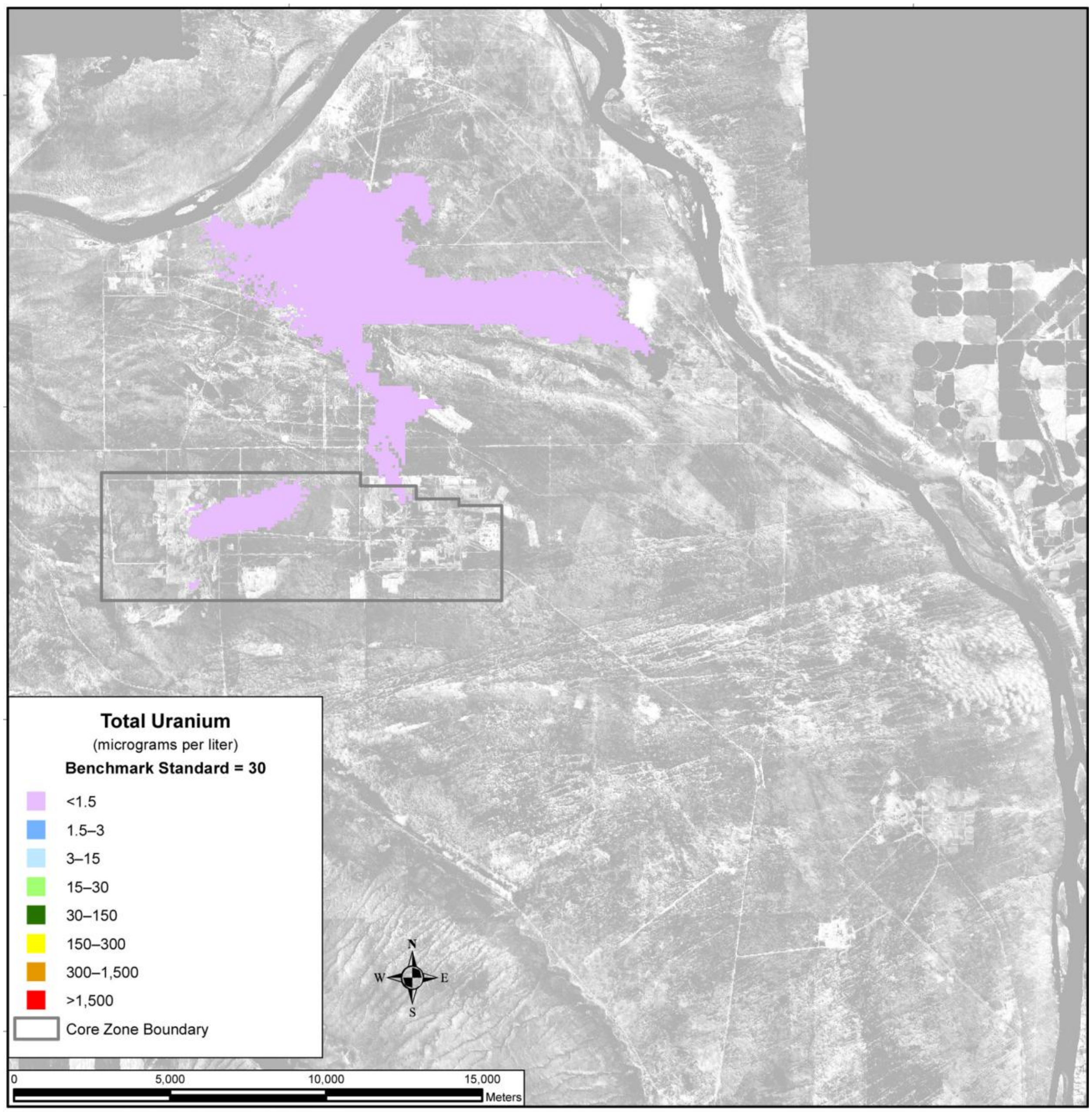
Note: To convert meters to feet, multiply by 3.281.

Figure 5–254. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 11,940



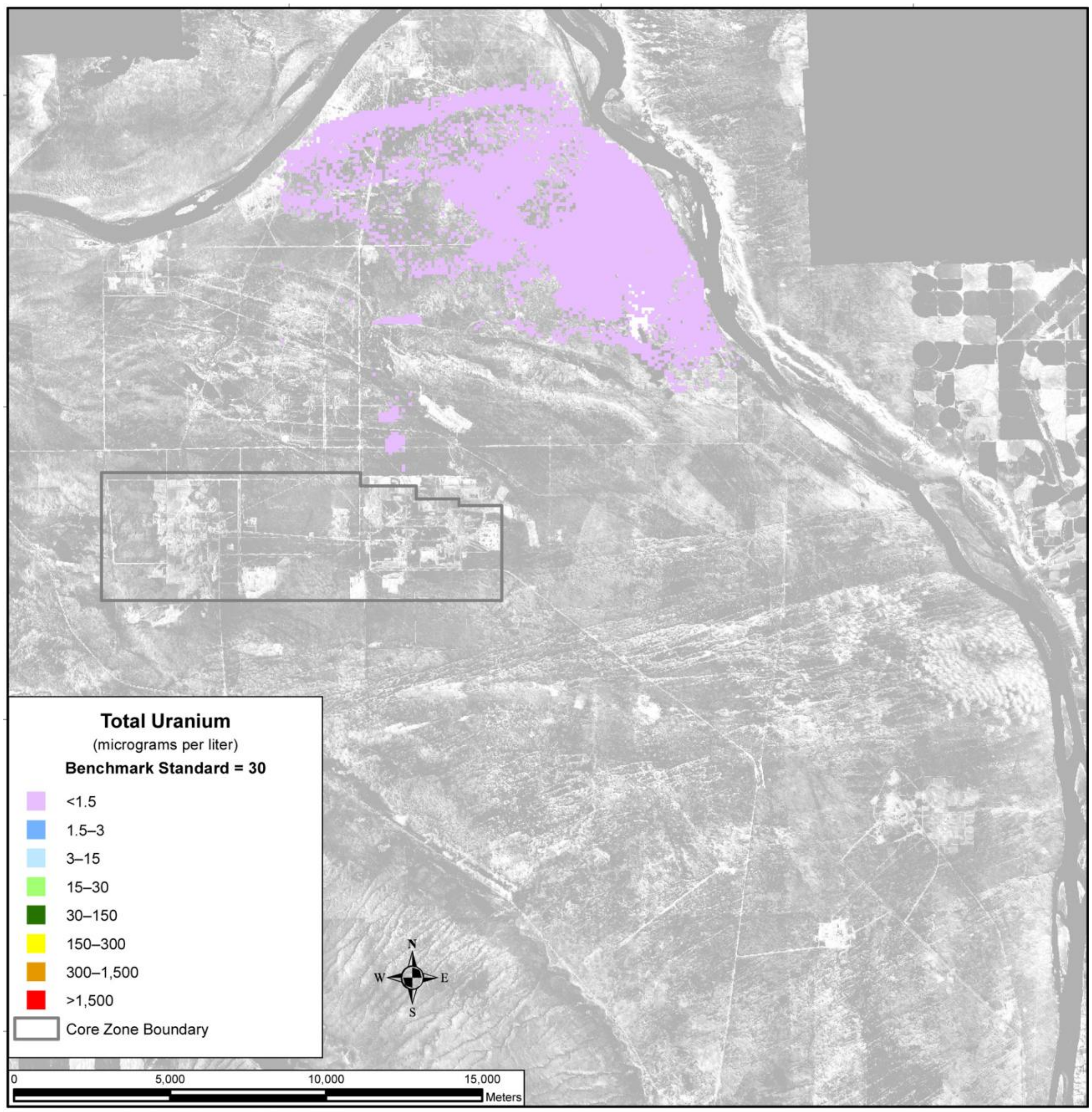
Note: To convert meters to feet, multiply by 3.281.

Figure 5–255. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration, Calendar Year 2010



Note: To convert meters to feet, multiply by 3.281.

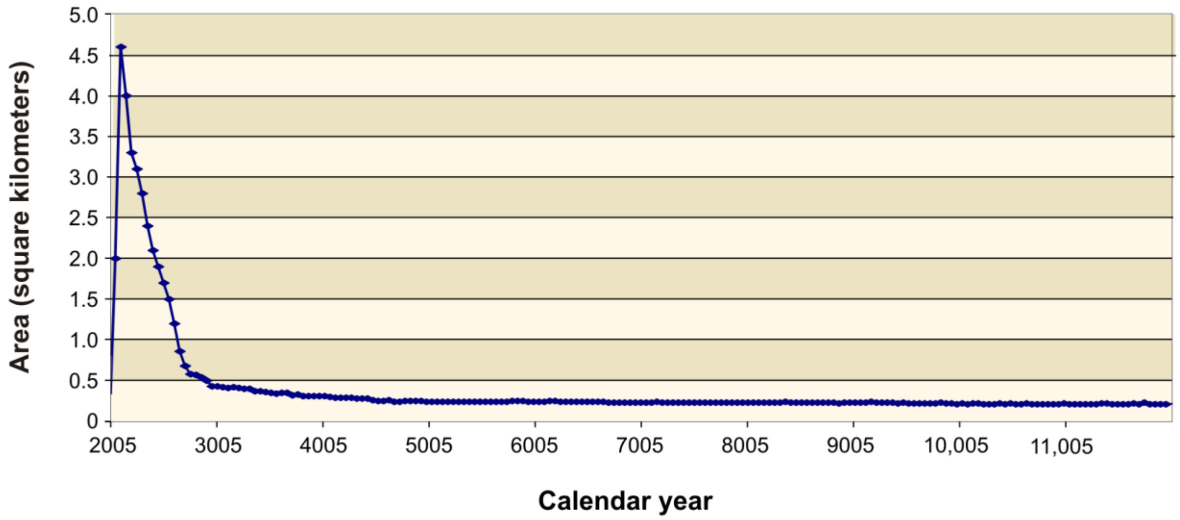
Figure 5–256. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration, Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281.

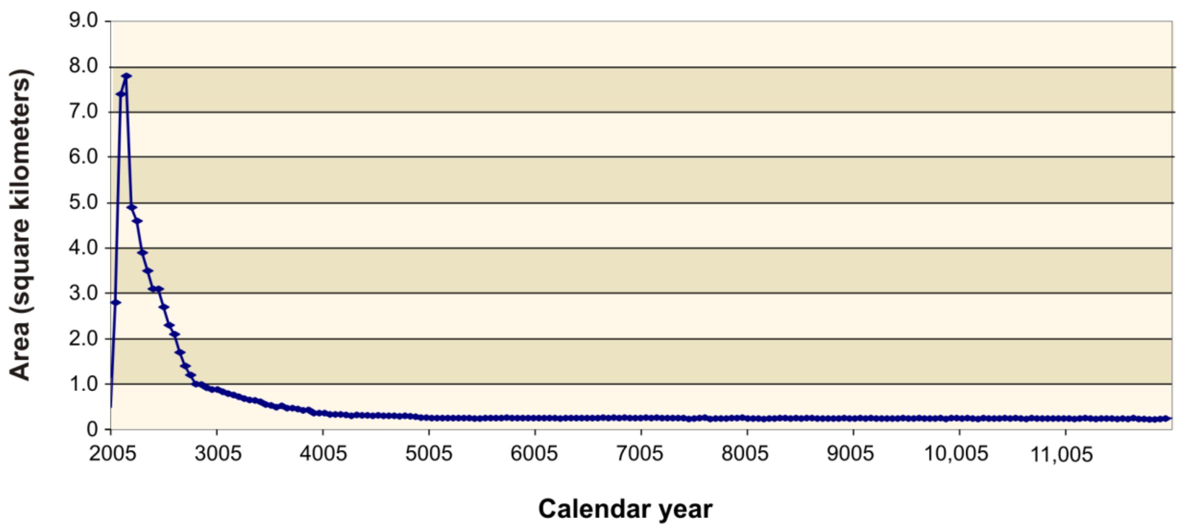
Figure 5–257. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration, Calendar Year 11,940

Figure 5–258 shows the area (in square kilometers) in which groundwater concentrations of technetium-99 exceed the benchmark concentration in the analysis as a function of time under the Base Case. A peak of 4.5 square kilometers (1.7 square miles) occurs around CY 2135, followed by a fairly sharp decrease. By about CY 4000, this area begins to level out around 0.25 square kilometers (0.1 square miles). Iodine-129 shows a pattern similar to that of technetium-99 (see Figure 5–259), as both constituents are conservative tracers.



Note: To convert square kilometers to square miles, multiply by 0.3861.

Figure 5–258. Tank Closure Alternative 6A, Base Case, Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time



Note: To convert square kilometers to square miles, multiply by 0.3861.

Figure 5–259. Tank Closure Alternative 6A, Base Case, Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

Under the Option Case, the areas in which concentrations of technetium-99 and iodine-129 exceed their respective benchmarks are essentially identical to those under the Base Case (see Figures 5–260 and 5–261).

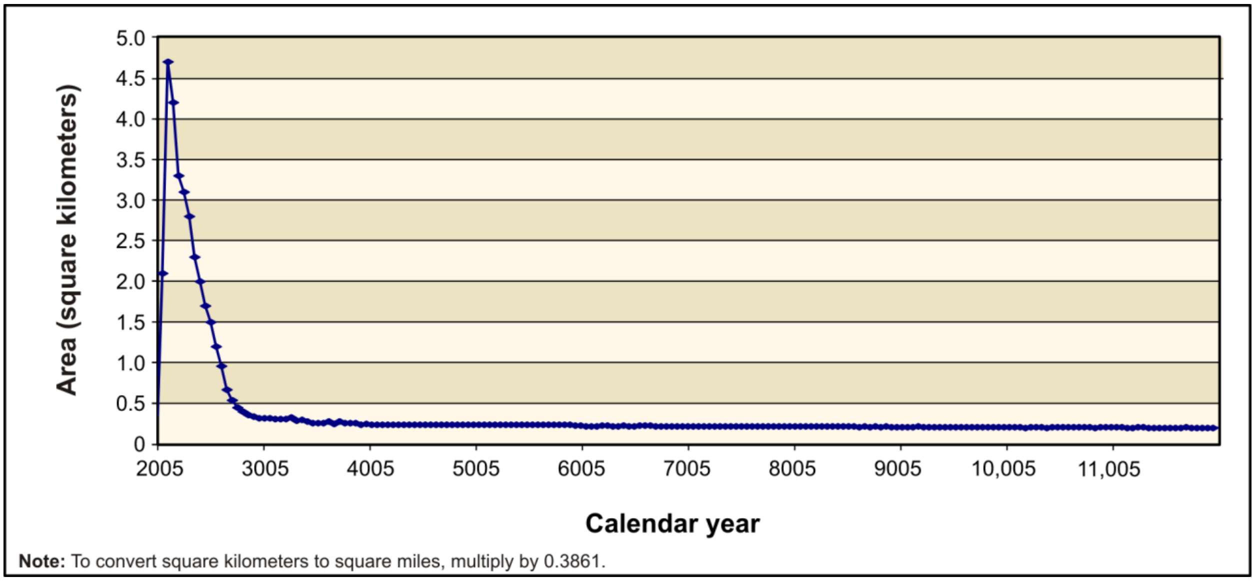


Figure 5–260. Tank Closure Alternative 6A, Option Case, Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

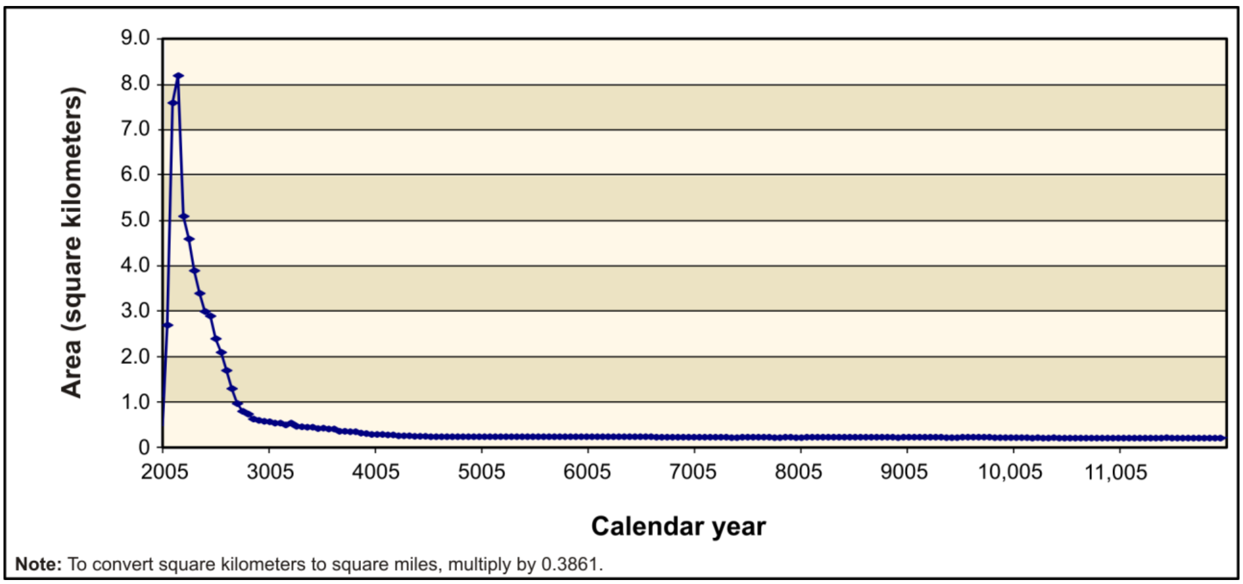
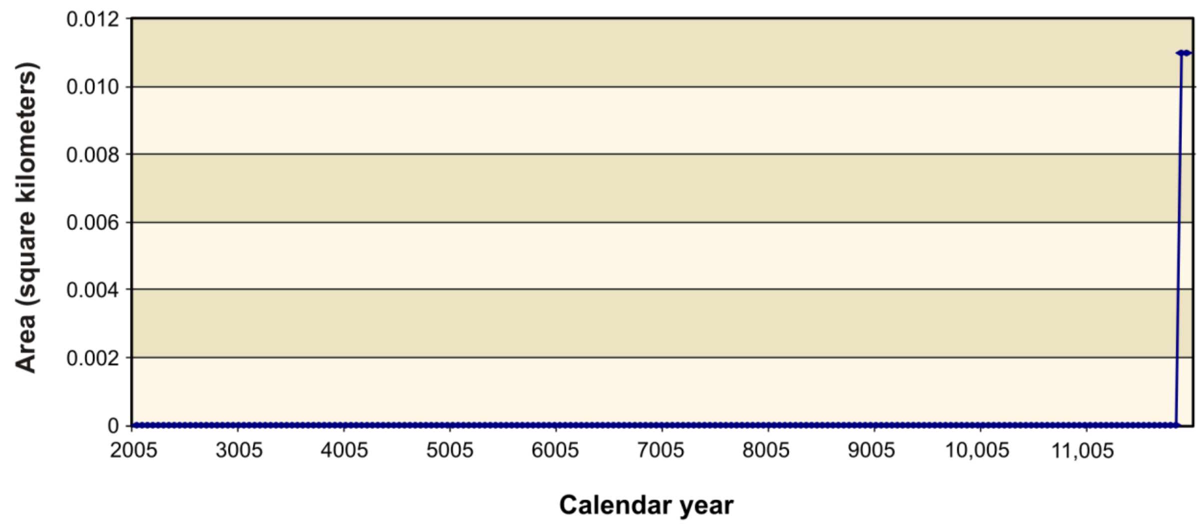


Figure 5–261. Tank Closure Alternative 6A, Option Case, Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

Under the Base Case, uranium-238 does not register above the benchmark concentration in any area until near the end of the simulation, in CY 11,840 (see Figure 5–262). The area of exceedance is only 0.01 square kilometers (0.004 square miles). Under the Option Case, uranium-238 never exceeds the benchmark concentration in any area during the period of analysis. This is a result of the high retardation rate and the removal and remediation of the cribs and trenches (ditches).



Note: To convert square kilometers to square miles, multiply by 0.3861.

Figure 5–262. Tank Closure Alternative 6A, Base Case, Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

5.1.1.9.6 Summary of Impacts

For the conservative tracers under the Base Case, concentrations at the Core Zone Boundary exceed the benchmark standards by about one to two orders of magnitude during the early part of the period of analysis beginning around CY 1956. Columbia River nearshore concentrations of the conservative tracers approach the benchmark concentration briefly during the early part of the analysis period, but decrease to levels below the benchmark for the remainder of the analysis period. The intensities and areas of these groundwater plumes peak around CY 1956.

The concentrations of iodine-129, technetium-99, chromium, and nitrate (the conservative tracers) under the Option Case are essentially identical to those under the Base Case during the early part of the period of analysis, but as a result of the clean closure of the cribs and trenches (ditches), concentrations fall dramatically around CY 3000.

Under the Base Case, concentrations of tritium at the Core Zone Boundary exceed the benchmark by about one to two orders of magnitude for a short period of time during the early part of the period of analysis, around CY 1956. The Columbia River nearshore tritium concentrations approach but never reach the benchmark. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts of tritium.

The concentrations of tritium under the Option Case are essentially identical to those under the Base Case.

For uranium-238 and total uranium under the Base Case, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species begin to approach the benchmark at the Core Zone Boundary toward the latter part of the period of analysis but never reach it. The concentration levels of uranium-238 and total uranium at the Columbia River nearshore never come to within about two orders of magnitude below the benchmark. The intensity is highest and the area of the contaminant plumes largest at the end of the period of analysis.

Under the Option Case, uranium-238 concentrations at the Core Zone Boundary peak at about two orders of magnitude below the benchmark at the beginning of the period of analysis. Around CY 3000, the uranium-238 concentrations at the Core Zone Boundary drastically fall to over nine orders of magnitude below the benchmark, while the Columbia River nearshore concentrations stay fairly constant at about five orders of magnitude below the benchmark. Total uranium concentrations are essentially identical to uranium-238 concentrations.

5.1.1.10 Tank Closure Alternative 6B: All Vitrification with Separations; Clean Closure, Base and Option Cases

This section describes the groundwater analysis results for Tank Closure Alternative 6B, including long-term groundwater impacts of contaminant sources within the tank farm barriers. Impacts of sources removed from within the tank farm barriers and disposed of in an IDF and the RPPDF are presented in Section 5.3, which discusses waste management impacts.

Tank Closure Alternative 6B, Base and Option Cases, resembles Tank Closure Alternative 6A, Base and Option Cases, except that waste retrieval and processing would proceed at a faster rate and closure would occur at an earlier date.

Under Tank Closure Alternative 6B, Base Case, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval; all tank farms would be clean closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. The adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier.

Under Tank Closure Alternative 6B, Option Case, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval; all tank farms would be clean closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. In addition, the adjacent cribs and trenches (ditches) would be clean closed.

5.1.1.10.1 Actions and Timeframes Influencing Groundwater Impacts

Summaries of the proposed actions and timelines for Tank Closure Alternative 6B are provided in Chapter 2, Section 2.5. For the long-term groundwater impacts analysis, three major periods were identified for Tank Closure Alternative 6B, as follows:

- The past-practice period was assumed to start with the onset of tank farm operations in 1944 and continue through 2007, when tank and infrastructure upgrades were complete. Releases to the vadose zone occurred during the past-practice period from past leaks at the SST farms and discharges to the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. The groundwater impacts during the past-practice period under Tank Closure Alternative 6B presented in this section are common to all of the Tank Closure alternatives.

- The retrieval period was assumed to start in 2008 and end in CY 2101. This period includes waste retrieval, WTP pretreatment and treatment, clean closure of the SST farm system, and 100 years of postclosure care. During this period, 99.9 percent of the waste would be retrieved from the tanks and all tank farms would be clean closed. Under Tank Closure Alternative 6B, Base Case, the adjacent cribs and trenches (ditches) would be covered with an engineered, modified RCRA Subtitle C barrier; under Alternative 6B, Option Case, they would be clean closed. In both cases, the highly contaminated soil would be treated at the PPF and the washed soil would be disposed of in the RPPDF.

- The post–administrative control period was assumed to start in CY 2102 and continue through the 10,000-year period of analysis until CY 11,940.

5.1.1.10.2 COPC Drivers

A total of 19 COPCs were analyzed for Tank Closure Alternative 6B. Complete results for all 19 COPCs are tabulated in Appendices M, N, and O, but this discussion of long-term impacts associated with Tank Closure Alternative 6B is focused on the following COPC drivers:

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

The COPC drivers for Tank Closure Alternative 6B were selected by evaluating the risk or hazard associated with all 19 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis, then selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers, although their contributions to risk and hazard are not dominant during the year of peak risk or hazard. Tritium was added to the list of COPC drivers because of its contribution to risk during the early part of the period of analysis. The radiological risk drivers account for essentially 100 percent of the radiological risk. The only predicted chemical risk is from 2,4,6-trichlorophenol, calculated as 1×10^{-11}, which is negligible for purposes of this discussion. The chemical hazard drivers account for 100 percent of the chemical hazard associated with Tank Closure Alternative 6B.

The COPC drivers that are discussed in detail in this section fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these three 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 limited inventories, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.1.1.10.3 Analysis of Release and Mass Balance

This section presents the impacts of Tank Closure Alternative 6B 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 5–263 through 5–274). Three subtotals are plotted, representing releases from cribs and trenches (ditches), past leaks, and other tank farm sources (e.g., tank residuals, ancillary equipment). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over four orders of magnitude within the same series of figures.

Figure 5–263 shows the estimated release to the vadose zone of the radiological risk drivers under the Base Case, which would include use of a modified RCRA Subtitle C barrier, and Figure 5–264, the chemical hazard drivers. The predominant sources of tritium, chromium, and nitrate are the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. For all other COPC drivers, the predominant sources are past leaks. This suggests that past leaks, which were released during the past-practice period, as well as the cribs and trenches (ditches), are both important impact drivers under Tank Closure Alternative 6B, Base Case.

Figure 5–265 shows the estimated release to the vadose zone of the radiological risk drivers under the Option Case, which would include clean closure of cribs and trenches (ditches), and Figure 5–266, the chemical hazard drivers. The predominant sources of tritium, the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), uranium-238, and total uranium are similar to those in the vadose zone under the Base Case.

Figure 5–267 shows the estimated release to groundwater of the radiological risk drivers under the Base Case and Figure 5–268, the chemical hazard drivers. In addition to the total inventory released, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), essentially all of the releases from cribs and trenches (ditches) to the vadose zone reach groundwater; for past leaks, about 80 percent reaches groundwater; and for other tank farm sources, less than 30 percent reaches groundwater.

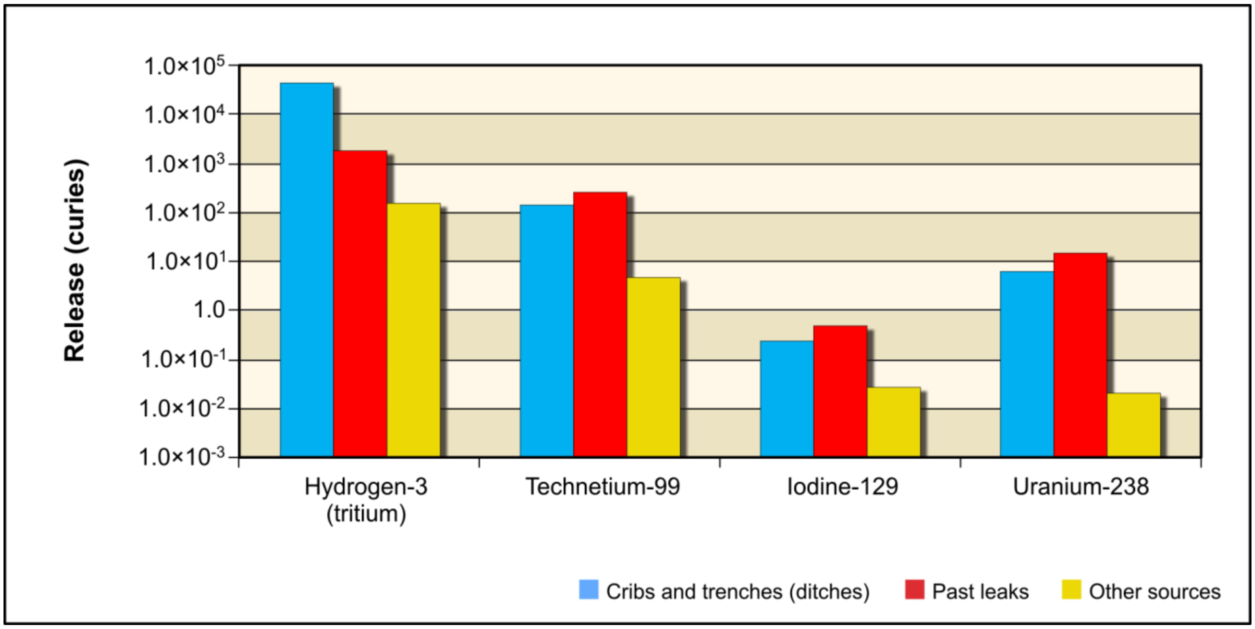


Figure 5–263. Tank Closure Alternative 6B, Base Case, Releases of Radioactive Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

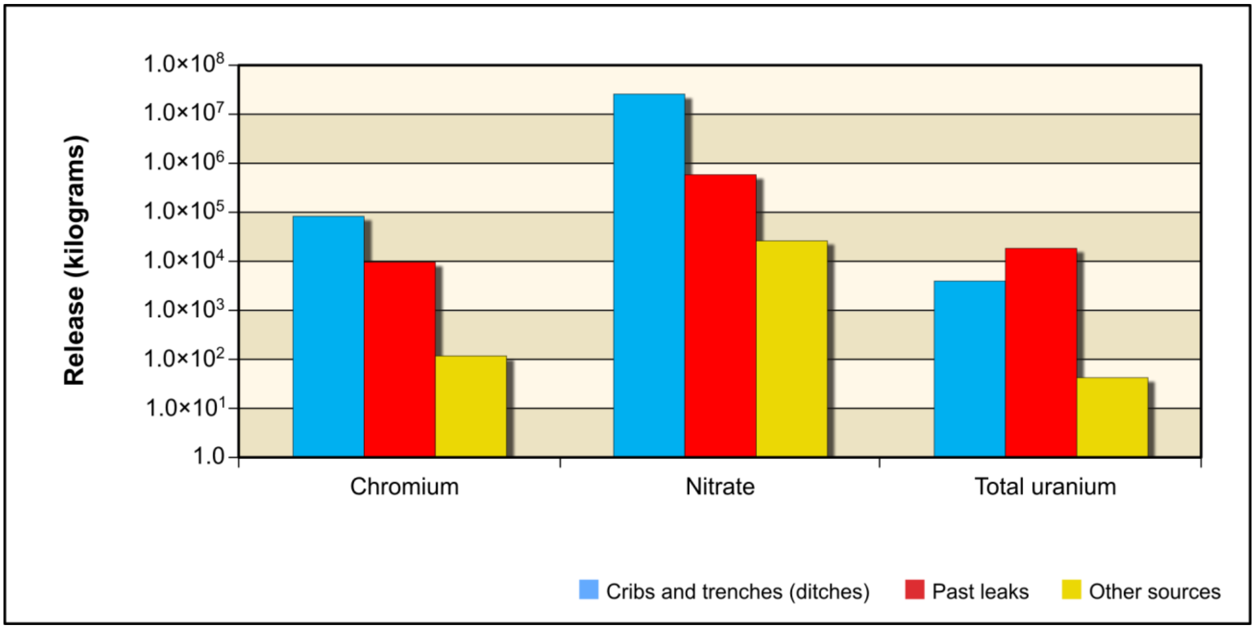


Figure 5–264. Tank Closure Alternative 6B, Base Case, Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

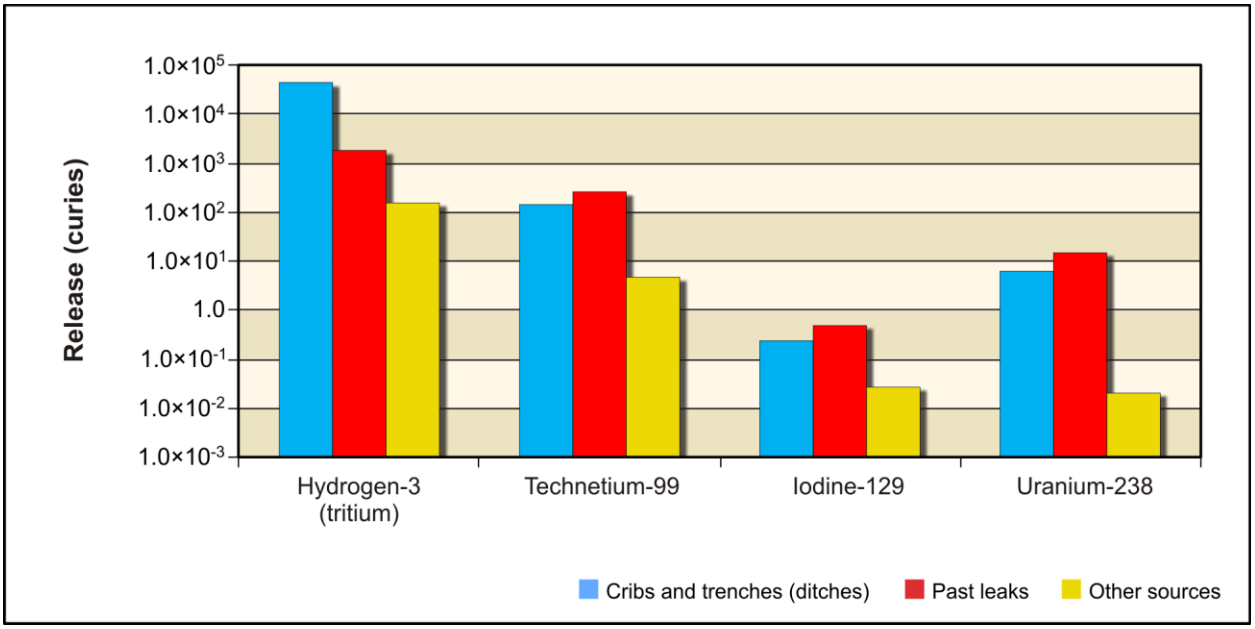


Figure 5–265. Tank Closure Alternative 6B, Option Case, Releases of Radioactive Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

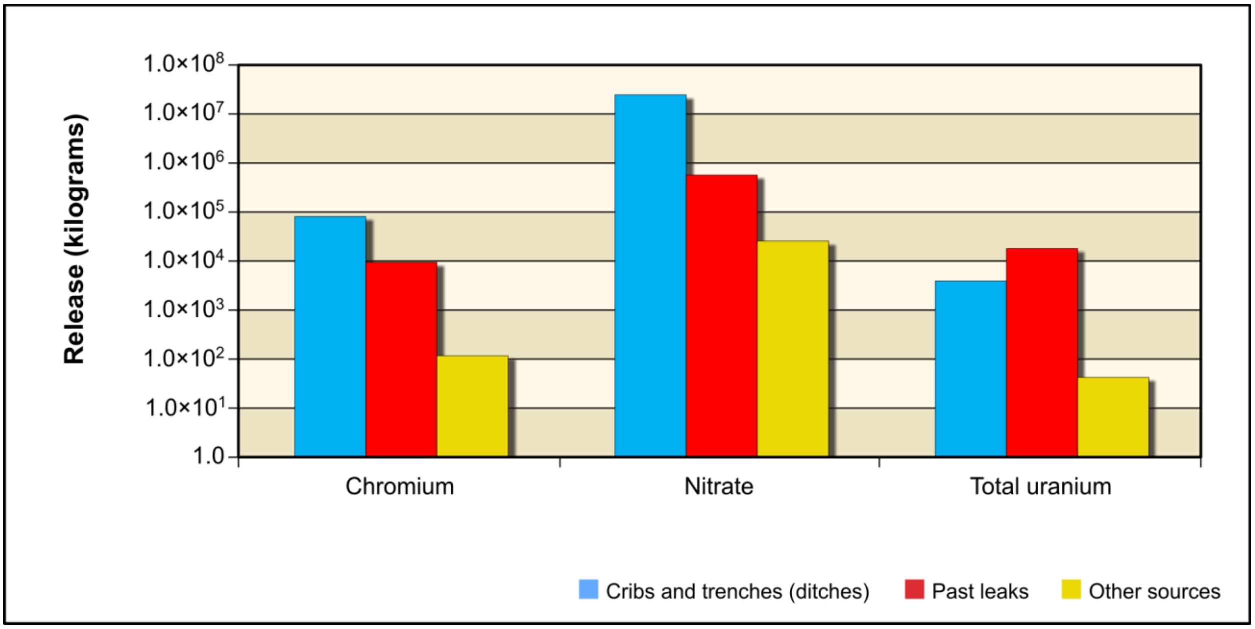


Figure 5–266. Tank Closure Alternative 6B, Option Case, Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

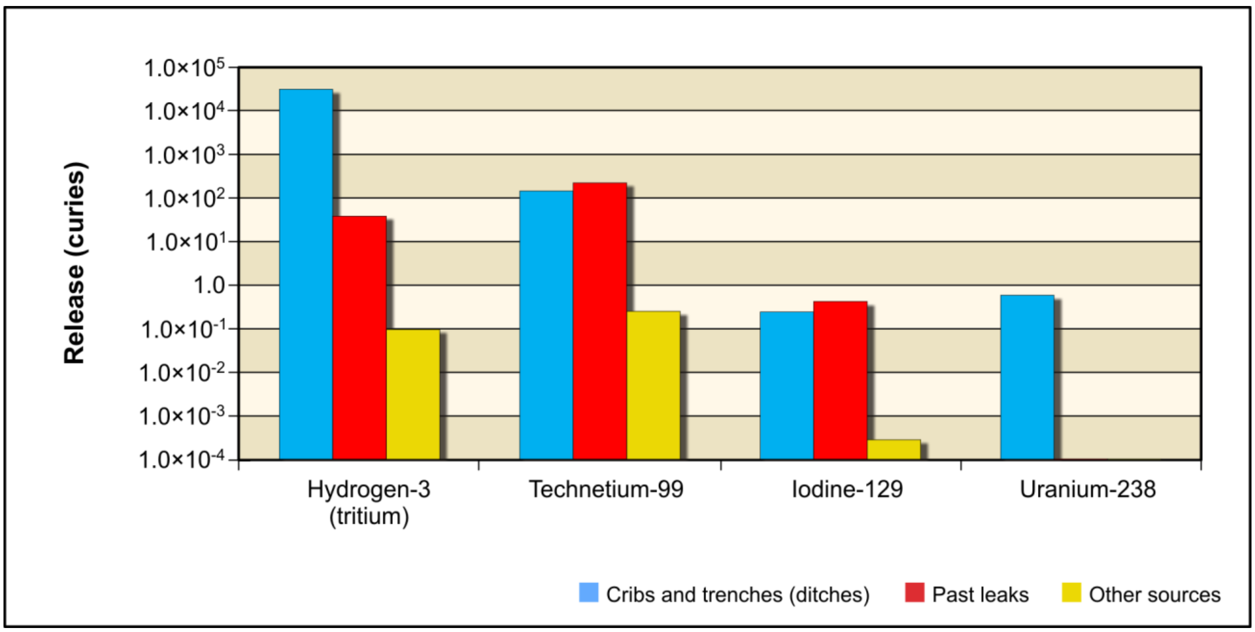


Figure 5–267. Tank Closure Alternative 6B, Base Case, Releases of Radioactive Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

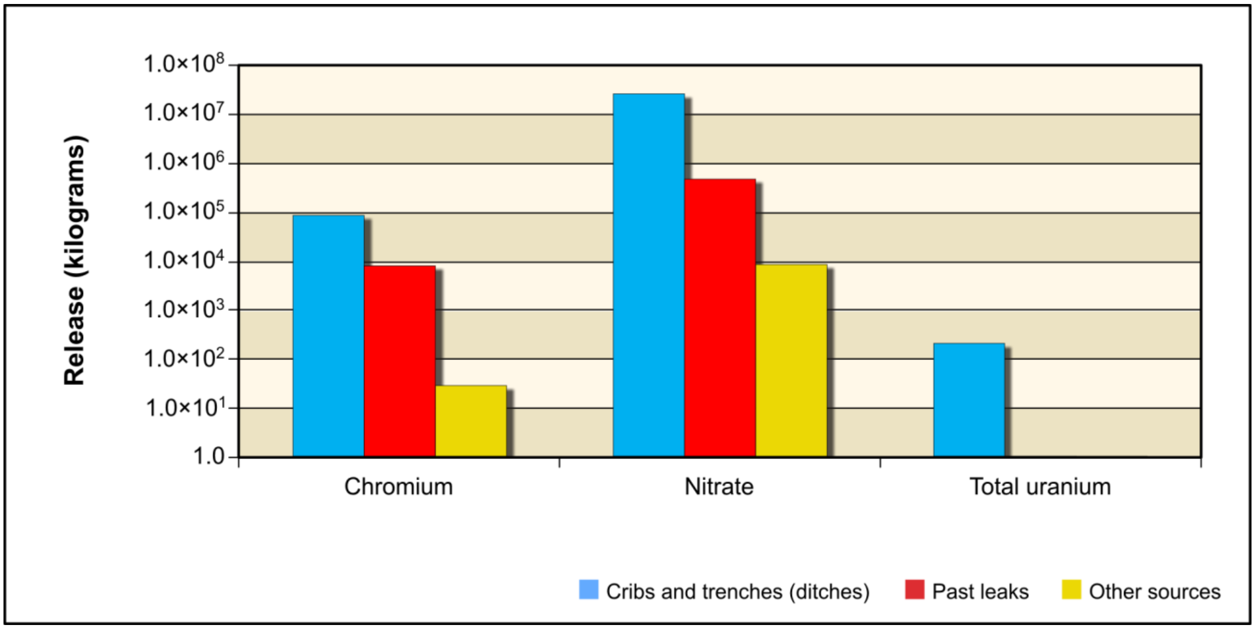


Figure 5–268. Tank Closure Alternative 6B, Base Case, Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For tritium under the Base Case, the amount released to groundwater is attenuated by radioactive decay. For cribs and trenches (ditches), about 71 percent of the total inventory reaches groundwater in the analysis; for past leaks, only 2 percent reaches groundwater; and for other tank farm sources, less than 1 percent reaches groundwater. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches) and that radioactive decay of tritium is an important attenuation process. They also suggest that uranium-238 and total uranium impacts on groundwater would occur later in the post–administrative control period because of the long travel times in the vadose zone for these COPCs.

Figure 5–269 shows the estimated release to groundwater of the radiological risk drivers under the Option Case and Figure 5–270, the chemical hazard drivers. In addition to the total inventory released, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater ranges from about 20 to 40 percent less than the amount released to the vadose zone.

For uranium-238 and total uranium under the Base Case, the amount released to groundwater is less than that released to the vadose zone because of vadose zone retention. The amount of this retention depends on the type of contaminant source, specifically volume and timing of moisture movement through the vadose zone. For releases from cribs and trenches (ditches), where moisture movement through the vadose zone is relatively rapid (because of the volume of water associated with the source), less than 10 percent of the total inventory reaches groundwater during the period of analysis. For past leaks and other sources, essentially none of the total inventory reaches groundwater during the period of analysis.

Under the Option Case, essentially none of the uranium-238 and total uranium inventories released to the vadose zone enter groundwater. Because of the long travel times in the vadose zone for these COPCs, much of what was released would be collected and treated when the cribs and trenches (ditches) are removed and their deep plumes remediated.

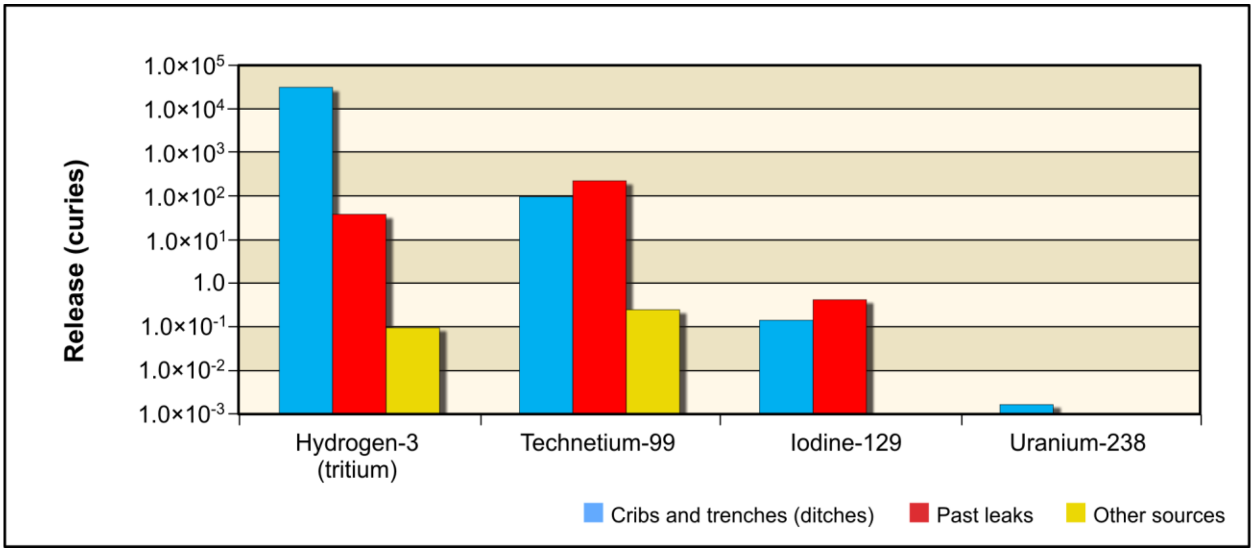


Figure 5–269. Tank Closure Alternative 6B, Option Case, Releases of Radioactive Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

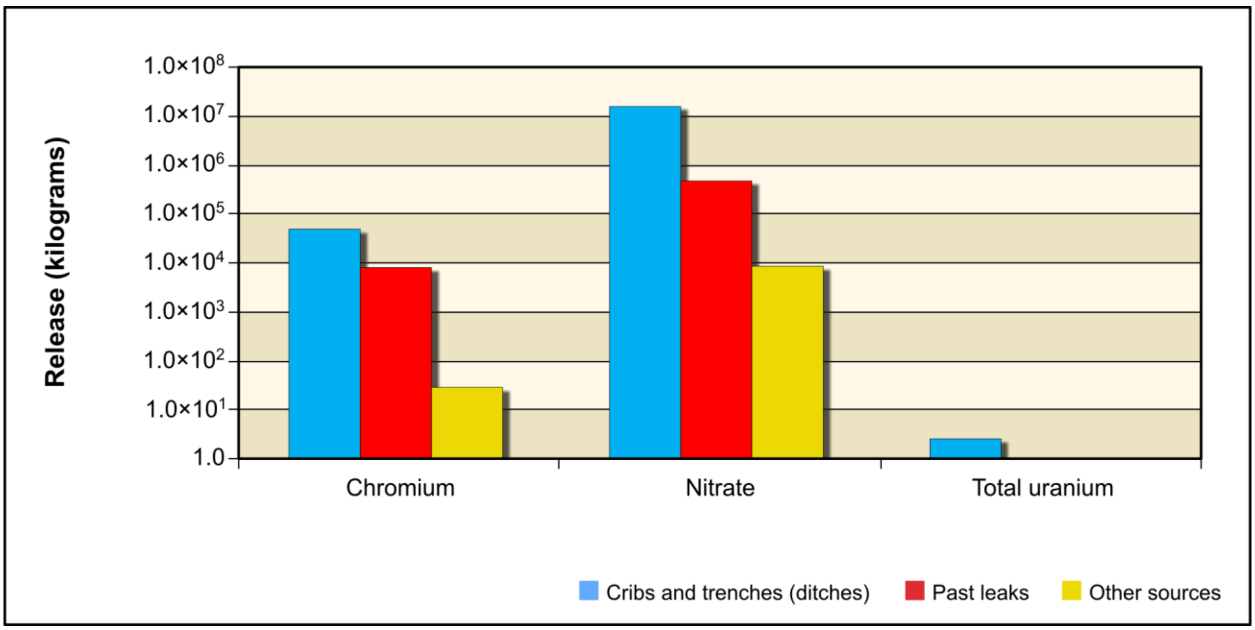


Figure 5–270. Tank Closure Alternative 6B, Option Case, Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For tritium under the Option Case, the amount released to groundwater is attenuated by radioactive decay. For cribs and trenches (ditches), about 71 percent of the total inventory reaches groundwater in the analysis; for past leaks, only 2 percent; and for other tank farm sources, less than one-tenth of 1 percent. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches) and that radioactive decay of tritium is an important attenuation process. They also suggest that uranium-238 and total uranium impacts on groundwater would decrease over time because the long travel times in the vadose zone for these COPCs allow much of what was released to be collected and treated when the cribs and trenches (ditches) are removed and their deep plumes remediated.

Figure 5–271 shows the estimated release to the Columbia River of the radiological risk drivers under the Base Case and Figure 5–272, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater.

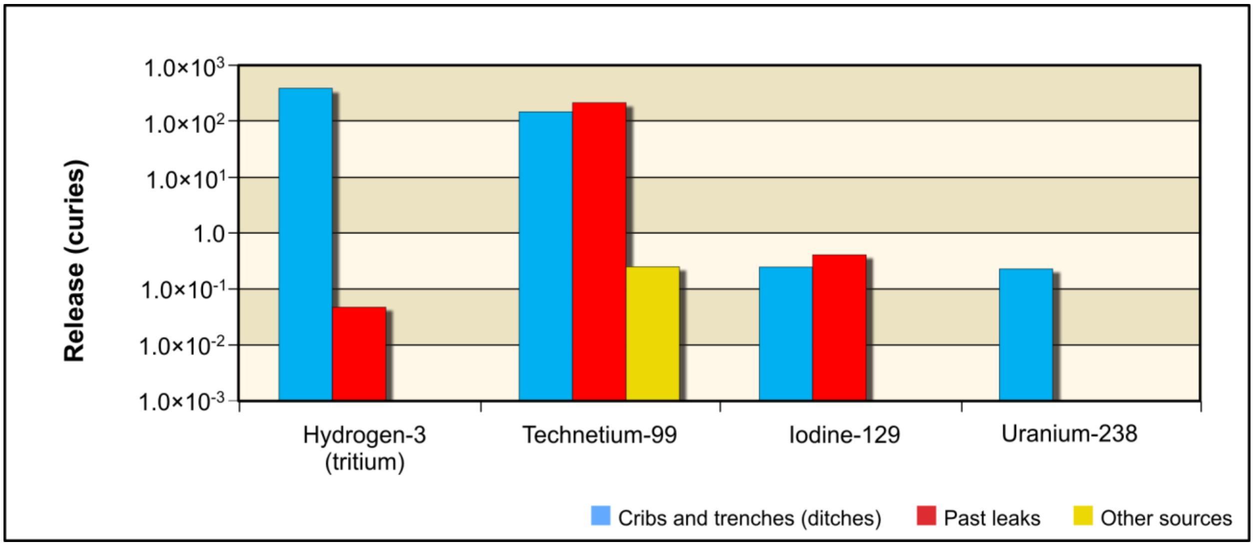


Figure 5–271. Tank Closure Alternative 6B, Base Case, Releases of Radioactive Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

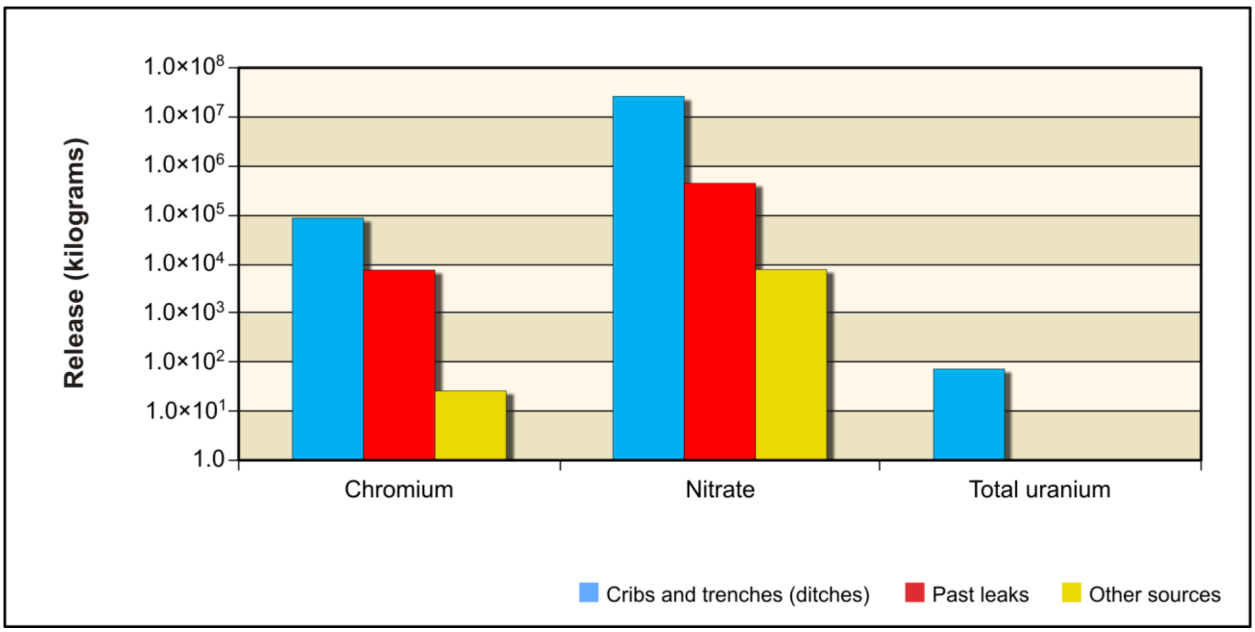


Figure 5–272. Tank Closure Alternative 6B, Base Case, Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium under the Base Case, the amount released to the Columbia River is less than that released to groundwater because of retardation. For cribs and trenches (ditches), less than 40 percent of the amount released to groundwater during the period of analysis reaches the Columbia River.

For tritium under the Base Case, the amount released to the Columbia River is attenuated by radioactive decay. For cribs and trenches (ditches), only about 1 percent of the tritium released to groundwater reaches the Columbia River during the period of analysis. For past leaks and other sources, less than 1 percent of the tritium released to groundwater reaches the Columbia River. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. They also suggest that uranium-238 and total uranium impacts on the Columbia River would occur later in the post-administrative control period because of the long travel times in the vadose zone and through the groundwater system for these COPCs.

Figure 5–273 shows the estimated release to the Columbia River of the radiological risk drivers under the Option Case and Figure 5–274, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater.

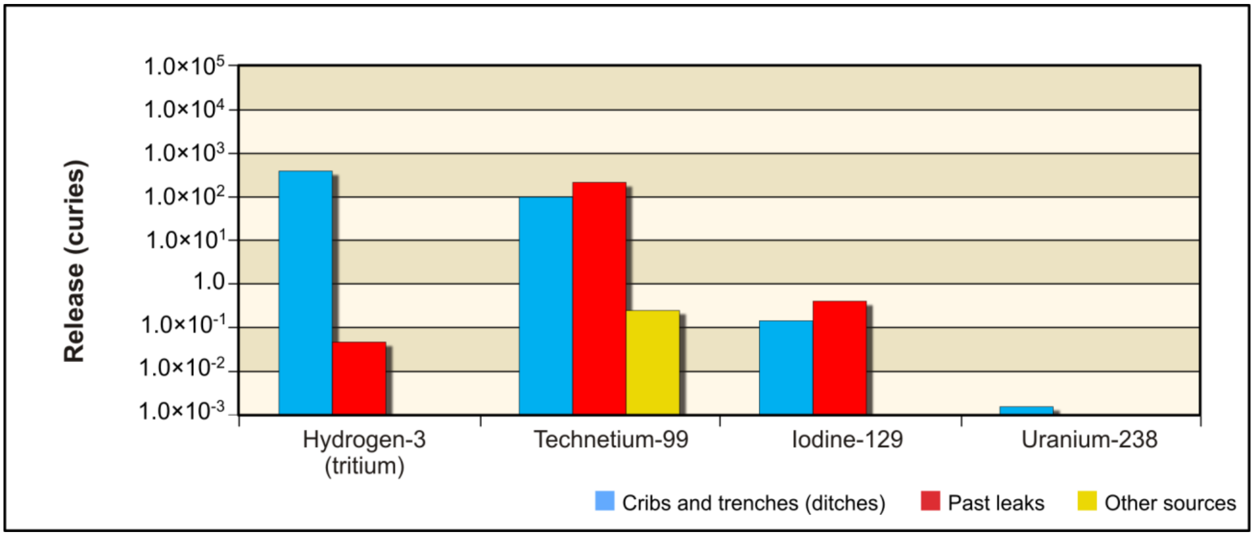


Figure 5–273. Tank Closure Alternative 6B, Option Case, Releases of Radioactive Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

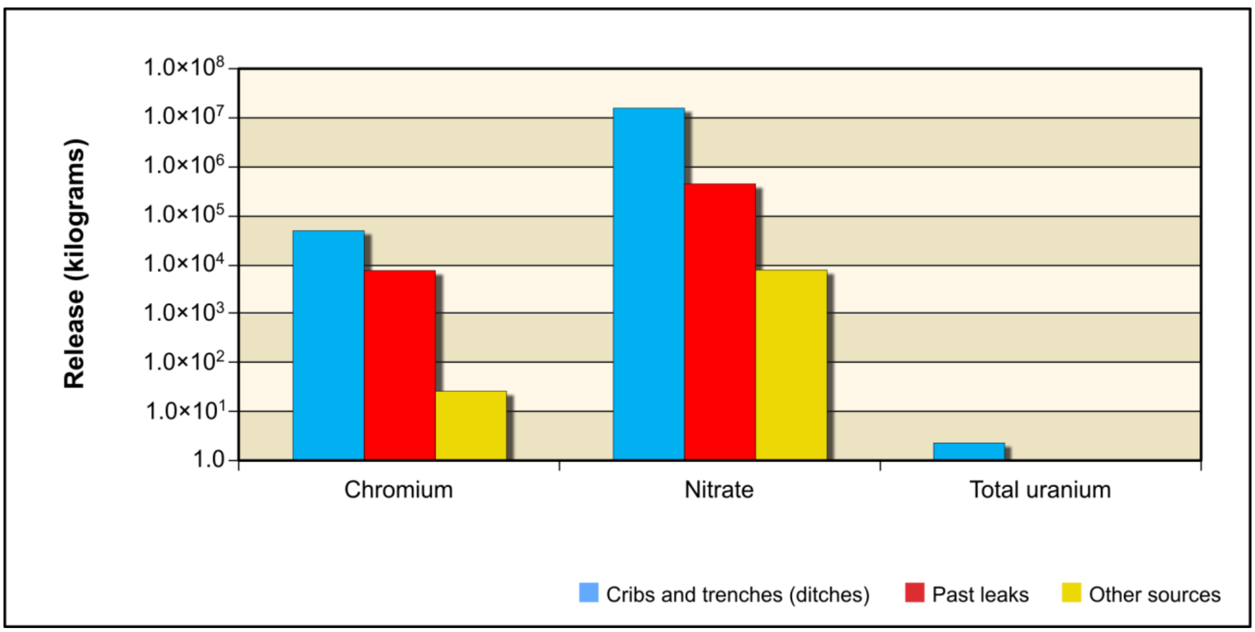


Figure 5–274. Tank Closure Alternative 6B, Option Case, Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium, the amount released to the Columbia River from groundwater is effectively zero, as essentially no uranium reaches groundwater from the vadose zone. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. For cribs and trenches (ditches), only about 1 percent of the tritium released to groundwater reaches the Columbia River during the period of analysis. For past leaks and other sources, less than 1 percent of the tritium released to groundwater reaches the Columbia River. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. They also suggest that uranium-238 and total uranium would not impact the Columbia River, as much of what was released would be collected when the cribs and trenches (ditches) are removed and their deep plumes remediated.

5.1.1.10.4 Analysis of Concentration Versus Time

This section presents the analysis of Tank Closure Alternative 6B impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter (see Tables 5–14 and 5–15 and Figures 5–275 through 5–288). The benchmark concentration of each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Tables 5–14 and 5–15 list the maximum concentrations under the Base and Option Cases of the COPCs in the peak year after CY 2050 at the tank farm barriers, Core Zone Boundary, and Columbia River nearshore. Under Tank Closure Alternative 6B, Base Case, tritium, uranium-238, and total uranium never exceed their benchmark concentrations at any location beyond CY 2050. The highest impact occurs at B, S, and T Barriers and the Core Zone Boundary, where concentrations of technetium-99, iodine-129, chromium, and nitrate approach their respective benchmark concentrations. At the Columbia River nearshore, iodine-129 approaches the benchmark concentration after CY 2050. The results for Tank Closure Alternative 6B, Option Case, are similar to those for Tank Closure Alternative 6B, Base Case.

Table 5–14. Tank Closure Alternative 6B, Base Case, Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide (picocuries per liter)								
Hydrogen-3 (tritium)	7 (2050)	572 (2052)	30 (2050)	2,870 (2050)	14 (2050)	627 (2051)	477 (2051)	20,000
Technetium-99	875 (2093)	**3,480** (2056)	**1,490** (2050)	**6,450** (2051)	137 (2067)	**3,480** (2056)	358 (2221)	900
Iodine-129	**1.6** (2095)	**4.6** (2092)	**2.9** (2051)	**12.7** (2050)	0.2 (2073)	**4.6** (2092)	0.7 (2217)	1
Chemical (micrograms per liter)								
Chromium	77 (2097)	**215** (2050)	**158** (2051)	**353** (2051)	6 (2050)	**215** (2050)	71 (2076)	100
Nitrate	16,600 (2172)	**171,000** (2055)	4,590 (2051)	**61,900** (2053)	407 (2051)	**171,000** (2055)	17,200 (2122)	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.

Table 5–15. Tank Closure Alternative 6B, Option Case, Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide (picocuries per liter)								
Hydrogen-3 (tritium)	8 (2051)	573 (2051)	30 (2050)	2,450 (2054)	14 (2050)	661 (2050)	490 (2050)	20,000
Technetium-99	875 (2093)	**3,760** (2065)	**1,490** (2050)	**6,450** (2051)	137 (2067)	**3,760** (2065)	351 (2275)	900
Iodine-129	**1.6** (2095)	**5.0** (2064)	**2.9** (2051)	**12.7** (2050)	0.2 (2073)	**5.0** (2064)	0.7 (2217)	1
Chemical (micrograms per liter)								
Chromium	75 (2097)	**196** (2087)	**158** (2051)	**337** (2050)	6 (2050)	**196** (2087)	60 (2074)	100
Nitrate	12,300 (2247)	**200,000** (2077)	4,590 (2051)	**64,000** (2051)	407 (2051)	**200,000** (2077)	15,500 (2138)	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.

Figure 5–275 shows the concentration versus time for tritium under the Base Case. Releases from cribs and trenches (ditches) cause the groundwater concentrations at the Core Zone Boundary to exceed the benchmark concentration by one to two orders of magnitude for a short period of time during the early part of the period of analysis. This time period is represented by the first series of sharp inflections in the curve for the Core Zone Boundary from approximately CY 1955 until CY 1980. During the same period of time, the Columbia River nearshore concentrations approach but never reach the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration.

The concentrations of tritium versus time under the Option Case are essentially identical to those under the Base Case (see Figure 5–276).

Figures 5–277 through 5–280 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers) under the Base Case. All of the conservative tracers show similar patterns. Releases from cribs and trenches (ditches) cause groundwater concentrations at the Core Zone Boundary to exceed benchmark concentrations by one to two orders of magnitude during the early part of the period of analysis, around CY 1956. The Columbia River nearshore concentrations approach the benchmark for a brief time during the early period of analysis but decrease to about two to three orders of magnitude below the benchmark by the end of the period of analysis.

The concentrations of iodine-129, technetium-99, chromium, and nitrate (the conservative tracers) versus time under the Option Case are essentially identical to those under the Base Case, except concentrations at the Core Zone Boundary decrease at a much faster rate; concentrations range over seven orders of magnitude below the benchmark by the end of the period of analysis. Concentrations at the Columbia River nearshore level out to about three orders of magnitude below the benchmark from about CY 6000 until the end of the period of analysis (see Figures 5–281 through 5–284).

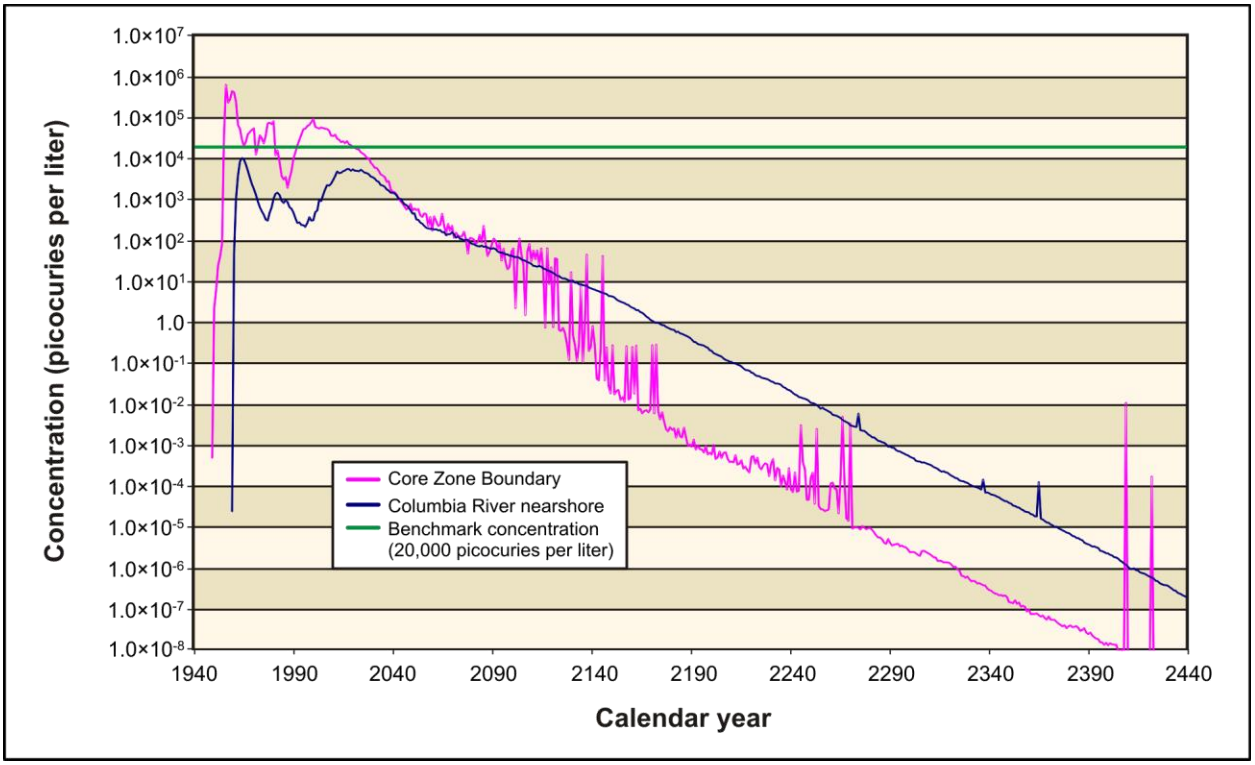


Figure 5–275. Tank Closure Alternative 6B, Base Case, Hydrogen-3 (Tritium) Concentration Versus Time

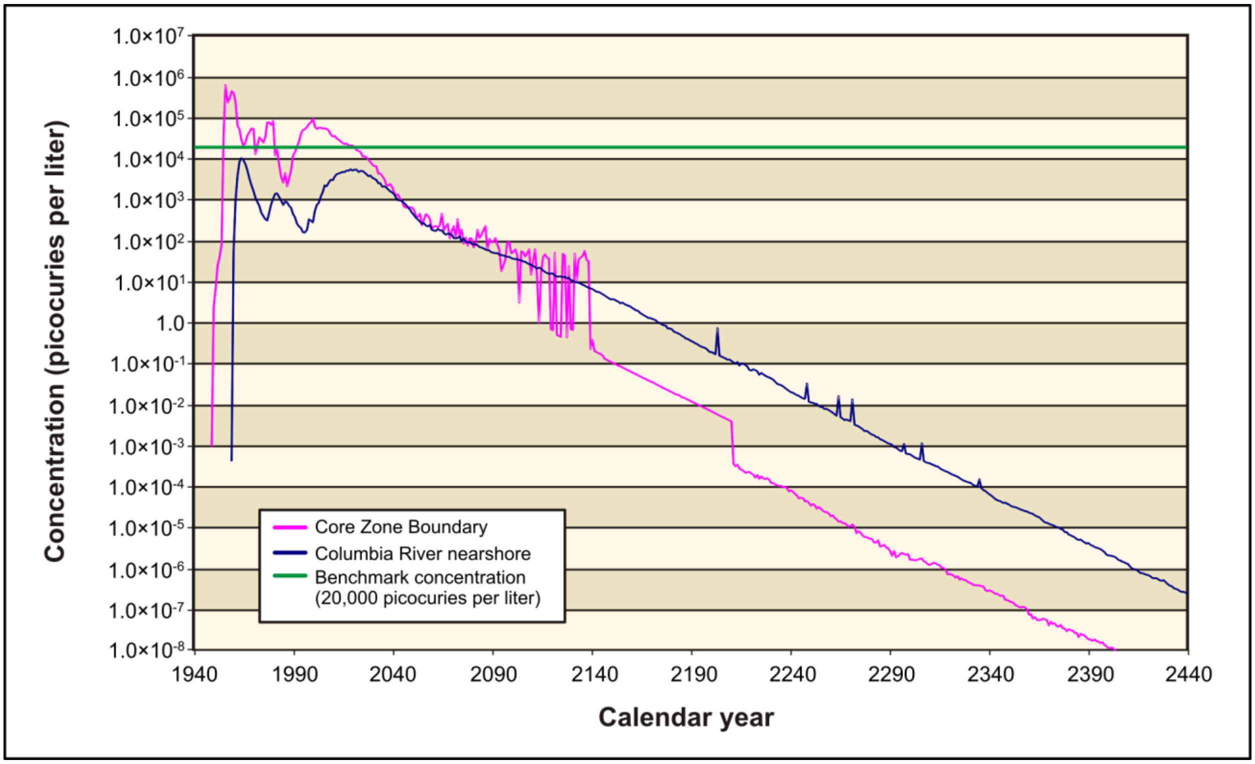


Figure 5–276. Tank Closure Alternative 6B, Option Case, Hydrogen-3 (Tritium) Concentration Versus Time

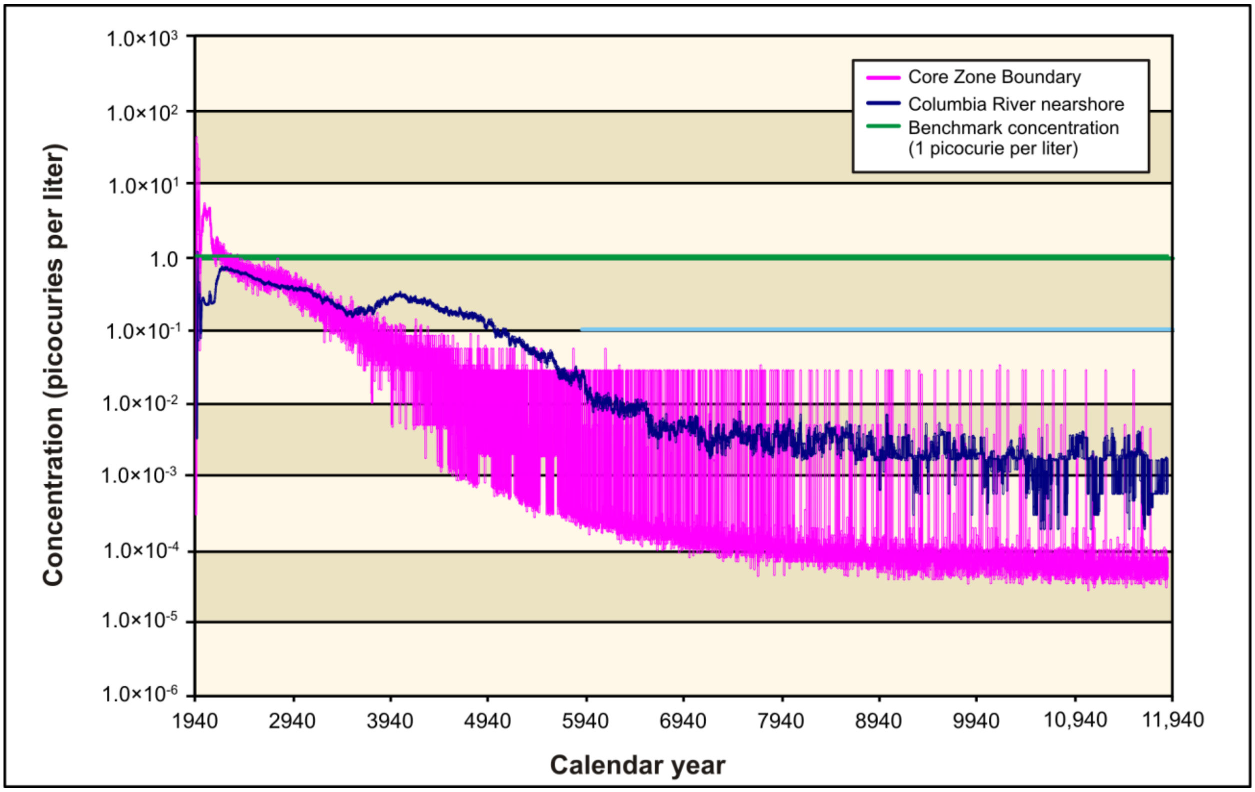


Figure 5–277. Tank Closure Alternative 6B, Base Case, Iodine-129 Concentration Versus Time

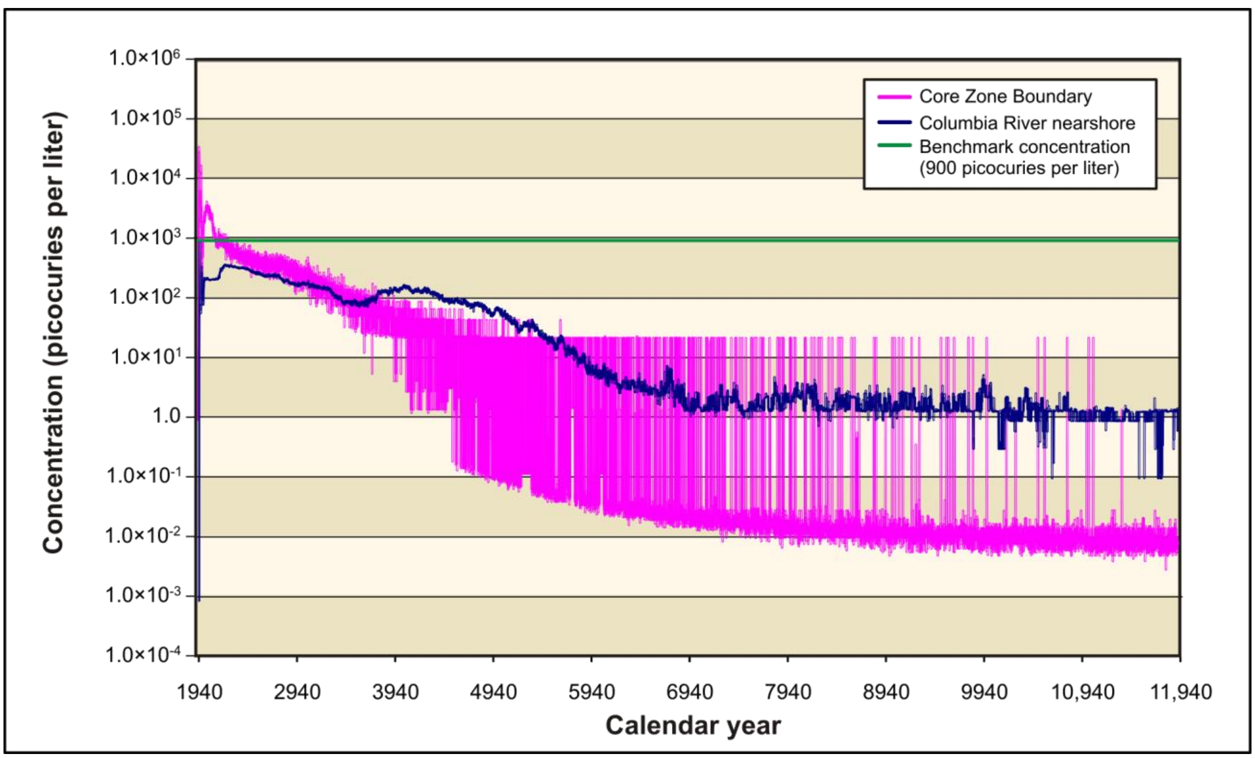


Figure 5–278. Tank Closure Alternative 6B, Base Case, Technetium-99 Concentration Versus Time

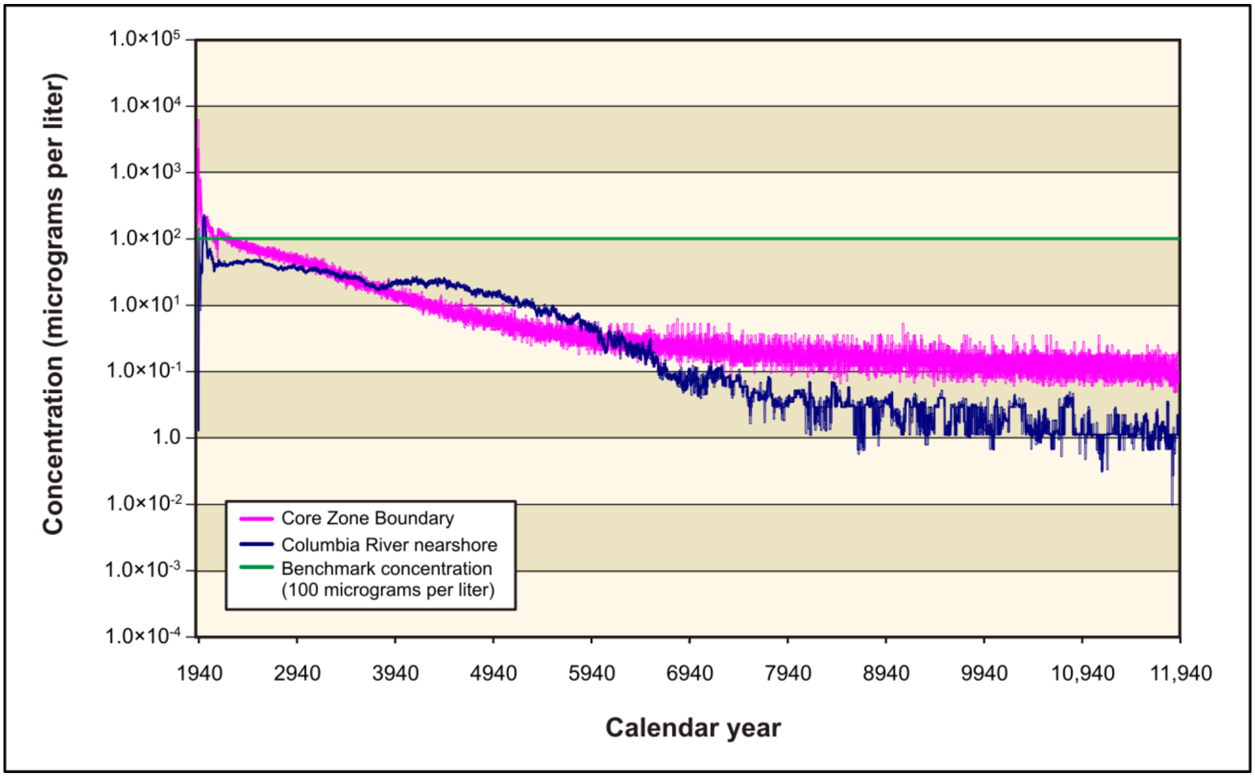


Figure 5–279. Tank Closure Alternative 6B, Base Case, Chromium Concentration Versus Time

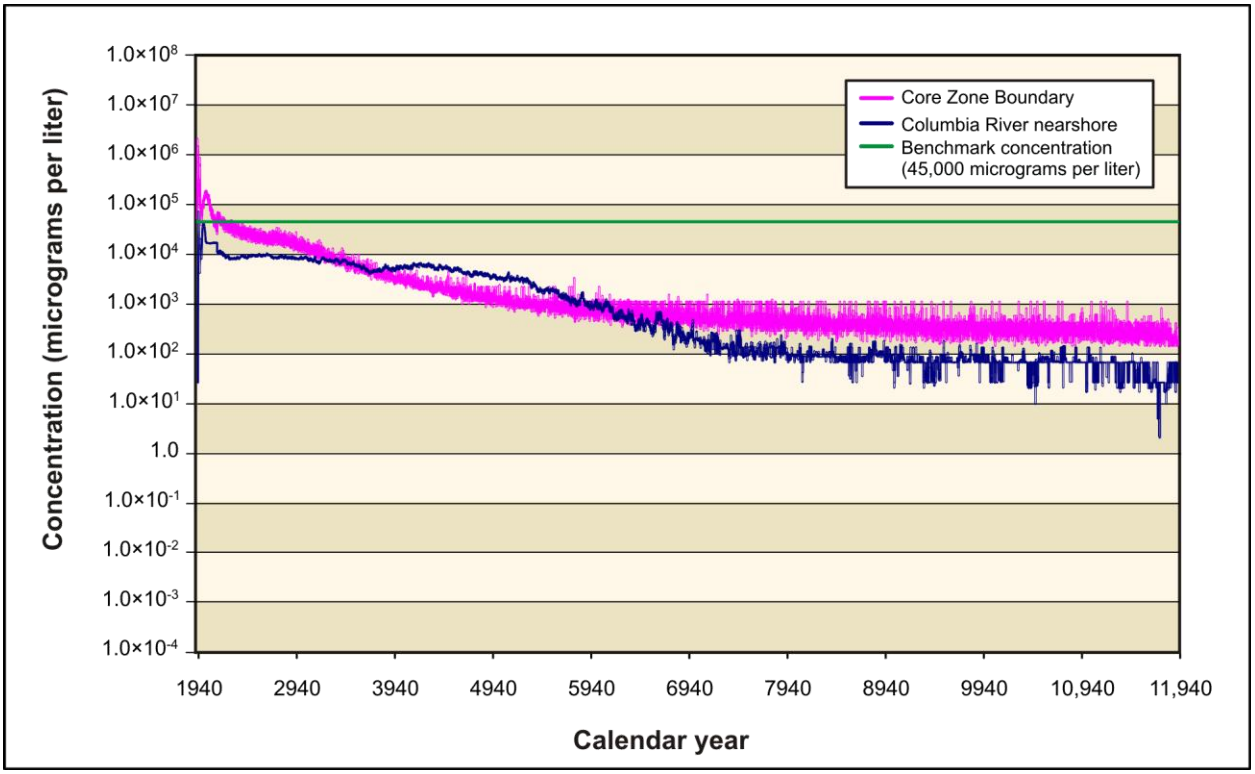


Figure 5–280. Tank Closure Alternative 6B, Base Case, Nitrate Concentration Versus Time

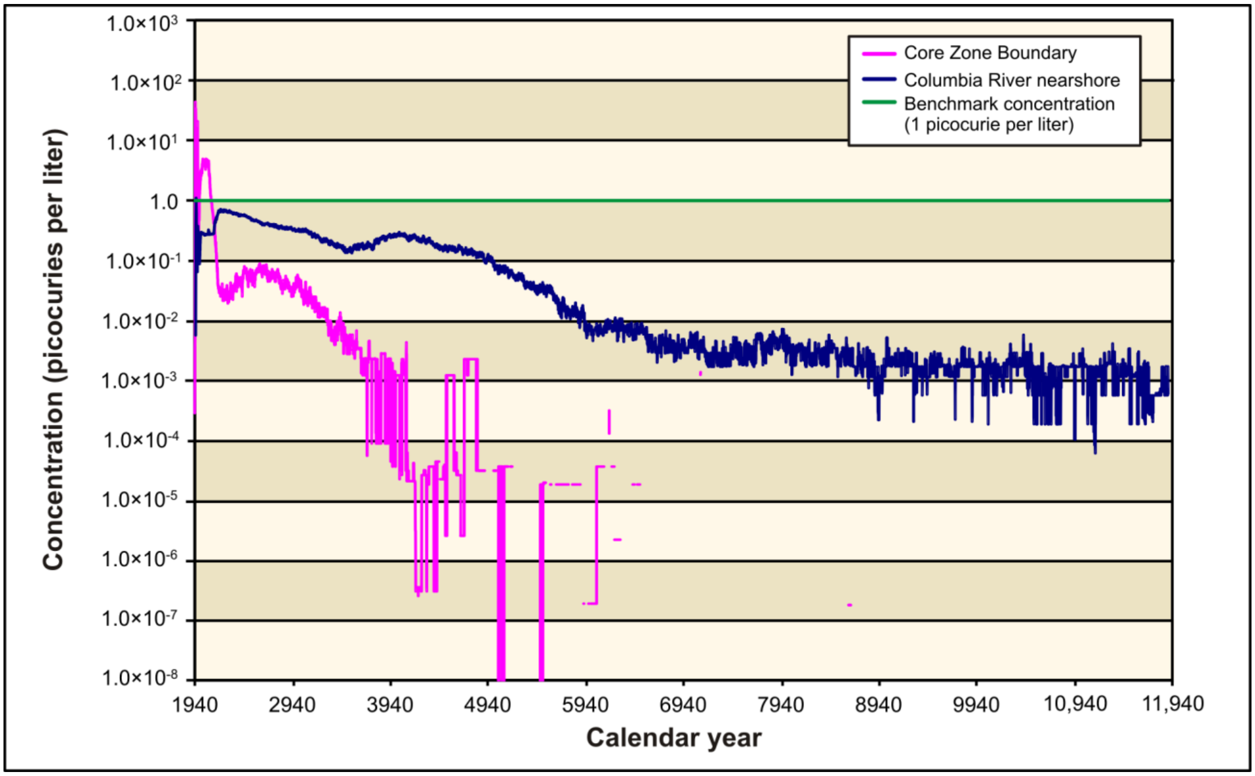


Figure 5–281. Tank Closure Alternative 6B, Option Case, Iodine-129 Concentration Versus Time

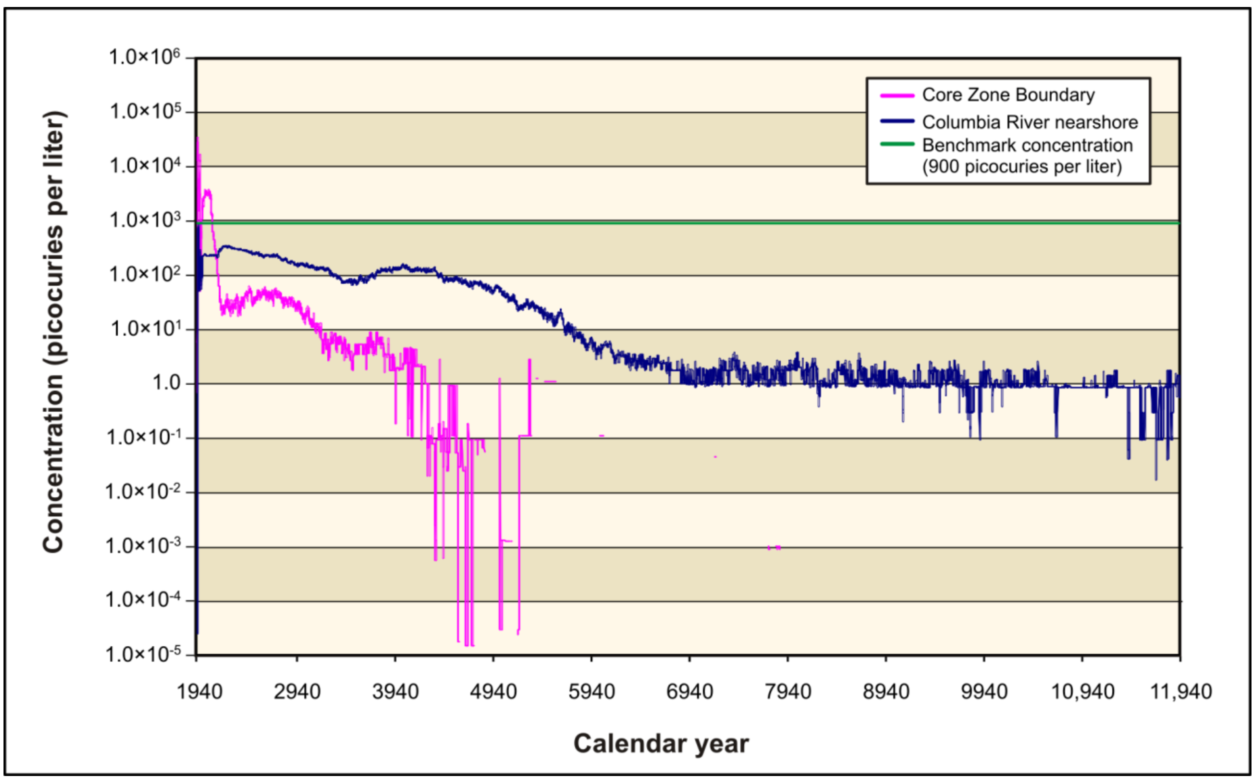


Figure 5–282. Tank Closure Alternative 6B, Option Case, Technetium-99 Concentration Versus Time

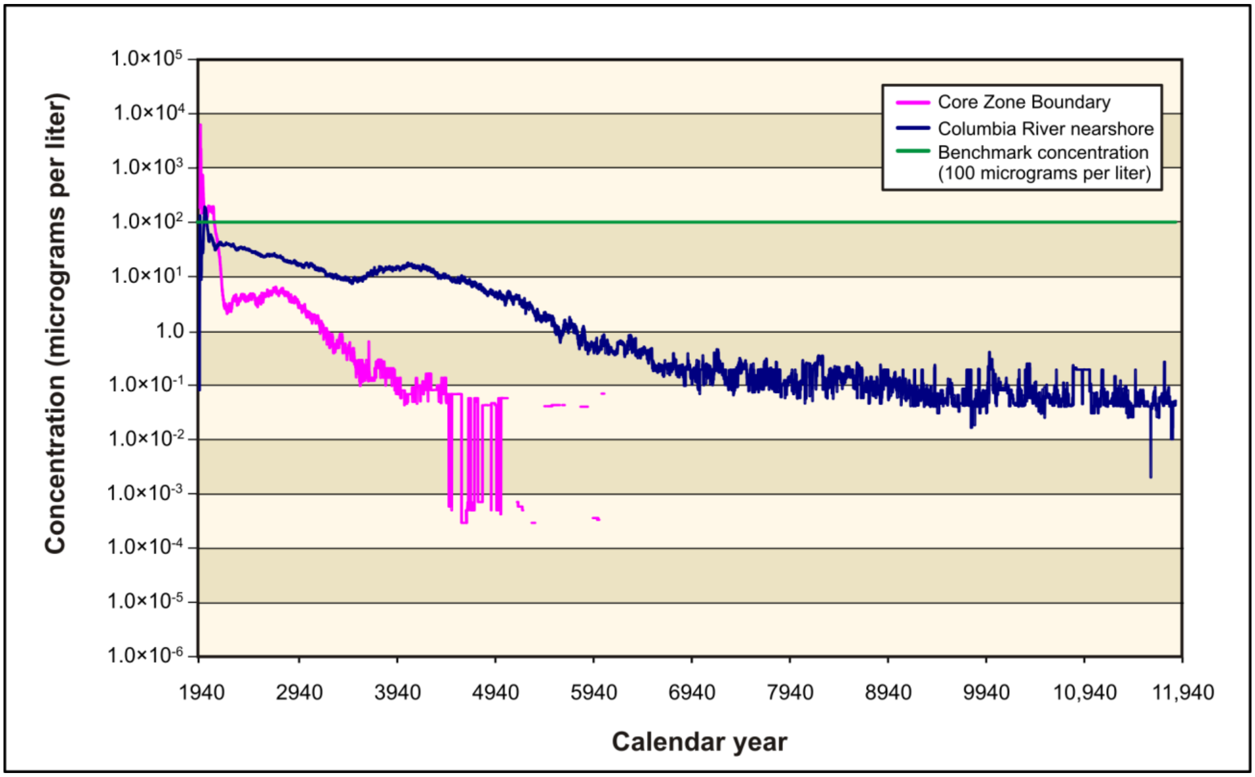


Figure 5–283. Tank Closure Alternative 6B, Option Case, Chromium Concentration Versus Time

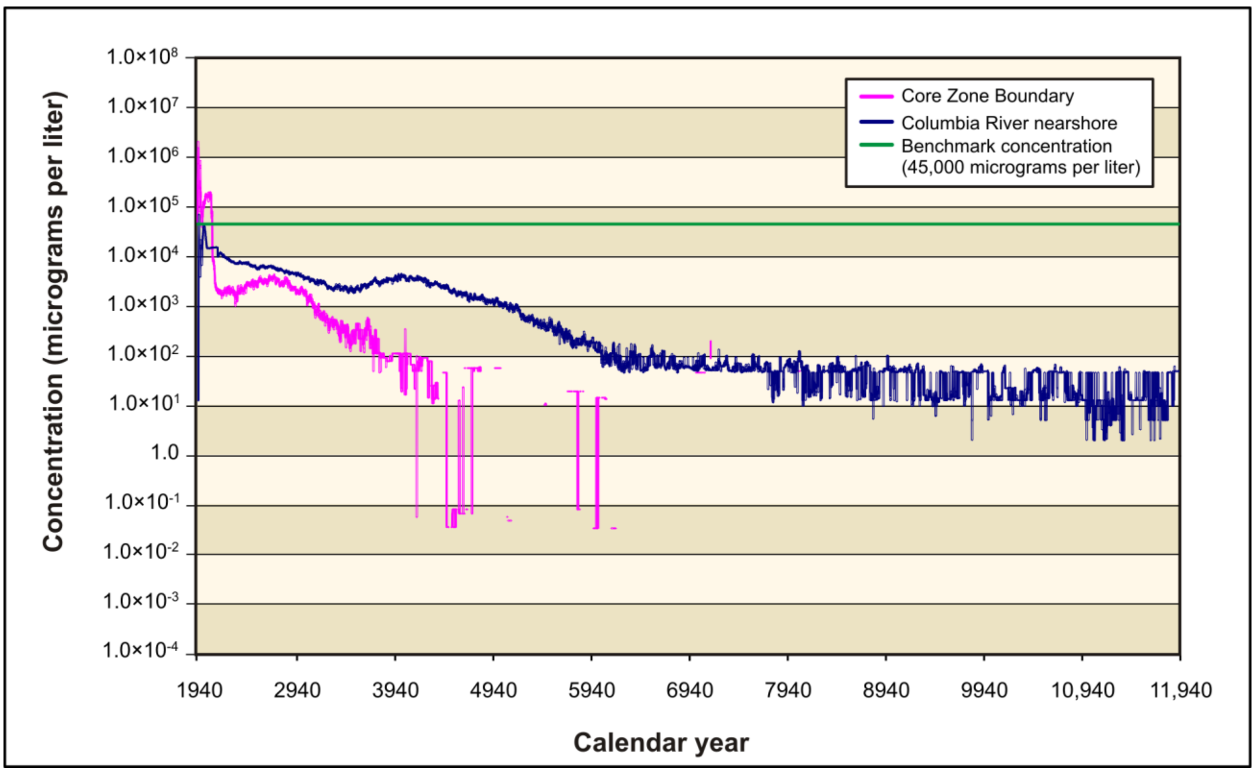


Figure 5–284. Tank Closure Alternative 6B, Option Case, Nitrate Concentration Versus Time

Figures 5–285 and 5–286 show concentration versus time for uranium-238 and total uranium under the Base Case. Although uranium-238 concentrations at the Core Zone Boundary begin to approach the benchmark toward the latter part of the period of analysis, they never reach it. Total uranium concentrations at the Core Zone Boundary also begin to increase toward the end of the period of analysis but never reach within about two orders of magnitude of the benchmark. The concentration levels of uranium-238 and total uranium at the Columbia River nearshore never reach within about two to three orders of magnitude below the benchmark.

Under the Option Case, uranium-238 concentrations at the Core Zone Boundary peak at about two orders of magnitude below the benchmark at the beginning of the period of analysis (see Figure 5–287). Around CY 3000, the uranium-238 Core Zone Boundary concentrations drastically fall to over nine orders of magnitude below the benchmark, while the Columbia River nearshore concentrations of uranium-238 stay fairly constant at about five orders of magnitude below the benchmark. Total uranium concentrations are essentially identical to uranium-238 concentrations (see Figure 5–288).

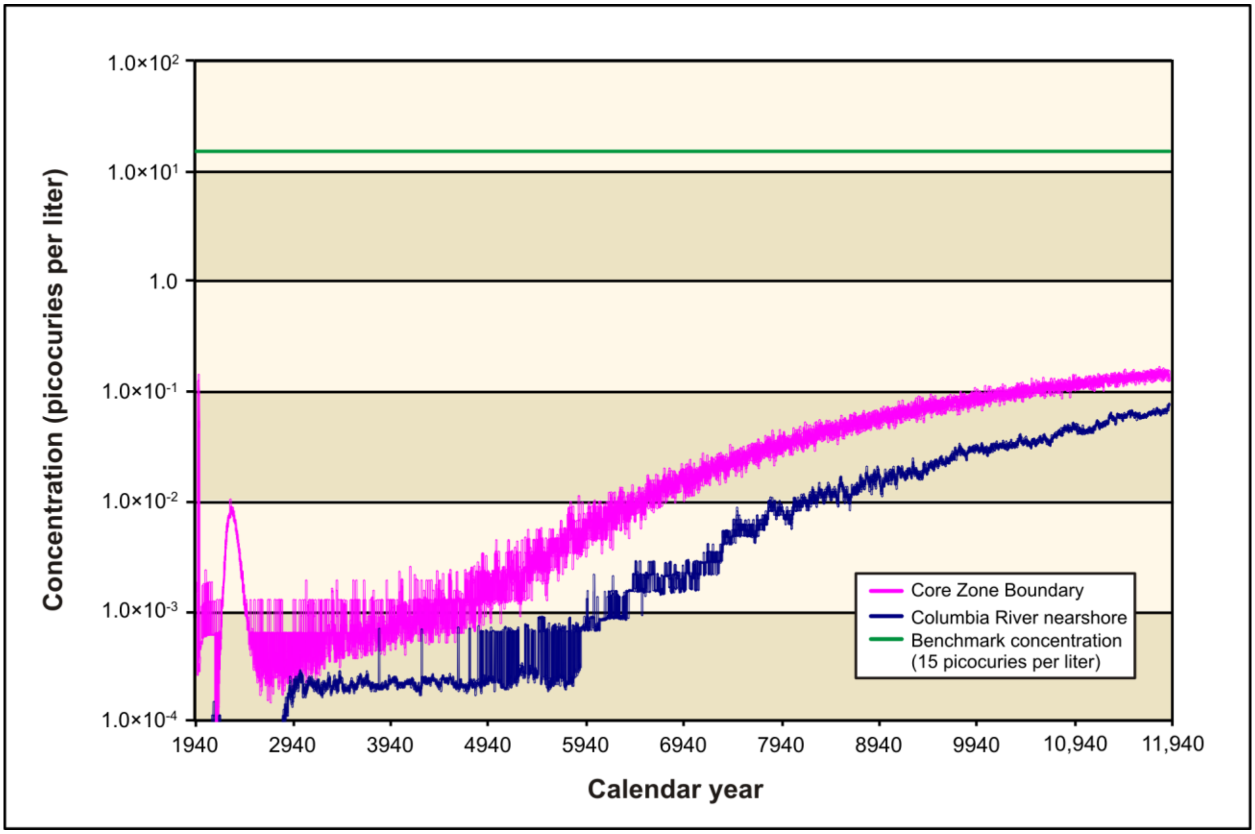


Figure 5–285. Tank Closure Alternative 6B, Base Case, Uranium-238 Concentration Versus Time

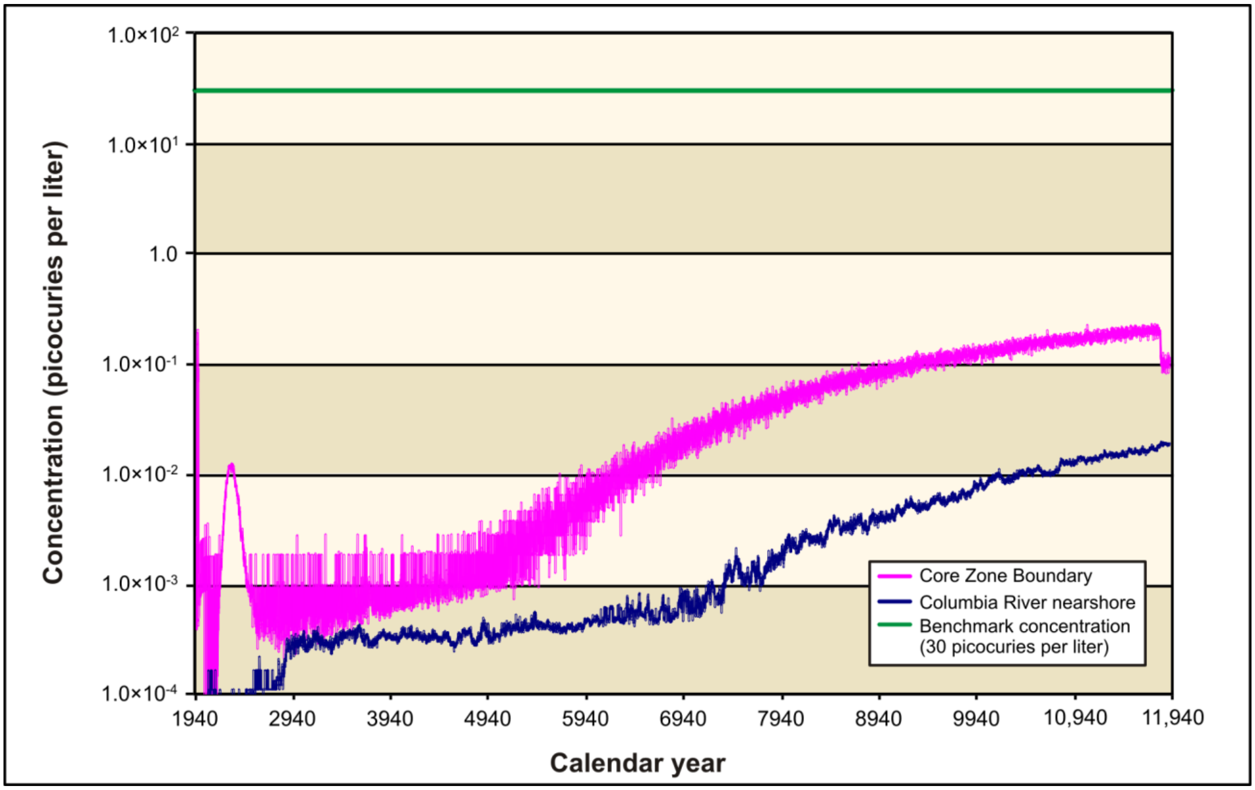


Figure 5–286. Tank Closure Alternative 6B, Base Case, Total Uranium Concentration Versus Time

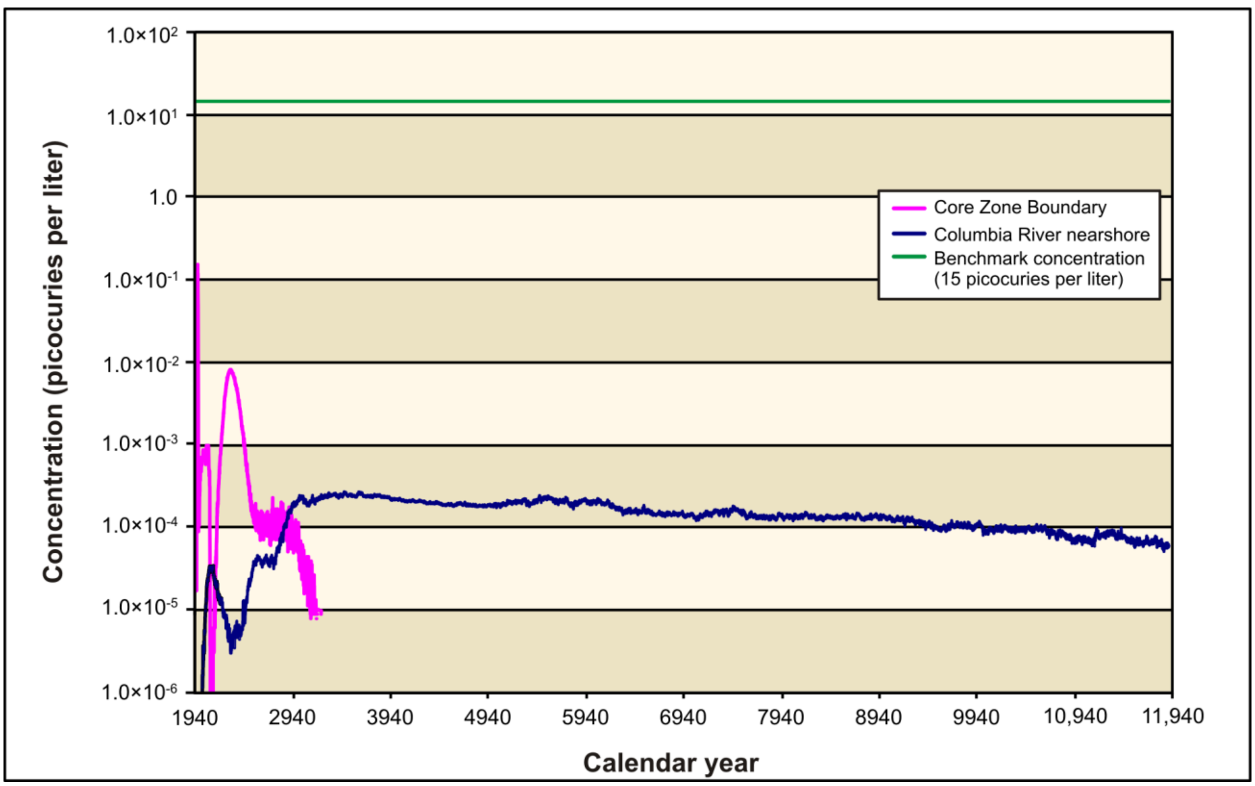


Figure 5–287. Tank Closure Alternative 6B, Option Case, Uranium-238 Concentration Versus Time

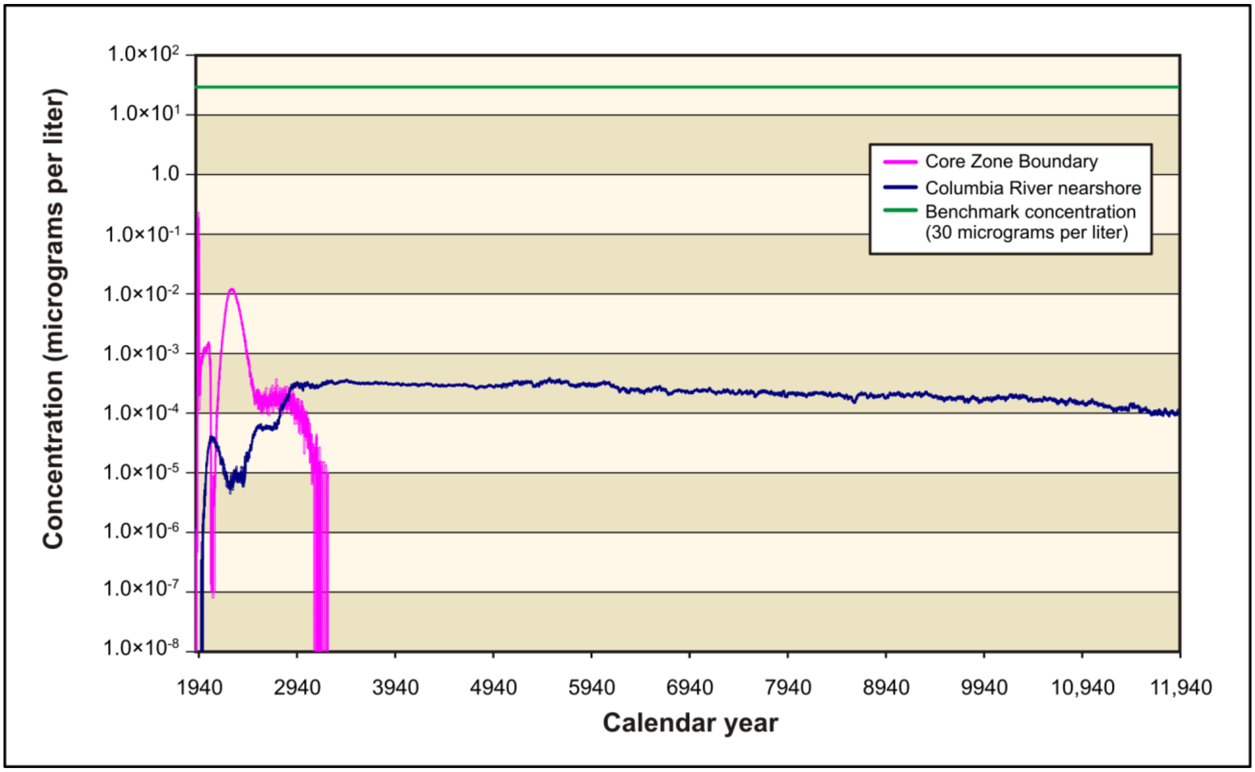
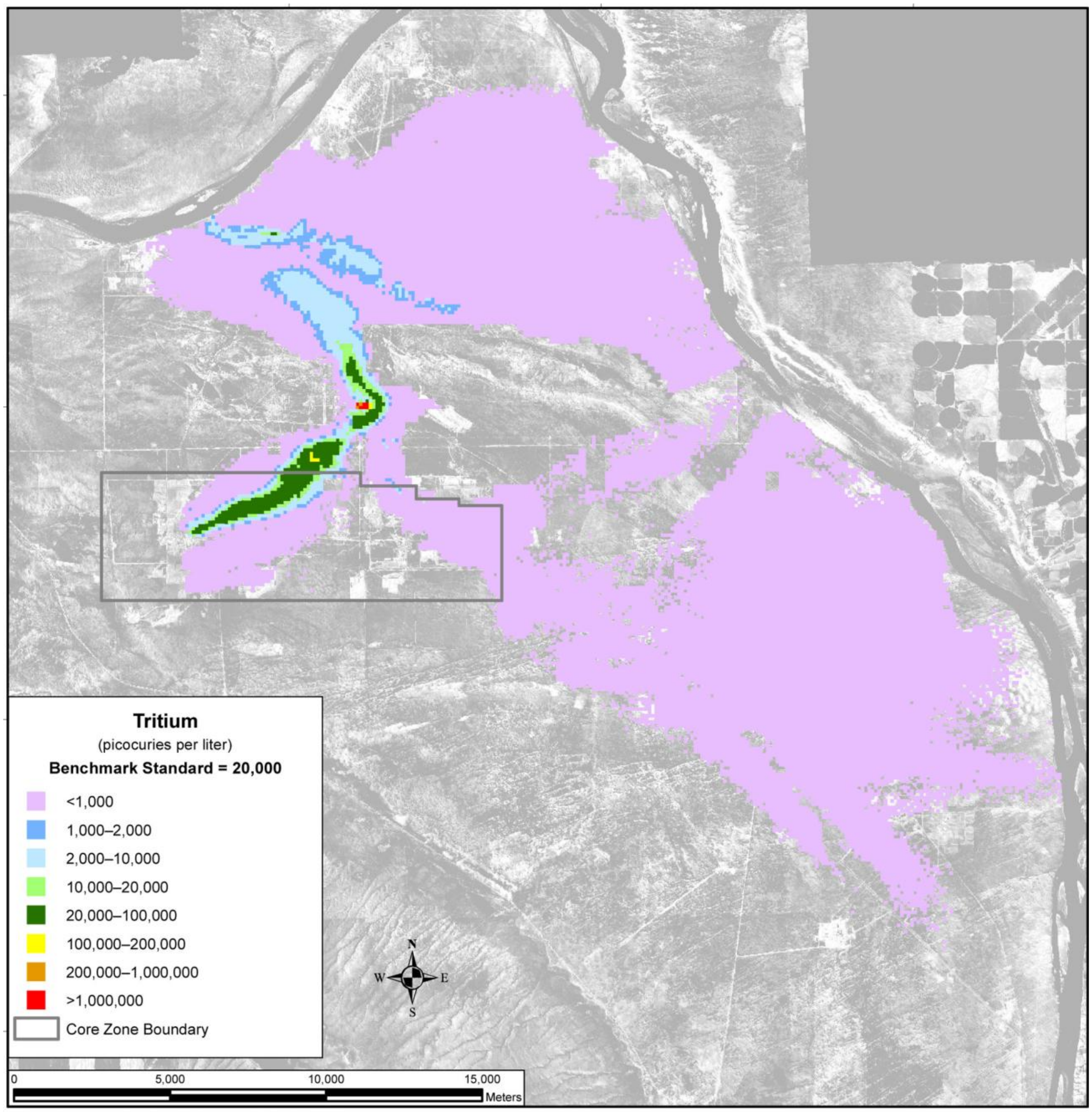


Figure 5–288. Tank Closure Alternative 6B, Option Case, Total Uranium Concentration Versus Time

5.1.1.10.5 Analysis of Spatial Distribution of Concentration

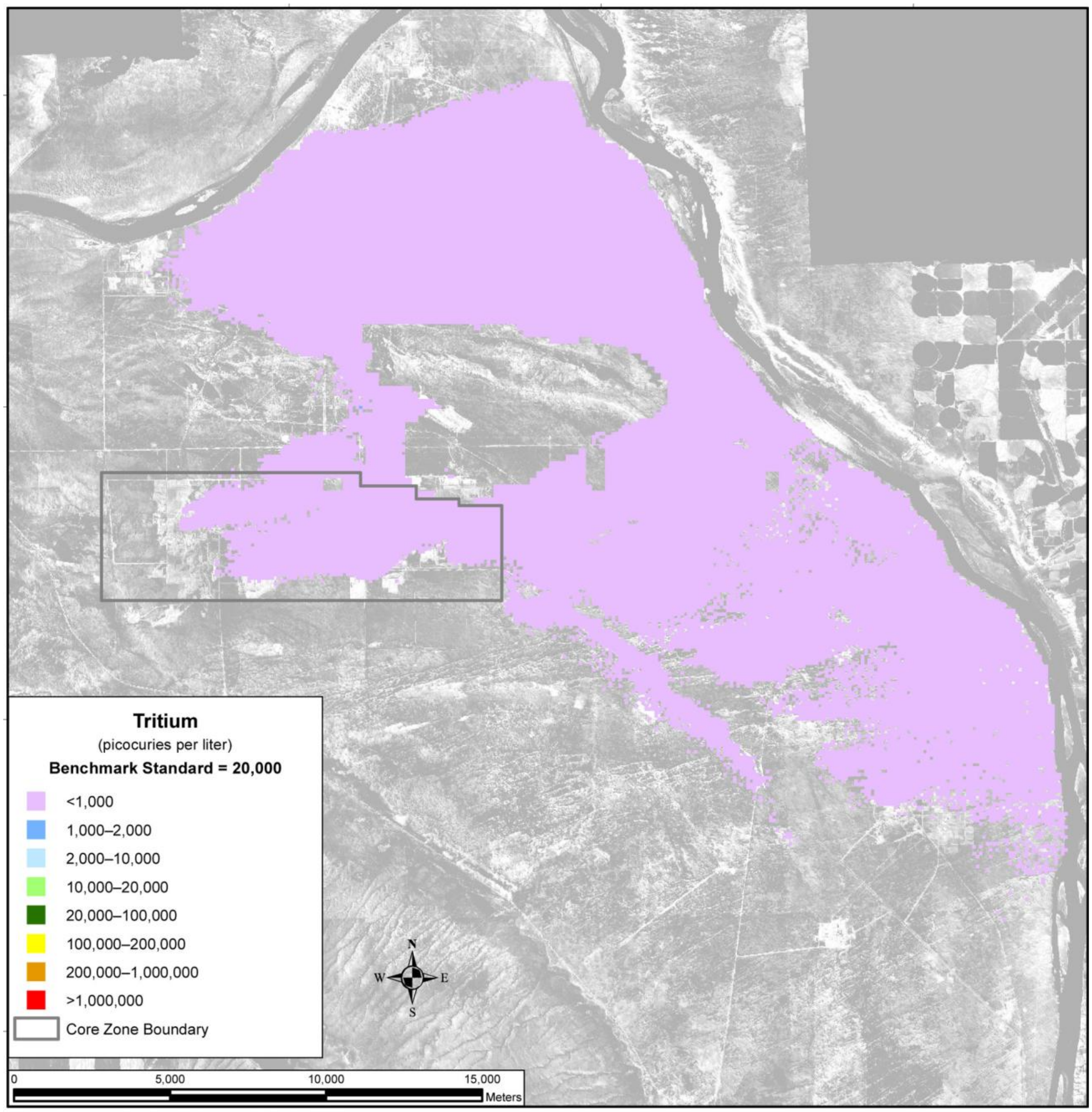
This section presents the impacts of Tank Closure Alternative 6B in terms of the spatial distribution of COPC driver concentrations in groundwater at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter (see Figures 5–289 through 5–333). Concentrations of each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations 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 5–289 shows the spatial distribution of tritium concentrations in groundwater in CY 2010 under the Base Case. Releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crosses the Core Zone Boundary, and continues toward Gable Gap. Peak concentrations in this plume are about 5 to 10 times greater than the benchmark. The overall tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135 (see Figure 5–290).



Note: To convert meters to feet, multiply by 3.281.

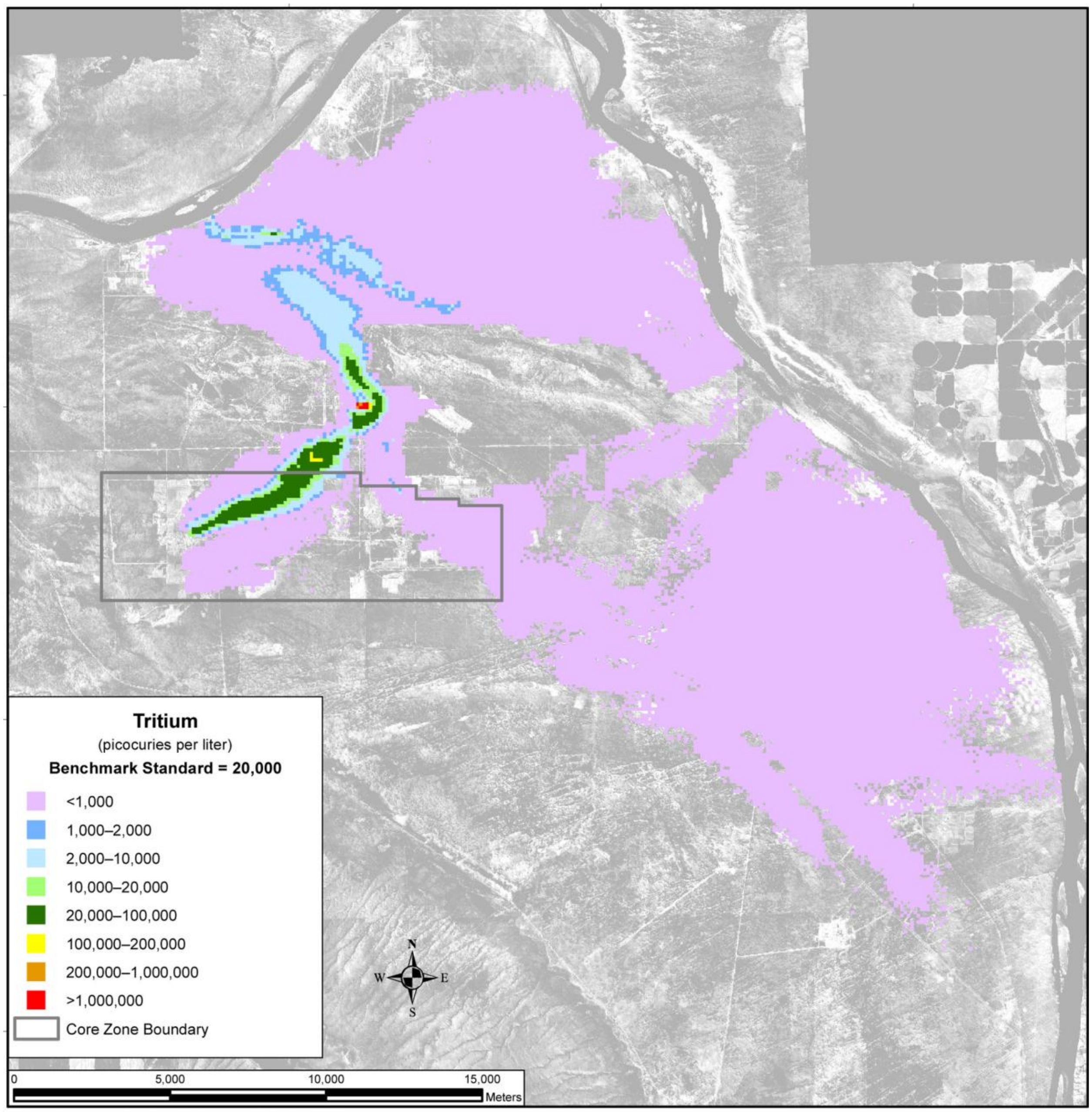
Figure 5–289. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration, Calendar Year 2010



Note: To convert meters to feet, multiply by 3.281.

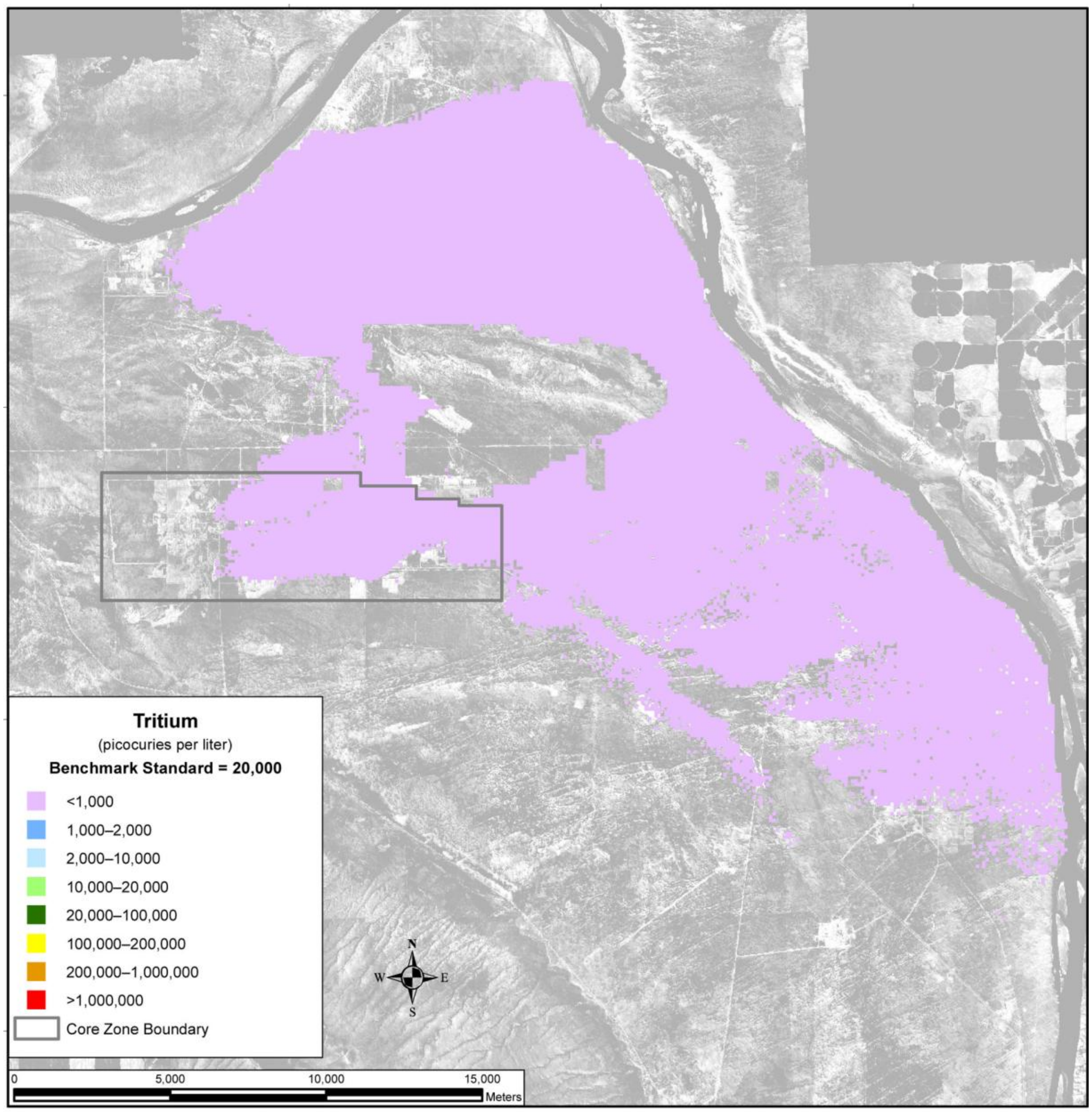
Figure 5–290. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration, Calendar Year 2135

The spatial distribution of tritium concentrations in groundwater under the Option Case, which would include removal of the six sets of cribs and trenches (ditches) and remediation of their plumes within the vadose zone, is essentially identical to that under the Base Case (see Figures 5–291 and 5–292).



Note: To convert meters to feet, multiply by 3.281.

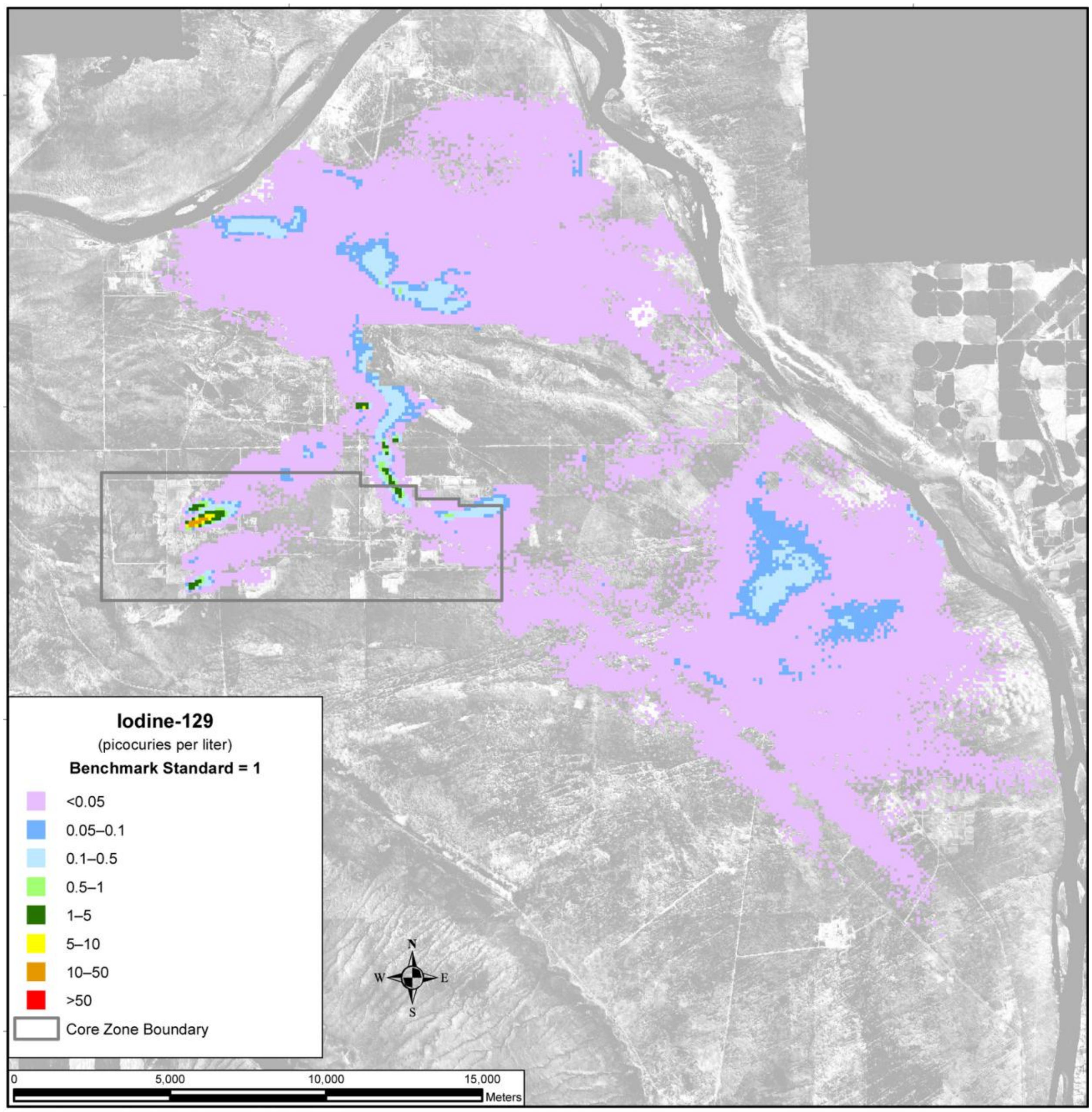
Figure 5–291. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration, Calendar Year 2010



Note: To convert meters to feet, multiply by 3.281.

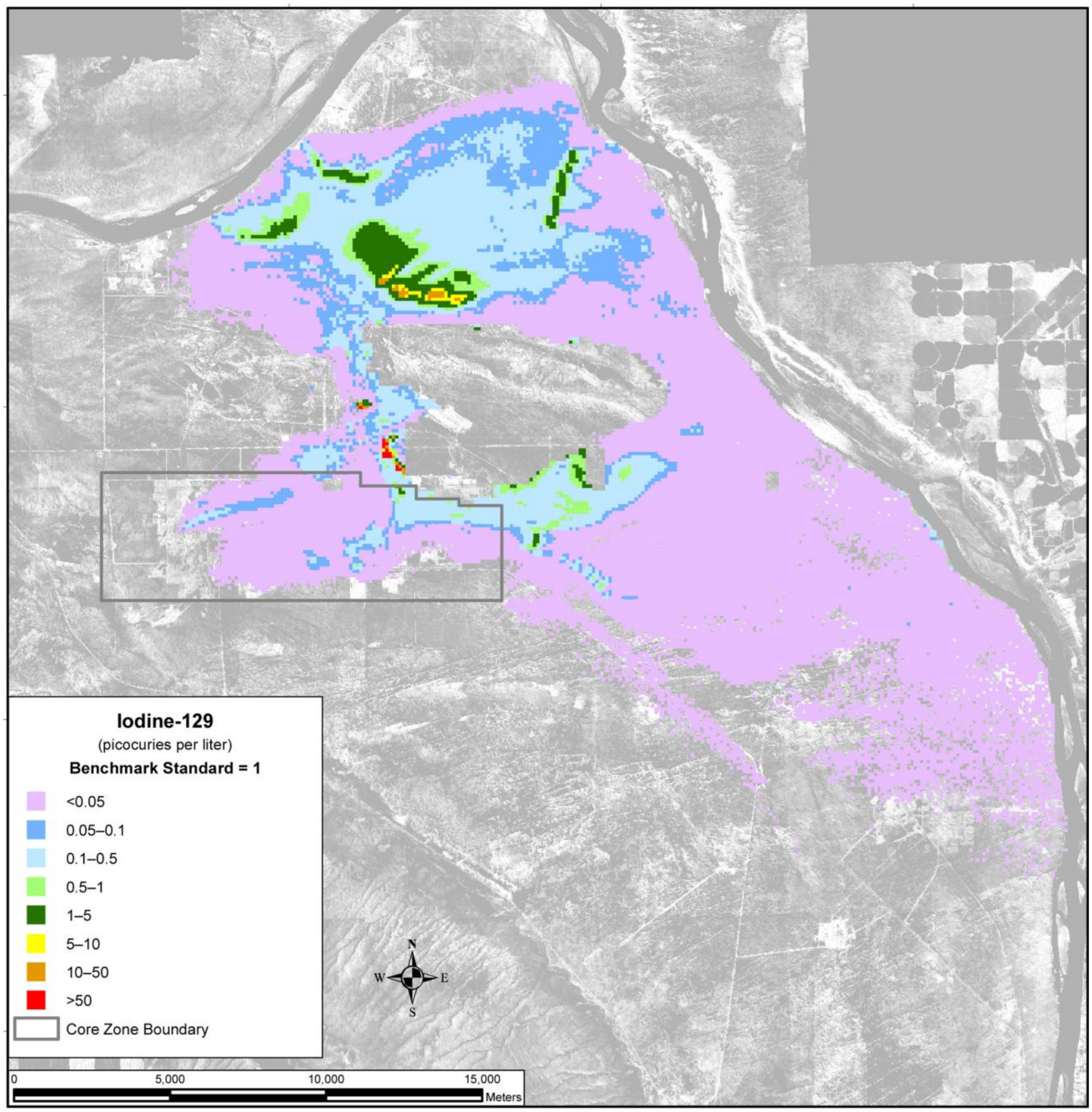
Figure 5–292. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration, Calendar Year 2135

Figure 5–293 shows the spatial distribution of iodine-129 concentrations in groundwater in CY 2010 under the Base Case. Releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that exceed the benchmark concentration at the B, S, and T Barriers. Peak concentrations in this plume are about 10 to 50 times greater than the benchmark and are mostly contained within the Core Zone Boundary. By CY 2135, the contaminant plumes have spread further north through Gable Gap and further east toward the Columbia River (see Figure 5–294). In the plume north of Gable Gap, contaminant concentrations are 10 to 50 times greater than the benchmark. In the east, just outside of the Core Zone Boundary, peak concentration levels are up to 5 times greater than the benchmark. By CY 7140, most of the mass in the plume has reached the Columbia River, with concentrations less than one-twentieth of the benchmark (see Figure 5–295). Technetium-99, chromium, and nitrate (see Figures 5–296 through 5–304) 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).



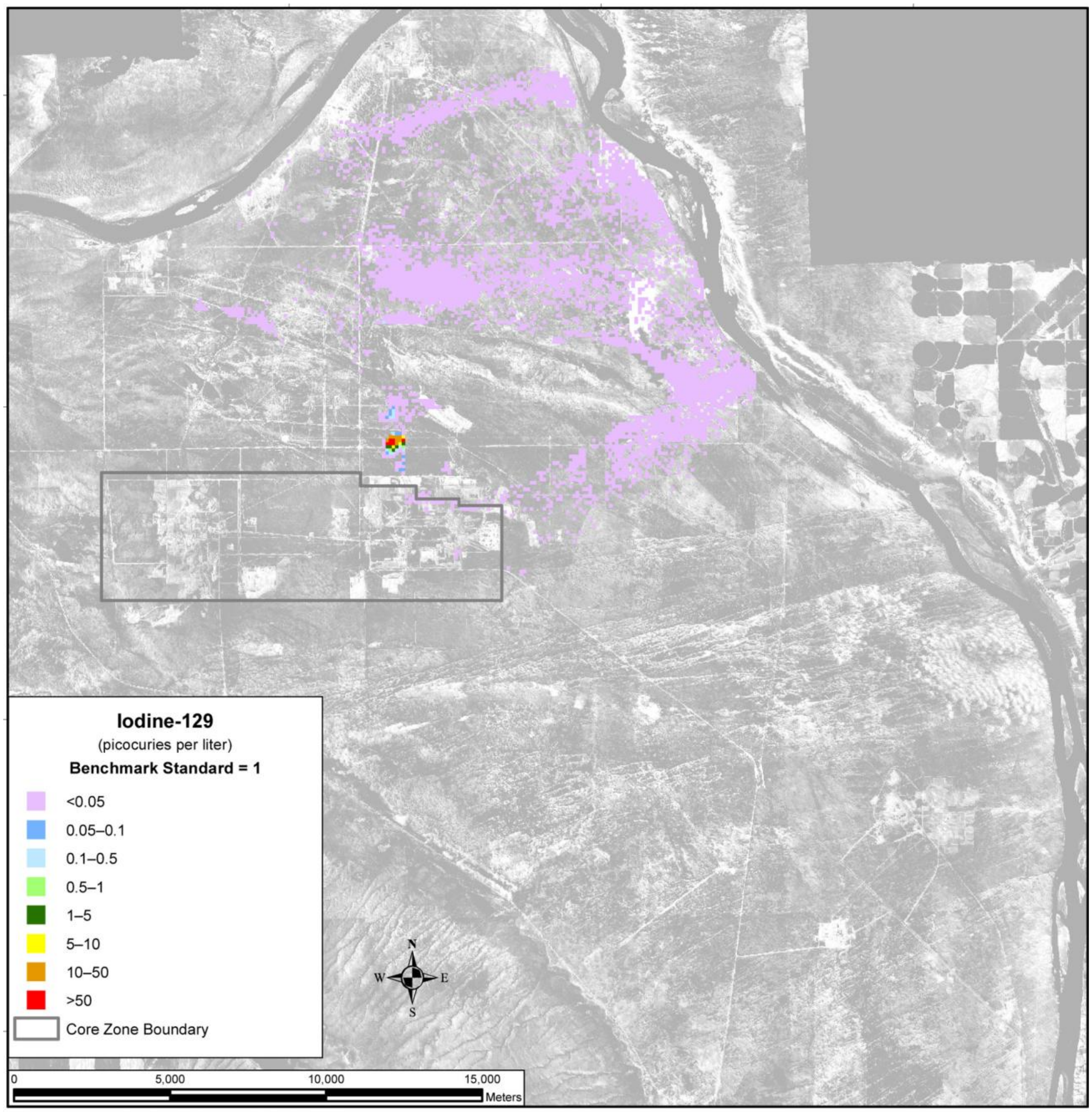
Note: To convert meters to feet, multiply by 3.281.

Figure 5–293. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 2010



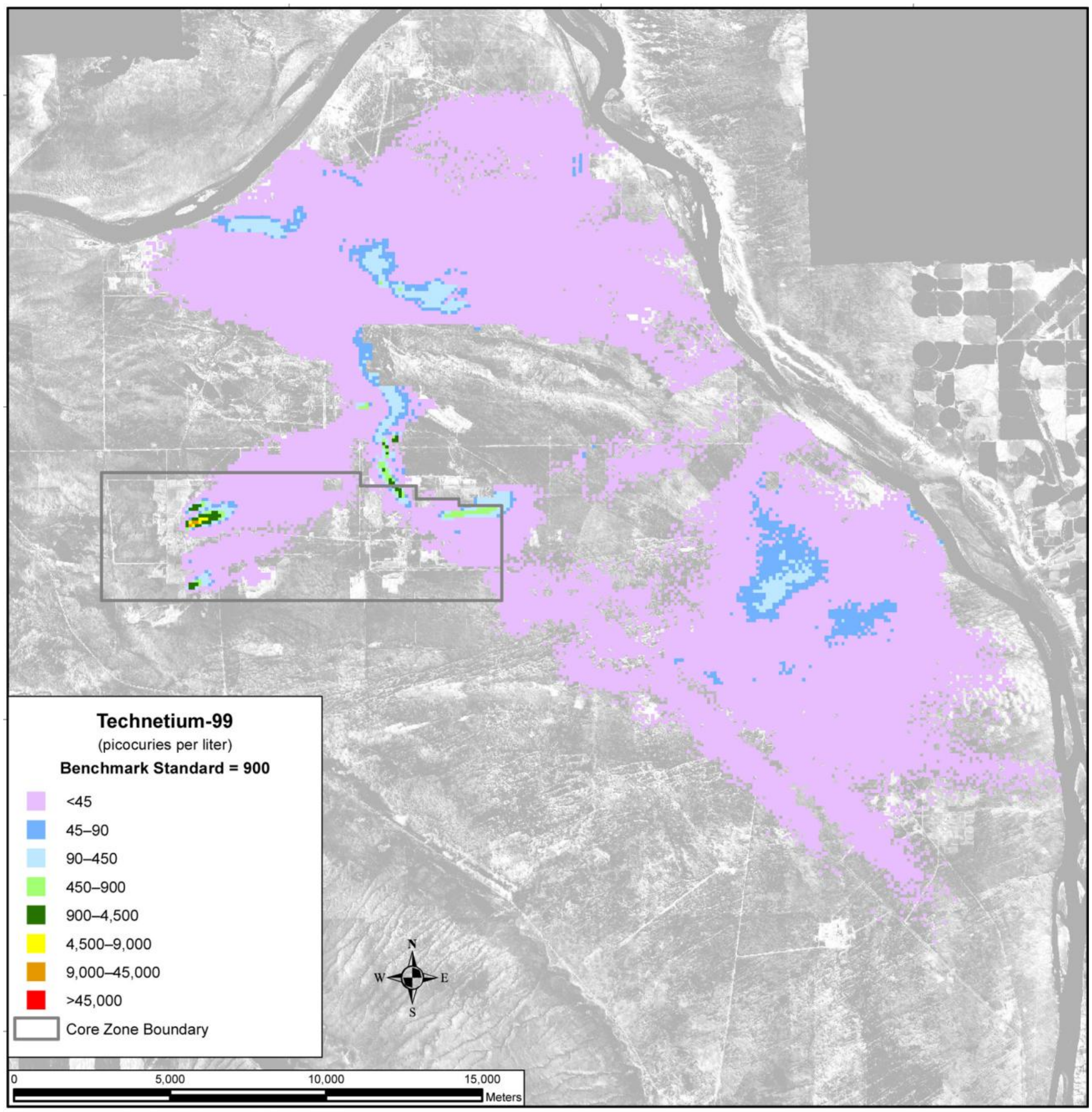
Note: To convert meters to feet, multiply by 3.281.

Figure 5–294. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 2135



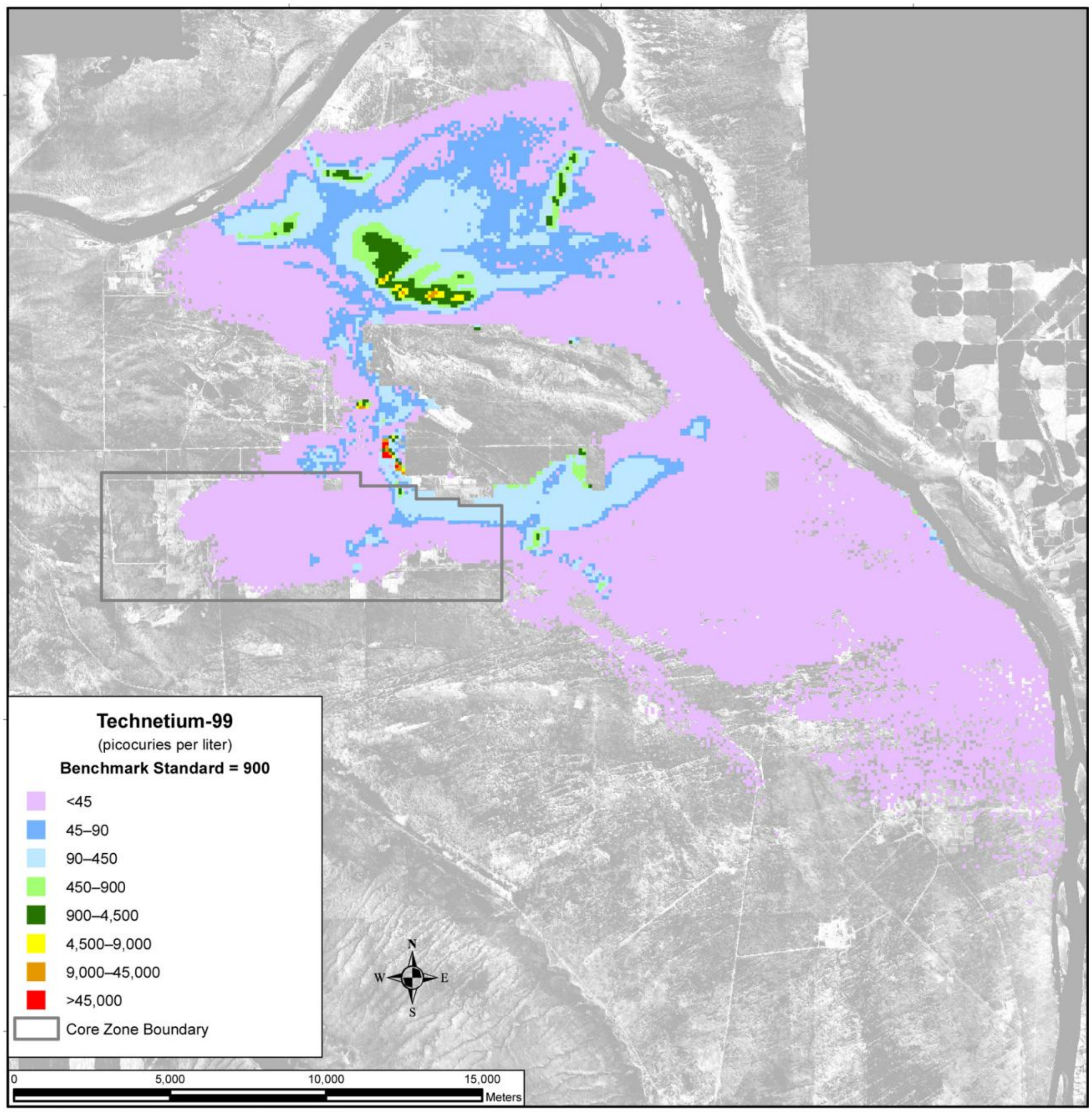
Note: To convert meters to feet, multiply by 3.281.

Figure 5–295. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 7140



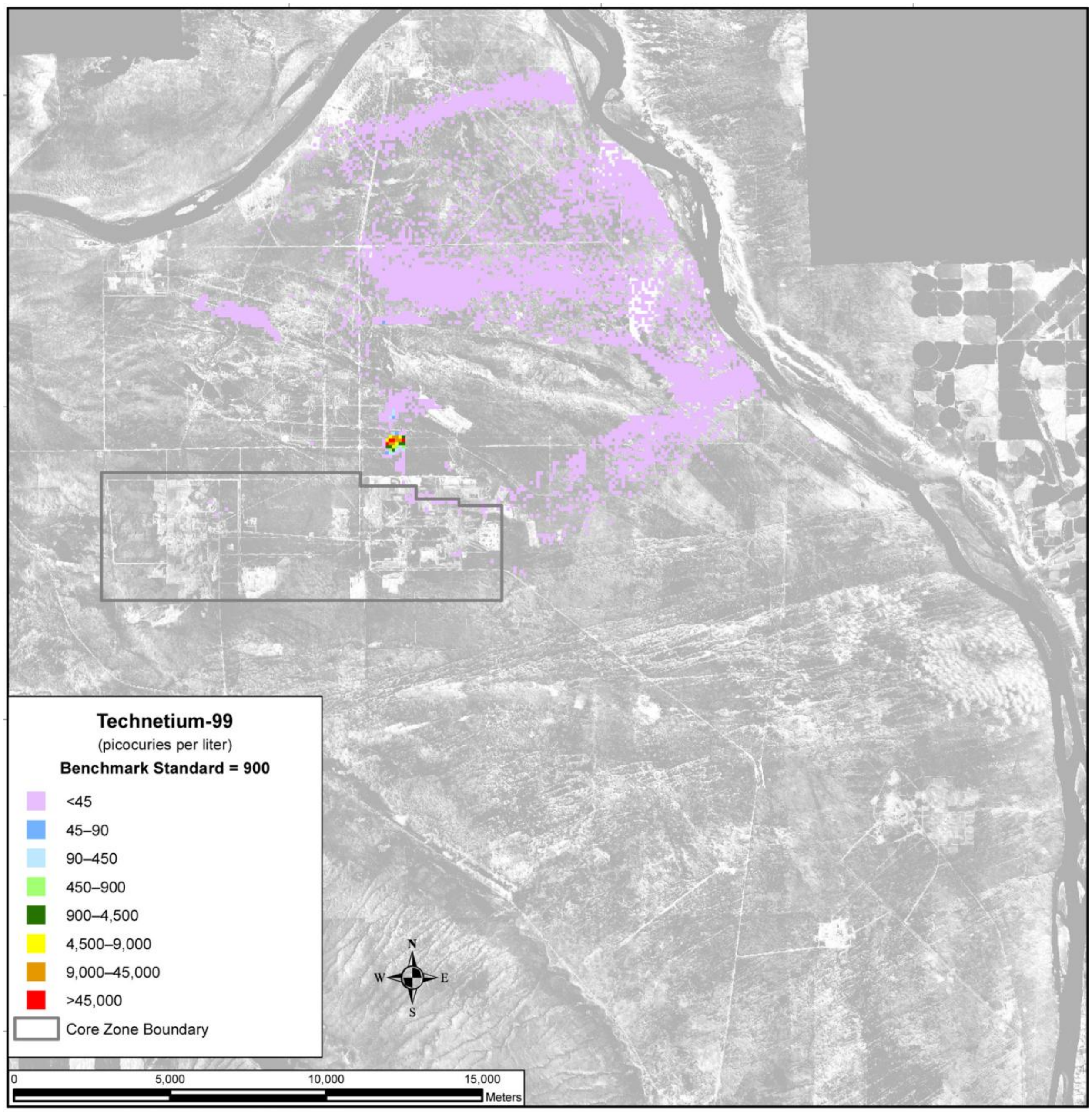
Note: To convert meters to feet, multiply by 3.281.

Figure 5–296. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 2010



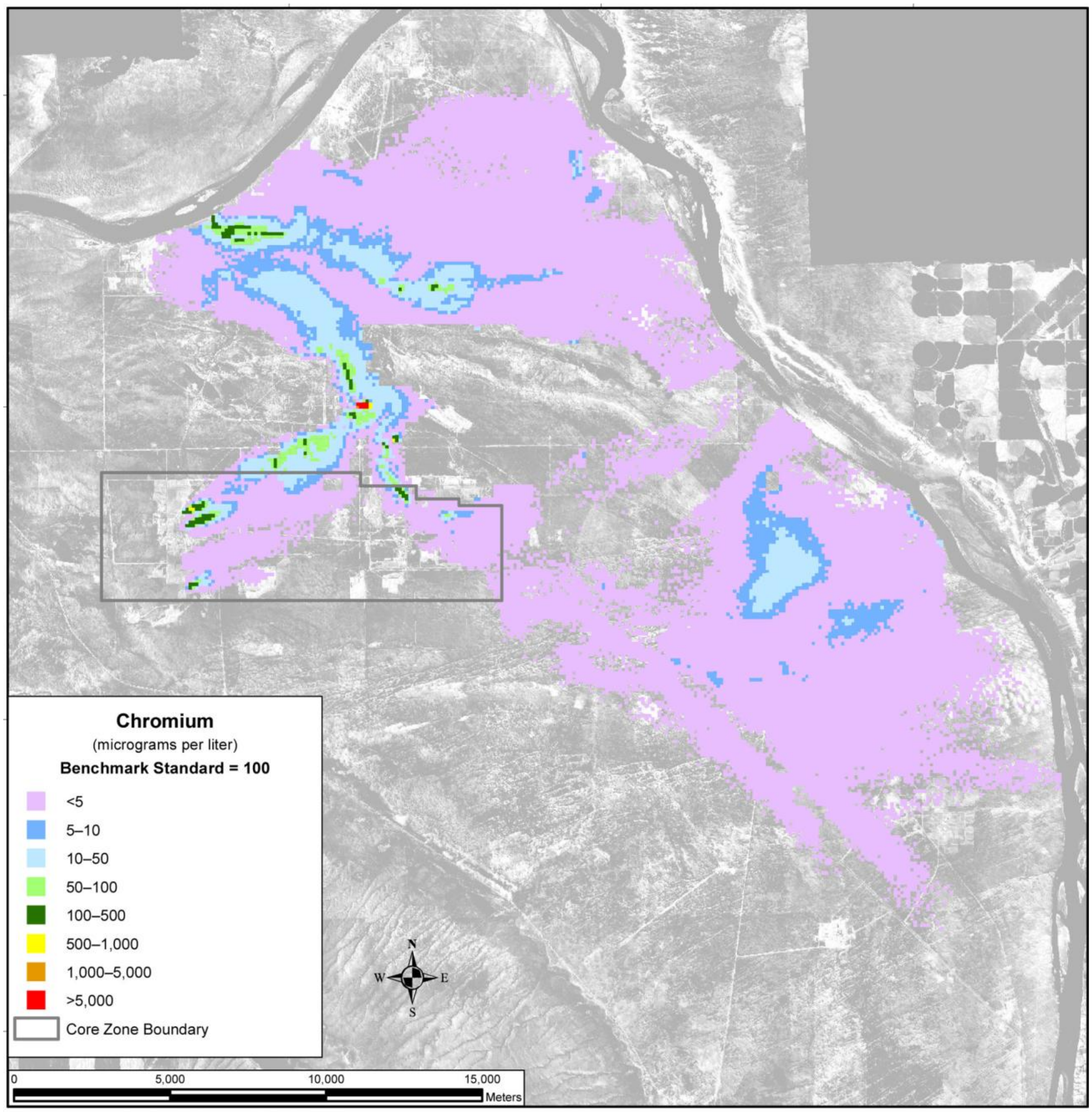
Note: To convert meters to feet, multiply by 3.281.

Figure 5–297. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 2135



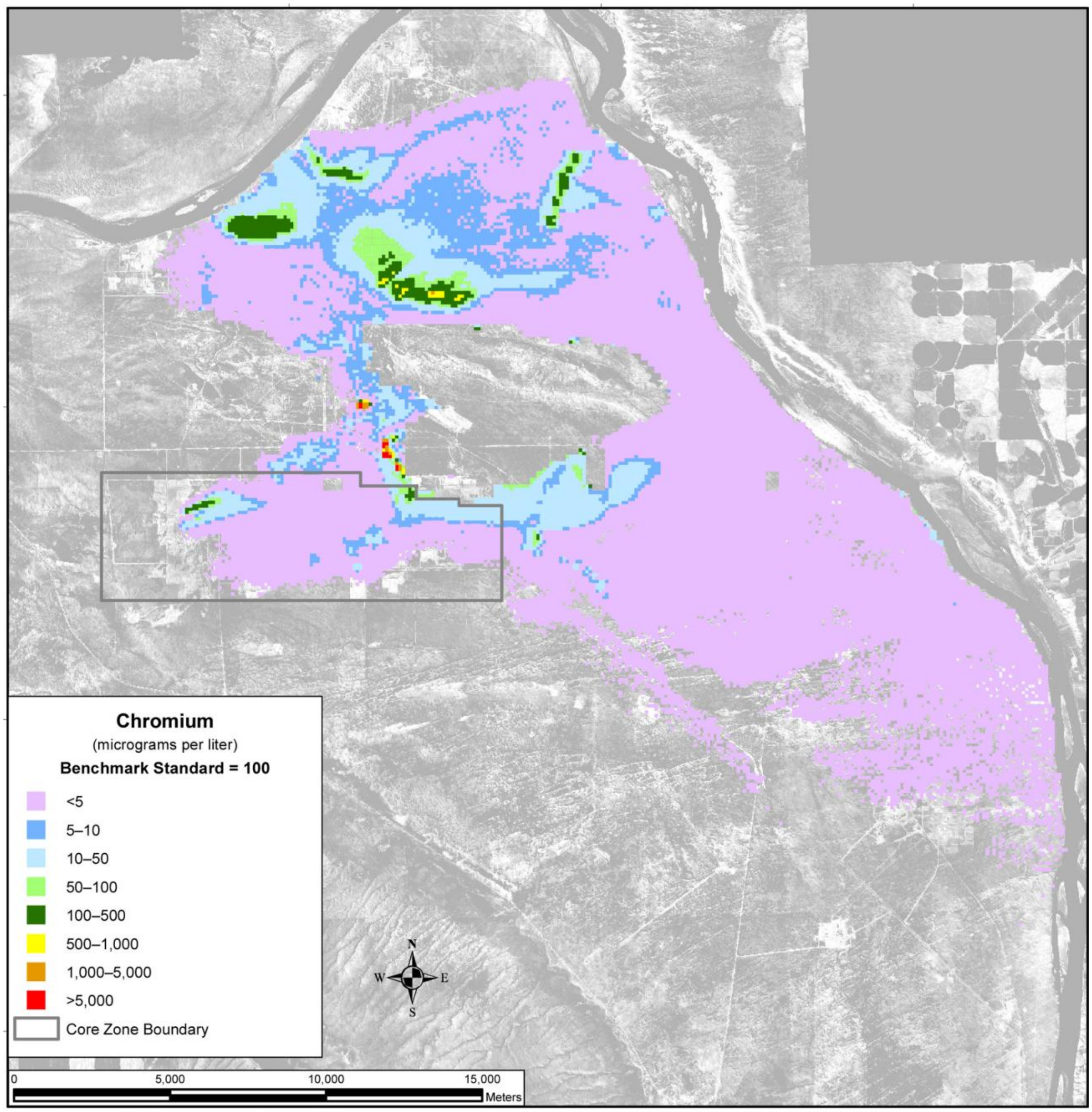
Note: To convert meters to feet, multiply by 3.281.

Figure 5–298. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 7140



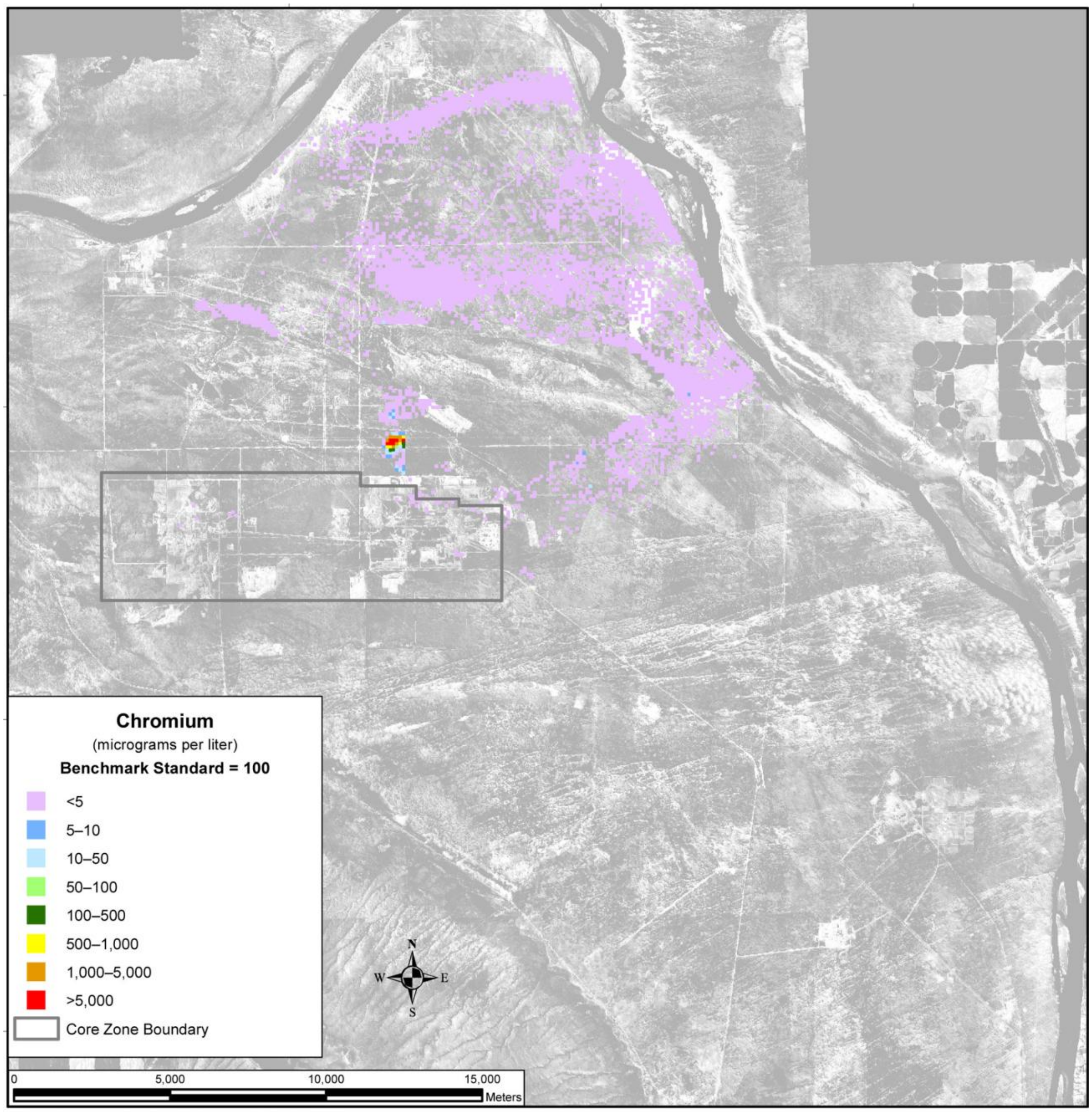
Note: To convert meters to feet, multiply by 3.281.

Figure 5–299. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 2010



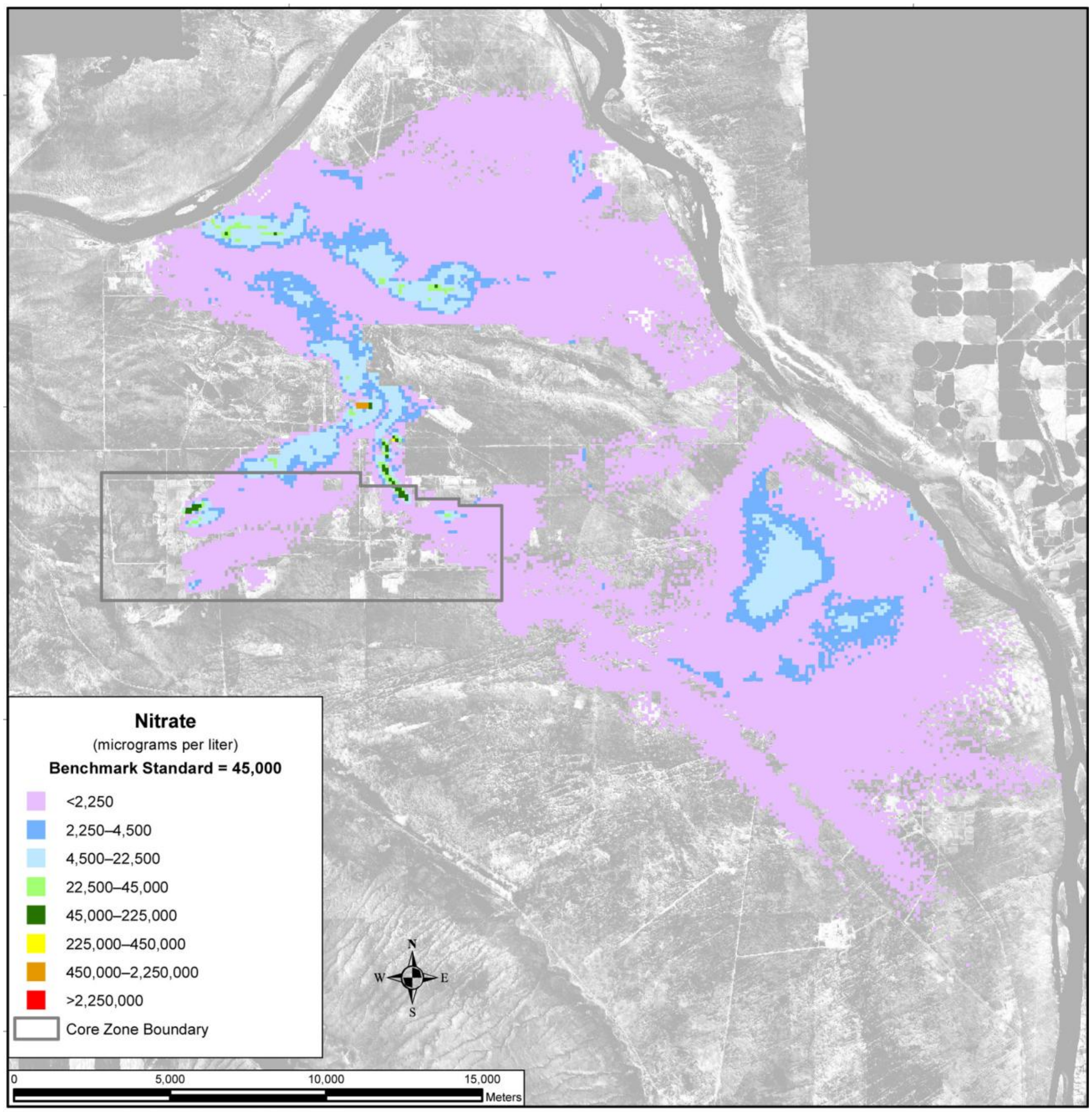
Note: To convert meters to feet, multiply by 3.281.

Figure 5–300. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 2135



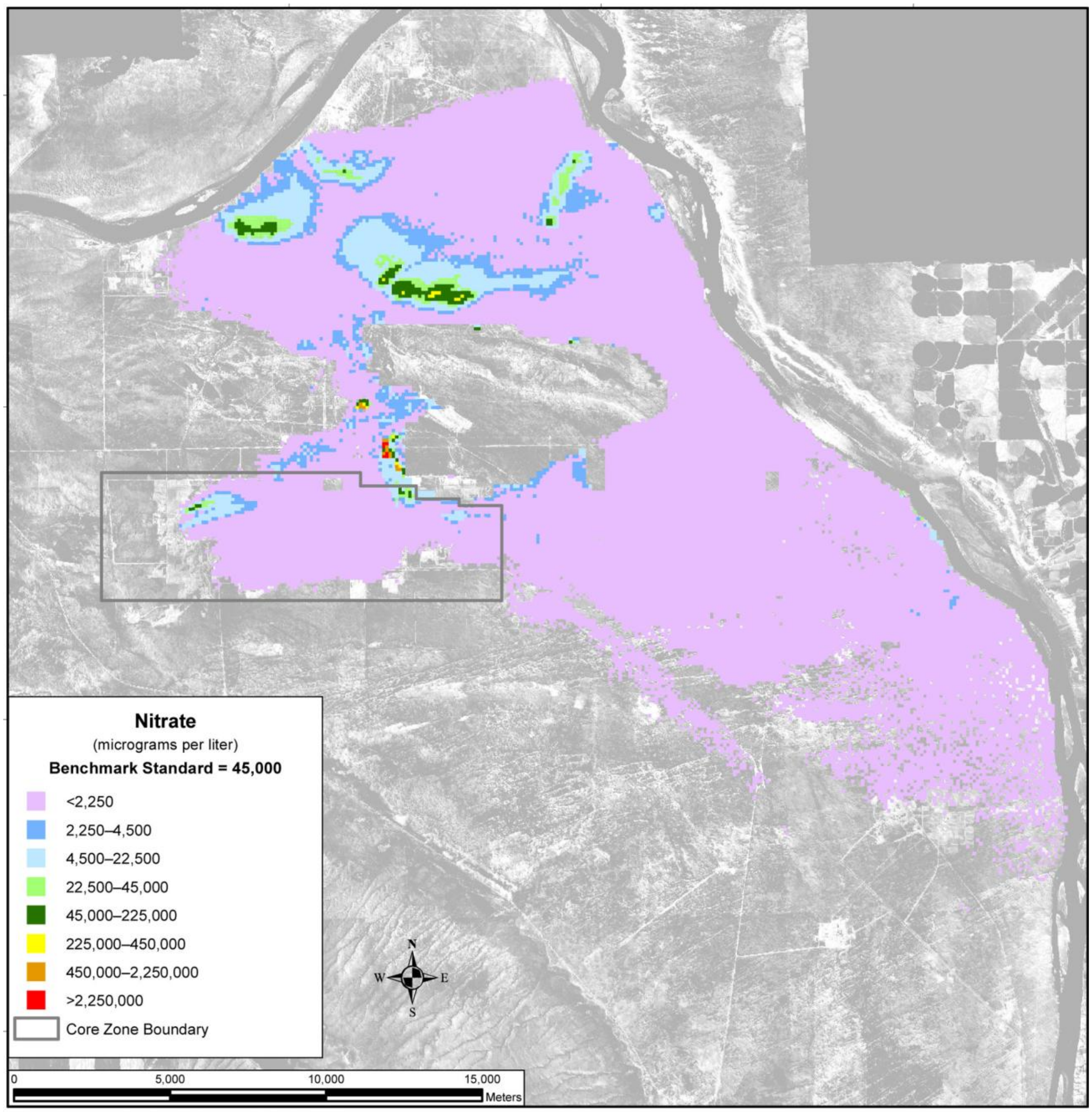
Note: To convert meters to feet, multiply by 3.281.

Figure 5–301. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 7140



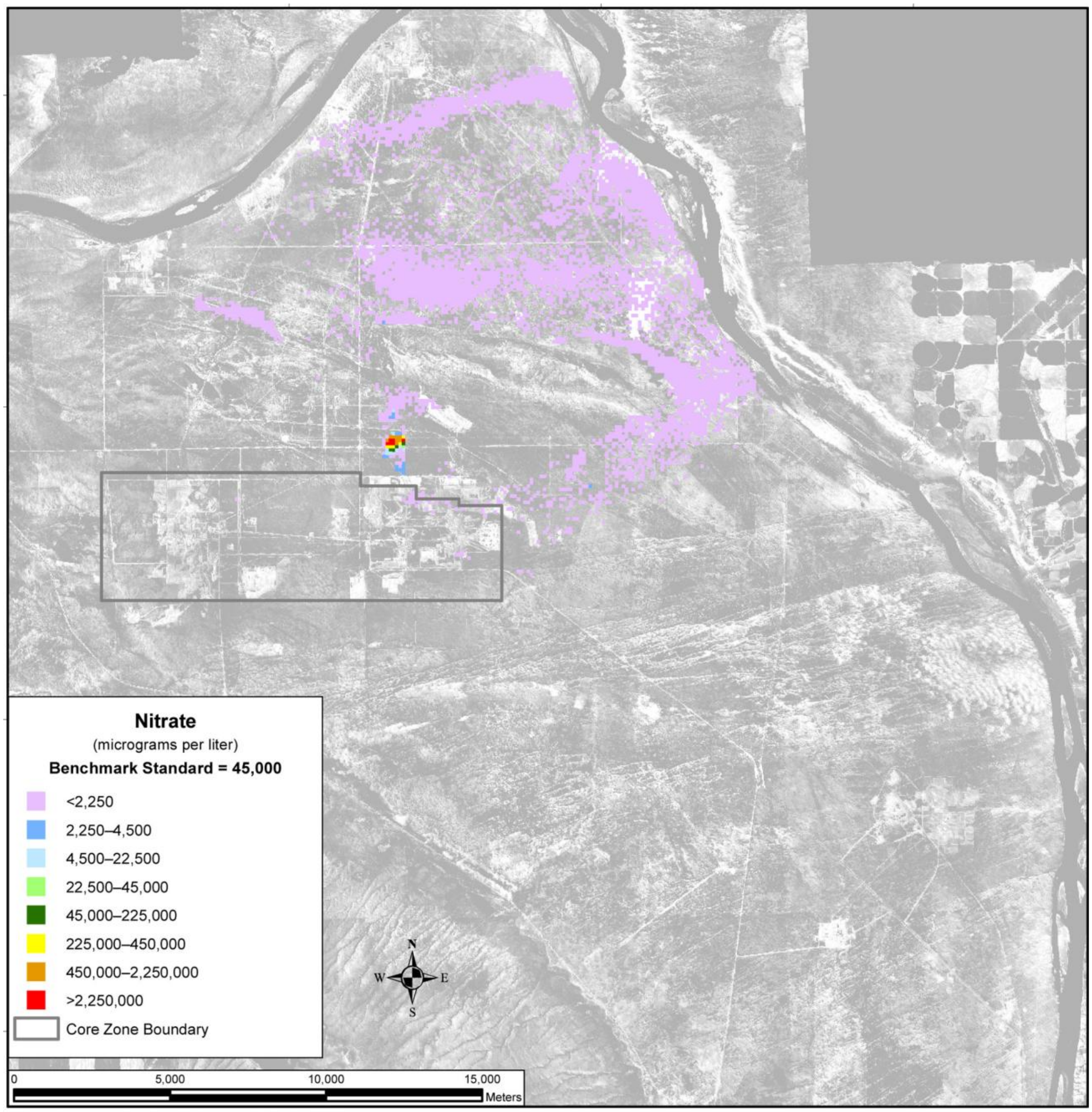
Note: To convert meters to feet, multiply by 3.281.

Figure 5–302. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 2010



Note: To convert meters to feet, multiply by 3.281.

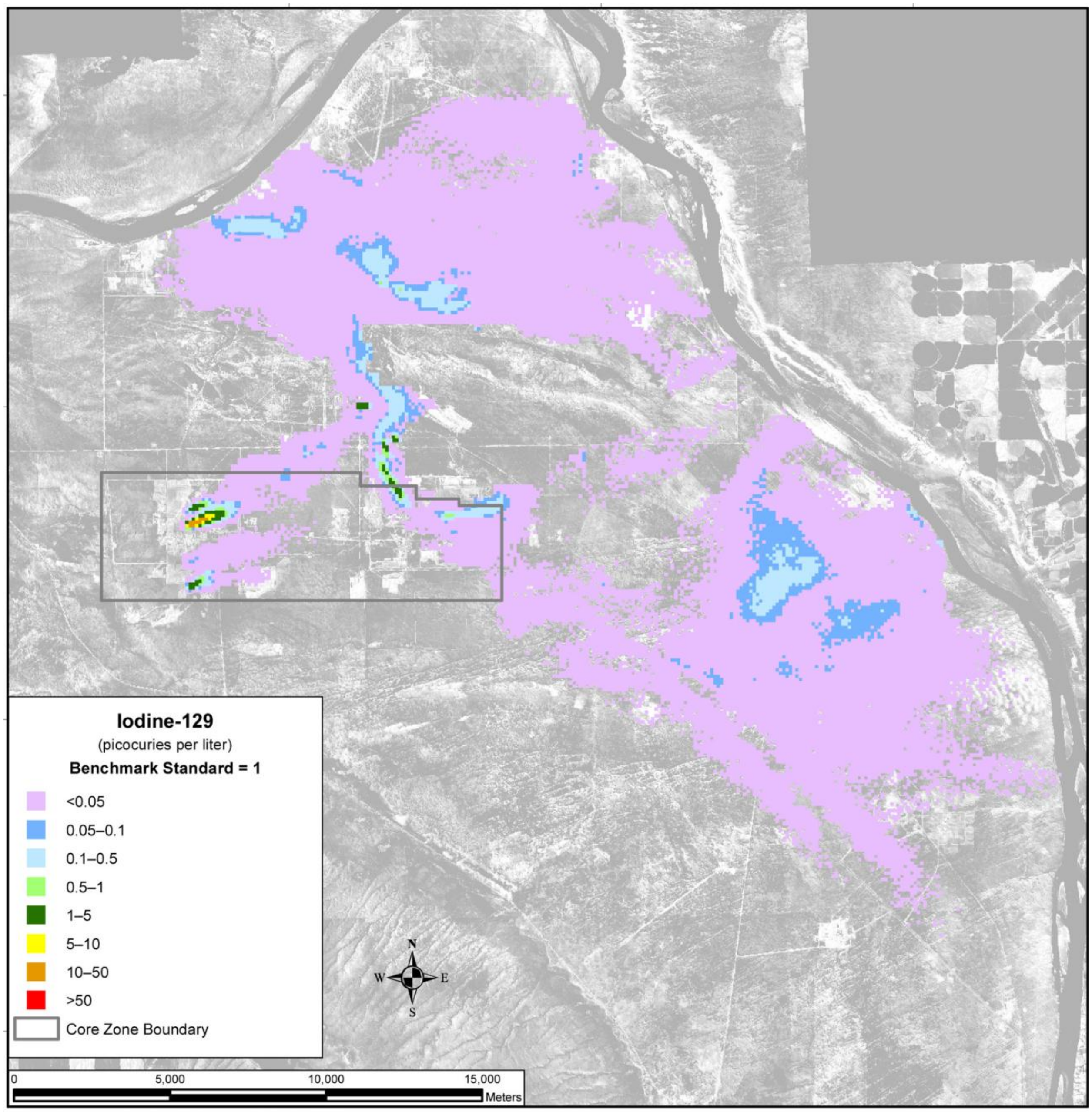
Figure 5–303. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281.

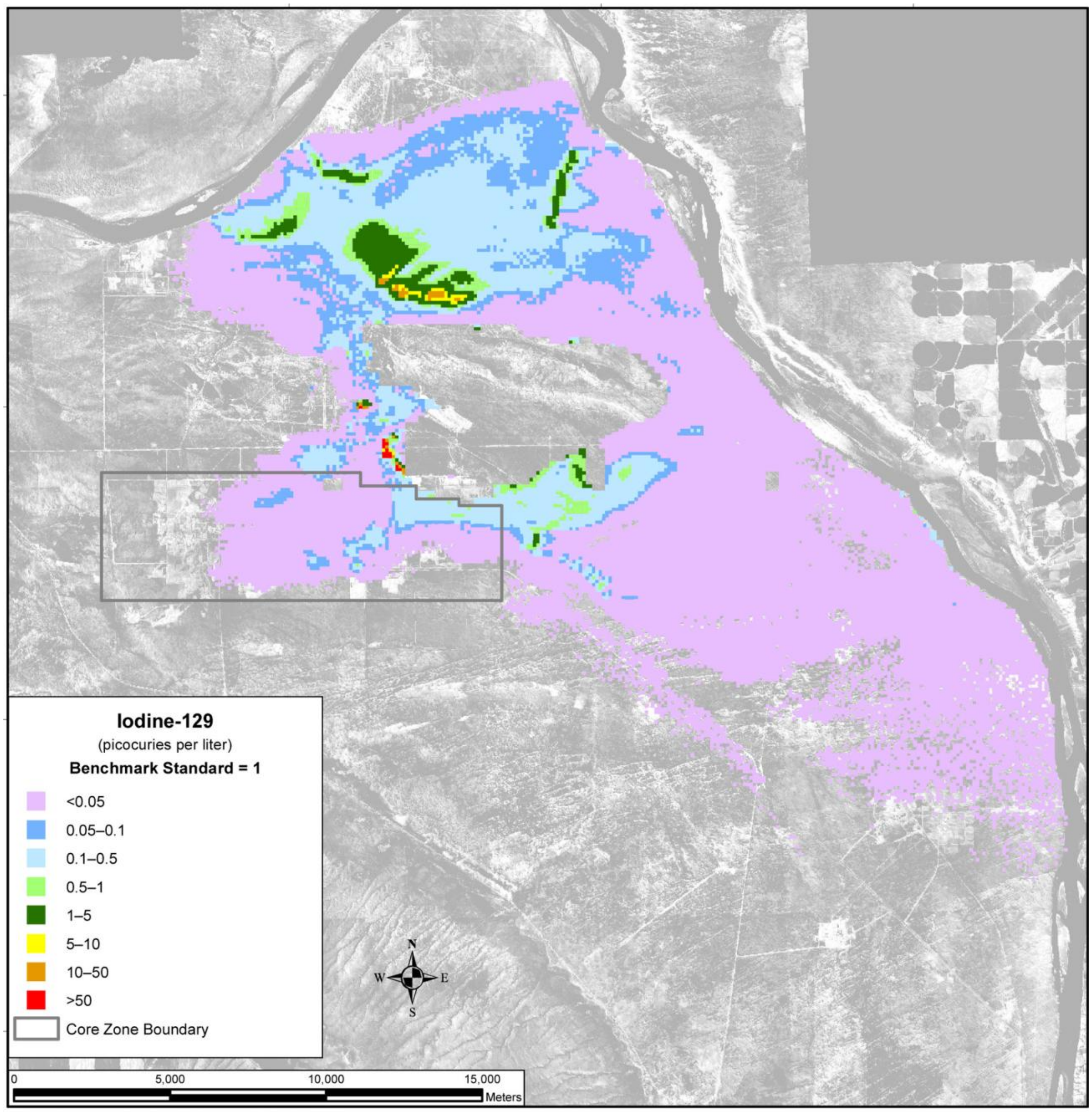
Figure 5–304. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 7140

The spatial distribution of concentrations of the conservative tracers in groundwater under the Option Case is essentially identical to that under the Base Case (see Figures 5–305 through 5–316).



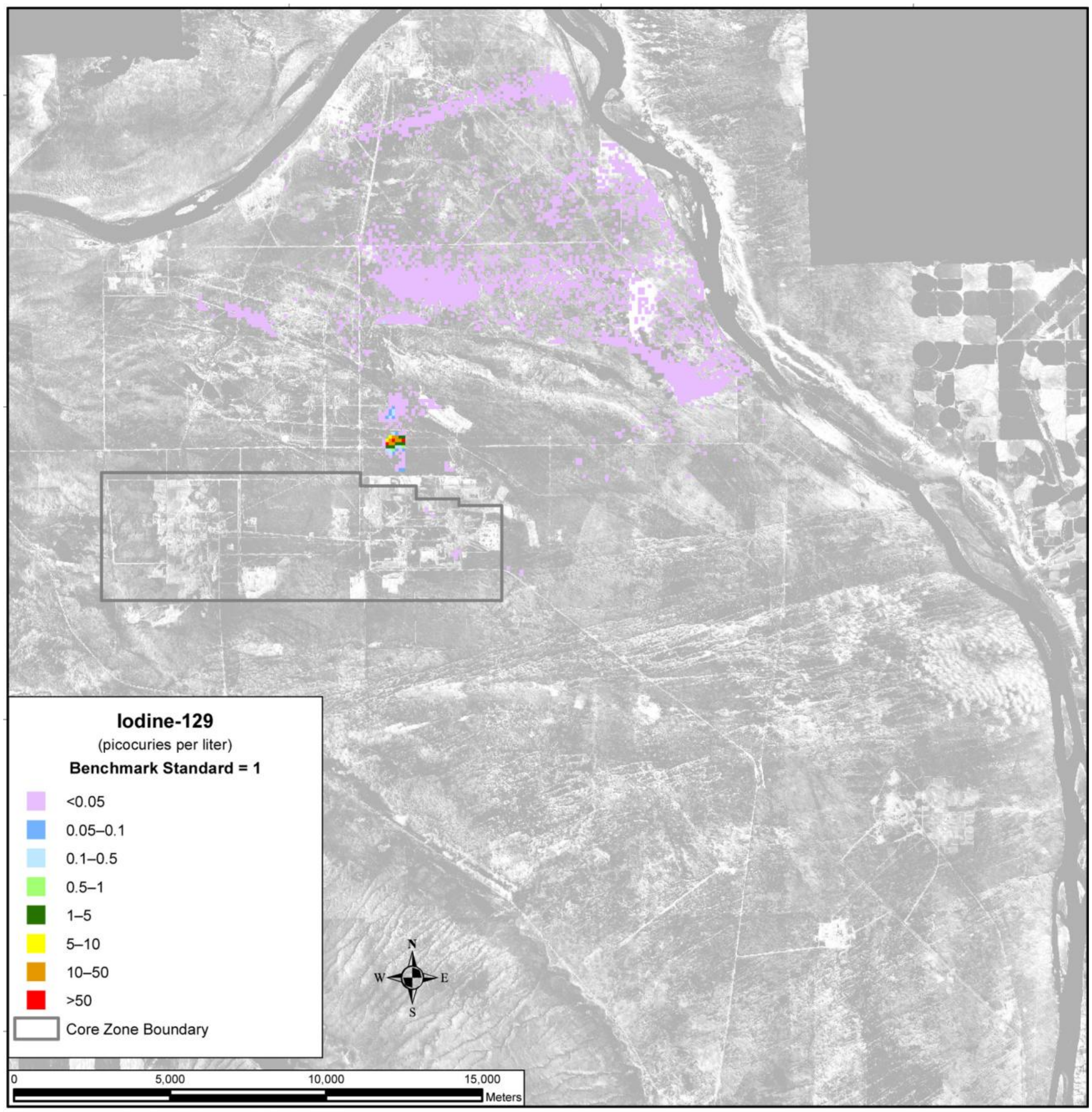
Note: To convert meters to feet, multiply by 3.281.

Figure 5–305. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 2010



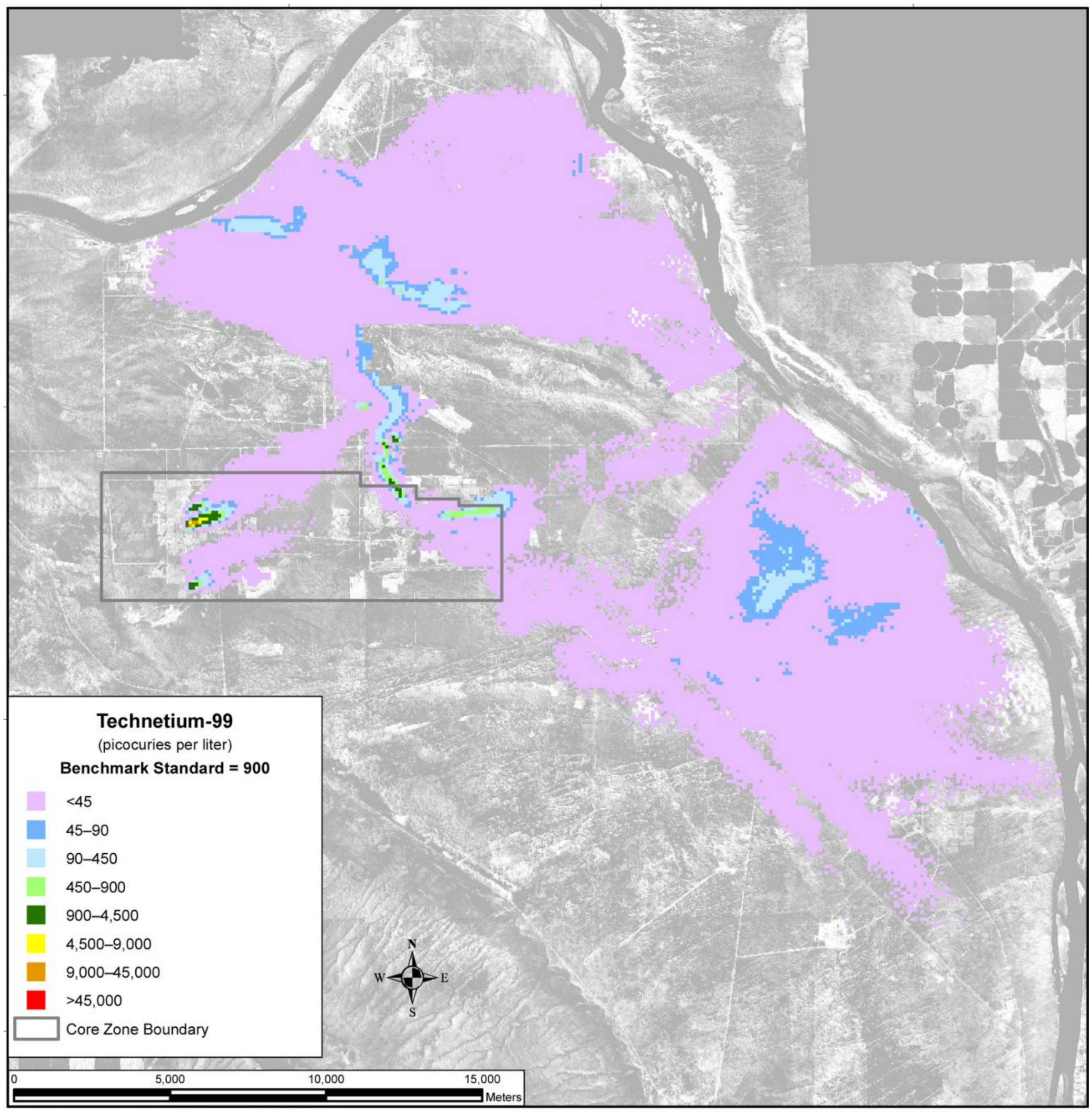
Note: To convert meters to feet, multiply by 3.281.

Figure 5–306. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 2135



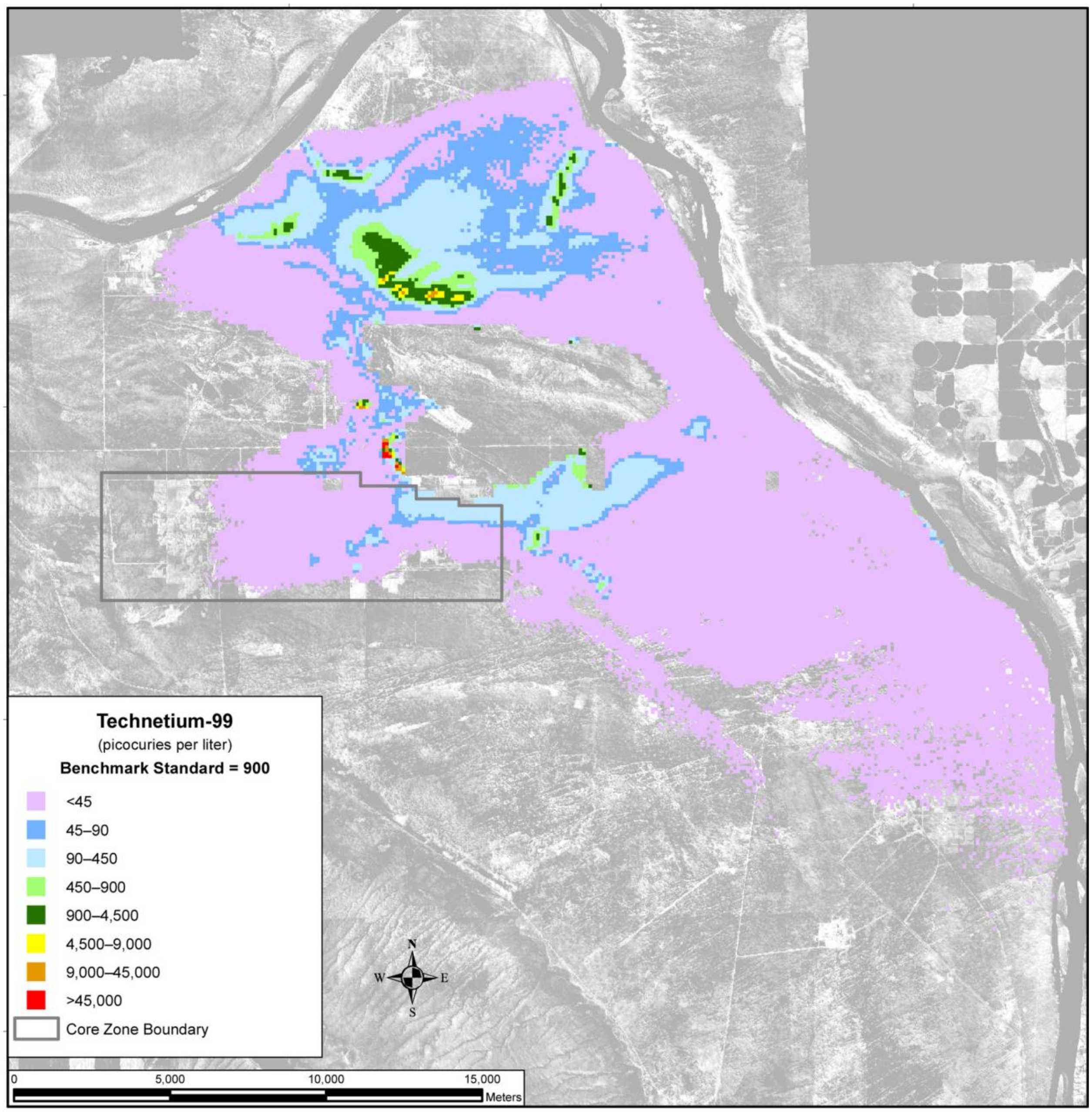
Note: To convert meters to feet, multiply by 3.281.

Figure 5–307. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 7140



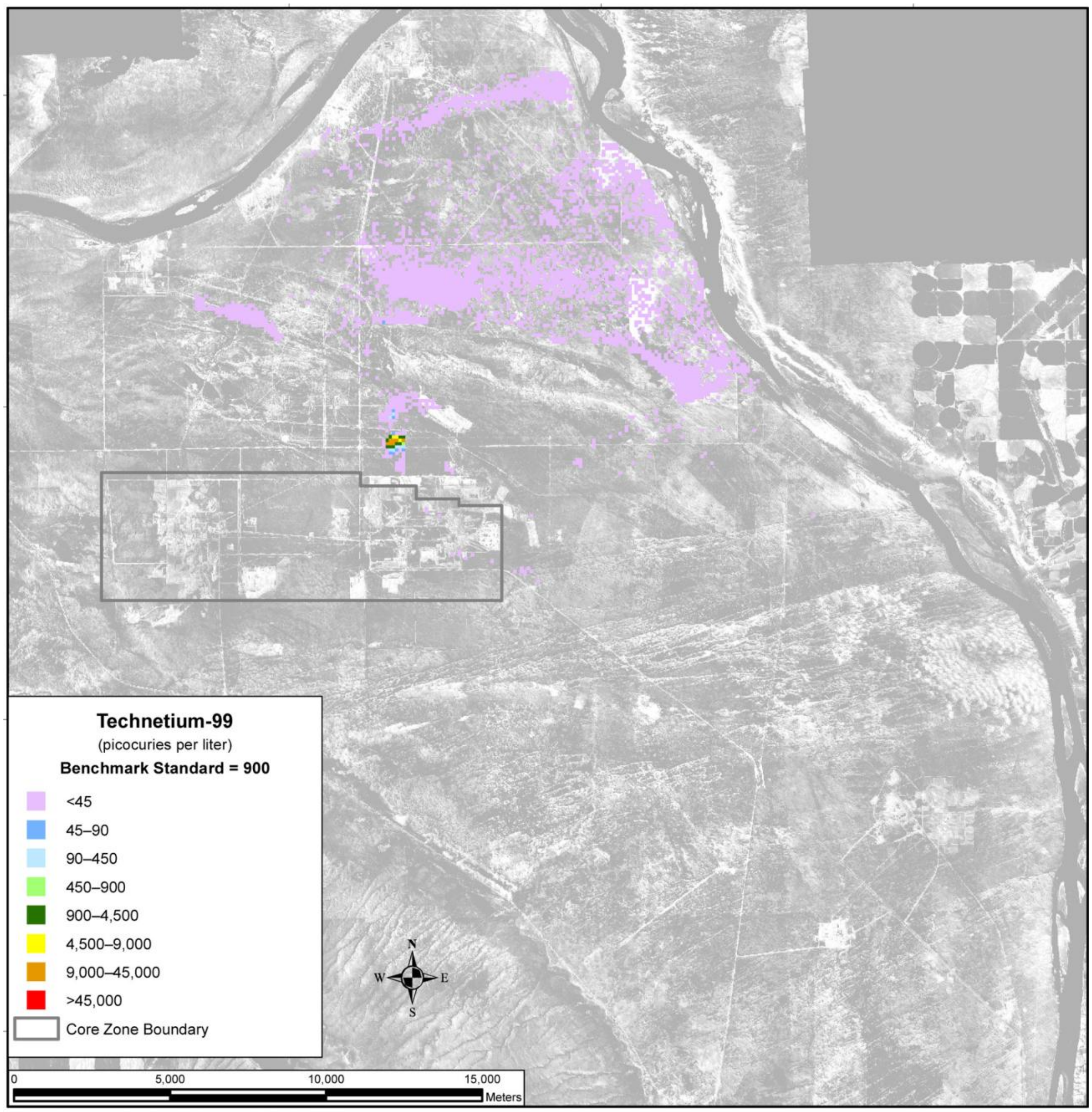
Note: To convert meters to feet, multiply by 3.281.

Figure 5–308. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 2010



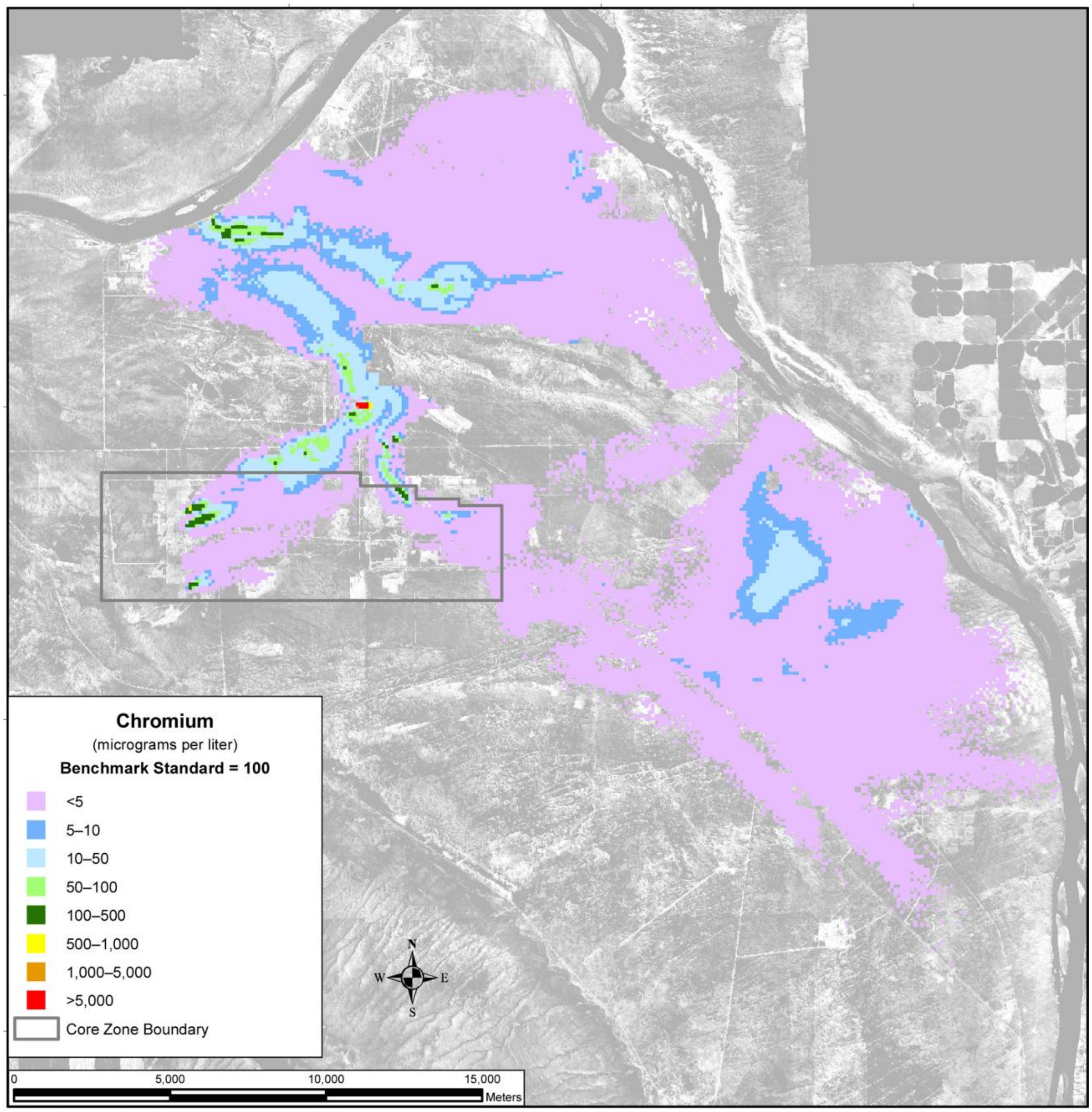
Note: To convert meters to feet, multiply by 3.281.

Figure 5–309. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 2135



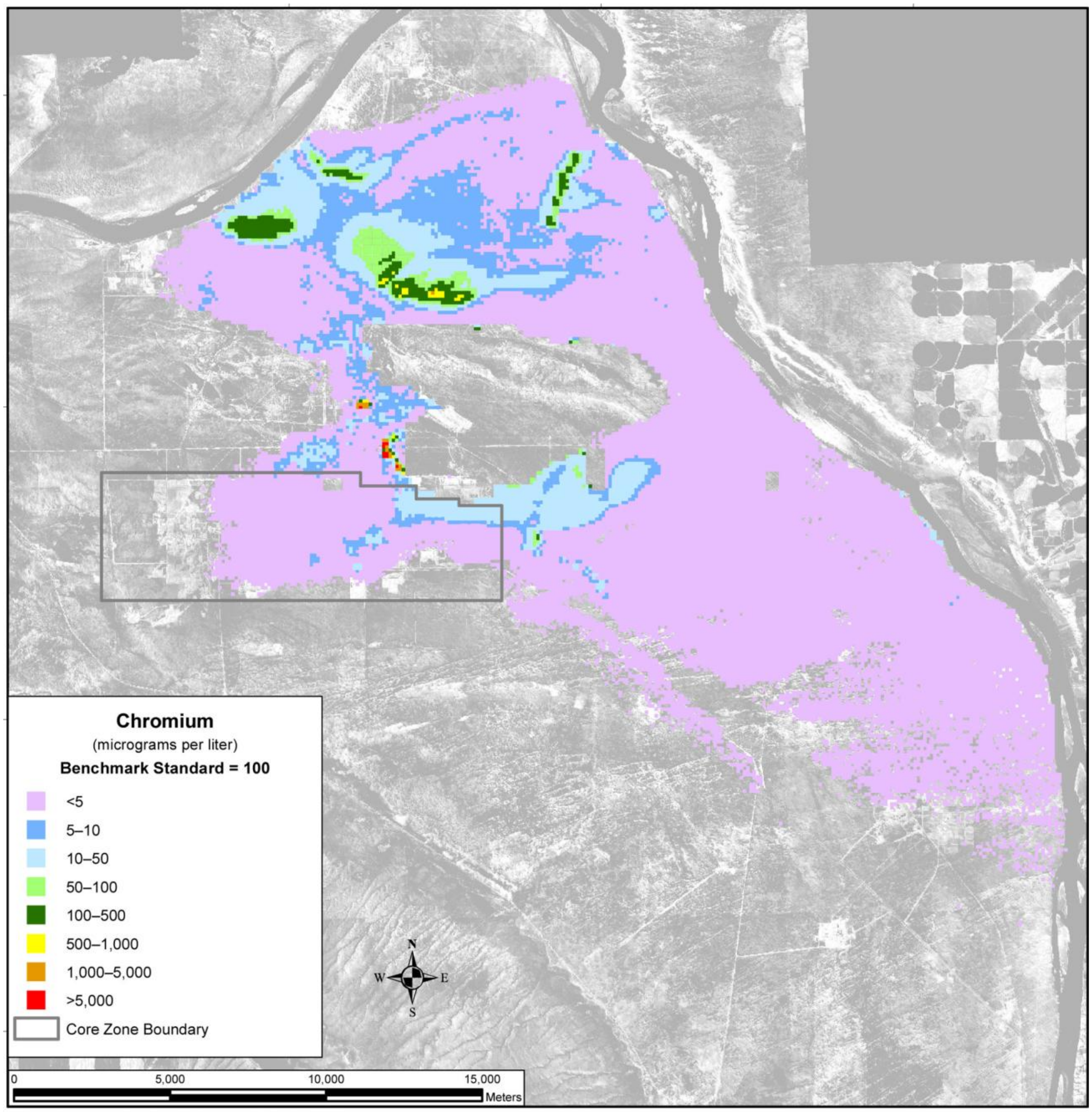
Note: To convert meters to feet, multiply by 3.281.

Figure 5–310. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 7140



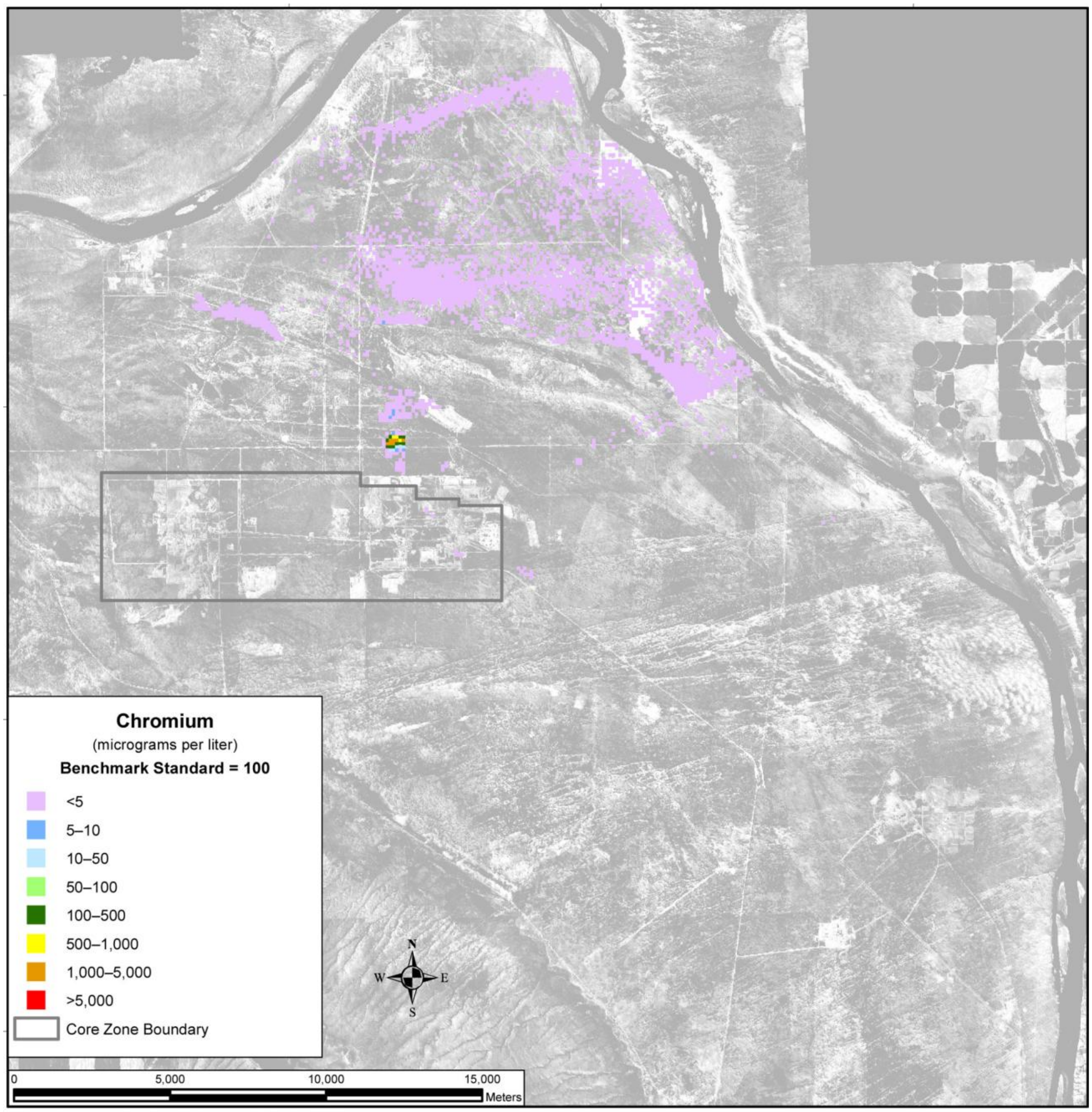
Note: To convert meters to feet, multiply by 3.281.

Figure 5–311. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 2010



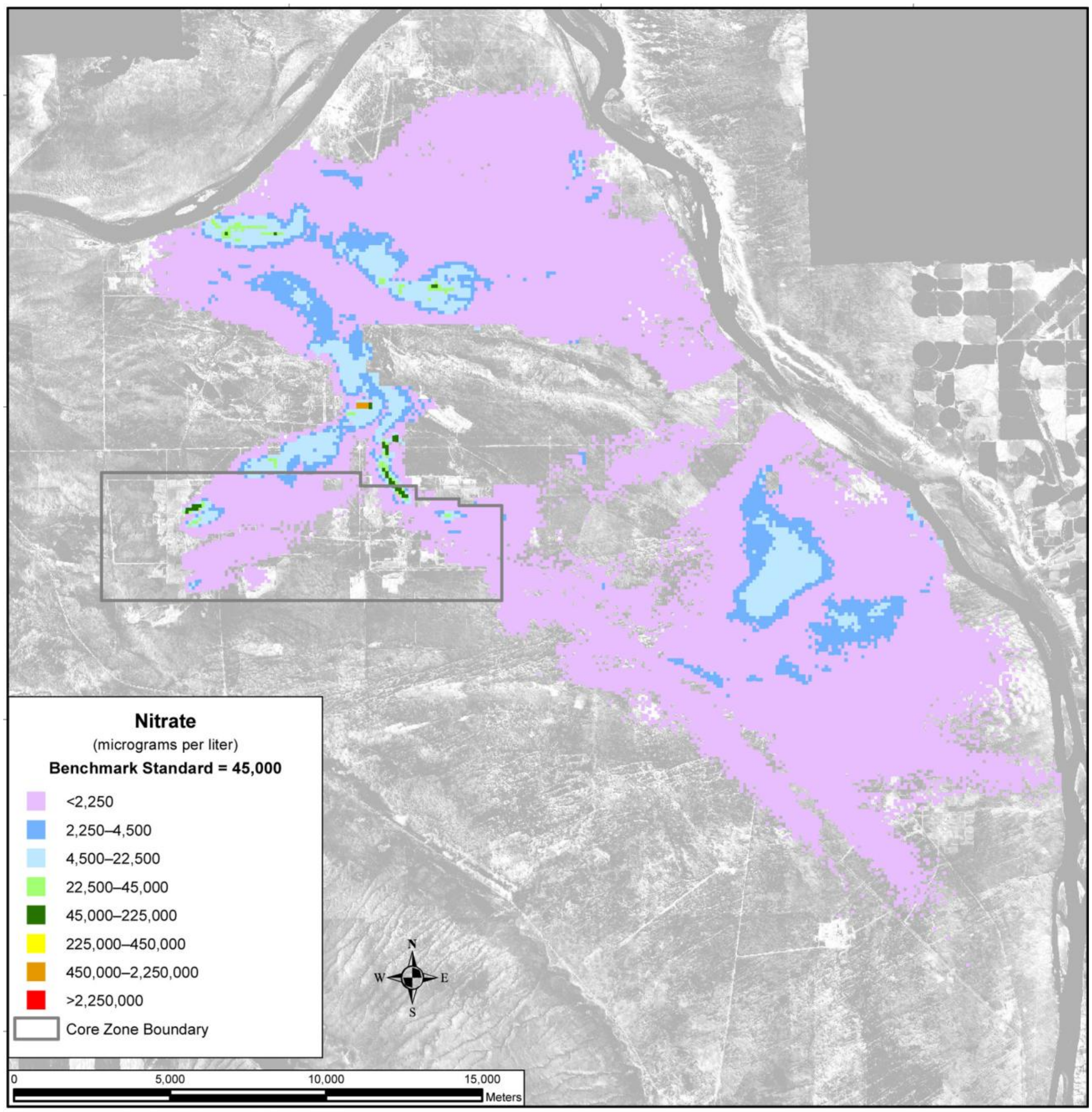
Note: To convert meters to feet, multiply by 3.281.

Figure 5–312. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 2135



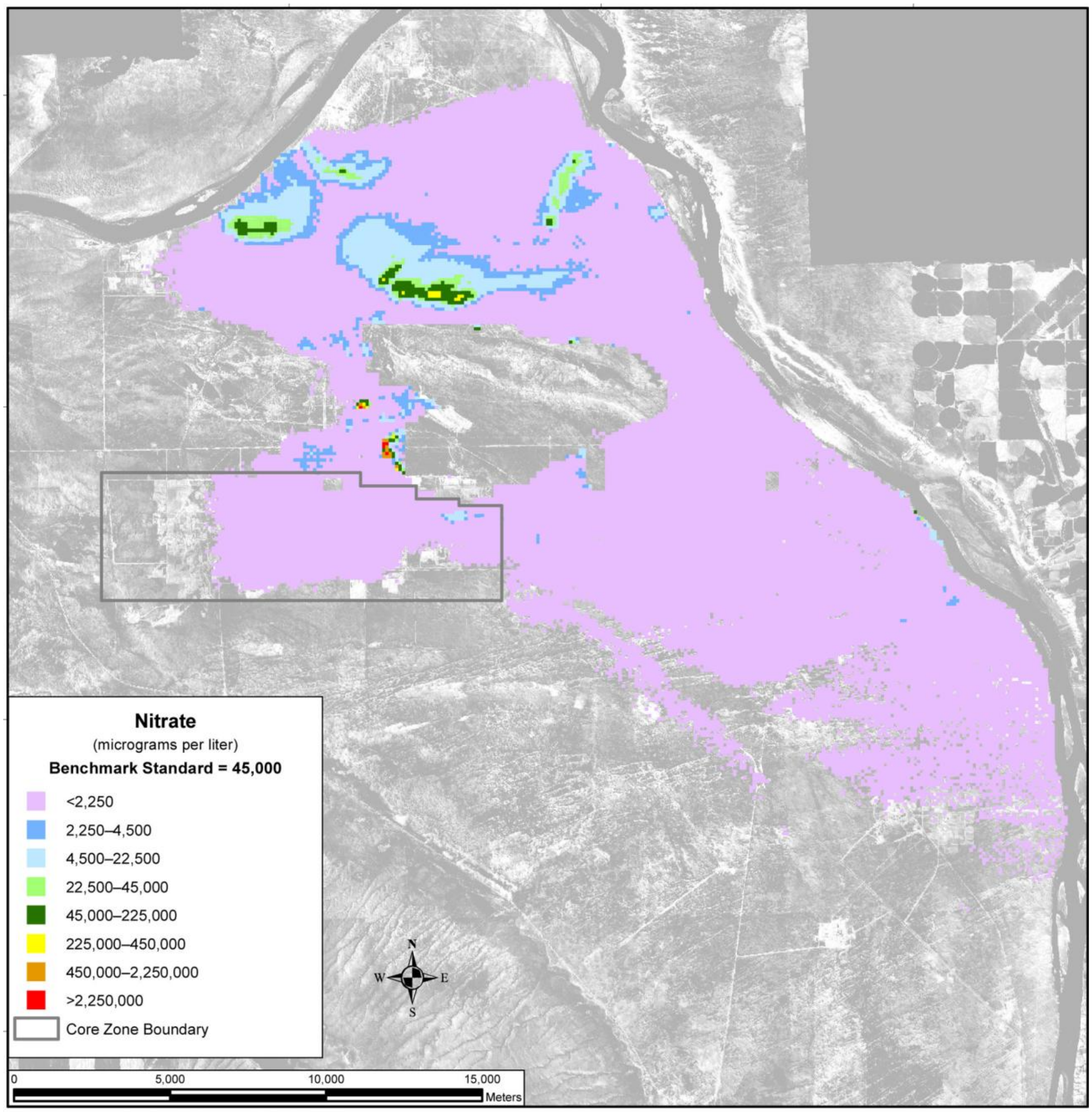
Note: To convert meters to feet, multiply by 3.281.

Figure 5–313. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 7140



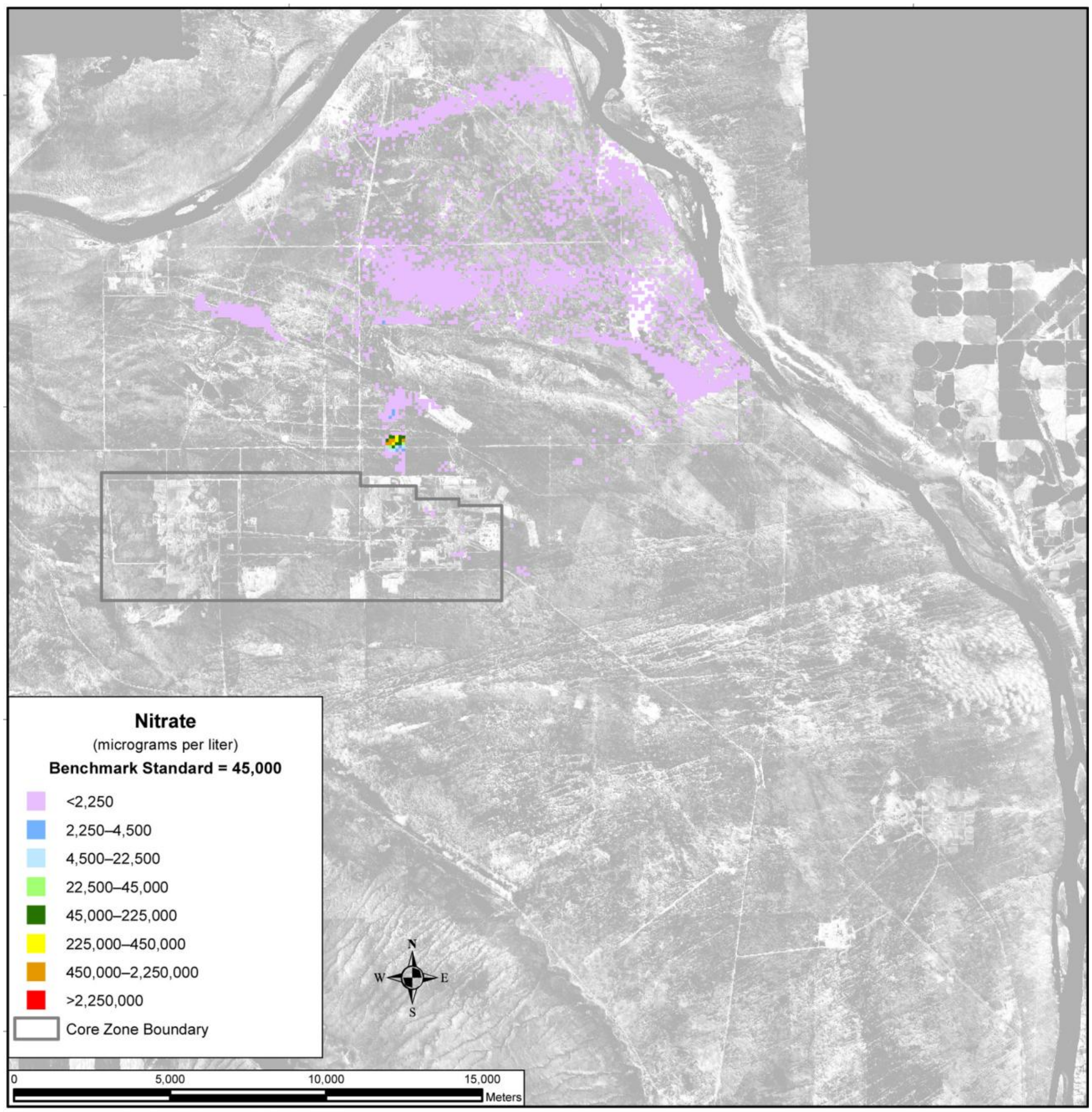
Note: To convert meters to feet, multiply by 3.281.

Figure 5–314. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 2010



Note: To convert meters to feet, multiply by 3.281.

Figure 5–315. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 2135

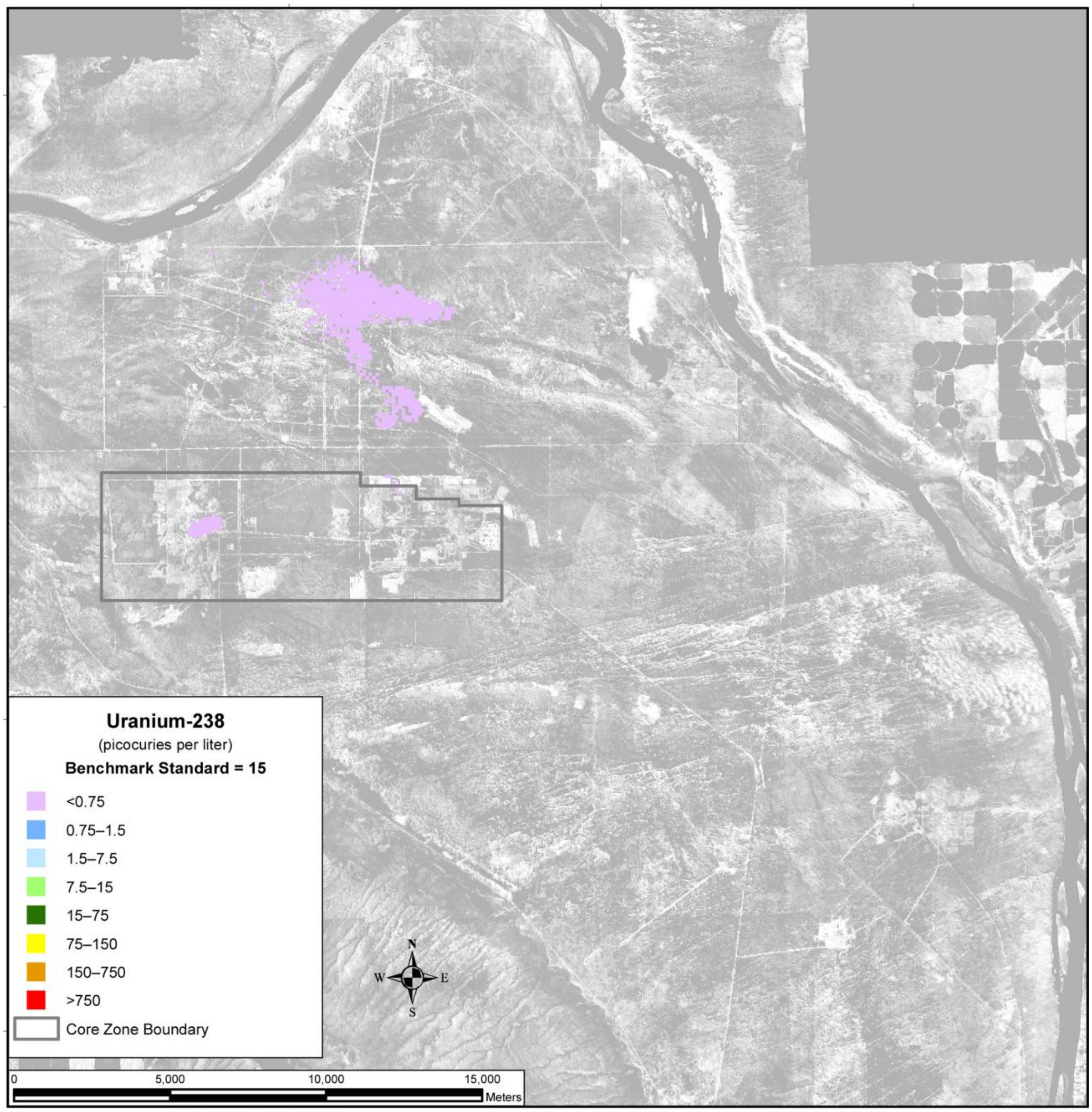


Note: To convert meters to feet, multiply by 3.281.

Figure 5–316. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 7140

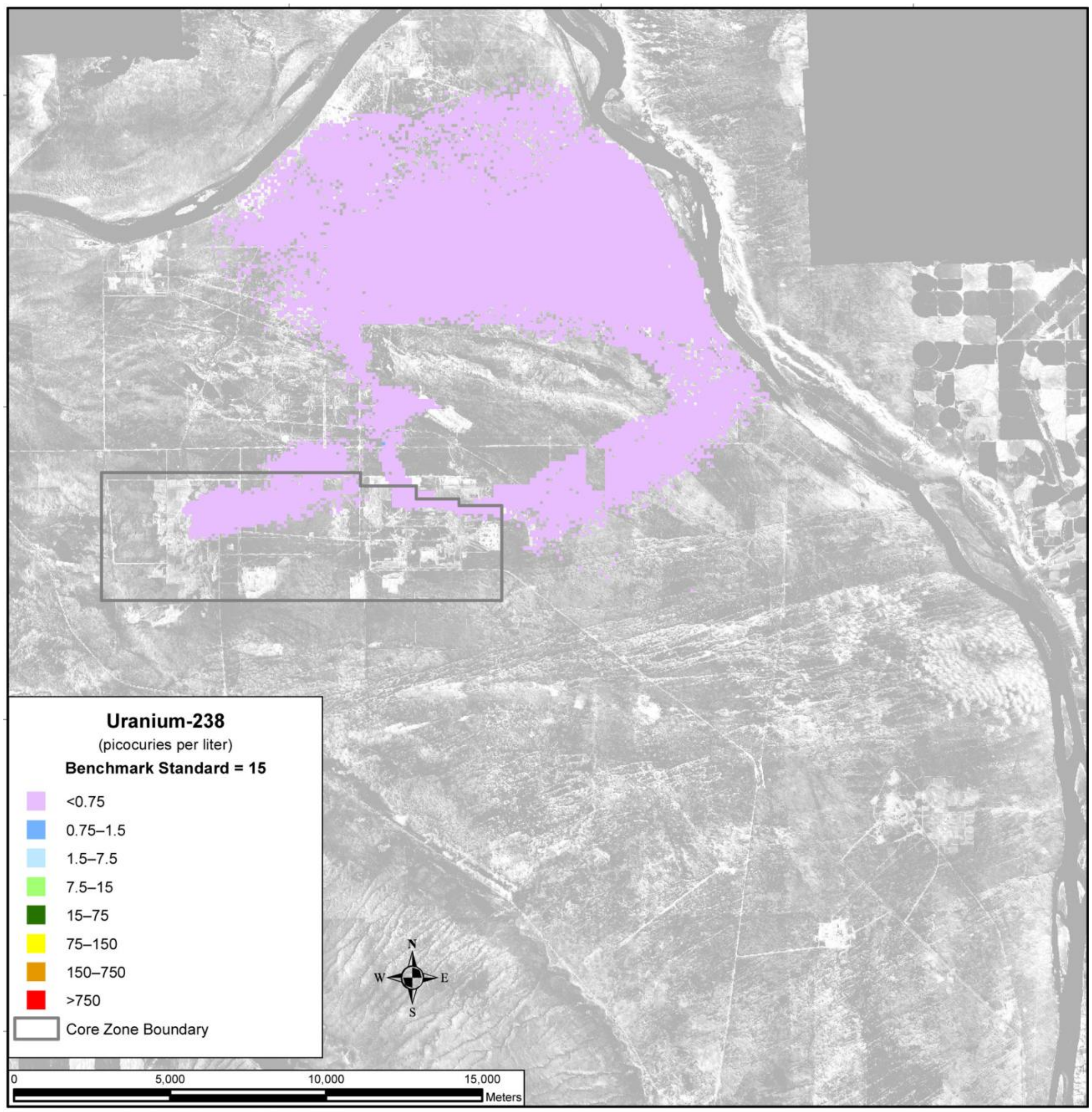
Uranium-238 and total uranium under the Base Case are not as mobile as those COPCs discussed above, moving about seven times more slowly than the pore-water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–317 shows the distribution of uranium-238 in CY 2010. There is a small plume associated with releases from cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark concentration and is contained within the Core Zone Boundary. By CY 7140, the area of the plume has grown and extended to the Columbia River (see Figure 5–318). Most of the plume is significantly below the benchmark except for a small area with higher concentrations in the southern region of Gable Gap extending north from the B Barrier. In CY 11,940, the greatest development of the plume during the analysis period is seen (see Figure 5–319).

The only area with a significant level of contaminant concentration is the area in the southern region of Gable Gap that originates from the B Barrier. Figures 5–320 through 5–322 show similar results for total uranium.



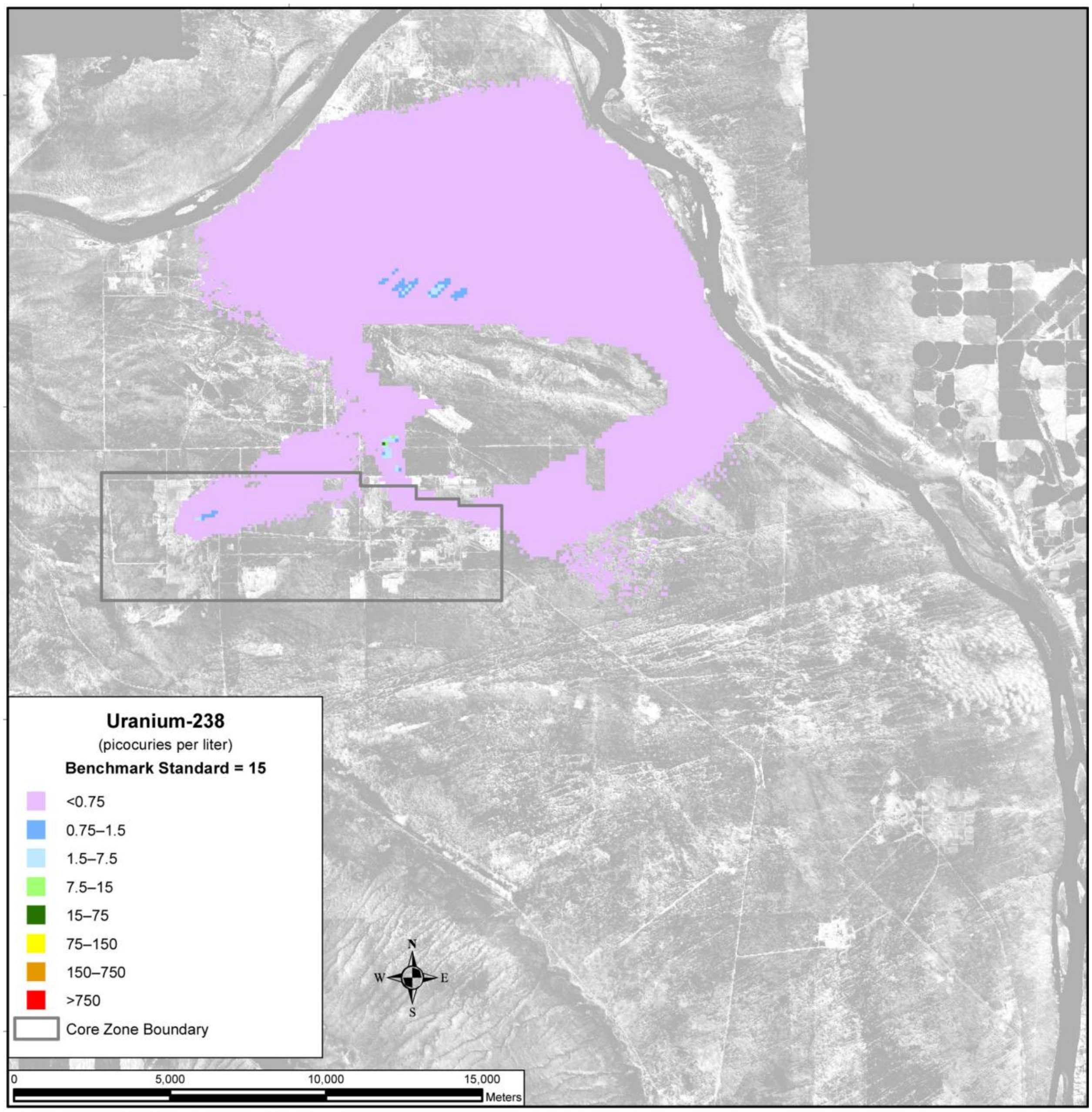
Note: To convert meters to feet, multiply by 3.281.

Figure 5–317. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 2010



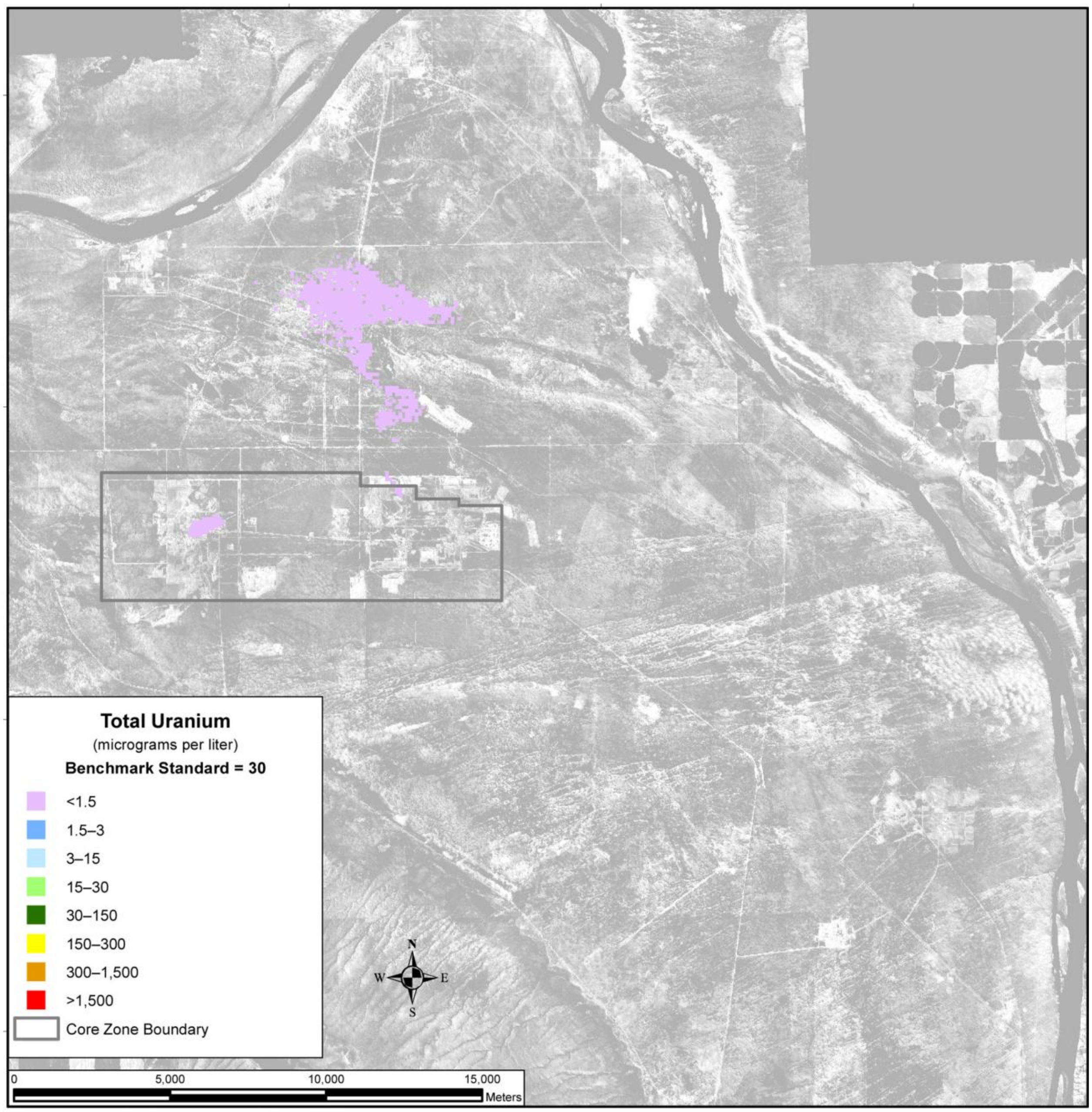
Note: To convert meters to feet, multiply by 3.281.

Figure 5–318. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 7140



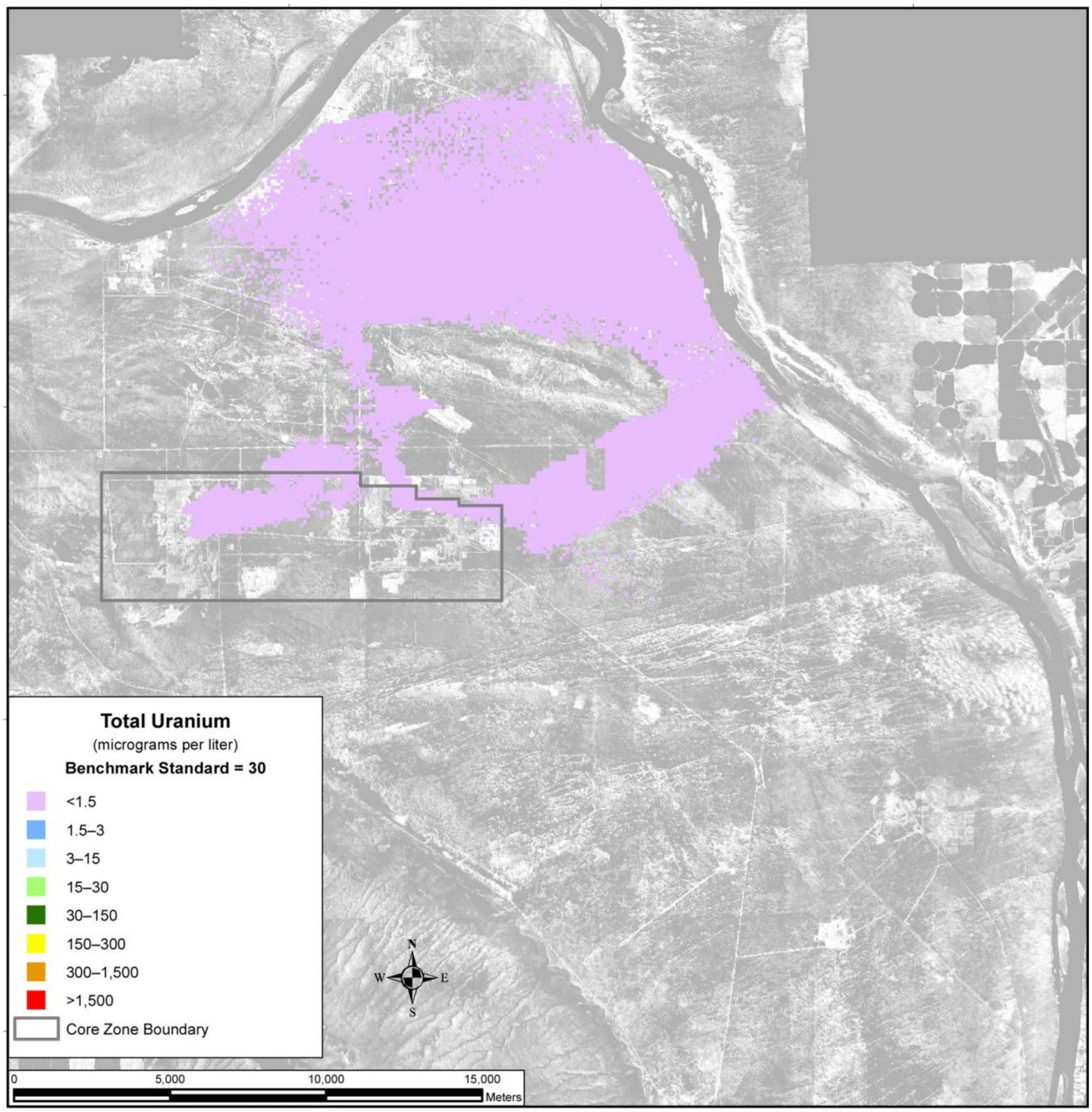
Note: To convert meters to feet, multiply by 3.281.

Figure 5–319. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 11,940



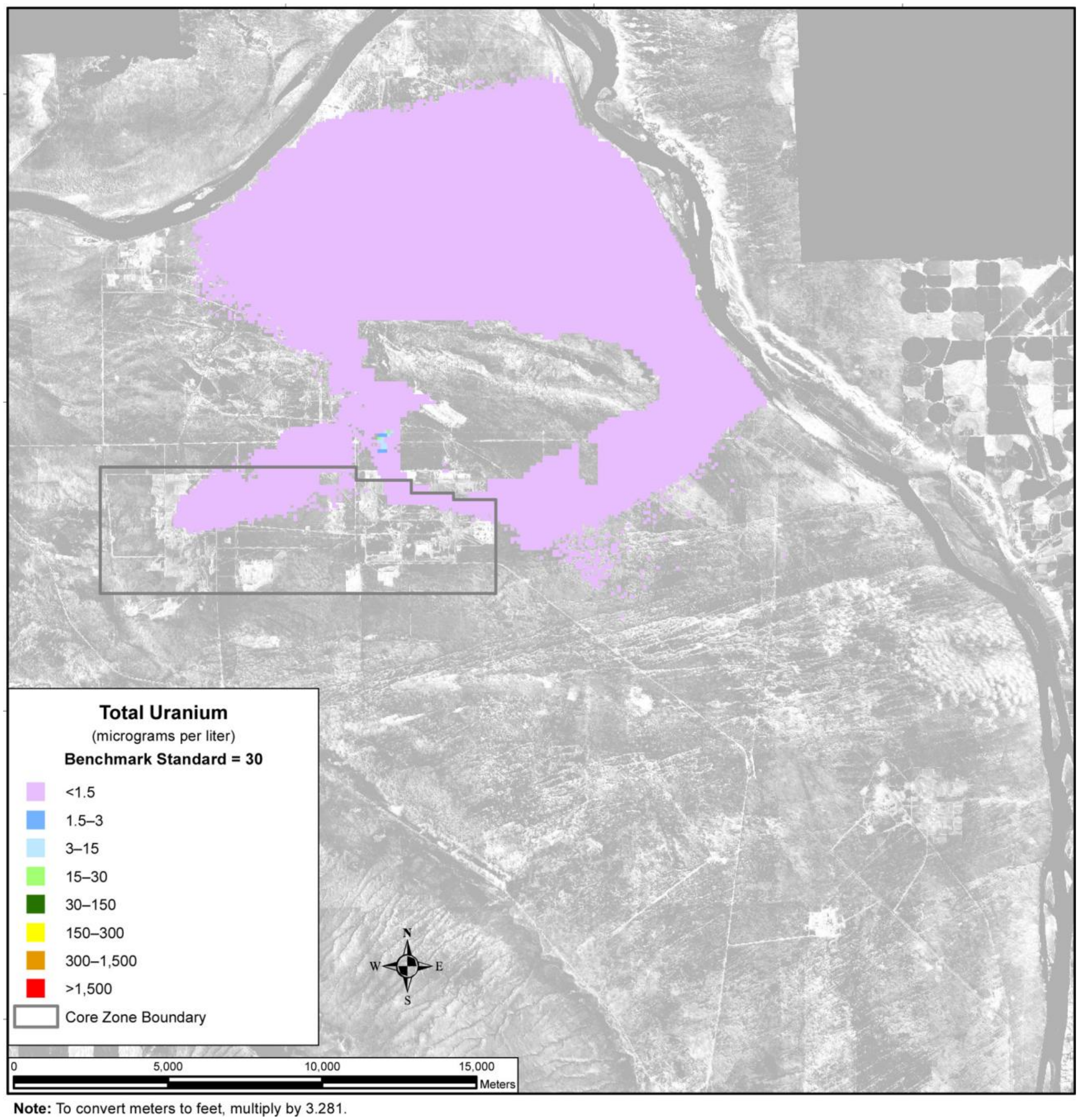
Note: To convert meters to feet, multiply by 3.281.

Figure 5–320. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration, Calendar Year 2010



Note: To convert meters to feet, multiply by 3.281.

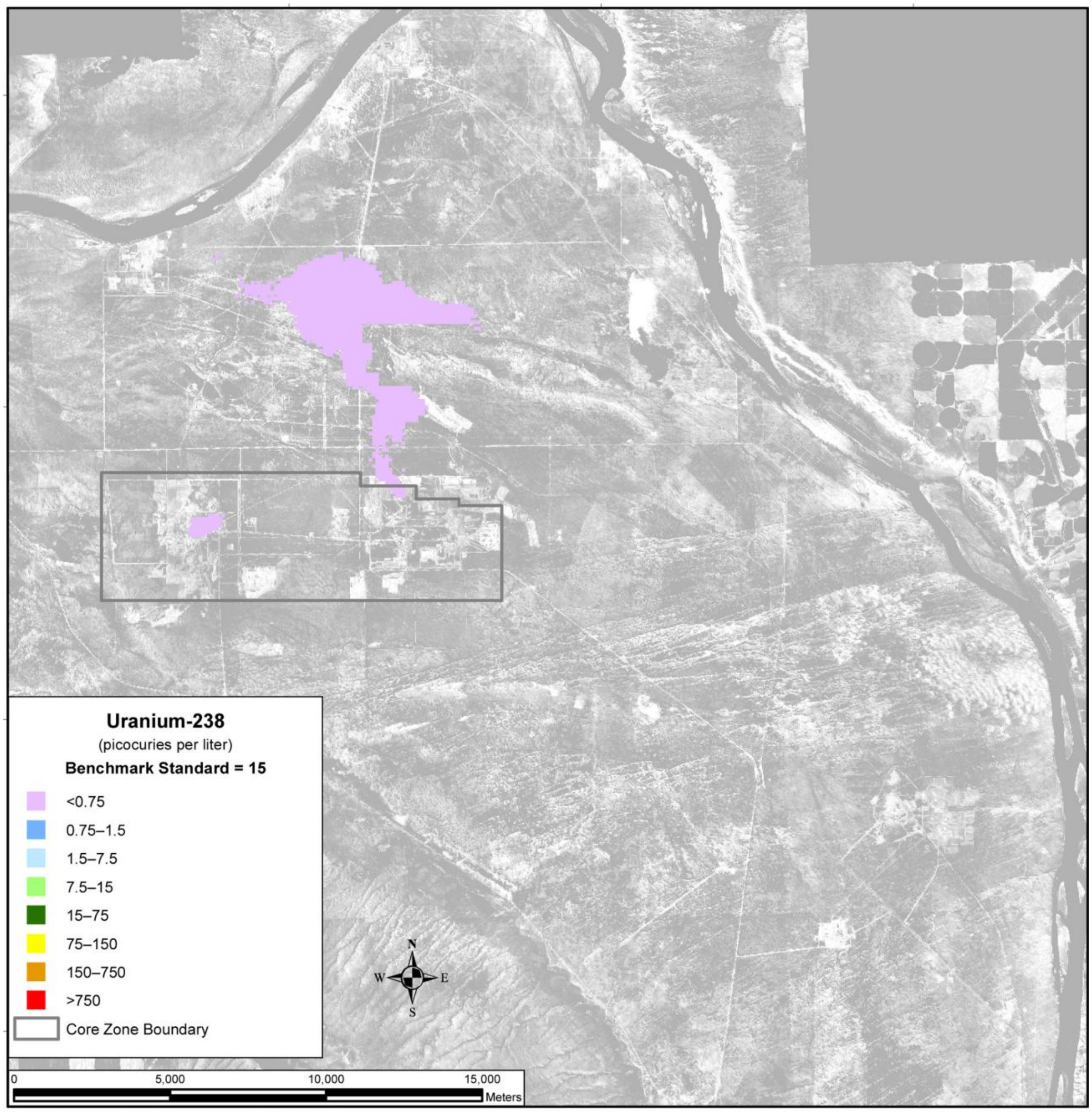
Figure 5–321. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration, Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281.

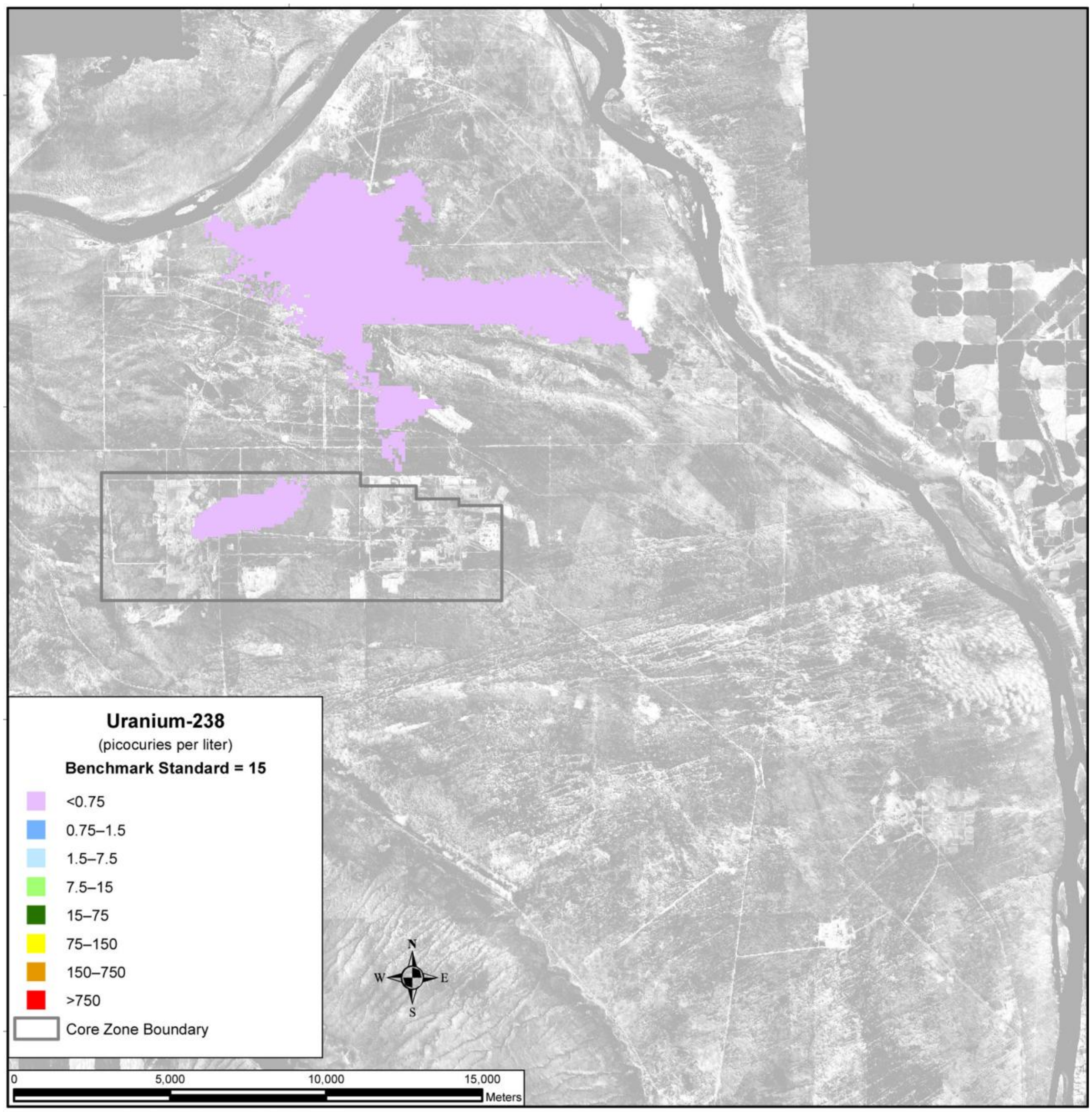
Figure 5–322. Tank Closure Alternative 6B, Base Case, Spatial Distribution of Groundwater Total Uranium Concentration, Calendar Year 11,940

Figure 5–323 shows the distribution of uranium-238 in CY 2010 under the Option Case. There are two plumes associated with this case, one originating from the T Barrier and the other from the B Barrier. Although there are no significant contaminant concentrations, the plumes under the Option Case are much larger than those under the Base Case. By CY 2135, the contaminant plumes have grown, but there are still no significant peaks in concentration levels (see Figure 5–324). By CY 11,940, the year in which the greatest development of the plumes occurs under the Base Case, the contaminant plume under the Option Case has begun to recede (see Figure 5–325). This recession is due to the removal of the six sets of cribs and trenches (ditches) and the remediation of their contaminant plumes. Figures 5–326 through 5–328 show similar results for total uranium.



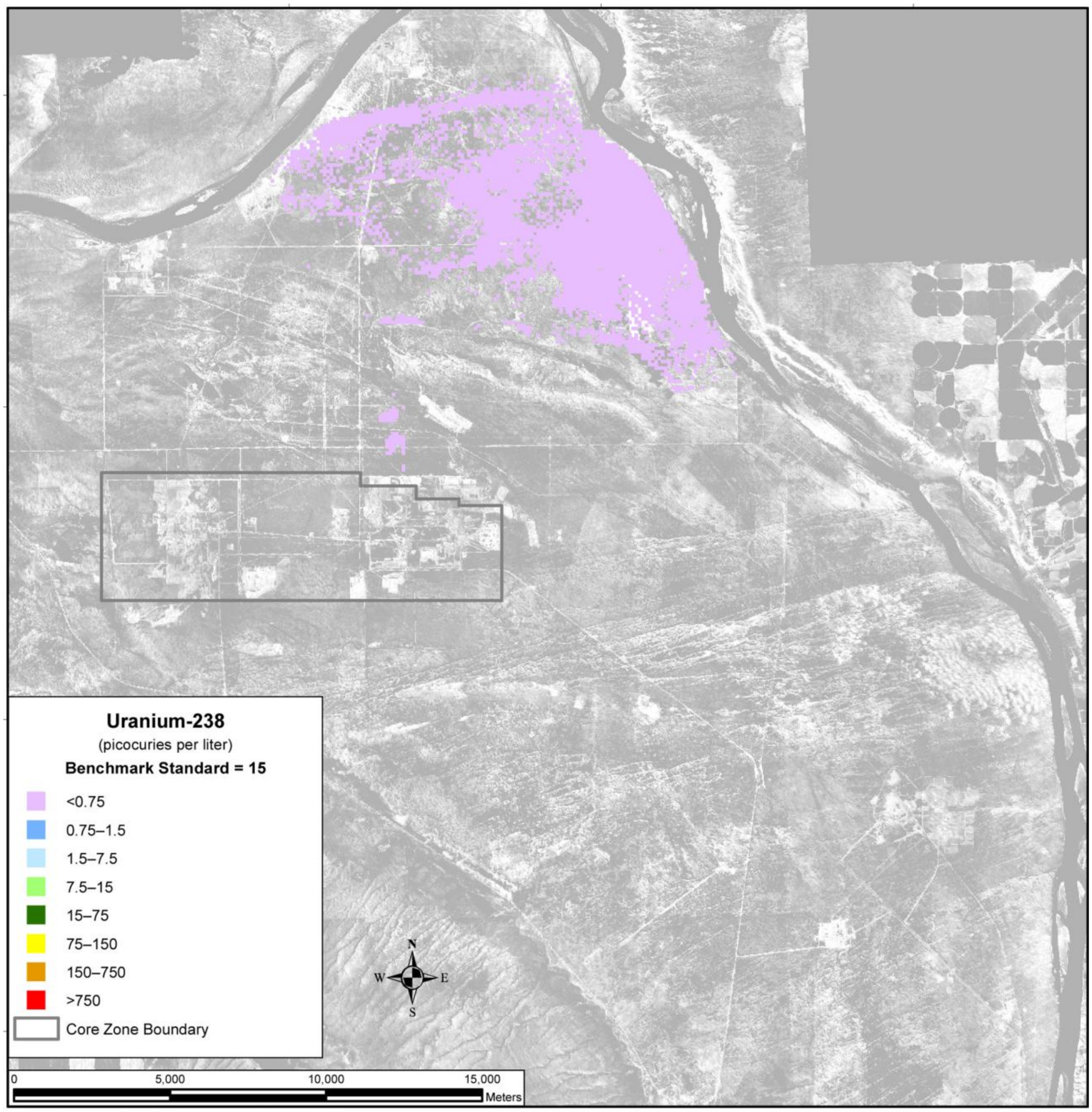
Note: To convert meters to feet, multiply by 3.281.

Figure 5–323. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 2010



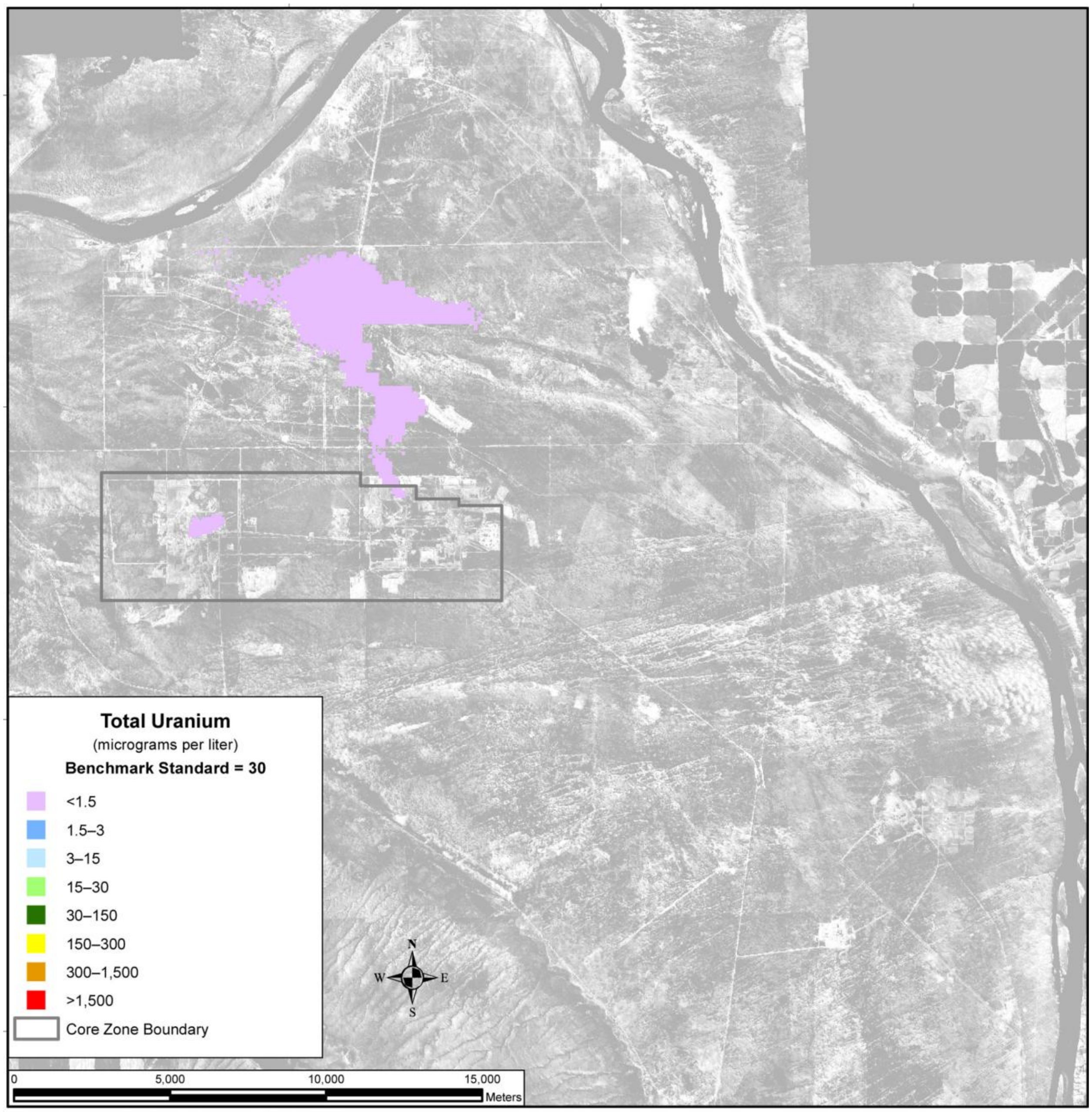
Note: To convert meters to feet, multiply by 3.281.

Figure 5–324. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 2135



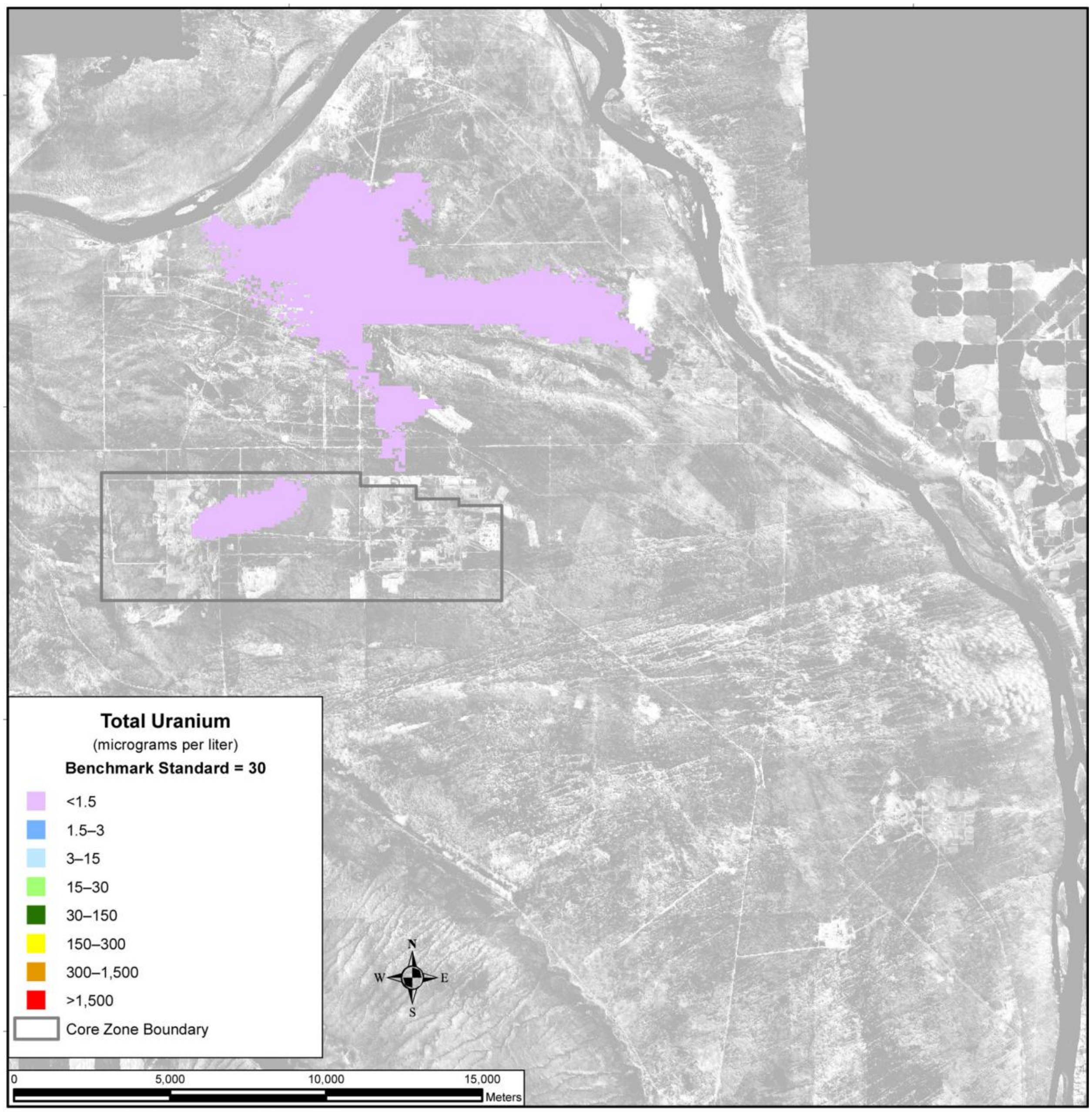
Note: To convert meters to feet, multiply by 3.281.

Figure 5–325. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 11,940



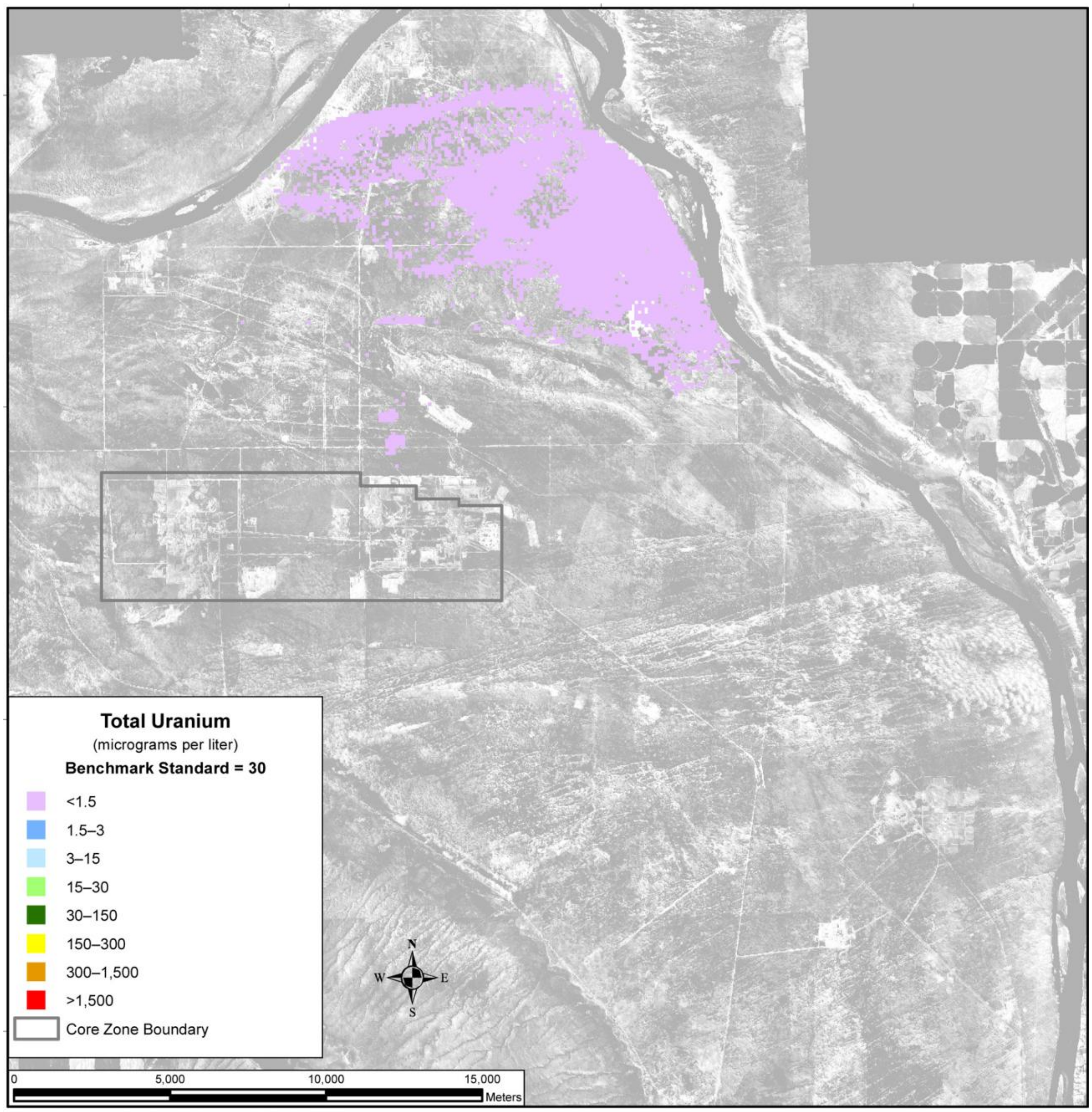
Note: To convert meters to feet, multiply by 3.281.

Figure 5–326. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration, Calendar Year 2010



Note: To convert meters to feet, multiply by 3.281.

Figure 5–327. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration, Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281.

Figure 5–328. Tank Closure Alternative 6B, Option Case, Spatial Distribution of Groundwater Total Uranium Concentration, Calendar Year 11,940

Figure 5–329 shows the area (in square kilometers) in which groundwater concentrations of technetium-99 exceed the benchmark concentration in the analysis as a function of time under the Base Case. A peak of almost 4.6 square kilometers (1.78 square miles) occurs around CY 2135, followed by a fairly sharp decrease. By about CY 4000, the area with a concentration above the benchmark begins to level out around 0.5 square kilometers (0.1 square miles). Iodine-129 shows a pattern similar to that of technetium-99 (see Figure 5–330), as both constituents are conservative tracers.

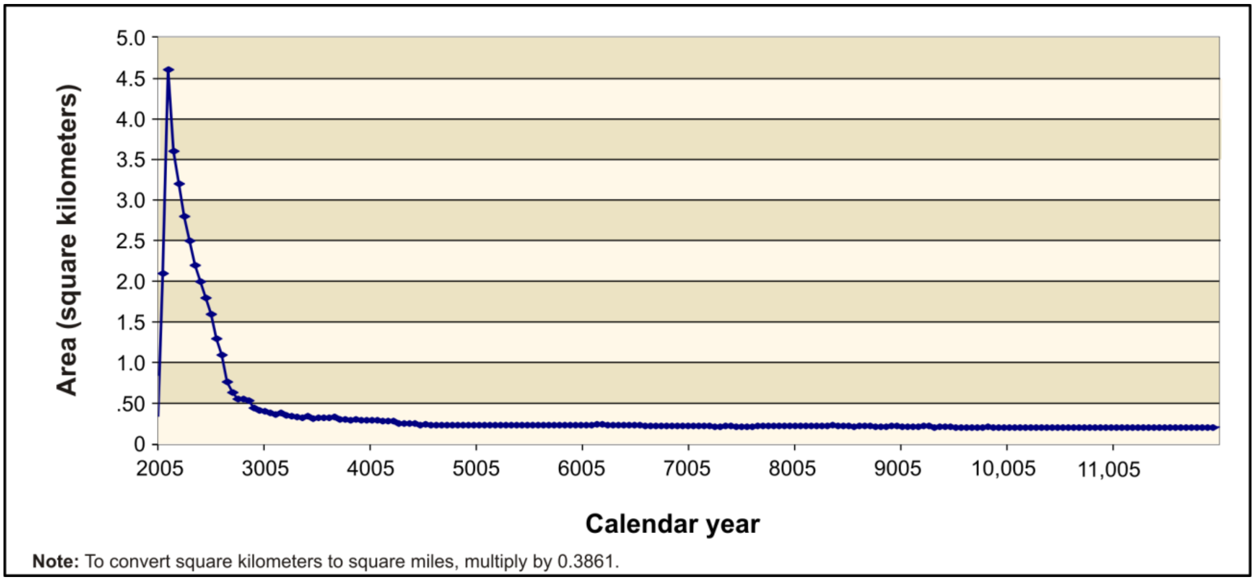


Figure 5–329. Tank Closure Alternative 6B, Base Case, Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

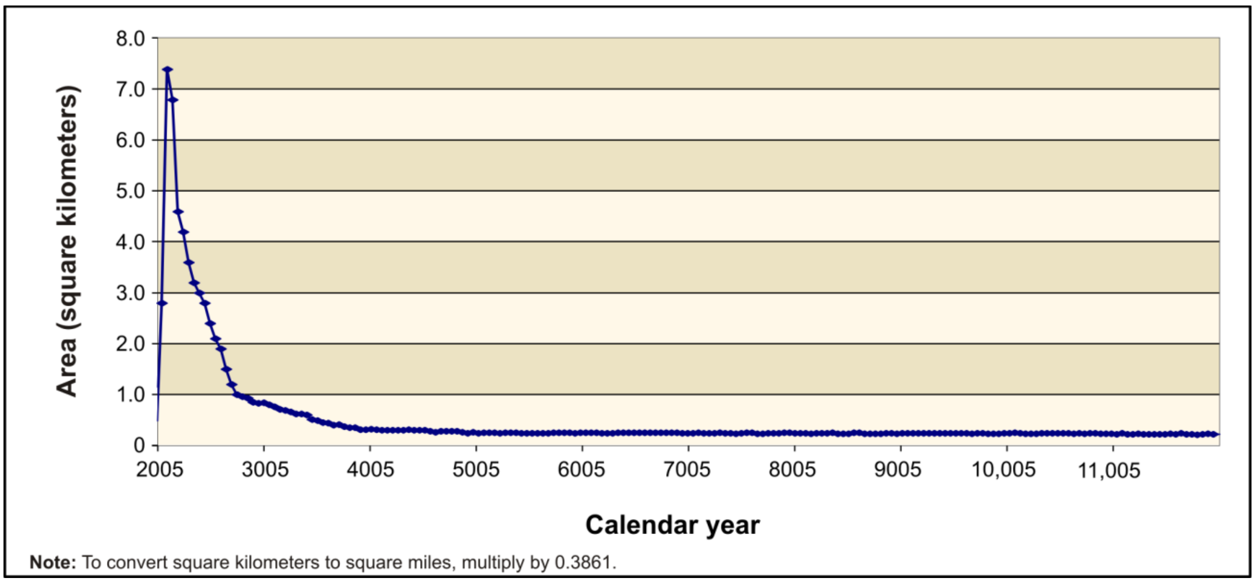


Figure 5–330. Tank Closure Alternative 6B, Base Case, Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

Under the Option Case, the areas in which concentrations of technetium-99 and iodine-129 exceed the benchmarks are essentially identical to those under the Base Case (see Figures 5–331 and 5–332).

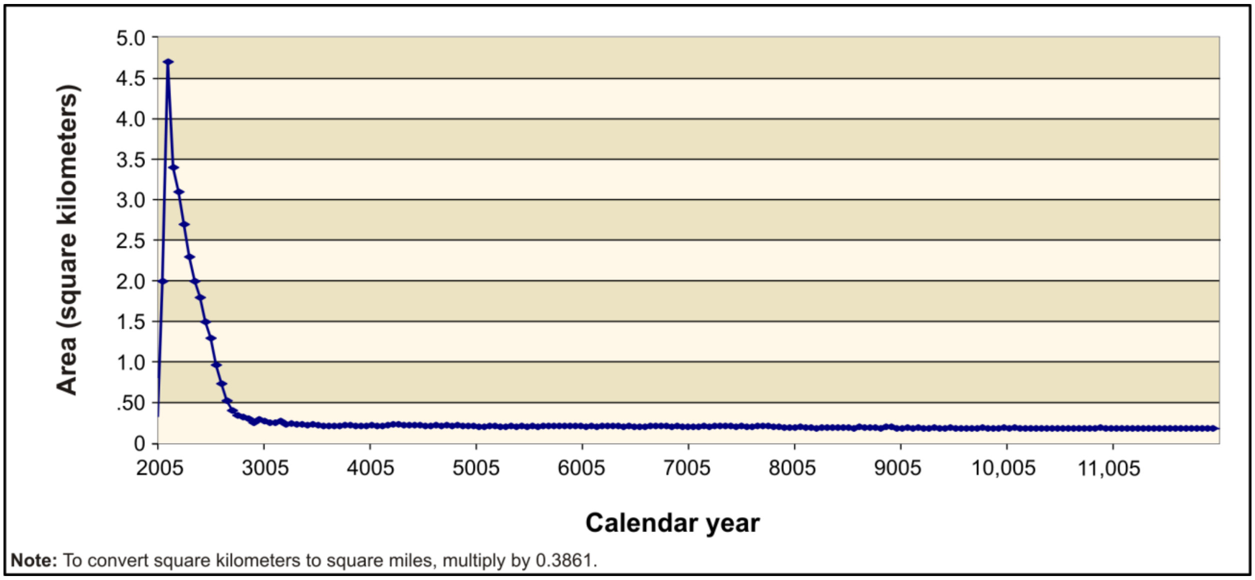


Figure 5–331. Tank Closure Alternative 6B, Option Case, Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

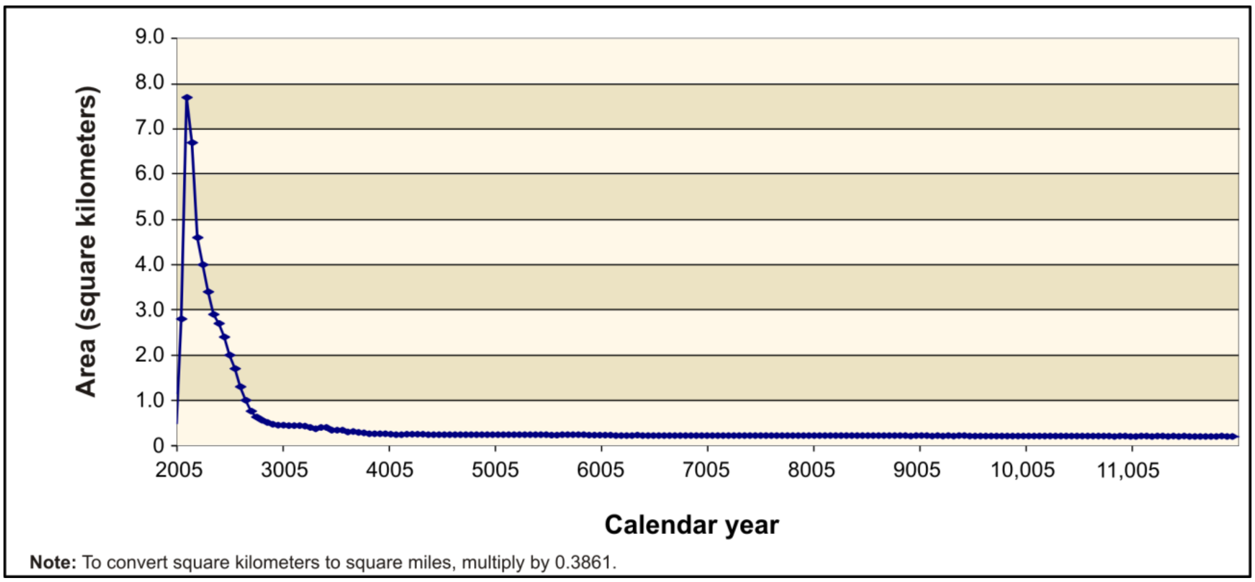
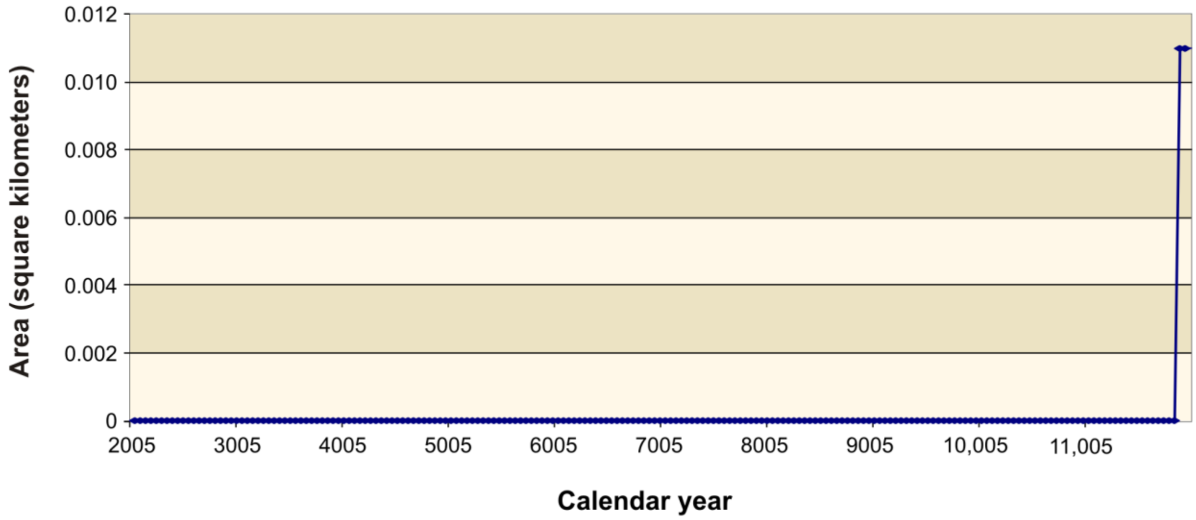


Figure 5–332. Tank Closure Alternative 6B, Option Case, Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

Under the Base Case, uranium-238 does not register above the benchmark in any area until near the end of the simulation period (see Figure 5–333). A sharp increase in area with concentrations above the benchmark standard is seen after CY 11,790 and is constant through the end of the period of analysis (CY 11,940). It is expected that the majority of the uranium-238 would continue to migrate through the vadose zone after the period of analysis is over.

Under the Option Case, uranium-238 does not register above the benchmark in any area during the period of analysis. This is a result of the high retardation rate and the removal and remediation of the cribs and trenches (ditches).



Note: To convert square kilometers to square miles, multiply by 0.3861.

Figure 5–333. Tank Closure Alternative 6B, Base Case, Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

5.1.1.10.6 Summary of Impacts

For the conservative tracers under the Base Case, concentrations at the Core Zone Boundary exceed the benchmark standards by about one to two orders of magnitude during the early part of the period of analysis, around CY 1956. Columbia River nearshore concentrations of the conservative tracers approach the benchmark for a brief time during the early period of analysis but decrease to about two to three orders of magnitude below the benchmark by the end of the period of analysis. The intensities and areas of these groundwater plumes peak around CY 1956.

The concentrations of iodine-129, technetium-99, chromium, and nitrate (the conservative tracers) under the Option Case are essentially identical to those under the Base Case during the early part of the period of analysis. Around CY 3000, clean closure of the cribs and trenches (ditches) results in concentrations at the Core Zone Boundary decreasing at a much faster rate; concentrations range over seven orders of magnitude below the benchmark by the end of the period of analysis. Concentrations of the conservative tracers at the Columbia River nearshore level out to about three orders of magnitude below the benchmark from about the middle to the latter part of the period of analysis.

Under the Base Case, concentrations of tritium at the Core Zone Boundary exceed the benchmark by about one to two orders of magnitude for a short period of time during the early part of the period of analysis, around CY 1956. During the same period of time, the Columbia River nearshore tritium concentrations approach but never reach the benchmark. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts of tritium.

The concentrations of tritium under the Option Case are essentially identical to those under the Base Case.

For uranium-238 and total uranium under the Base Case, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species begin to approach the benchmark at the Core Zone Boundary toward the latter part of the period of analysis but never reach it. The concentration levels of uranium-238 and total uranium at the Columbia River nearshore never come to within about two orders of magnitude below the benchmark. The intensity is highest and the area of the contaminant plumes largest at the end of the period of analysis.

Under the Option Case, uranium-238 and total uranium concentrations at the Core Zone Boundary peak at about one order of magnitude below the benchmark at the beginning of the period of analysis. Around CY 3000, the Core Zone Boundary concentrations drastically fall to over nine orders of magnitude below the benchmark, while the Columbia River nearshore concentrations stay fairly constant at about five orders of magnitude below the benchmark.

5.1.1.11 Tank Closure Alternative 6C: All Vitrification with Separations; Landfill Closure

Activities under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C would be similar in scope and timing. Tank waste would be retrieved to a volume corresponding to 99 percent retrieval, and residual waste in tanks would be grouted in place. The tank farms and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. From the long-term groundwater impact perspective, the results from the analyses of these alternatives are identical. See Section 5.1.3 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, Case 1, which are identical to those for Tank Closure Alternative 6C.

5.1.1.11.1 Actions and Timeframes Influencing Groundwater Impacts

See Section 5.1.1.3.1 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, Case 1, which are identical to those for Tank Closure Alternative 6C.

5.1.1.11.2 COPC Drivers

See Section 5.1.1.3.2 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, Case 1, which are identical to those for Tank Closure Alternative 6C.

5.1.1.11.3 Analysis of Release and Mass Balance

See Section 5.1.1.3.3 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, Case 1, which are identical to those for Tank Closure Alternative 6C.

5.1.1.11.4 Analysis of Concentration Versus Time

See Section 5.1.1.3.4 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, Case 1, which are identical to those for Tank Closure Alternative 6C.

5.1.1.11.5 Analysis of Spatial Distribution of Concentration

See Section 5.1.1.3.5 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, Case 1, which are identical to those for Tank Closure Alternative 6C.

5.1.1.11.6 Summary of Impacts

See Section 5.1.1.3.6 for detailed, long-term groundwater analysis results for Tank Closure Alternative 2B, Case 1, which are identical to those for Tank Closure Alternative 6C.

5.1.2 Human Health Impacts

Potential human health impacts due to release of radionuclides are estimated as dose and as lifetime risk of incidence of cancer (i.e., radiological risk). For long-term performance assessment, radiological dose and risk are estimated consistent with the recommendations of *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, Federal Guidance Report No. 13 (Eckerman et al. 1999), including use of radionuclide-specific dose factors and risk coefficients. Potential human health effects due to release of chemical constituents include both carcinogenic effects and other forms of toxicity. Impacts of carcinogenic chemicals are estimated as lifetime risk of incidence of cancer. Noncarcinogenic effects are estimated as a Hazard Quotient, the ratio of the long-term intake of a single chemical to intake that produces no observable effect, and as a Hazard Index, the sum of the Hazard Quotients of a group of chemicals. Further information on the nature of human health effects in response to exposure to radioactive and chemical constituents is provided in Appendix K, Section K.1. Screening analysis identified 14 radioactive and 26 chemical constituents as contributing the greatest risk of adverse impacts. Appendix Q provides more information on the screening analysis and on results of detailed analysis, including time of occurrence of peak impacts and constituent- and location-specific impacts under each Tank Closure, FFTF Decommissioning, and Waste Management alternative.

The four measures of human health impacts considered in this analysis—lifetime risks of developing cancer from radioactive and chemical constituents, dose from radioactive constituents, and Hazard Index from chemical constituents—were calculated for each year for 10,000 years for each receptor at eight specific locations (i.e., A, B, S, T, and U Barriers; Core Zone Boundary; Columbia River nearshore; and Columbia River surface water). This is a large amount of information that must be summarized to allow interpretation of results. The method chosen is to present dose for the year of maximum dose, risk for the year of maximum risk, and Hazard Index for the year of maximum Hazard Index. This choice is based on regulation of radiological impacts expressed as dose and the observation that peak risk and peak noncarcinogenic impacts expressed as Hazard Index may occur at times other than that of peak dose. Also, to summarize the time dependence of impacts, time series of lifetime risk are presented only for locations of likely maximum impact, that is, nearfield barriers and the Core Zone Boundary.

Three types of release are considered under the Tank Closure alternatives. The first type of release is the past practice of direct discharge of liquid to cribs and trenches (ditches). The second type of release is due to past leaks from damaged tanks. The third type of release, identified in the following text and figures as "other tank farm sources," is due to past unplanned releases that occurred in the tank farms and future activities, including leaks projected to occur during retrieval of waste from the tanks (i.e., retrieval leaks), as well as long-term leaching of waste material in tanks (i.e., tank residuals) and ancillary equipment.

Onsite locations comprise the boundaries of the tank farms, Core Zone Boundary, and Columbia River nearshore. Offsite locations comprise access points to Columbia River surface water near the site and at population centers downstream of the site. Estimates of concentration of constituents in the Columbia River surface water are used to calculate impacts for both the offsite location points of analysis. The total population of downstream water users was assumed to be 5 million people for the entire 10,000-year period of analysis (DOE 1987). Four types of receptors are considered. The first type, a drinking-water well user, uses groundwater as a source of drinking water. The second type, a resident farmer, uses either groundwater or surface water for drinking water consumption and irrigation of crops. Garden size and crop yield are adequate to produce approximately 25 percent of average requirements of crops and animal products. The third type, an American Indian resident farmer, also uses either groundwater or surface water for drinking water consumption and irrigation of crops. Garden size and crop yield are adequate to produce the entirety of average requirements of crops and animal products. The fourth type, an American Indian hunter-gatherer, is impacted by both groundwater and surface water because he uses surface water for drinking water consumption and consumes both wild plant materials, which use groundwater, and game, which use surface water. In Appendix Q, estimates of impacts are presented in two sets of tables, one set for receptors using groundwater and one set for users of surface water. To facilitate presentation, estimates of impacts on the American Indian hunter-gatherer are presented in the set of tables for surface-water users in Appendix Q. However, in this section and in subsequent sections, the impacts on the American Indian hunter-gatherer are presented under the Columbia River nearshore location. Members of the offsite population are assumed to have the activity pattern of a residential farmer, using surface water to meet the total annual drinking water requirement and to irrigate a garden that provides approximately 25 percent of annual crop and animal product requirements. These receptors are also assumed to consume fish harvested from the river. Impacts on an individual of the offsite population are the same as those reported in tables in this chapter for the resident farmer at the Columbia River surface-water location.

The significance of dose impacts is evaluated by comparison against the 100-millirem-per-year all-exposure-modes standard specified for protection of the public and the environment in DOE Order 458.1, Radiation Protection of the Public and the Environment. The level of protection provided for the drinking water pathway is evaluated by comparison with applicable drinking water standards presented in Section 5.1.1. Population doses are compared against total effective dose equivalent from natural background sources of 311 millirem per year for a member of the population of the United States (NCRP 2009). The significance of noncarcinogenic chemical impacts is evaluated by comparison against a guideline value of unity (1) for Hazard Index. Estimation of Hazard Index less than unity indicates that observable effects would not occur.

5.1.2.1 Tank Closure Alternative 1: No Action

Under Tank Closure Alternative 1, the tank farms would be maintained in the current condition indefinitely but, for analysis purposes, the structural integrity of the tanks is assumed to fail after an administrative control period of 100 years. At this time, the salt cake in the SSTs is assumed to be available for leaching into the vadose zone and the liquid contents of the DSTs are assumed to be discharged directly to the vadose zone. Potential human health impacts under Tank Closure Alternative 1 are detailed in Appendix Q and summarized in Tables 5–16 through 5–21; those related to cribs and trenches (ditches) after CY 1940, in Tables 5–16 and 5–17; to past leaks after CY 1940, in Tables 5–18 and 5–19; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050, in Tables 5–20 and 5–21.

Due to the large magnitude of the liquid release in the analysis, transport through the vadose zone is rapid, and impacts exceeding dose standards are estimated for onsite locations. The largest contributors are the cribs and trenches (ditches) and the presence of tritium, technetium-99, iodine-129, uranium-238, chromium, nitrate and total uranium. Due to large dilution in the Columbia River, offsite impacts on individuals are small. The population dose is estimated as 3.12 person-rem per year for the year of maximum impact. This corresponds to 2.01×10^{-4} percent of the annual population dose due to background exposure.

Table 5–16. Tank Closure Alternative 1 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	1.51×10^{2}	8.84×10^{1}	2.98×10^{-3}	0.00	2.98×10^{-3}	2.63×10^{2}	3.13×10^{2}	8.04×10^{-3}	2.39×10^{-8}	8.04×10^{-3}
T Barrier	8.88×10^{2}	9.18×10^{1}	8.43×10^{-3}	0.00	8.43×10^{-3}	1.03×10^{3}	2.85×10^{2}	1.02×10^{-2}	2.64×10^{-8}	1.02×10^{-2}
Core Zone Boundary	1.51×10^{2}	8.84×10^{1}	2.98×10^{-3}	0.00	2.98×10^{-3}	2.63×10^{2}	3.13×10^{2}	8.04×10^{-3}	2.39×10^{-8}	8.04×10^{-3}
Columbia River nearshore	3.06	2.97	6.72×10^{-5}	0.00	6.72×10^{-5}	5.72	1.14×10^{1}	1.90×10^{-4}	9.09×10^{-10}	1.90×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.43×10^{-4}	8.90×10^{-4}	1.10×10^{-8}	6.85×10^{-14}	1.10×10^{-8}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–17. Tank Closure Alternative 1 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	4.50×10^{2}	6.77×10^{2}	1.66×10^{-2}	1.09×10^{-3}	1.71×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.23×10^{3}	5.88×10^{2}	1.30×10^{-2}	1.21×10^{-3}	1.32×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.50×10^{2}	6.77×10^{2}	1.66×10^{-2}	1.09×10^{-3}	1.71×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.02×10^{1}	2.44×10^{1}	3.99×10^{-4}	4.17×10^{-5}	4.24×10^{-4}	9.75×10^{-2}	4.58	2.73×10^{-6}	4.17×10^{-5}	4.28×10^{-5}
Off Site										
Columbia River	9.78×10^{-4}	4.51×10^{-1}	3.39×10^{-8}	3.14×10^{-9}	3.51×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–18. Tank Closure Alternative 1 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.56	6.75×10^{-1}	8.40×10^{-5}	0.00	8.40×10^{-5}	6.37	9.72×10^{-1}	2.73×10^{-4}	2.62×10^{-10}	2.73×10^{-4}
B Barrier	5.61	6.59×10^{-1}	1.62×10^{-4}	0.00	1.62×10^{-4}	1.27×10^{1}	1.18	5.06×10^{-4}	2.45×10^{-10}	5.06×10^{-4}
S Barrier	5.66	2.45	1.64×10^{-4}	0.00	1.64×10^{-4}	1.28×10^{1}	3.38	5.12×10^{-4}	9.59×10^{-10}	5.12×10^{-4}
T Barrier	2.46×10^{1}	3.31	7.04×10^{-4}	0.00	7.04×10^{-4}	5.52×10^{1}	6.34	2.20×10^{-3}	1.19×10^{-9}	2.20×10^{-3}
U Barrier	2.85×10^{-1}	6.71×10^{-2}	8.72×10^{-6}	0.00	8.72×10^{-6}	6.71×10^{-1}	1.24×10^{-1}	2.77×10^{-5}	2.44×10^{-11}	2.77×10^{-5}
Core Zone Boundary	5.61	8.45×10^{-1}	1.62×10^{-4}	0.00	1.62×10^{-4}	1.27×10^{1}	1.35	5.06×10^{-4}	3.25×10^{-10}	5.06×10^{-4}
Columbia River nearshore	7.86×10^{-1}	9.24×10^{-2}	2.28×10^{-5}	0.00	2.28×10^{-5}	1.78	1.72×10^{-1}	7.15×10^{-5}	3.35×10^{-11}	7.15×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.06×10^{-5}	5.43×10^{-6}	1.63×10^{-9}	1.19×10^{-15}	1.63×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–19. Tank Closure Alternative 1 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	$1.28×10^{1}$	1.69	$5.95×10^{-4}$	$1.20×10^{-5}$	$5.96×10^{-4}$	N/A	N/A	N/A	N/A	N/A
B Barrier	$2.46×10^{1}$	2.19	$1.09×10^{-3}$	$1.12×10^{-5}$	$1.10×10^{-3}$	N/A	N/A	N/A	N/A	N/A
S Barrier	$2.49×10^{1}$	5.80	$1.10×10^{-3}$	$4.40×10^{-5}$	$1.15×10^{-3}$	N/A	N/A	N/A	N/A	N/A
T Barrier	$1.07×10^{2}$	$1.20×10^{1}$	$4.73×10^{-3}$	$5.45×10^{-5}$	$4.79×10^{-3}$	N/A	N/A	N/A	N/A	N/A
U Barrier	1.33	$2.32×10^{-1}$	$6.01×10^{-5}$	$1.12×10^{-6}$	$6.10×10^{-5}$	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	$2.46×10^{1}$	2.45	$1.09×10^{-3}$	$1.49×10^{-5}$	$1.10×10^{-3}$	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.47	$3.23×10^{-1}$	$1.54×10^{-4}$	$1.54×10^{-6}$	$1.56×10^{-4}$	$1.29×10^{-2}$	$7.05×10^{-2}$	$6.18×10^{-7}$	$1.54×10^{-6}$	$2.11×10^{-6}$
Off Site										
Columbia River	$1.61×10^{-4}$	$1.54×10^{-3}$	$5.79×10^{-9}$	$5.45×10^{-11}$	$5.84×10^{-9}$	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–20. Tank Closure Alternative 1 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	8.37×10^{1}	3.64	2.63×10^{-3}	1.93×10^{-12}	2.63×10^{-3}	2.01×10^{2}	8.22	8.44×10^{-3}	1.27×10^{-9}	8.44×10^{-3}
B Barrier	5.88×10^{1}	9.20	1.73×10^{-3}	5.39×10^{-13}	1.73×10^{-3}	1.34×10^{2}	2.79×10^{1}	5.45×10^{-3}	3.39×10^{-9}	5.45×10^{-3}
S Barrier	4.73×10^{1}	5.91	1.46×10^{-3}	3.50×10^{-12}	1.46×10^{-3}	1.12×10^{2}	1.06×10^{1}	4.65×10^{-3}	2.12×10^{-9}	4.65×10^{-3}
T Barrier	1.52×10^{1}	4.28	4.33×10^{-4}	0.00	4.33×10^{-4}	3.40×10^{1}	1.19×10^{1}	1.35×10^{-3}	1.32×10^{-9}	1.35×10^{-3}
U Barrier	2.23×10^{1}	2.33	6.48×10^{-4}	0.00	6.48×10^{-4}	5.05×10^{1}	5.13	2.03×10^{-3}	8.18×10^{-10}	2.03×10^{-3}
Core Zone Boundary	5.88×10^{1}	9.20	1.73×10^{-3}	1.13×10^{-12}	1.73×10^{-3}	1.34×10^{2}	2.79×10^{1}	5.45×10^{-3}	3.39×10^{-9}	5.45×10^{-3}
Columbia River nearshore	4.37	1.01	1.11×10^{-4}	2.41×10^{-13}	1.11×10^{-4}	9.01	2.86	3.45×10^{-4}	3.28×10^{-10}	3.45×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	6.24×10^{-4}	7.44×10^{-5}	2.54×10^{-8}	1.09×10^{-14}	2.54×10^{-8}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–21. Tank Closure Alternative 1 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	4.01×10^{2}	1.72×10^{1}	1.83×10^{-2}	5.82×10^{-5}	1.84×10^{-2}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.63×10^{2}	6.10×10^{1}	1.18×10^{-2}	1.56×10^{-4}	1.19×10^{-2}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.22×10^{2}	1.97×10^{1}	1.01×10^{-2}	9.74×10^{-5}	1.02×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	6.58×10^{1}	2.42×10^{1}	2.90×10^{-3}	6.06×10^{-5}	2.97×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	9.85×10^{1}	1.00×10^{1}	4.39×10^{-3}	3.75×10^{-5}	4.42×10^{-3}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.63×10^{2}	6.10×10^{1}	1.18×10^{-2}	1.56×10^{-4}	1.19×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.68×10^{1}	5.92	7.49×10^{-4}	1.50×10^{-5}	7.57×10^{-4}	6.82×10^{-2}	1.02	3.08×10^{-6}	1.50×10^{-5}	1.72×10^{-5}
Off Site										
Columbia River	2.32×10^{-3}	3.13×10^{-2}	8.59×10^{-8}	5.02×10^{-10}	8.63×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

For releases from the cribs and trenches (ditches), peak impacts at the B and T Barriers are estimated to occur in the past, prior to CY 2000. For past leaks, peak impacts at the tank farm barriers are estimated to occur in the vicinity of, or prior to, CY 2050. As shown in Figure 5–334, peak impacts at the Core Zone Boundary due to all sources result primarily from assumed tank failure and occur as a narrow, early peak and as a broad pulse extending between CYs 2500 and 5000. An elevated level of risk due to tank failure extends over the entire period of analysis. At the Core Zone Boundary, peak risk due to tank failure is approximately a factor of 2 less than peak risk due to releases from cribs and trenches (ditches) and a factor of 10 greater than peak risk due to past leaks.

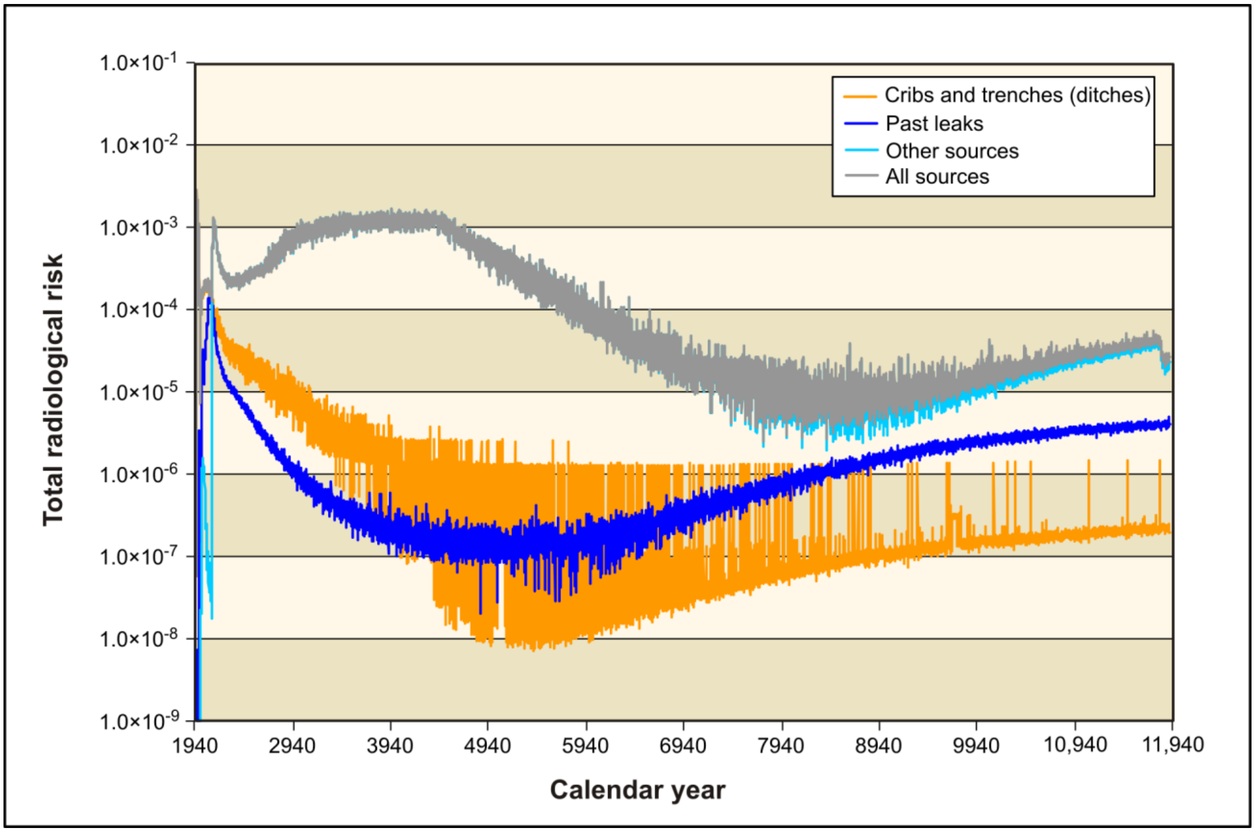


Figure 5–334. Tank Closure Alternative 1 Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.1.2.2 Tank Closure Alternative 2A: Existing WTP Vitrification; No Closure

Under Tank Closure Alternative 2A, tank waste would be retrieved to a volume corresponding to 99 percent retrieval, but the residual material in tanks would not be stabilized. After an administrative control period of 100 years, salt cake in the tanks is assumed to be available for dissolution in infiltrating water and the liquid contents of the DSTs are assumed to be discharged directly to the vadose zone. Potential human health impacts under Tank Closure Alternative 2A are detailed in Appendix Q and summarized in Tables 5–22 through 5–27; those related to cribs and trenches (ditches) after CY 1940, in Tables 5–22 and 5–23; to past leaks after CY 1940, in Tables 5–24 and 5–25; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050, in Tables 5–26 and 5–27.

Table 5–22. Tank Closure Alternative 2A Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	1.50×10^{2}	8.90×10^{1}	2.91×10^{-3}	0.00	2.91×10^{-3}	2.58×10^{2}	3.14×10^{2}	7.75×10^{-3}	2.37×10^{-8}	7.75×10^{-3}
T Barrier	8.89×10^{2}	9.16×10^{1}	8.44×10^{-3}	0.00	8.44×10^{-3}	1.03×10^{3}	2.84×10^{2}	1.02×10^{-2}	2.63×10^{-8}	1.02×10^{-2}
Core Zone Boundary	1.50×10^{2}	8.90×10^{1}	2.91×10^{-3}	0.00	2.91×10^{-3}	2.58×10^{2}	3.14×10^{2}	7.75×10^{-3}	2.37×10^{-8}	7.75×10^{-3}
Columbia River nearshore	3.06	2.91	6.72×10^{-5}	0.00	6.72×10^{-5}	5.72	1.12×10^{1}	1.90×10^{-4}	8.70×10^{-10}	1.90×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.44×10^{-4}	8.90×10^{-4}	1.11×10^{-8}	6.83×10^{-14}	1.11×10^{-8}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–23. Tank Closure Alternative 2A American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	4.38×10^{2}	6.81×10^{2}	1.60×10^{-2}	1.09×10^{-3}	1.65×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.23×10^{3}	5.86×10^{2}	1.30×10^{-2}	1.21×10^{-3}	1.32×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.38×10^{2}	6.81×10^{2}	1.60×10^{-2}	1.09×10^{-3}	1.65×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.02×10^{1}	2.40×10^{1}	4.00×10^{-4}	3.99×10^{-5}	4.25×10^{-4}	9.76×10^{-2}	4.61	2.73×10^{-6}	3.99×10^{-5}	4.09×10^{-5}
Off Site										
Columbia River	9.78×10^{-4}	4.52×10^{-1}	3.39×10^{-8}	3.13×10^{-9}	3.52×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–24. Tank Closure Alternative 2A Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.61	7.12×10^{-1}	8.57×10^{-5}	0.00	8.57×10^{-5}	6.49	1.00	2.78×10^{-4}	2.78×10^{-10}	2.78×10^{-4}
B Barrier	5.63	7.04×10^{-1}	1.63×10^{-4}	0.00	1.63×10^{-4}	1.27×10^{1}	1.16	5.09×10^{-4}	2.65×10^{-10}	5.09×10^{-4}
S Barrier	5.69	2.45	1.65×10^{-4}	0.00	1.65×10^{-4}	1.29×10^{1}	3.41	5.15×10^{-4}	9.58×10^{-10}	5.15×10^{-4}
T Barrier	2.44×10^{1}	3.30	7.04×10^{-4}	0.00	7.04×10^{-4}	5.51×10^{1}	6.36	2.20×10^{-3}	1.18×10^{-9}	2.20×10^{-3}
U Barrier	2.87×10^{-1}	6.56×10^{-2}	8.80×10^{-6}	0.00	8.80×10^{-6}	6.78×10^{-1}	1.22×10^{-1}	2.80×10^{-5}	2.39×10^{-11}	2.80×10^{-5}
Core Zone Boundary	5.63	8.55×10^{-1}	1.63×10^{-4}	0.00	1.63×10^{-4}	1.27×10^{1}	1.34	5.09×10^{-4}	3.27×10^{-10}	5.09×10^{-4}
Columbia River nearshore	7.80×10^{-1}	9.10×10^{-2}	2.28×10^{-5}	0.00	2.28×10^{-5}	1.78	1.73×10^{-1}	7.16×10^{-5}	3.29×10^{-11}	7.16×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.06×10^{-5}	5.45×10^{-6}	1.63×10^{-9}	1.20×10^{-15}	1.63×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–25. Tank Closure Alternative 2A American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.31×10^{1}	1.73	6.07×10^{-4}	1.27×10^{-5}	6.08×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.47×10^{1}	2.15	1.10×10^{-3}	1.22×10^{-5}	1.11×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.50×10^{1}	5.85	1.11×10^{-3}	4.39×10^{-5}	1.15×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.07×10^{2}	1.20×10^{1}	4.74×10^{-3}	5.43×10^{-5}	4.79×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.34	2.28×10^{-1}	6.07×10^{-5}	1.09×10^{-6}	6.16×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.47×10^{1}	2.40	1.10×10^{-3}	1.50×10^{-5}	1.11×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.47	3.28×10^{-1}	1.54×10^{-4}	1.51×10^{-6}	1.56×10^{-4}	1.25×10^{-2}	6.95×10^{-2}	6.08×10^{-7}	1.51×10^{-6}	2.10×10^{-6}
Off Site										
Columbia River	1.61×10^{-4}	1.54×10^{-3}	5.78×10^{-9}	5.50×10^{-11}	5.83×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–26. Tank Closure Alternative 2A Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.17	1.43	6.35×10^{-5}	0.00	6.35×10^{-5}	4.95	4.17	1.99×10^{-4}	4.25×10^{-10}	1.99×10^{-4}
B Barrier	8.64	5.26	2.59×10^{-4}	0.00	2.59×10^{-4}	2.01×10^{1}	2.88×10^{1}	8.19×10^{-4}	8.94×10^{-10}	8.19×10^{-4}
S Barrier	3.50	1.58	1.02×10^{-4}	0.00	1.02×10^{-4}	7.95	2.21	3.19×10^{-4}	6.15×10^{-10}	3.19×10^{-4}
T Barrier	1.51×10^{1}	4.32	4.33×10^{-4}	0.00	4.33×10^{-4}	3.39×10^{1}	1.21×10^{1}	1.35×10^{-3}	1.34×10^{-9}	1.35×10^{-3}
U Barrier	1.14	2.44×10^{-1}	3.34×10^{-5}	0.00	3.34×10^{-5}	2.60	9.41×10^{-1}	1.05×10^{-4}	5.90×10^{-11}	1.05×10^{-4}
Core Zone Boundary	8.64	5.26	2.59×10^{-4}	0.00	2.59×10^{-4}	2.01×10^{1}	2.88×10^{1}	8.19×10^{-4}	8.94×10^{-10}	8.19×10^{-4}
Columbia River nearshore	9.41×10^{-1}	1.01	2.75×10^{-5}	0.00	2.75×10^{-5}	2.15	3.11	8.64×10^{-5}	2.92×10^{-10}	8.64×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	5.37×10^{-5}	6.41×10^{-5}	2.16×10^{-9}	4.13×10^{-15}	2.16×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–27. Tank Closure Alternative 2A American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	9.66	8.53	4.30×10^{-4}	1.95×10^{-5}	4.44×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	3.94×10^{1}	6.29×10^{1}	1.77×10^{-3}	4.10×10^{-5}	1.81×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	1.55×10^{1}	3.80	6.88×10^{-4}	2.82×10^{-5}	7.16×10^{-4}	N/A	N/A	N/A	N/A	N/A
T Barrier	6.58×10^{1}	2.45×10^{1}	2.90×10^{-3}	6.15×10^{-5}	2.97×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	5.08	2.00	2.27×10^{-4}	2.71×10^{-6}	2.29×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.94×10^{1}	6.29×10^{1}	1.77×10^{-3}	4.10×10^{-5}	1.81×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	4.19	6.40	1.87×10^{-4}	1.34×10^{-5}	1.95×10^{-4}	1.53×10^{-2}	1.06	7.39×10^{-7}	1.34×10^{-5}	1.38×10^{-5}
Off Site										
Columbia River	2.10×10^{-4}	3.34×10^{-2}	7.58×10^{-9}	1.89×10^{-10}	7.77×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

The dose standard would be exceeded at the B Barrier, T Barrier, and Core Zone Boundary for the drinking-water well user, resident farmer, and American Indian resident farmer due to the presence of tritium, technetium-99, and iodine-129 released from the cribs and trenches (ditches), but would not be exceeded at the other locations. The Hazard Index guideline would be exceeded at the B Barrier, T Barrier, Core Zone Boundary, and Columbia River nearshore location for the same receptors due primarily to release of chromium and nitrate from the cribs and trenches (ditches). The Hazard Index guideline would also be exceeded for the American Indian hunter-gatherer located near the Columbia River due to releases from cribs and trenches (ditches).

The dose standard would be exceeded at the T Barrier for the American Indian resident farmer due to the presence of tritium, technetium-99, and iodine-129 released from past leaks. The Hazard Index guideline would be exceeded for the drinking-water well user, resident farmer, and American Indian resident farmer at the S and T Barriers due primarily to release of chromium and nitrate from past leaks. The Hazard Index guideline would also be exceeded for the resident farmer and the American Indian resident farmer at the A and B Barriers and the Core Zone Boundary due primarily to chromium and/or nitrate from past leaks.

After CY 2050, the dose standard would not be exceeded at any onsite location for the resident farmer and American Indian resident farmer. The Hazard Index guideline would be exceeded for the drinking-water well user, resident farmer, and American Indian resident farmer at the A, B, S, and T Barriers and the Core Zone Boundary due primarily to chromium, nitrate, and total uranium. The Hazard Index guideline would also be exceeded at the U Barrier for the American Indian resident farmer. The population dose is estimated as 2.68×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.73×10^{-5} percent of the annual population dose due to background exposure.

For releases from cribs and trenches (ditches) and past leaks, estimates of the magnitude and time series of impacts are substantially the same as those reported for Tank Closure Alternative 1. As shown in Figure 5–335, peak impacts at the Core Zone Boundary due to tank salt cake or liquid release are reduced by approximately a factor of 100 due to tank retrieval activity. A substantial peak due to tank failure remains centered on CY 2900, but the major contributor for long-term impacts shifts to past leaks under Tank Closure Alternative 2A.

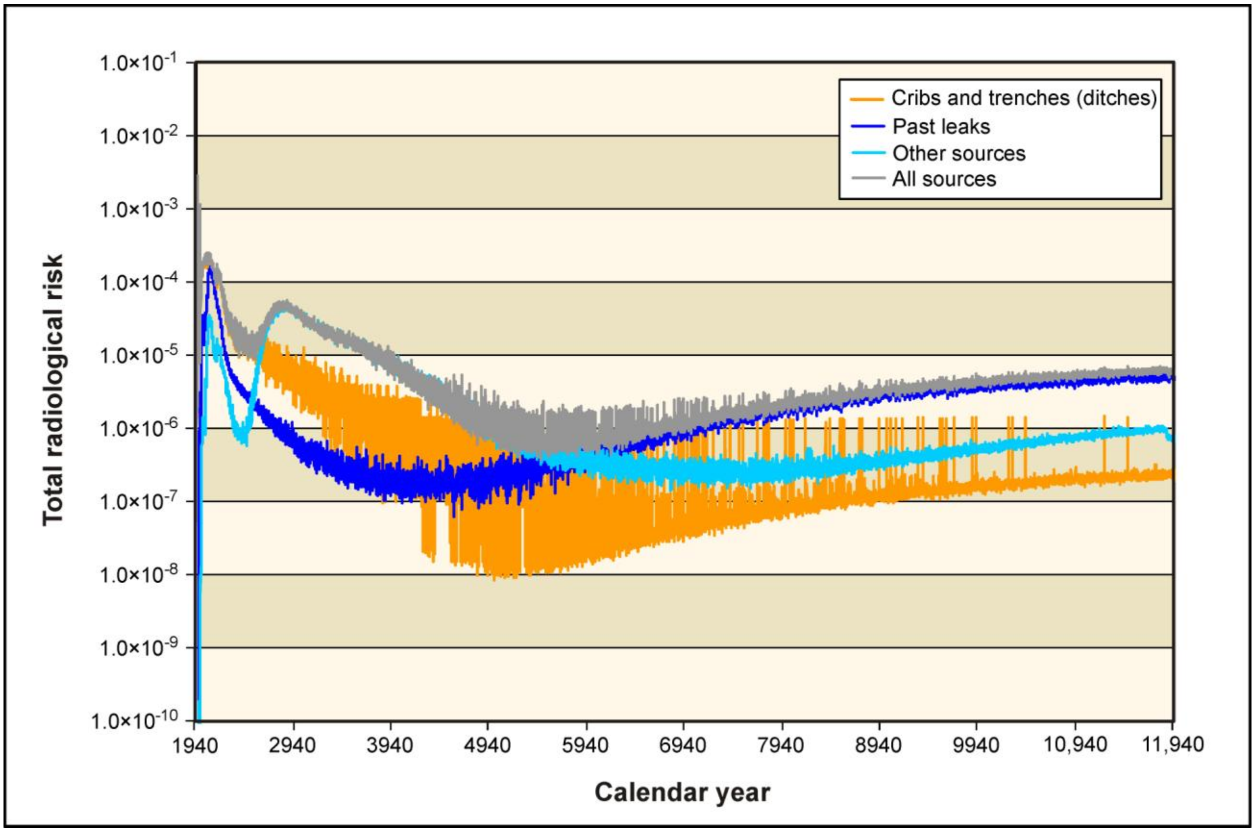


Figure 5–335. Tank Closure Alternative 2A Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.1.2.3 Alternative 2B: Expanded WTP Vitrification; Landfill Closure

Activities under Tank Closure Alternative 2B would be similar to those under Tank Closure Alternative 2A, except that residual material in tanks would be stabilized in place. Soil would be removed down to 4.6 meters (15 feet) for the BX and SX tank farms and replaced with clean soils from onsite sources. The tank farms and six sets of adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Potential human health impacts under Tank Closure Alternative 2B are detailed in Appendix Q and summarized in Tables 5–28 through 5–33; those related to cribs and trenches (ditches) after CY 1940, in Tables 5–28 and 5–29; to past leaks after CY 1940, in Tables 5–30 and 5–31; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050, in Tables 5–32 and 5–33.

In addition, potential impacts specific to tank farm unplanned releases, retrieval leaks, and releases from ancillary equipment and tank residuals are summarized in Tables 5–34 through 5–41 to provide a detailed breakdown of tank farm sources. For these sources, exceedances of the dose standard are not projected to occur. Exceedances of the Hazard Index guideline are also not projected to occur except for the American Indian resident farmer at the A Barrier due to retrieval leaks.

The risk and hazard drivers are tritium, technetium-99, iodine-129, uranium-238, chromium, nitrate, and total uranium. Impacts would be slightly less than those under Tank Closure Alternative 2A, and standards would be exceeded, as under Alternative 2A, except the Hazard Index guideline would not be exceeded due to past leaks at the A and B Barriers for the American Indian resident farmer, nor would it be exceeded as a result of combination of cribs and trenches (ditches), past leaks, and other tank farm sources at the U Barrier for the drinking-water well user, resident farmer, or American Indian resident farmer. The population dose is estimated as 2.51×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.61×10^{-5} percent of the annual population dose due to background exposure.

For releases from cribs and trenches (ditches) and past leaks, estimates of the magnitude and time series of impacts are substantially the same as those reported for Tank Closure Alternatives 1 and 2A. As shown in Figure 5–336, radiological risks at the Core Zone Boundary due to releases from cribs and trenches (ditches) and past leaks prior to CY 3000 are nearly identical to those under Tank Closure Alternative 2A, while long-term risks are reduced slightly due to placement of caps under Tank Closure Alternative 2B. As in the case of Tank Closure Alternative 2A, peak impacts are due to releases from cribs and trenches (ditches) for the early time period, to leaching from other tank farm sources for the intermediate time period, and to past leaks for the long-term time period. Radiological risks for the drinking-water well user at the Core Zone Boundary due to unplanned releases, retrieval leaks, and releases from ancillary equipment and tank residuals are shown in Figure 5–337. The peak radiological risk of approximately 3×10^{-5} is projected to occur around CY 2940 due primarily to releases from tank residuals.

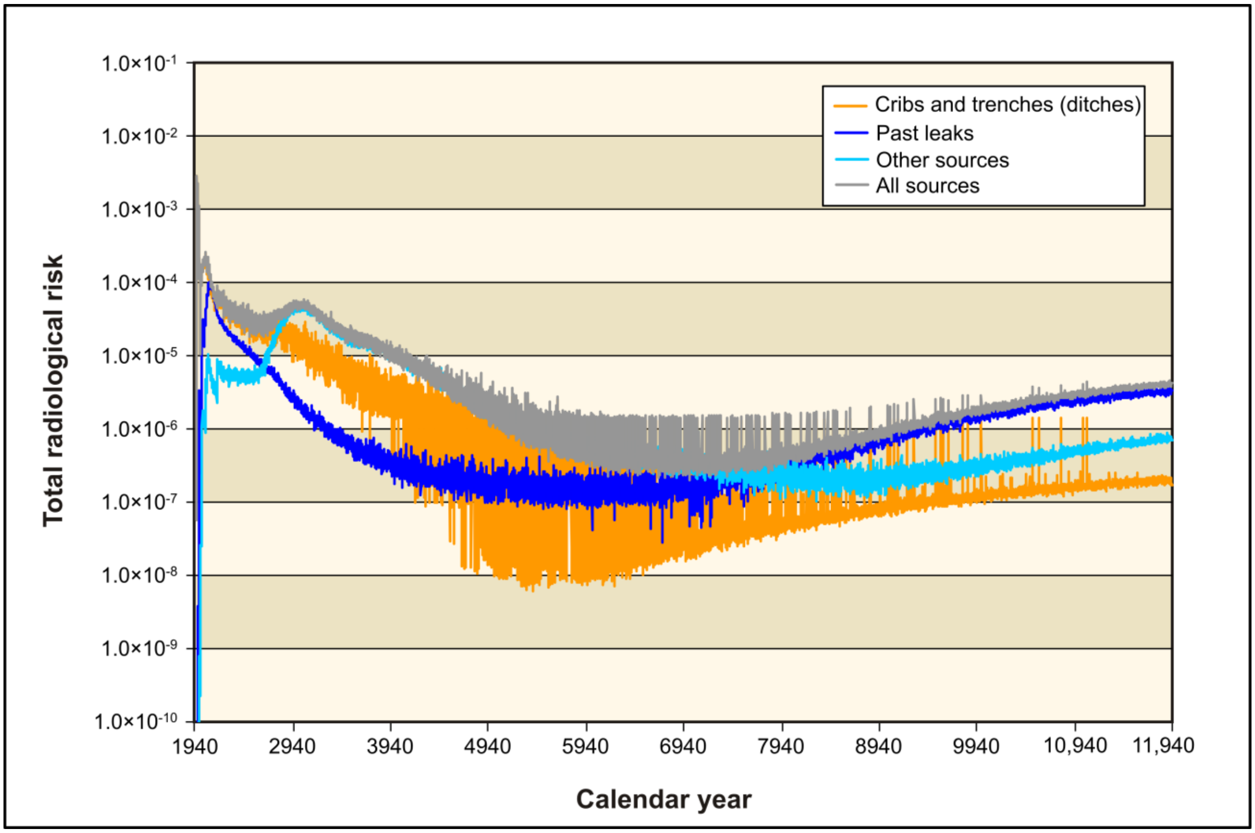


Figure 5–336. Tank Closure Alternative 2B Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

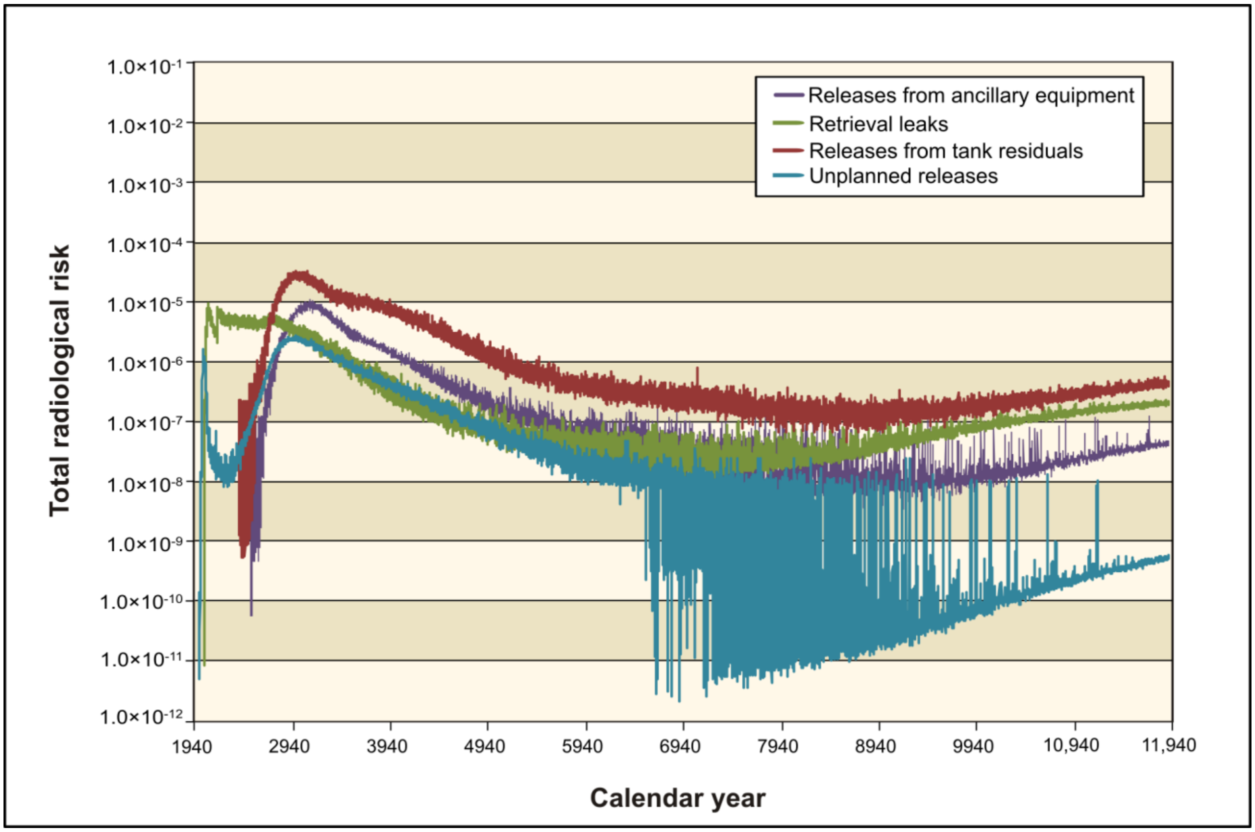


Figure 5–337. Tank Closure Alternative 2B Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary for the Other Tank Farm Sources

Table 5–28. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	1.50×10^{2}	8.96×10^{1}	2.91×10^{-3}	0.00	2.91×10^{-3}	2.58×10^{2}	3.25×10^{2}	7.78×10^{-3}	2.41×10^{-8}	7.78×10^{-3}
T Barrier	8.91×10^{2}	9.18×10^{1}	8.46×10^{-3}	0.00	8.46×10^{-3}	1.04×10^{3}	2.84×10^{2}	1.02×10^{-2}	2.65×10^{-8}	1.02×10^{-2}
Core Zone Boundary	1.50×10^{2}	8.96×10^{1}	2.91×10^{-3}	0.00	2.91×10^{-3}	2.58×10^{2}	3.25×10^{2}	7.78×10^{-3}	2.41×10^{-8}	7.78×10^{-3}
Columbia River nearshore	3.00	2.88	6.49×10^{-5}	0.00	6.49×10^{-5}	5.51	1.15×10^{1}	1.85×10^{-4}	8.95×10^{-10}	1.85×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.44×10^{-4}	8.95×10^{-4}	1.11×10^{-8}	6.82×10^{-14}	1.11×10^{-8}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–29. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	4.39×10^{2}	7.04×10^{2}	1.60×10^{-2}	1.11×10^{-3}	1.66×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.23×10^{3}	5.85×10^{2}	1.30×10^{-2}	1.21×10^{-3}	1.32×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.39×10^{2}	7.04×10^{2}	1.60×10^{-2}	1.11×10^{-3}	1.66×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	9.82	2.47×10^{1}	3.90×10^{-4}	4.10×10^{-5}	4.12×10^{-4}	9.67×10^{-2}	4.61	2.66×10^{-6}	4.10×10^{-5}	4.20×10^{-5}
Off Site										
Columbia River	9.82×10^{-4}	4.54×10^{-1}	3.41×10^{-8}	3.13×10^{-9}	3.53×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–30. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.62	$6.64{\times}10^{-1}$	$8.60{\times}10^{-5}$	0.00	$8.60{\times}10^{-5}$	6.52	$9.49{\times}10^{-1}$	$2.79{\times}10^{-4}$	$2.58{\times}10^{-10}$	$2.79{\times}10^{-4}$
B Barrier	3.49	$6.01{\times}10^{-1}$	$1.02{\times}10^{-4}$	0.00	$1.02{\times}10^{-4}$	7.96	$9.47{\times}10^{-1}$	$3.21{\times}10^{-4}$	$2.29{\times}10^{-10}$	$3.21{\times}10^{-4}$
S Barrier	5.65	2.47	$1.64{\times}10^{-4}$	0.00	$1.64{\times}10^{-4}$	$1.28{\times}10^{1}$	3.42	$5.13{\times}10^{-4}$	$9.68{\times}10^{-10}$	$5.13{\times}10^{-4}$
T Barrier	$2.44{\times}10^{1}$	3.31	$7.01{\times}10^{-4}$	0.00	$7.01{\times}10^{-4}$	$5.49{\times}10^{1}$	6.37	$2.19{\times}10^{-3}$	$1.19{\times}10^{-9}$	$2.19{\times}10^{-3}$
U Barrier	$2.72{\times}10^{-1}$	$6.63{\times}10^{-2}$	$8.31{\times}10^{-6}$	0.00	$8.31{\times}10^{-6}$	$6.41{\times}10^{-1}$	$1.21{\times}10^{-1}$	$2.64{\times}10^{-5}$	$2.42{\times}10^{-11}$	$2.64{\times}10^{-5}$
Core Zone Boundary	3.49	$7.90{\times}10^{-1}$	$1.02{\times}10^{-4}$	0.00	$1.02{\times}10^{-4}$	7.96	1.15	$3.21{\times}10^{-4}$	$3.07{\times}10^{-10}$	$3.21{\times}10^{-4}$
Columbia River nearshore	$8.05{\times}10^{-1}$	$8.18{\times}10^{-2}$	$2.37{\times}10^{-5}$	0.00	$2.37{\times}10^{-5}$	1.84	$1.57{\times}10^{-1}$	$7.45{\times}10^{-5}$	$2.94{\times}10^{-11}$	$7.45{\times}10^{-5}$
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	$3.88{\times}10^{-5}$	$5.21{\times}10^{-6}$	$1.55{\times}10^{-9}$	$1.15{\times}10^{-15}$	$1.55{\times}10^{-9}$

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–31. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.31×10^{1}	1.64	6.09×10^{-4}	1.18×10^{-5}	6.11×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	1.55×10^{1}	1.70	6.92×10^{-4}	1.05×10^{-5}	7.00×10^{-4}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.49×10^{1}	5.87	1.11×10^{-3}	4.44×10^{-5}	1.15×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.07×10^{2}	1.20×10^{1}	4.71×10^{-3}	5.46×10^{-5}	4.77×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.27	2.26×10^{-1}	5.72×10^{-5}	1.11×10^{-6}	5.83×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.55×10^{1}	2.05	6.92×10^{-4}	1.41×10^{-5}	7.01×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.60	3.03×10^{-1}	1.61×10^{-4}	1.35×10^{-6}	1.62×10^{-4}	1.32×10^{-2}	6.35×10^{-2}	6.38×10^{-7}	1.35×10^{-6}	1.97×10^{-6}
Off Site										
Columbia River	1.55×10^{-4}	1.48×10^{-3}	5.55×10^{-9}	5.27×10^{-11}	5.60×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–32. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

	Receptor									
	Drinking-Water Well User					Resident Farmer				
Location	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.74	1.05	5.09×10^{-5}	0.00	5.24×10^{-4}	3.97	3.17	1.60×10^{-4}	3.18×10^{-10}	1.46×10^{-3}
B Barrier	7.55	4.81	2.30×10^{-4}	0.00	2.91×10^{-3}	1.77×10^{1}	2.57×10^{1}	7.30×10^{-4}	8.44×10^{-10}	7.78×10^{-3}
S Barrier	3.43	1.57	9.97×10^{-5}	0.00	1.64×10^{-4}	7.79	2.21	3.12×10^{-4}	6.14×10^{-10}	5.13×10^{-4}
T Barrier	1.55×10^{1}	4.47	4.41×10^{-4}	0.00	8.46×10^{-3}	3.46×10^{1}	1.22×10^{1}	1.37×10^{-3}	1.39×10^{-9}	1.02×10^{-2}
U Barrier	5.20×10^{-1}	6.73×10^{-2}	1.63×10^{-5}	0.00	1.63×10^{-5}	1.25	1.76×10^{-1}	5.24×10^{-5}	2.30×10^{-11}	5.24×10^{-5}
Core Zone Boundary	7.58	4.81	2.30×10^{-4}	0.00	2.91×10^{-3}	1.78×10^{1}	2.57×10^{1}	7.30×10^{-4}	8.44×10^{-10}	7.78×10^{-3}
Columbia River nearshore	8.85×10^{-1}	9.71×10^{-1}	2.60×10^{-5}	0.00	6.49×10^{-5}	2.03	3.03	8.18×10^{-5}	2.78×10^{-10}	1.85×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	5.02×10^{-5}	5.77×10^{-5}	2.03×10^{-9}	3.85×10^{-15}	1.11×10^{-8}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–33. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	7.74	6.59	3.45×10^{-4}	1.46×10^{-5}	3.21×10^{-3}	N/A	N/A	N/A	N/A	N/A
B Barrier	3.50×10^{1}	5.62×10^{1}	1.58×10^{-3}	3.87×10^{-5}	1.66×10^{-2}	N/A	N/A	N/A	N/A	N/A
S Barrier	1.52×10^{1}	3.82	6.74×10^{-4}	2.81×10^{-5}	1.15×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	6.70×10^{1}	2.46×10^{1}	2.96×10^{-3}	6.36×10^{-5}	1.32×10^{-2}	N/A	N/A	N/A	N/A	N/A
U Barrier	2.49	3.57×10^{-1}	1.14×10^{-4}	1.06×10^{-6}	1.15×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.50×10^{1}	5.62×10^{1}	1.58×10^{-3}	3.87×10^{-5}	1.66×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.96	6.24	1.77×10^{-4}	1.28×10^{-5}	4.12×10^{-4}	1.45×10^{-2}	1.03	6.99×10^{-7}	1.28×10^{-5}	4.20×10^{-5}
Off Site										
Columbia River	1.93×10^{-4}	2.99×10^{-2}	7.04×10^{-9}	1.76×10^{-10}	3.53×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–34. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Unplanned Releases

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.18×10^{-1}	4.61×10^{-3}	3.68×10^{-6}	0.00	3.68×10^{-6}	2.82×10^{-1}	1.16×10^{-2}	1.18×10^{-5}	1.51×10^{-12}	1.18×10^{-5}
B Barrier	7.30×10^{-2}	1.64×10^{-2}	2.39×10^{-6}	0.00	2.39×10^{-6}	1.81×10^{-1}	6.12×10^{-2}	7.78×10^{-6}	4.24×10^{-12}	7.78×10^{-6}
S Barrier	3.61×10^{-7}	0.00	1.24×10^{-11}	0.00	1.24×10^{-11}	9.30×10^{-7}	0.00	4.08×10^{-11}	0.00	4.08×10^{-11}
T Barrier	1.26×10^{-4}	7.50×10^{-4}	2.60×10^{-9}	0.00	2.60×10^{-9}	2.24×10^{-4}	2.67×10^{-3}	7.13×10^{-9}	1.95×10^{-13}	7.13×10^{-9}
U Barrier	2.46×10^{-4}	2.23×10^{-5}	7.66×10^{-9}	0.00	7.66×10^{-9}	5.88×10^{-4}	3.86×10^{-5}	2.45×10^{-8}	8.27×10^{-15}	2.45×10^{-8}
Core Zone Boundary	1.04×10^{-1}	1.64×10^{-2}	3.06×10^{-6}	0.00	3.06×10^{-6}	2.38×10^{-1}	6.12×10^{-2}	9.60×10^{-6}	4.24×10^{-12}	9.60×10^{-6}
Columbia River nearshore	3.09×10^{-3}	3.28×10^{-4}	7.01×10^{-8}	0.00	7.01×10^{-8}	5.88×10^{-3}	1.08×10^{-3}	1.99×10^{-7}	9.41×10^{-14}	1.99×10^{-7}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.35×10^{-7}	0.00	1.90×10^{-12}	0.00	1.90×10^{-12}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–35. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Unplanned Releases

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	5.62×10^{-1}	2.32×10^{-2}	2.56×10^{-5}	6.94×10^{-8}	2.57×10^{-5}	N/A	N/A	N/A	N/A	N/A
B Barrier	3.66×10^{-1}	1.29×10^{-1}	1.69×10^{-5}	1.94×10^{-7}	1.70×10^{-5}	N/A	N/A	N/A	N/A	N/A
S Barrier	1.90×10^{-6}	0.00	8.92×10^{-11}	0.00	8.92×10^{-11}	N/A	N/A	N/A	N/A	N/A
T Barrier	3.89×10^{-4}	5.59×10^{-3}	1.47×10^{-8}	8.96×10^{-9}	2.33×10^{-8}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.17×10^{-3}	7.20×10^{-5}	5.32×10^{-8}	3.79×10^{-10}	5.35×10^{-8}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.65×10^{-1}	1.29×10^{-1}	2.07×10^{-5}	1.94×10^{-7}	2.08×10^{-5}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.05×10^{-2}	2.28×10^{-3}	4.21×10^{-7}	4.32×10^{-9}	4.23×10^{-7}	5.75×10^{-5}	3.08×10^{-4}	2.16×10^{-9}	4.31×10^{-9}	5.04×10^{-9}
Off Site										
Columbia River	2.06×10^{-6}	0.00	4.95×10^{-11}	0.00	4.95×10^{-11}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–36. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Retrieval Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.12×10^{-1}	6.97×10^{-2}	6.21×10^{-6}	0.00	6.21×10^{-6}	4.84×10^{-1}	4.61×10^{-1}	1.95×10^{-5}	1.27×10^{-11}	1.95×10^{-5}
B Barrier	3.70×10^{-1}	7.37×10^{-2}	1.07×10^{-5}	0.00	1.07×10^{-5}	8.35×10^{-1}	3.32×10^{-1}	3.34×10^{-5}	2.24×10^{-11}	3.34×10^{-5}
S Barrier	2.21×10^{-1}	9.16×10^{-2}	6.49×10^{-6}	0.00	6.49×10^{-6}	5.05×10^{-1}	2.15×10^{-1}	2.04×10^{-5}	3.05×10^{-11}	2.04×10^{-5}
T Barrier	5.00×10^{-1}	5.67×10^{-2}	1.45×10^{-5}	0.00	1.45×10^{-5}	1.13	1.57×10^{-1}	4.53×10^{-5}	1.74×10^{-11}	4.53×10^{-5}
U Barrier	1.13×10^{-1}	2.52×10^{-2}	3.27×10^{-6}	0.00	3.27×10^{-6}	2.55×10^{-1}	1.12×10^{-1}	1.02×10^{-5}	5.36×10^{-12}	1.02×10^{-5}
Core Zone Boundary	3.70×10^{-1}	8.20×10^{-2}	1.07×10^{-5}	0.00	1.07×10^{-5}	8.35×10^{-1}	3.32×10^{-1}	3.34×10^{-5}	2.24×10^{-11}	3.34×10^{-5}
Columbia River nearshore	3.23×10^{-2}	6.98×10^{-3}	9.65×10^{-7}	0.00	9.65×10^{-7}	7.48×10^{-2}	2.35×10^{-2}	3.05×10^{-6}	2.01×10^{-12}	3.05×10^{-6}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	2.37×10^{-6}	1.43×10^{-7}	9.72×10^{-11}	5.69×10^{-17}	9.72×10^{-11}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–37. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Retrieval Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	9.45×10^{-1}	1.02	4.21×10^{-5}	5.82×10^{-7}	4.24×10^{-5}	N/A	N/A	N/A	N/A	N/A
B Barrier	1.62	7.14×10^{-1}	7.21×10^{-5}	1.03×10^{-6}	7.30×10^{-5}	N/A	N/A	N/A	N/A	N/A
S Barrier	9.87×10^{-1}	4.24×10^{-1}	4.41×10^{-5}	1.40×10^{-6}	4.55×10^{-5}	N/A	N/A	N/A	N/A	N/A
T Barrier	2.20	3.20×10^{-1}	9.77×10^{-5}	8.00×10^{-7}	9.85×10^{-5}	N/A	N/A	N/A	N/A	N/A
U Barrier	4.96×10^{-1}	2.42×10^{-1}	2.20×10^{-5}	2.46×10^{-7}	2.23×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.62	7.14×10^{-1}	7.21×10^{-5}	1.03×10^{-6}	7.30×10^{-5}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.47×10^{-1}	4.90×10^{-2}	6.61×10^{-6}	9.24×10^{-8}	6.69×10^{-6}	5.36×10^{-4}	6.79×10^{-3}	2.61×10^{-8}	9.24×10^{-8}	1.13×10^{-7}
Off Site										
Columbia River	8.42×10^{-6}	2.34×10^{-7}	3.18×10^{-10}	2.61×10^{-12}	3.20×10^{-10}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–38. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Releases from Ancillary Equipment

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	6.48×10^{-2}	1.54×10^{-2}	1.99×10^{-6}	0.00	1.99×10^{-6}	1.53×10^{-1}	3.80×10^{-2}	6.33×10^{-6}	5.12×10^{-12}	6.33×10^{-6}
B Barrier	3.72×10^{-1}	5.67×10^{-2}	1.19×10^{-5}	0.00	1.19×10^{-5}	9.09×10^{-1}	1.12×10^{-1}	3.85×10^{-5}	2.07×10^{-11}	3.85×10^{-5}
S Barrier	1.07×10^{-1}	2.22×10^{-2}	3.16×10^{-6}	0.00	3.16×10^{-6}	2.46×10^{-1}	4.33×10^{-2}	9.97×10^{-6}	7.91×10^{-12}	9.97×10^{-6}
T Barrier	2.04×10^{-1}	2.02×10^{-2}	6.09×10^{-6}	0.00	6.09×10^{-6}	4.72×10^{-1}	6.14×10^{-2}	1.92×10^{-5}	5.97×10^{-12}	1.92×10^{-5}
U Barrier	1.72×10^{-1}	1.90×10^{-2}	5.23×10^{-6}	0.00	5.23×10^{-6}	4.03×10^{-1}	4.04×10^{-2}	1.67×10^{-5}	6.61×10^{-12}	1.67×10^{-5}
Core Zone Boundary	3.72×10^{-1}	5.67×10^{-2}	1.19×10^{-5}	0.00	1.19×10^{-5}	9.09×10^{-1}	1.12×10^{-1}	3.85×10^{-5}	2.07×10^{-11}	3.85×10^{-5}
Columbia River nearshore	3.15×10^{-2}	4.65×10^{-3}	9.46×10^{-7}	0.00	9.46×10^{-7}	7.33×10^{-2}	1.13×10^{-2}	2.99×10^{-6}	1.56×10^{-12}	2.99×10^{-6}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	2.19×10^{-6}	1.07×10^{-7}	8.95×10^{-11}	4.27×10^{-17}	8.95×10^{-11}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–39. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Releases from Ancillary Equipment

	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
Location	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	3.03×10^{-1}	7.58×10^{-2}	1.37×10^{-5}	2.35×10^{-7}	1.39×10^{-5}	N/A	N/A	N/A	N/A	N/A
B Barrier	1.82	2.18×10^{-1}	8.38×10^{-5}	9.49×10^{-7}	8.46×10^{-5}	N/A	N/A	N/A	N/A	N/A
S Barrier	4.81×10^{-1}	8.20×10^{-2}	2.16×10^{-5}	3.63×10^{-7}	2.19×10^{-5}	N/A	N/A	N/A	N/A	N/A
T Barrier	9.27×10^{-1}	1.27×10^{-1}	4.16×10^{-5}	2.74×10^{-7}	4.18×10^{-5}	N/A	N/A	N/A	N/A	N/A
U Barrier	7.96×10^{-1}	7.87×10^{-2}	3.62×10^{-5}	3.03×10^{-7}	3.64×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.82	2.18×10^{-1}	8.38×10^{-5}	9.49×10^{-7}	8.46×10^{-5}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.44×10^{-1}	2.23×10^{-2}	6.48×10^{-6}	7.14×10^{-8}	6.54×10^{-6}	5.31×10^{-4}	3.58×10^{-3}	2.58×10^{-8}	7.13×10^{-8}	9.63×10^{-8}
Off Site										
Columbia River	8.15×10^{-6}	1.76×10^{-7}	2.99×10^{-10}	1.96×10^{-12}	3.01×10^{-10}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–40. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Releases from Tank Residuals

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.99×10^{-1}	6.02×10^{-2}	9.83×10^{-6}	0.00	9.83×10^{-6}	7.44×10^{-1}	1.18×10^{-1}	3.19×10^{-5}	2.13×10^{-11}	3.19×10^{-5}
B Barrier	1.14	2.04×10^{-1}	3.77×10^{-5}	0.00	3.77×10^{-5}	2.85	3.97×10^{-1}	1.23×10^{-4}	7.39×10^{-11}	1.23×10^{-4}
S Barrier	8.59×10^{-1}	1.51×10^{-1}	2.82×10^{-5}	0.00	2.82×10^{-5}	2.14	2.81×10^{-1}	9.18×10^{-5}	5.40×10^{-11}	9.18×10^{-5}
T Barrier	6.78×10^{-1}	7.61×10^{-2}	2.22×10^{-5}	0.00	2.22×10^{-5}	1.68	2.35×10^{-1}	7.23×10^{-5}	2.26×10^{-11}	7.23×10^{-5}
U Barrier	3.25×10^{-1}	3.99×10^{-2}	1.05×10^{-5}	0.00	1.05×10^{-5}	7.94×10^{-1}	8.59×10^{-2}	3.40×10^{-5}	1.38×10^{-11}	3.40×10^{-5}
Core Zone Boundary	1.14	2.04×10^{-1}	3.77×10^{-5}	0.00	3.77×10^{-5}	2.85	3.97×10^{-1}	1.23×10^{-4}	7.39×10^{-11}	1.23×10^{-4}
Columbia River nearshore	9.54×10^{-2}	1.28×10^{-2}	2.98×10^{-6}	0.00	2.98×10^{-6}	2.28×10^{-1}	3.33×10^{-2}	9.54×10^{-6}	4.18×10^{-12}	9.54×10^{-6}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	1.11×10^{-5}	1.34×10^{-6}	4.69×10^{-10}	1.90×10^{-16}	4.69×10^{-10}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–41. Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Releases from Tank Residuals

	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
Location	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.50	2.30×10^{-1}	6.96×10^{-5}	9.77×10^{-7}	7.05×10^{-5}	N/A	N/A	N/A	N/A	N/A
B Barrier	5.76	7.61×10^{-1}	2.68×10^{-4}	3.39×10^{-6}	2.71×10^{-4}	N/A	N/A	N/A	N/A	N/A
S Barrier	4.31	5.33×10^{-1}	2.00×10^{-4}	2.48×10^{-6}	2.02×10^{-4}	N/A	N/A	N/A	N/A	N/A
T Barrier	3.40	4.88×10^{-1}	1.58×10^{-4}	1.04×10^{-6}	1.59×10^{-4}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.60	1.67×10^{-1}	7.40×10^{-5}	6.34×10^{-7}	7.46×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	5.76	7.61×10^{-1}	2.68×10^{-4}	3.39×10^{-6}	2.71×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	4.54×10^{-1}	6.69×10^{-2}	2.07×10^{-5}	1.92×10^{-7}	2.09×10^{-5}	1.66×10^{-3}	1.46×10^{-2}	8.20×10^{-8}	1.92×10^{-7}	2.67×10^{-7}
Off Site										
Columbia River	3.41×10^{-5}	5.44×10^{-4}	1.38×10^{-9}	8.74×10^{-12}	1.39×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

5.1.2.4 Tank Closure Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

Activities under Tank Closure Alternative 3A would be similar to those under Tank Closure Alternative 2B. Likewise, impacts exceeding dose and risk standards, the estimated population dose for the year of maximum impact, and corresponding percentage of the annual population dose due to background exposure would be the same as those under Tank Closure Alternative 2B for cribs and trenches (ditches), past leaks, and other tank farm sources.

5.1.2.5 Tank Closure Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

Activities under Tank Closure Alternative 3B would be similar to those under Tank Closure Alternative 2B. Likewise, impacts exceeding dose and risk standards, the estimated population dose for the year of maximum impact, and corresponding percentage of the annual population dose due to background exposure would be the same as those under Tank Closure Alternative 2B for cribs and trenches (ditches), past leaks, and other tank farm sources.

5.1.2.6 Tank Closure Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Activities under Tank Closure Alternative 3C would be similar to those under Tank Closure Alternative 2B. Likewise, impacts exceeding dose and risk standards, the estimated population dose for the year of maximum impact, and corresponding percentage of the annual population dose due to background exposure would be the same as those under Tank Closure Alternative 2B for cribs and trenches (ditches), past leaks, and other tank farm sources.

5.1.2.7 Tank Closure Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Under Tank Closure Alternative 4, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval. Except for the BX and SX tank farms, residual material in tanks would be stabilized in place and the tank farms and adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. The BX and SX tank farms would be clean closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. Potential human health impacts under Tank Closure Alternative 4 are detailed in Appendix Q and summarized in Tables 5–42 through 5–47; those related to cribs and trenches (ditches) after CY 1940, in Tables 5–42 and 5–43; to past leaks after CY 1940, in Tables 5–44 and 5–45; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050, in Tables 5–46 and 5–47.

Table 5–42. Tank Closure Alternative 4 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	1.50×10^{2}	8.96×10^{1}	2.91×10^{-3}	0.00	2.91×10^{-3}	2.58×10^{2}	3.25×10^{2}	7.78×10^{-3}	2.41×10^{-8}	7.78×10^{-3}
T Barrier	8.91×10^{2}	9.18×10^{1}	8.46×10^{-3}	0.00	8.46×10^{-3}	1.04×10^{3}	2.84×10^{2}	1.02×10^{-2}	2.65×10^{-8}	1.02×10^{-2}
Core Zone Boundary	1.50×10^{2}	8.96×10^{1}	2.91×10^{-3}	0.00	2.91×10^{-3}	2.58×10^{2}	3.25×10^{2}	7.78×10^{-3}	2.41×10^{-8}	7.78×10^{-3}
Columbia River nearshore	3.00	2.88	6.49×10^{-5}	0.00	6.49×10^{-5}	5.51	1.15×10^{1}	1.85×10^{-4}	8.95×10^{-10}	1.85×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.44×10^{-4}	8.95×10^{-4}	1.11×10^{-8}	6.82×10^{-14}	1.11×10^{-8}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–43. Tank Closure Alternative 4 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	4.39×10^{2}	7.04×10^{2}	1.60×10^{-2}	1.11×10^{-3}	1.66×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.23×10^{3}	5.85×10^{2}	1.30×10^{-2}	1.21×10^{-3}	1.32×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.39×10^{2}	7.04×10^{2}	1.60×10^{-2}	1.11×10^{-3}	1.66×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	9.82	2.47×10^{1}	3.90×10^{-4}	4.10×10^{-5}	4.12×10^{-4}	9.67×10^{-2}	4.61	2.66×10^{-6}	4.10×10^{-5}	4.20×10^{-5}
Off Site										
Columbia River	9.82×10^{-4}	4.54×10^{-1}	3.41×10^{-8}	3.13×10^{-9}	3.53×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–44. Tank Closure Alternative 4 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.62	6.30×10^{-1}	8.60×10^{-5}	0.00	8.60×10^{-5}	6.52	8.93×10^{-1}	2.79×10^{-4}	2.45×10^{-10}	2.79×10^{-4}
B Barrier	3.45	5.81×10^{-1}	1.03×10^{-4}	0.00	1.03×10^{-4}	7.98	9.09×10^{-1}	3.25×10^{-4}	2.21×10^{-10}	3.25×10^{-4}
S Barrier	5.64	2.47	1.63×10^{-4}	0.00	1.63×10^{-4}	1.28×10^{1}	3.41	5.10×10^{-4}	9.65×10^{-10}	5.10×10^{-4}
T Barrier	2.44×10^{1}	3.31	7.01×10^{-4}	0.00	7.01×10^{-4}	5.49×10^{1}	6.37	2.19×10^{-3}	1.19×10^{-9}	2.19×10^{-3}
U Barrier	2.72×10^{-1}	6.63×10^{-2}	8.31×10^{-6}	0.00	8.31×10^{-6}	6.41×10^{-1}	1.21×10^{-1}	2.64×10^{-5}	2.42×10^{-11}	2.64×10^{-5}
Core Zone Boundary	3.45	7.43×10^{-1}	1.03×10^{-4}	0.00	1.03×10^{-4}	7.98	1.09	3.25×10^{-4}	2.87×10^{-10}	3.25×10^{-4}
Columbia River nearshore	8.02×10^{-1}	8.04×10^{-2}	2.35×10^{-5}	0.00	2.35×10^{-5}	1.83	1.57×10^{-1}	7.40×10^{-5}	2.89×10^{-11}	7.40×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.85×10^{-5}	4.99×10^{-6}	1.54×10^{-9}	1.09×10^{-15}	1.54×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–45. Tank Closure Alternative 4 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.31×10^{1}	1.54	6.09×10^{-4}	1.13×10^{-5}	6.11×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	1.56×10^{1}	1.64	7.02×10^{-4}	1.01×10^{-5}	7.06×10^{-4}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.48×10^{1}	5.85	1.10×10^{-3}	4.43×10^{-5}	1.14×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.07×10^{2}	1.20×10^{1}	4.71×10^{-3}	5.46×10^{-5}	4.77×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.27	2.26×10^{-1}	5.72×10^{-5}	1.11×10^{-6}	5.83×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.56×10^{1}	1.91	7.02×10^{-4}	1.32×10^{-5}	7.06×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.58	3.02×10^{-1}	1.60×10^{-4}	1.33×10^{-6}	1.61×10^{-4}	1.30×10^{-2}	6.19×10^{-2}	6.32×10^{-7}	1.33×10^{-6}	1.94×10^{-6}
Off Site										
Columbia River	1.54×10^{-4}	1.44×10^{-3}	5.50×10^{-9}	4.99×10^{-11}	5.55×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–46. Tank Closure Alternative 4 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.78	9.48×10^{-1}	5.20×10^{-5}	0.00	5.20×10^{-5}	4.06	3.07	1.63×10^{-4}	2.79×10^{-10}	1.63×10^{-4}
B Barrier	7.38	4.80	2.25×10^{-4}	0.00	2.25×10^{-4}	1.74×10^{1}	2.57×10^{1}	7.15×10^{-4}	8.44×10^{-10}	7.15×10^{-4}
S Barrier	4.54×10^{-1}	2.72×10^{-1}	1.31×10^{-5}	0.00	1.31×10^{-5}	1.02	3.94×10^{-1}	4.08×10^{-5}	1.05×10^{-10}	4.08×10^{-5}
T Barrier	1.55×10^{1}	4.47	4.41×10^{-4}	0.00	4.41×10^{-4}	3.46×10^{1}	1.22×10^{1}	1.37×10^{-3}	1.39×10^{-9}	1.37×10^{-3}
U Barrier	3.14×10^{-1}	6.73×10^{-2}	9.47×10^{-6}	0.00	9.47×10^{-6}	7.33×10^{-1}	1.76×10^{-1}	3.00×10^{-5}	2.30×10^{-11}	3.00×10^{-5}
Core Zone Boundary	7.41	4.80	2.25×10^{-4}	0.00	2.25×10^{-4}	1.74×10^{1}	2.57×10^{1}	7.15×10^{-4}	8.44×10^{-10}	7.15×10^{-4}
Columbia River nearshore	8.82×10^{-1}	9.71×10^{-1}	2.58×10^{-5}	0.00	2.58×10^{-5}	2.01	3.03	8.10×10^{-5}	2.78×10^{-10}	8.10×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.97×10^{-5}	5.76×10^{-5}	2.01×10^{-9}	3.84×10^{-15}	2.01×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–47. Tank Closure Alternative 4 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	7.91	6.41	3.52×10^{-4}	1.28×10^{-5}	3.64×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	3.43×10^{1}	5.60×10^{1}	1.55×10^{-3}	3.87×10^{-5}	1.58×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	1.99	6.91×10^{-1}	8.79×10^{-5}	4.84×10^{-6}	9.22×10^{-5}	N/A	N/A	N/A	N/A	N/A
T Barrier	6.70×10^{1}	2.46×10^{1}	2.96×10^{-3}	6.36×10^{-5}	3.02×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.44	3.57×10^{-1}	6.50×10^{-5}	1.06×10^{-6}	6.60×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.43×10^{1}	5.60×10^{1}	1.55×10^{-3}	3.87×10^{-5}	1.58×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.92	6.24	1.75×10^{-4}	1.28×10^{-5}	1.82×10^{-4}	1.43×10^{-2}	1.03	6.93×10^{-7}	1.28×10^{-5}	1.31×10^{-5}
Off Site										
Columbia River	1.92×10^{-4}	2.99×10^{-2}	6.97×10^{-9}	1.76×10^{-10}	7.15×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Similar to Alternatives 2A, 2B, 3A, 3B, and 3C, the risk and hazard drivers are tritium, technetium-99, iodine-129, uranium-238, chromium, nitrate, and total uranium. The dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors as under Alternatives 2B, 3A, 3B, and 3C for releases from cribs and trenches (ditches). The dose standard would be exceeded at the same locations and for the same receptors as under Alternatives 2B, 3A, 3B, and 3C for releases from past leaks, with slightly less impacts at the B Barrier, S Barrier, and Core Zone Boundary as a result of clean closure of the BX and SX tank farms, located within the B and S Barriers. Impacts would be slightly less than those under Alternatives 2B, 3A, 3B, 3C, and 6C as a result of the combination of cribs and trenches (ditches), past leaks, and other tank farm sources, except the S Barrier, where no exceedances of the Hazard Index guideline were identified for the drinking-water well user or the resident farmer, and the A Barrier, where no exceedances of the Hazard Index guideline were identified for the drinking-water well user. Overall, the population dose is estimated as 2.49×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.60×10^{-5} percent of the annual population dose due to background exposure.

For releases from cribs and trenches (ditches) and past leaks, estimates of the magnitude and time series of impacts are substantially the same as those reported for Tank Closure Alternative 2B. The time series of radiological risk at the Core Zone Boundary for Tank Closure Alternative 4 is presented in Figure 5–338. Comparison of the time series of risk for other tank farm sources under Tank Closure Alternative 4 with the time series of risk under Tank Closure Alternative 2B (see Figure 5–336) identifies three points of interest. First, for the time period prior to CY 2500, the estimated risks under the two alternatives, presumably due to retrieval leaks, are nearly identical. Second, for the intermediate time between CYs 3000 and 4000, the broad peak is reduced by a factor of approximately 2 under Tank Closure Alternative 4 relative to that under Tank Closure Alternative 2B. Third, for the long-term period extending out to CY 11,940, risk is reduced by a factor of 5 under Tank Closure Alternative 4 relative to that under Tank Closure Alternative 2B. The reduction in risk estimate is due to clean closure of the BX and SX tank farms and greater retrieval of tank waste under Tank Closure Alternative 4 relative to that under Tank Closure Alternative 2B.

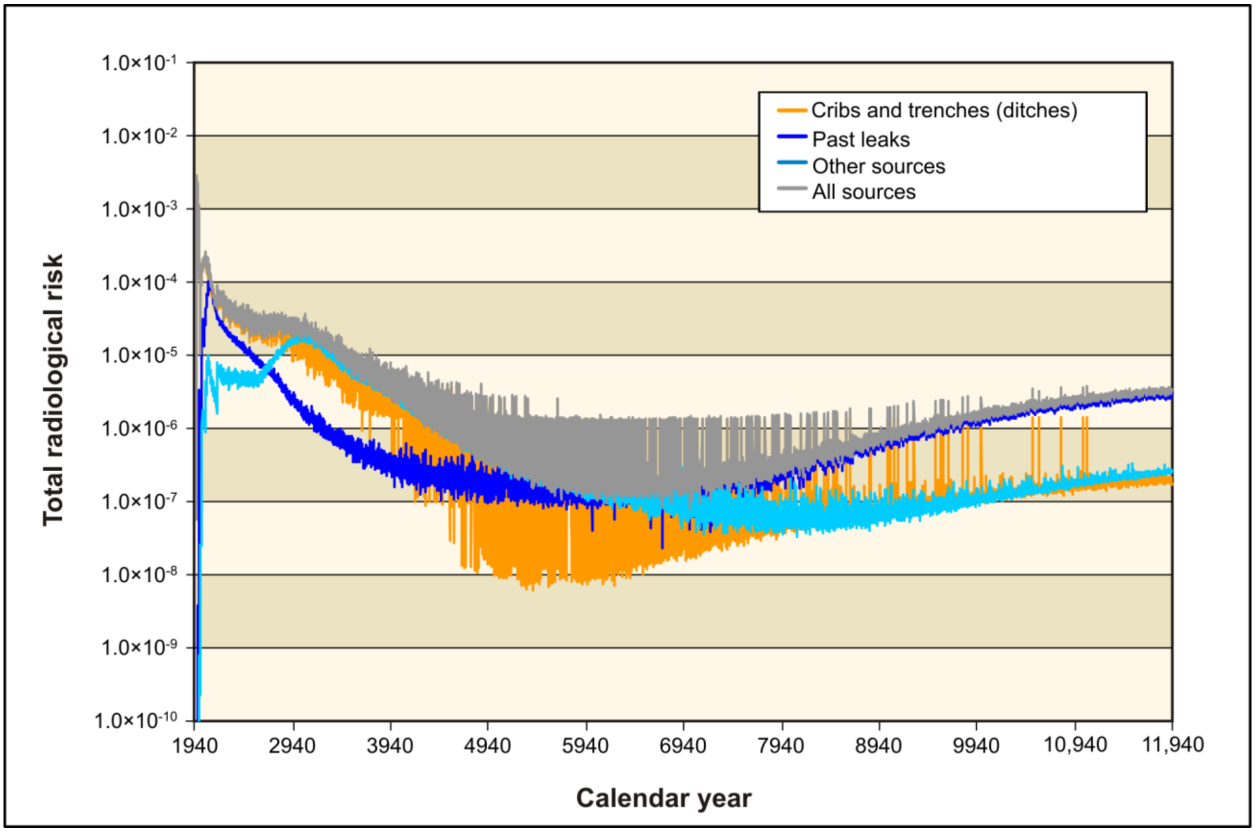


Figure 5–338. Tank Closure Alternative 4 Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.1.2.8 Tank Closure Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

Under Tank Closure Alternative 5, tank waste would be retrieved to a volume corresponding to 90 percent retrieval, residual material in tanks would be stabilized in place, and the tank farms and adjacent cribs and trenches (ditches) would be covered with the Hanford barrier. Potential human health impacts under Tank Closure Alternative 5 are detailed in Appendix Q and summarized in Tables 5–48 through 5–53; those related to cribs and trenches (ditches) after CY 1940, in Tables 5–48 and 5–49; to past leaks after CY 1940, in Tables 5–50 and 5–51; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050, in Tables 5–52 and 5–53.

The dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors as under Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, and 4 for releases from cribs and trenches (ditches). The dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors as under Tank Closure Alternatives 2B, 3A, 3B, and 3C for releases from past leaks, but would be slightly higher than under these alternatives. Impacts would occur at a later date than under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C for onsite locations as a result of the combination of cribs and trenches (ditches), past leaks, and other tank farm sources. This may be due to the Hanford barrier. However, exceedances at the offsite locations would be higher. The population dose is estimated as 4.24×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 2.73×10^{-5} percent of the annual population dose due to background exposure.

Table 5–48. Tank Closure Alternative 5 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	1.50×10^{2}	8.96×10^{1}	2.91×10^{-3}	0.00	2.91×10^{-3}	2.58×10^{2}	3.25×10^{2}	7.78×10^{-3}	2.41×10^{-8}	7.78×10^{-3}
T Barrier	8.91×10^{2}	9.18×10^{1}	8.46×10^{-3}	0.00	8.46×10^{-3}	1.04×10^{3}	2.84×10^{2}	1.02×10^{-2}	2.65×10^{-8}	1.02×10^{-2}
Core Zone Boundary	1.50×10^{2}	8.96×10^{1}	2.91×10^{-3}	0.00	2.91×10^{-3}	2.58×10^{2}	3.25×10^{2}	7.78×10^{-3}	2.41×10^{-8}	7.78×10^{-3}
Columbia River nearshore	3.00	2.88	6.49×10^{-5}	0.00	6.49×10^{-5}	5.51	1.15×10^{1}	1.85×10^{-4}	8.95×10^{-10}	1.85×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.44×10^{-4}	8.95×10^{-4}	1.11×10^{-8}	6.82×10^{-14}	1.11×10^{-8}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–49. Tank Closure Alternative 5 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	4.39×10^{2}	7.04×10^{2}	1.60×10^{-2}	1.11×10^{-3}	1.66×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.23×10^{3}	5.85×10^{2}	1.30×10^{-2}	1.21×10^{-3}	1.32×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.39×10^{2}	7.04×10^{2}	1.60×10^{-2}	1.11×10^{-3}	1.66×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	9.82	2.47×10^{1}	3.90×10^{-4}	4.10×10^{-5}	4.12×10^{-4}	9.67×10^{-2}	4.61	2.66×10^{-6}	4.10×10^{-5}	4.20×10^{-5}
Off Site										
Columbia River	9.82×10^{-4}	4.54×10^{-1}	3.41×10^{-8}	3.13×10^{-9}	3.53×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–50. Tank Closure Alternative 5 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.56	6.73×10^{-1}	8.39×10^{-5}	0.00	8.39×10^{-5}	6.36	9.38×10^{-1}	2.72×10^{-4}	2.63×10^{-10}	2.72×10^{-4}
B Barrier	3.48	6.65×10^{-1}	1.01×10^{-4}	0.00	1.01×10^{-4}	7.90	9.95×10^{-1}	3.17×10^{-4}	2.56×10^{-10}	3.17×10^{-4}
S Barrier	5.63	2.40	1.63×10^{-4}	0.00	1.63×10^{-4}	1.27×10^{1}	3.35	5.08×10^{-4}	9.39×10^{-10}	5.08×10^{-4}
T Barrier	2.43×10^{1}	3.30	6.97×10^{-4}	0.00	6.97×10^{-4}	5.46×10^{1}	6.32	2.18×10^{-3}	1.18×10^{-9}	2.18×10^{-3}
U Barrier	2.69×10^{-1}	6.65×10^{-2}	8.16×10^{-6}	0.00	8.16×10^{-6}	6.30×10^{-1}	1.22×10^{-1}	2.59×10^{-5}	2.42×10^{-11}	2.59×10^{-5}
Core Zone Boundary	3.48	8.07×10^{-1}	1.01×10^{-4}	0.00	1.01×10^{-4}	7.90	1.14	3.17×10^{-4}	3.14×10^{-10}	3.17×10^{-4}
Columbia River nearshore	7.99×10^{-1}	9.28×10^{-2}	2.30×10^{-5}	0.00	2.30×10^{-5}	1.80	1.70×10^{-1}	7.19×10^{-5}	3.38×10^{-11}	7.19×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.90×10^{-5}	5.22×10^{-6}	1.56×10^{-9}	1.16×10^{-15}	1.56×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–51. Tank Closure Alternative 5 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.28×10^{1}	1.61	5.94×10^{-4}	1.21×10^{-5}	5.95×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	1.54×10^{1}	1.75	6.85×10^{-4}	1.17×10^{-5}	6.94×10^{-4}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.47×10^{1}	5.76	1.09×10^{-3}	4.30×10^{-5}	1.14×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.06×10^{2}	1.19×10^{1}	4.69×10^{-3}	5.43×10^{-5}	4.74×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.24	2.28×10^{-1}	5.61×10^{-5}	1.11×10^{-6}	5.72×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	1.54×10^{1}	1.99	6.85×10^{-4}	1.44×10^{-5}	6.97×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.50	3.19×10^{-1}	1.55×10^{-4}	1.55×10^{-6}	1.56×10^{-4}	1.28×10^{-2}	6.66×10^{-2}	6.15×10^{-7}	1.55×10^{-6}	2.13×10^{-6}
Off Site										
Columbia River	1.57×10^{-4}	1.47×10^{-3}	5.61×10^{-9}	5.31×10^{-11}	5.65×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–52. Tank Closure Alternative 5 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.00	1.03	6.76×10^{-5}	0.00	6.76×10^{-5}	5.08	3.16	2.21×10^{-4}	3.09×10^{-10}	2.21×10^{-4}
B Barrier	7.54	4.81	2.38×10^{-4}	0.00	2.38×10^{-4}	1.79×10^{1}	2.57×10^{1}	7.75×10^{-4}	8.42×10^{-10}	7.75×10^{-4}
S Barrier	6.15	1.59	2.08×10^{-4}	0.00	2.08×10^{-4}	1.57×10^{1}	2.67	6.83×10^{-4}	6.22×10^{-10}	6.83×10^{-4}
T Barrier	1.56×10^{1}	4.48	4.44×10^{-4}	0.00	4.44×10^{-4}	3.48×10^{1}	1.22×10^{1}	1.38×10^{-3}	1.39×10^{-9}	1.38×10^{-3}
U Barrier	2.58	3.42×10^{-1}	8.64×10^{-5}	0.00	8.64×10^{-5}	6.52	7.60×10^{-1}	2.82×10^{-4}	1.19×10^{-10}	2.82×10^{-4}
Core Zone Boundary	7.57	4.81	2.38×10^{-4}	0.00	2.38×10^{-4}	1.79×10^{1}	2.57×10^{1}	7.75×10^{-4}	8.42×10^{-10}	7.75×10^{-4}
Columbia River nearshore	8.94×10^{-1}	9.71×10^{-1}	2.94×10^{-5}	0.00	2.94×10^{-5}	2.23	3.03	9.57×10^{-5}	2.78×10^{-10}	9.57×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	8.48×10^{-5}	5.77×10^{-5}	3.68×10^{-9}	3.85×10^{-15}	3.68×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–53. Tank Closure Alternative 5 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.03×10^{1}	6.56	4.83×10^{-4}	1.42×10^{-5}	4.90×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	3.63×10^{1}	5.62×10^{1}	1.69×10^{-3}	3.86×10^{-5}	1.71×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	3.19×10^{1}	5.05	1.49×10^{-3}	2.85×10^{-5}	1.51×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	6.74×10^{1}	2.46×10^{1}	2.97×10^{-3}	6.38×10^{-5}	3.03×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.32×10^{1}	1.49	6.16×10^{-4}	5.46×10^{-6}	6.19×10^{-4}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.63×10^{1}	5.62×10^{1}	1.69×10^{-3}	3.86×10^{-5}	1.71×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	4.50	6.24	2.09×10^{-4}	1.28×10^{-5}	2.12×10^{-4}	1.53×10^{-2}	1.03	7.95×10^{-7}	1.28×10^{-5}	1.31×10^{-5}
Off Site										
Columbia River	2.16×10^{-4}	2.99×10^{-2}	9.69×10^{-9}	1.77×10^{-10}	9.76×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

For releases from cribs and trenches (ditches) and past leaks, estimates of the magnitude and time series of impacts are substantially the same as those reported for Tank Closure Alternative 2B. The time series of radiological risk at the Core Zone Boundary under Tank Closure Alternative 5 is presented in Figure 5–339. Comparison of the time series of risk for other tank farm sources under Tank Closure Alternative 5 with the time series of risk under Tank Closure Alternative 2B (see Figure 5–336) identifies three points of interest. First, for the time period prior to CY 2500, the estimated risks under the two alternatives, presumably due to retrieval leaks, are nearly identical. Second, for the intermediate time between CYs 3000 and 4000, the broad peak is increased by a factor of approximately five under Tank Closure Alternative 5 relative to that under Tank Closure Alternative 2B. Third, for the long-term period extending out to CY 11,940, risk is increased by a factor of three under Tank Closure Alternative 5 relative to that under Tank Closure Alternative 2B. The increase in risk estimate is due to less retrieval of tank waste under Tank Closure Alternative 5 relative to that under Tank Closure Alternative 2B.

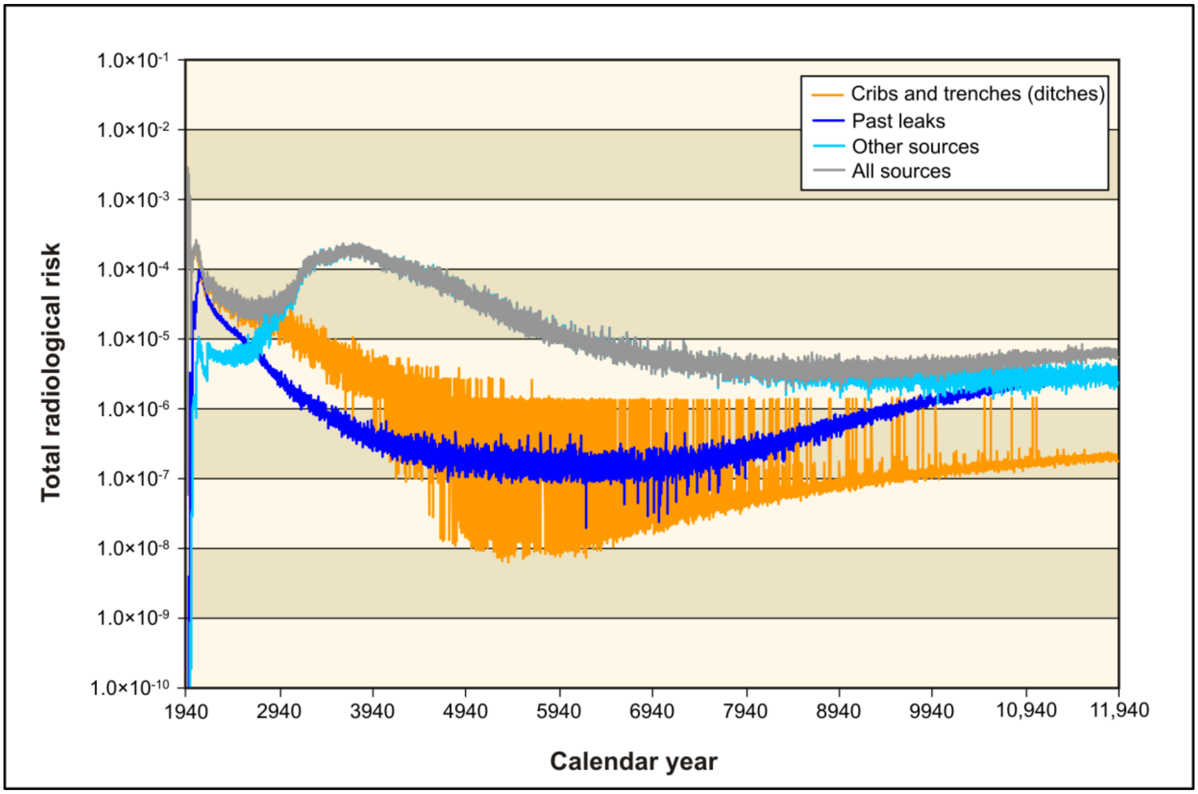


Figure 5–339. Tank Closure Alternative 5 Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.1.2.9 Tank Closure Alternative 6A: All Vitrification/No Separations; Clean Closure

5.1.2.9.1 Base Case

Under Tank Closure Alternative 6A, Base Case, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval, and all tank farms would be clean closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. The adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Potential human health impacts under Tank Closure Alternative 6A, Base Case, are detailed in Appendix Q and summarized in Tables 5–54 through 5–59; those related to cribs and trenches (ditches) after CY 1940, in Tables 5–54 and 5–55; to past leaks after CY 1940, in Tables 5–56 and 5–57; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050, in Tables 5–58 and 5–59.

Table 5–54. Tank Closure Alternative 6A, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

	Receptor									
	Drinking-Water Well User					Resident Farmer				
Location	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	1.50×10^{2}	8.96×10^{1}	2.91×10^{-3}	0.00	2.91×10^{-3}	2.58×10^{2}	3.25×10^{2}	7.78×10^{-3}	2.41×10^{-8}	7.78×10^{-3}
T Barrier	8.91×10^{2}	9.18×10^{1}	8.46×10^{-3}	0.00	8.46×10^{-3}	1.04×10^{3}	2.84×10^{2}	1.02×10^{-2}	2.65×10^{-8}	1.02×10^{-2}
Core Zone Boundary	1.50×10^{2}	8.96×10^{1}	2.91×10^{-3}	0.00	2.91×10^{-3}	2.58×10^{2}	3.25×10^{2}	7.78×10^{-3}	2.41×10^{-8}	7.78×10^{-3}
Columbia River nearshore	3.00	2.88	6.49×10^{-5}	0.00	6.49×10^{-5}	5.51	1.15×10^{1}	1.85×10^{-4}	8.95×10^{-10}	1.85×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.44×10^{-4}	8.95×10^{-4}	1.11×10^{-8}	6.82×10^{-14}	1.11×10^{-8}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–55. Tank Closure Alternative 6A, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
Location	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	4.39×10^{2}	7.04×10^{2}	1.60×10^{-2}	1.11×10^{-3}	1.66×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.23×10^{3}	5.85×10^{2}	1.30×10^{-2}	1.21×10^{-3}	1.32×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.39×10^{2}	7.04×10^{2}	1.60×10^{-2}	1.11×10^{-3}	1.66×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	9.82	2.47×10^{1}	3.90×10^{-4}	4.10×10^{-5}	4.12×10^{-4}	9.67×10^{-2}	4.61	2.66×10^{-6}	4.10×10^{-5}	4.20×10^{-5}
Off Site										
Columbia River	9.82×10^{-4}	4.54×10^{-1}	3.41×10^{-8}	3.13×10^{-9}	3.53×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–56. Tank Closure Alternative 6A, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.52	7.05×10^{-1}	8.27×10^{-5}	0.00	8.27×10^{-5}	6.27	9.91×10^{-1}	2.68×10^{-4}	2.75×10^{-10}	2.68×10^{-4}
B Barrier	5.44	6.88×10^{-1}	1.58×10^{-4}	0.00	1.58×10^{-4}	1.23×10^{1}	1.18	4.94×10^{-4}	2.56×10^{-10}	4.94×10^{-4}
S Barrier	5.75	2.47	1.67×10^{-4}	0.00	1.67×10^{-4}	1.30×10^{1}	3.44	5.21×10^{-4}	9.67×10^{-10}	5.21×10^{-4}
T Barrier	2.45×10^{1}	3.28	7.05×10^{-4}	0.00	7.05×10^{-4}	5.52×10^{1}	6.29	2.20×10^{-3}	1.18×10^{-9}	2.20×10^{-3}
U Barrier	2.89×10^{-1}	6.64×10^{-2}	8.84×10^{-6}	0.00	8.84×10^{-6}	6.81×10^{-1}	1.22×10^{-1}	2.81×10^{-5}	2.42×10^{-11}	2.81×10^{-5}
Core Zone Boundary	5.44	8.89×10^{-1}	1.58×10^{-4}	0.00	1.58×10^{-4}	1.23×10^{1}	1.37	4.94×10^{-4}	3.40×10^{-10}	4.94×10^{-4}
Columbia River nearshore	8.15×10^{-1}	9.05×10^{-2}	2.35×10^{-5}	0.00	2.35×10^{-5}	1.84	1.76×10^{-1}	7.35×10^{-5}	3.23×10^{-11}	7.35×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.09×10^{-5}	5.49×10^{-6}	1.64×10^{-9}	1.19×10^{-15}	1.64×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–57. Tank Closure Alternative 6A, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.26×10^{1}	1.71	5.85×10^{-4}	1.26×10^{-5}	5.87×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.40×10^{1}	2.16	1.07×10^{-3}	1.17×10^{-5}	1.08×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.53×10^{1}	5.92	1.12×10^{-3}	4.44×10^{-5}	1.17×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.07×10^{2}	1.19×10^{1}	4.74×10^{-3}	5.40×10^{-5}	4.80×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.35	2.29×10^{-1}	6.09×10^{-5}	1.11×10^{-6}	6.18×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.40×10^{1}	2.43	1.07×10^{-3}	1.56×10^{-5}	1.08×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.57	3.35×10^{-1}	1.58×10^{-4}	1.48×10^{-6}	1.60×10^{-4}	1.32×10^{-2}	7.06×10^{-2}	6.31×10^{-7}	1.48×10^{-6}	2.09×10^{-6}
Off Site										
Columbia River	1.63×10^{-4}	1.57×10^{-3}	5.84×10^{-9}	5.47×10^{-11}	5.89×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–58. Tank Closure Alternative 6A, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.16	1.06	6.33×10^{-5}	0.00	6.33×10^{-5}	4.93	3.05	1.99×10^{-4}	3.27×10^{-10}	1.99×10^{-4}
B Barrier	7.34	4.80	2.24×10^{-4}	0.00	2.24×10^{-4}	1.73×10^{1}	2.57×10^{1}	7.11×10^{-4}	8.40×10^{-10}	7.11×10^{-4}
S Barrier	3.36	1.56	9.76×10^{-5}	0.00	9.76×10^{-5}	7.62	2.18	3.06×10^{-4}	6.11×10^{-10}	3.06×10^{-4}
T Barrier	1.54×10^{1}	4.48	4.37×10^{-4}	0.00	4.37×10^{-4}	3.43×10^{1}	1.22×10^{1}	1.36×10^{-3}	1.39×10^{-9}	1.36×10^{-3}
U Barrier	2.89×10^{-1}	6.09×10^{-2}	8.84×10^{-6}	0.00	8.84×10^{-6}	6.81×10^{-1}	1.14×10^{-1}	2.81×10^{-5}	2.21×10^{-11}	2.81×10^{-5}
Core Zone Boundary	7.37	4.80	2.24×10^{-4}	0.00	2.24×10^{-4}	1.73×10^{1}	2.57×10^{1}	7.12×10^{-4}	8.40×10^{-10}	7.12×10^{-4}
Columbia River nearshore	8.76×10^{-1}	9.71×10^{-1}	2.54×10^{-5}	0.00	2.54×10^{-5}	1.98	3.03	7.93×10^{-5}	2.78×10^{-10}	7.93×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.97×10^{-5}	5.71×10^{-5}	2.00×10^{-9}	3.85×10^{-15}	2.00×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–59. Tank Closure Alternative 6A, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	9.63	6.30	4.30×10^{-4}	1.50×10^{-5}	4.41×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	3.41×10^{1}	5.61×10^{1}	1.54×10^{-3}	3.85×10^{-5}	1.57×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	1.48×10^{1}	3.75	6.59×10^{-4}	2.80×10^{-5}	6.86×10^{-4}	N/A	N/A	N/A	N/A	N/A
T Barrier	6.64×10^{1}	2.46×10^{1}	2.93×10^{-3}	6.38×10^{-5}	2.99×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.35	2.13×10^{-1}	6.09×10^{-5}	1.01×10^{-6}	6.18×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.41×10^{1}	5.61×10^{1}	1.54×10^{-3}	3.85×10^{-5}	1.57×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.85	6.24	1.71×10^{-4}	1.28×10^{-5}	1.78×10^{-4}	1.42×10^{-2}	1.03	6.82×10^{-7}	1.28×10^{-5}	1.31×10^{-5}
Off Site										
Columbia River	1.93×10^{-4}	2.95×10^{-2}	7.00×10^{-9}	1.77×10^{-10}	7.18×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

The dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors as under Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, 4, and 5 for releases from cribs and trenches (ditches). The dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors as under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 4 for releases from past leaks, except the B Barrier, where the Hazard Index guideline would be exceeded for the resident farmer. Impacts would be slightly lower than those under Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C for onsite locations as a result of the combination of cribs and trenches (ditches), past leaks, and other tank farm sources, except the T Barrier, where the results would be slightly higher. This may be due to the timing of tank removal under this alternative. However, after CY 2940, the impacts would drop significantly as a result of tank farm removal and clean closure activities. The population dose is estimated as 2.49×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.60×10^{-5} percent of the annual population dose due to background exposure.

The time series of radiological risk under Tank Closure Alternative 6A, Base Case, is presented in Figure 5–340. Because of removal operations, impacts due to retrieval leaks and leaching from other tank farm sources would not occur. For cribs and trenches (ditches), estimated risk is similar to that estimated for Tank Closure Alternative 2B. For past leaks, risk estimated for the period prior to CY 3000 is similar to that estimated for Tank Closure Alternative 2B, while risk estimated for the long-term period is reduced by a factor of 100 relative to that estimated for Tank Closure Alternative 2B.

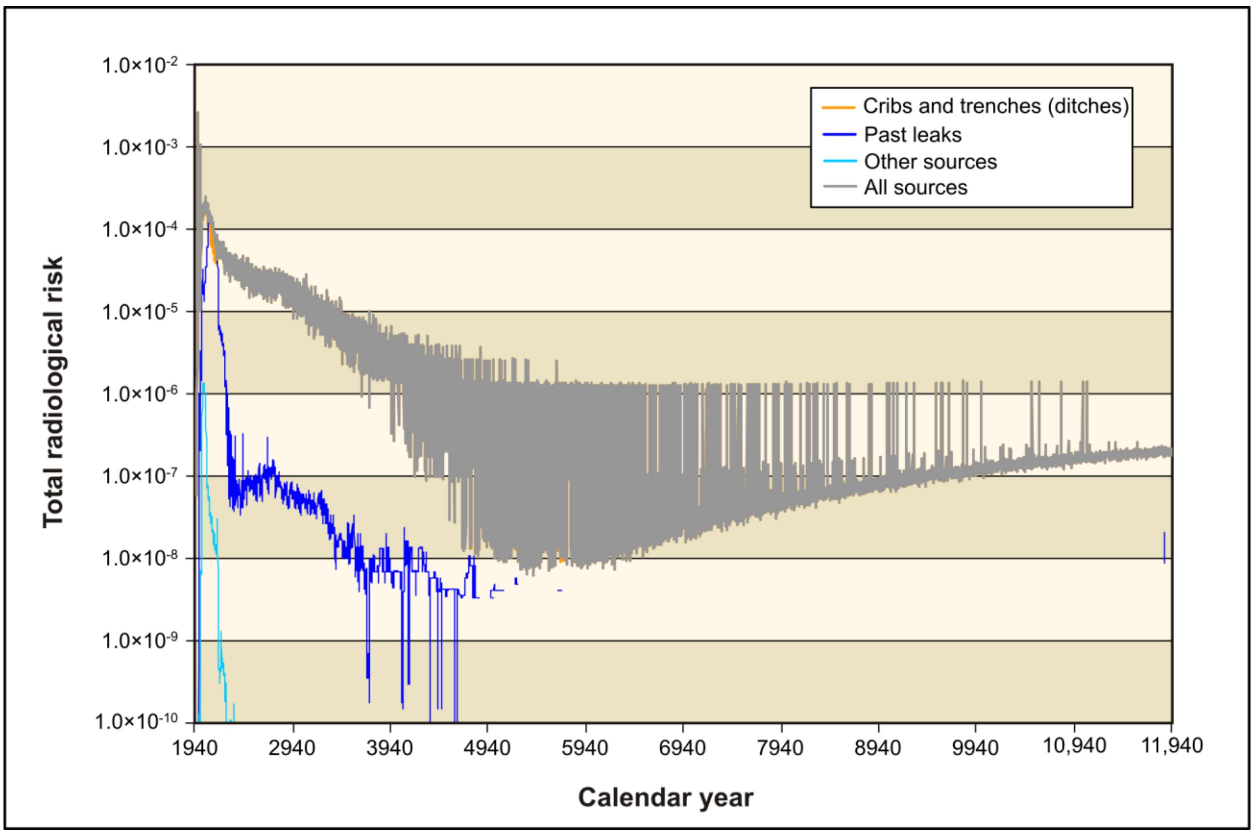


Figure 5–340. Tank Closure Alternative 6A, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

5.1.2.9.2 Option Case

Under Tank Closure Alternative 6A, Option Case, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval, and all tanks farms would be clean closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. In addition, the adjacent cribs and trenches (ditches) would be clean closed. Potential human health impacts under Tank Closure Alternative 6A, Option Case, are detailed in Appendix Q and summarized in Tables 5–60 through 5–65; those related to cribs and trenches (ditches) after CY 1940, in Tables 5–60 and 5–61; to past leaks after CY 1940, in Tables 5–62 and 5–63; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050, in Tables 5–64 and 5–65.

The dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors as under Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, 4, 5, and 6A, Base Case, for releases from cribs and trenches (ditches). Similar to Tank Closure Alternative 6A, Base Case, the dose standard and Hazard Index guideline would be exceeded at the same locations and for the same receptors for releases from past leaks. Impacts would be similar to those under Tank Closure Alternative 6A, Base Case, for onsite locations as a result of the combination of cribs and trenches (ditches), past leaks, and other tank farm sources. However, after CY 2940, the impacts would drop significantly as a result of tank farm removal. The population dose is estimated as 2.60×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.67×10^{-5} percent of the annual population dose due to background exposure.

The time series of radiological risk under Tank Closure Alternative 6A, Option Case, is presented in Figure 5–341. Because of removal operations, impacts due to retrieval leaks and leaching from other tank farm sources would not occur. For cribs and trenches (ditches), estimated risk is similar to that estimated for Tank Closure Alternative 6A, Base Case, prior to CY 2500, but is reduced by a factor of 1,000 for the long-term period. For past leaks, estimates of risk are similar to those estimated for Tank Closure Alternative 6A, Base Case.

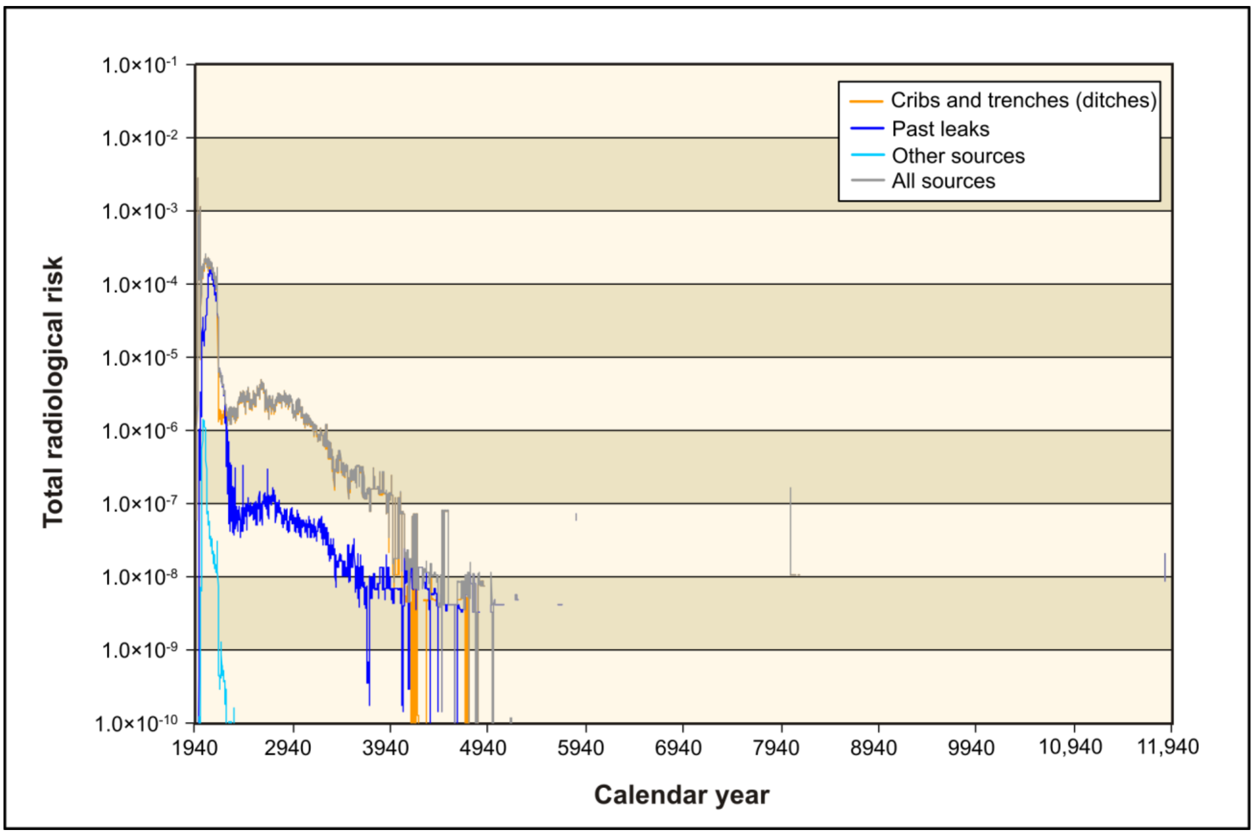


Figure 5–341. Tank Closure Alternative 6A, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

Table 5–60. Tank Closure Alternative 6A, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	1.48×10^{2}	8.92×10^{1}	2.84×10^{-3}	0.00	2.84×10^{-3}	2.53×10^{2}	3.15×10^{2}	7.55×10^{-3}	2.41×10^{-8}	7.55×10^{-3}
T Barrier	8.93×10^{2}	8.79×10^{1}	8.47×10^{-3}	0.00	8.47×10^{-3}	1.04×10^{3}	2.80×10^{2}	1.02×10^{-2}	2.48×10^{-8}	1.02×10^{-2}
Core Zone Boundary	1.48×10^{2}	8.92×10^{1}	2.84×10^{-3}	0.00	2.84×10^{-3}	2.53×10^{2}	3.15×10^{2}	7.55×10^{-3}	2.41×10^{-8}	7.55×10^{-3}
Columbia River nearshore	3.10	2.65	6.78×10^{-5}	0.00	6.78×10^{-5}	5.77	1.11×10^{1}	1.92×10^{-4}	7.80×10^{-10}	1.92×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.45×10^{-4}	8.96×10^{-4}	1.11×10^{-8}	7.03×10^{-14}	1.11×10^{-8}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–61. Tank Closure Alternative 6A, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	4.28×10^{2}	6.83×10^{2}	1.55×10^{-2}	1.10×10^{-3}	1.60×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.24×10^{3}	5.79×10^{2}	1.30×10^{-2}	1.14×10^{-3}	1.32×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.28×10^{2}	6.83×10^{2}	1.55×10^{-2}	1.10×10^{-3}	1.60×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.02×10^{1}	2.38×10^{1}	4.02×10^{-4}	3.58×10^{-5}	4.27×10^{-4}	9.85×10^{-2}	4.64	2.75×10^{-6}	3.57×10^{-5}	3.68×10^{-5}
Off Site										
Columbia River	9.81×10^{-4}	4.54×10^{-1}	3.41×10^{-8}	3.22×10^{-9}	3.53×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–62. Tank Closure Alternative 6A, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.52	7.05×10^{-1}	8.27×10^{-5}	0.00	8.27×10^{-5}	6.27	9.91×10^{-1}	2.68×10^{-4}	2.75×10^{-10}	2.68×10^{-4}
B Barrier	5.44	6.88×10^{-1}	1.58×10^{-4}	0.00	1.58×10^{-4}	1.23×10^{1}	1.18	4.94×10^{-4}	2.56×10^{-10}	4.94×10^{-4}
S Barrier	5.75	2.47	1.67×10^{-4}	0.00	1.67×10^{-4}	1.30×10^{1}	3.44	5.21×10^{-4}	9.67×10^{-10}	5.21×10^{-4}
T Barrier	2.45×10^{1}	3.28	7.05×10^{-4}	0.00	7.05×10^{-4}	5.52×10^{1}	6.29	2.20×10^{-3}	1.18×10^{-9}	2.20×10^{-3}
U Barrier	2.89×10^{-1}	6.64×10^{-2}	8.84×10^{-6}	0.00	8.84×10^{-6}	6.81×10^{-1}	1.22×10^{-1}	2.81×10^{-5}	2.42×10^{-11}	2.81×10^{-5}
Core Zone Boundary	5.44	8.89×10^{-1}	1.58×10^{-4}	0.00	1.58×10^{-4}	1.23×10^{1}	1.37	4.94×10^{-4}	3.40×10^{-10}	4.94×10^{-4}
Columbia River nearshore	8.15×10^{-1}	9.05×10^{-2}	2.35×10^{-5}	0.00	2.35×10^{-5}	1.84	1.76×10^{-1}	7.35×10^{-5}	3.23×10^{-11}	7.35×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.09×10^{-5}	5.49×10^{-6}	1.64×10^{-9}	1.19×10^{-15}	1.64×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–63. Tank Closure Alternative 6A, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.26×10^{1}	1.71	5.85×10^{-4}	1.26×10^{-5}	5.87×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.40×10^{1}	2.16	1.07×10^{-3}	1.17×10^{-5}	1.08×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.53×10^{1}	5.92	1.12×10^{-3}	4.44×10^{-5}	1.17×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.07×10^{2}	1.19×10^{1}	4.74×10^{-3}	5.40×10^{-5}	4.80×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.35	2.29×10^{-1}	6.09×10^{-5}	1.11×10^{-6}	6.18×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.40×10^{1}	2.43	1.07×10^{-3}	1.56×10^{-5}	1.08×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.57	3.35×10^{-1}	1.58×10^{-4}	1.48×10^{-6}	1.60×10^{-4}	1.32×10^{-2}	7.06×10^{-2}	6.31×10^{-7}	1.48×10^{-6}	2.09×10^{-6}
Off Site										
Columbia River	1.63×10^{-4}	1.57×10^{-3}	5.84×10^{-9}	5.47×10^{-11}	5.89×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–64. Tank Closure Alternative 6A, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.16	1.07	6.33×10^{-5}	0.00	6.33×10^{-5}	4.93	3.24	1.99×10^{-4}	3.13×10^{-10}	1.99×10^{-4}
B Barrier	7.64	5.22	2.34×10^{-4}	0.00	2.34×10^{-4}	1.80×10^{1}	2.84×10^{1}	7.44×10^{-4}	8.18×10^{-10}	7.44×10^{-4}
S Barrier	3.36	1.56	9.76×10^{-5}	0.00	9.76×10^{-5}	7.62	2.18	3.06×10^{-4}	6.11×10^{-10}	3.06×10^{-4}
T Barrier	1.53×10^{1}	4.35	4.36×10^{-4}	0.00	4.36×10^{-4}	3.42×10^{1}	1.22×10^{1}	1.36×10^{-3}	1.33×10^{-9}	1.36×10^{-3}
U Barrier	2.89×10^{-1}	6.09×10^{-2}	8.84×10^{-6}	0.00	8.84×10^{-6}	6.81×10^{-1}	1.14×10^{-1}	2.81×10^{-5}	2.21×10^{-11}	2.81×10^{-5}
Core Zone Boundary	7.64	5.22	2.34×10^{-4}	0.00	2.34×10^{-4}	1.80×10^{1}	2.84×10^{1}	7.44×10^{-4}	8.18×10^{-10}	7.44×10^{-4}
Columbia River nearshore	8.99×10^{-1}	9.12×10^{-1}	2.61×10^{-5}	0.00	2.61×10^{-5}	2.04	2.99	8.19×10^{-5}	2.53×10^{-10}	8.19×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	5.19×10^{-5}	6.25×10^{-5}	2.09×10^{-9}	4.00×10^{-15}	2.09×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–65. Tank Closure Alternative 6A, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	9.63	6.64	4.30×10^{-4}	1.44×10^{-5}	4.42×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	3.56×10^{1}	6.19×10^{1}	1.61×10^{-3}	3.75×10^{-5}	1.64×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	1.48×10^{1}	3.75	6.59×10^{-4}	2.80×10^{-5}	6.86×10^{-4}	N/A	N/A	N/A	N/A	N/A
T Barrier	6.63×10^{1}	2.47×10^{1}	2.93×10^{-3}	6.11×10^{-5}	2.99×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.35	2.13×10^{-1}	6.09×10^{-5}	1.01×10^{-6}	6.18×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.56×10^{1}	6.19×10^{1}	1.61×10^{-3}	3.75×10^{-5}	1.64×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.97	6.21	1.77×10^{-4}	1.16×10^{-5}	1.84×10^{-4}	1.47×10^{-2}	1.02	7.05×10^{-7}	1.16×10^{-5}	1.19×10^{-5}
Off Site										
Columbia River	2.01×10^{-4}	3.26×10^{-2}	7.29×10^{-9}	1.83×10^{-10}	7.48×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

5.1.2.10 Tank Closure Alternative 6B: All Vitrification with Separations; Clean Closure

5.1.2.10.1 Base Case

Tank Closure Alternative 6B, Base Case, resembles Tank Closure Alternative 6A, Base Case, except that waste retrieval and processing would proceed at a faster rate and closure would occur at an earlier date. All tank farms would be clean closed, and the adjacent crib and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier. Potential human health impacts under Tank Closure Alternative 6B, Base Case, are detailed in Appendix Q and summarized in Tables 5–66 through 5–71; those related to cribs and trenches (ditches) after CY 1940, in Tables 5–66 and 5–67; to past leaks after CY 1940, in Tables 5–68 and 5–69; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050, in Tables 5–70 and 5–71.

Impacts would be similar to those under Tank Closure Alternative 6A, Base Case, and standards would be exceeded, as under Tank Closure Alternative 6A, Base Case, except there would be no exceedances of the Hazard Index guideline at the A Barrier for the drinking-water well user. The population dose is estimated as 2.43×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.56×10^{-5} percent of the annual population dose due to background exposure.

The time series of radiological risk under Tank Closure Alternative 6B, Base Case, is presented in Figure 5–342.

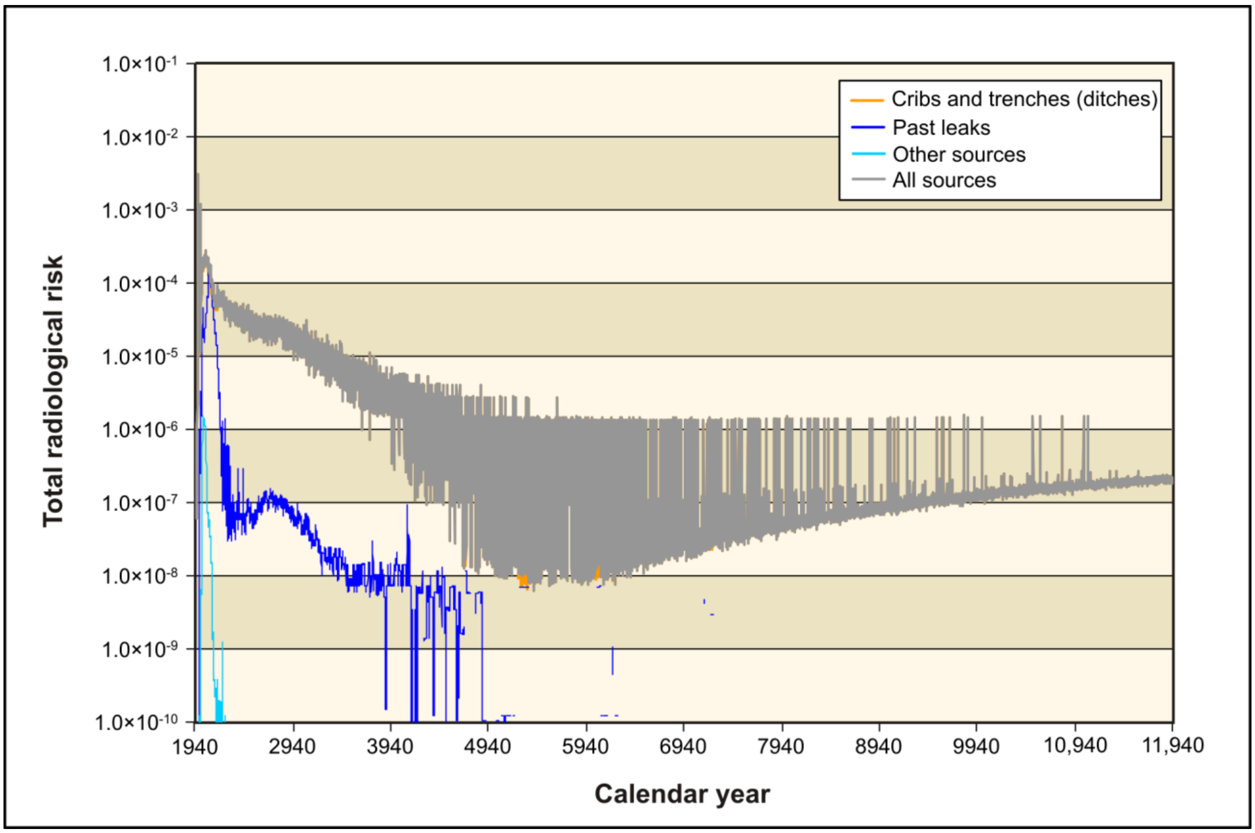


Figure 5–342. Tank Closure Alternative 6B, Base Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

Table 5–66. Tank Closure Alternative 6B, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

	Receptor									
	Drinking-Water Well User					Resident Farmer				
Location	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	1.50×10^{2}	8.96×10^{1}	2.91×10^{-3}	0.00	2.91×10^{-3}	2.58×10^{2}	3.25×10^{2}	7.78×10^{-3}	2.41×10^{-8}	7.78×10^{-3}
T Barrier	8.91×10^{2}	9.18×10^{1}	8.46×10^{-3}	0.00	8.46×10^{-3}	1.04×10^{3}	2.84×10^{2}	1.02×10^{-2}	2.65×10^{-8}	1.02×10^{-2}
Core Zone Boundary	1.50×10^{2}	8.96×10^{1}	2.91×10^{-3}	0.00	2.91×10^{-3}	2.58×10^{2}	3.25×10^{2}	7.78×10^{-3}	2.41×10^{-8}	7.78×10^{-3}
Columbia River nearshore	3.00	2.88	6.49×10^{-5}	0.00	6.49×10^{-5}	5.51	1.15×10^{1}	1.85×10^{-4}	8.95×10^{-10}	1.85×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.44×10^{-4}	8.95×10^{-4}	1.11×10^{-8}	6.82×10^{-14}	1.11×10^{-8}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–67. Tank Closure Alternative 6B, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	4.39×10^{2}	7.04×10^{2}	1.60×10^{-2}	1.11×10^{-3}	1.66×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.23×10^{3}	5.85×10^{2}	1.30×10^{-2}	1.21×10^{-3}	1.32×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.39×10^{2}	7.04×10^{2}	1.60×10^{-2}	1.11×10^{-3}	1.66×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	9.82	2.47×10^{1}	3.90×10^{-4}	4.10×10^{-5}	4.12×10^{-4}	9.67×10^{-2}	4.61	2.66×10^{-6}	4.10×10^{-5}	4.20×10^{-5}
Off Site										
Columbia River	9.82×10^{-4}	4.54×10^{-1}	3.41×10^{-8}	3.13×10^{-9}	3.53×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–68. Tank Closure Alternative 6B, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.56	6.96×10^{-1}	8.40×10^{-5}	0.00	8.40×10^{-5}	6.37	9.62×10^{-1}	2.73×10^{-4}	2.72×10^{-10}	2.73×10^{-4}
B Barrier	5.74	6.52×10^{-1}	1.67×10^{-4}	0.00	1.67×10^{-4}	1.30×10^{1}	1.11	5.24×10^{-4}	2.43×10^{-10}	5.24×10^{-4}
S Barrier	5.64	2.47	1.63×10^{-4}	0.00	1.63×10^{-4}	1.27×10^{1}	3.41	5.09×10^{-4}	9.67×10^{-10}	5.09×10^{-4}
T Barrier	2.44×10^{1}	3.29	7.00×10^{-4}	0.00	7.00×10^{-4}	5.48×10^{1}	6.39	2.18×10^{-3}	1.18×10^{-9}	2.18×10^{-3}
U Barrier	2.86×10^{-1}	6.56×10^{-2}	8.76×10^{-6}	0.00	8.76×10^{-6}	6.75×10^{-1}	1.21×10^{-1}	2.79×10^{-5}	2.38×10^{-11}	2.79×10^{-5}
Core Zone Boundary	5.74	8.24×10^{-1}	1.67×10^{-4}	0.00	1.67×10^{-4}	1.30×10^{1}	1.22	5.24×10^{-4}	3.20×10^{-10}	5.24×10^{-4}
Columbia River nearshore	7.48×10^{-1}	8.86×10^{-2}	2.16×10^{-5}	0.00	2.16×10^{-5}	1.69	1.62×10^{-1}	6.77×10^{-5}	3.23×10^{-11}	6.77×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.03×10^{-5}	5.32×10^{-6}	1.62×10^{-9}	1.17×10^{-15}	1.62×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–69. Tank Closure Alternative 6B, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.28×10^{1}	1.65	5.95×10^{-4}	1.25×10^{-5}	5.96×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.54×10^{1}	2.04	1.13×10^{-3}	1.11×10^{-5}	1.14×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.47×10^{1}	5.85	1.10×10^{-3}	4.44×10^{-5}	1.14×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.06×10^{2}	1.21×10^{1}	4.71×10^{-3}	5.41×10^{-5}	4.76×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.33	2.27×10^{-1}	6.04×10^{-5}	1.09×10^{-6}	6.13×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.54×10^{1}	2.20	1.13×10^{-3}	1.47×10^{-5}	1.14×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.28	3.04×10^{-1}	1.46×10^{-4}	1.48×10^{-6}	1.48×10^{-4}	1.21×10^{-2}	6.66×10^{-2}	5.82×10^{-7}	1.48×10^{-6}	2.05×10^{-6}
Off Site										
Columbia River	1.59×10^{-4}	1.50×10^{-3}	5.73×10^{-9}	5.38×10^{-11}	5.78×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–70. Tank Closure Alternative 6B, Base Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.99	9.53×10^{-1}	5.79×10^{-5}	0.00	5.79×10^{-5}	4.52	2.92	1.81×10^{-4}	3.02×10^{-10}	1.81×10^{-4}
B Barrier	7.32	4.80	2.23×10^{-4}	0.00	2.23×10^{-4}	1.72×10^{1}	2.57×10^{1}	7.11×10^{-4}	8.43×10^{-10}	7.11×10^{-4}
S Barrier	3.42	1.58	9.87×10^{-5}	0.00	9.87×10^{-5}	7.72	2.20	3.08×10^{-4}	6.19×10^{-10}	3.08×10^{-4}
T Barrier	1.52×10^{1}	4.47	4.32×10^{-4}	0.00	4.32×10^{-4}	3.40×10^{1}	1.22×10^{1}	1.34×10^{-3}	1.39×10^{-9}	1.34×10^{-3}
U Barrier	2.86×10^{-1}	6.18×10^{-2}	8.76×10^{-6}	0.00	8.76×10^{-6}	6.75×10^{-1}	1.13×10^{-1}	2.79×10^{-5}	2.25×10^{-11}	2.79×10^{-5}
Core Zone Boundary	7.35	4.80	2.24×10^{-4}	0.00	2.24×10^{-4}	1.73×10^{1}	2.57×10^{1}	7.11×10^{-4}	8.43×10^{-10}	7.11×10^{-4}
Columbia River nearshore	8.22×10^{-1}	9.72×10^{-1}	2.38×10^{-5}	0.00	2.38×10^{-5}	1.86	3.03	7.43×10^{-5}	2.79×10^{-10}	7.43×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.85×10^{-5}	5.70×10^{-5}	1.96×10^{-9}	3.82×10^{-15}	1.96×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–71. Tank Closure Alternative 6B, Base Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	8.80	6.08	3.91×10^{-4}	1.38×10^{-5}	4.02×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	3.40×10^{1}	5.61×10^{1}	1.54×10^{-3}	3.86×10^{-5}	1.57×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	1.50×10^{1}	3.78	6.65×10^{-4}	2.84×10^{-5}	6.92×10^{-4}	N/A	N/A	N/A	N/A	N/A
T Barrier	6.56×10^{1}	2.46×10^{1}	2.89×10^{-3}	6.36×10^{-5}	2.95×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.33	2.12×10^{-1}	6.04×10^{-5}	1.03×10^{-6}	6.13×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.41×10^{1}	5.61×10^{1}	1.54×10^{-3}	3.86×10^{-5}	1.57×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.61	6.24	1.60×10^{-4}	1.28×10^{-5}	1.68×10^{-4}	1.34×10^{-2}	1.03	6.43×10^{-7}	1.28×10^{-5}	1.31×10^{-5}
Off Site										
Columbia River	1.86×10^{-4}	2.95×10^{-2}	6.78×10^{-9}	1.75×10^{-10}	6.96×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

5.1.2.10.2 Option Case

Tank Closure Alternative 6B, Option Case, resembles Tank Closure Alternative 6A, Option Case, except that waste retrieval and processing would proceed at a faster rate and closure would occur at an earlier date. All tank farms and adjacent crib and trenches (ditches) would be clean closed. Potential human health impacts under Tank Closure Alternative 6B, Option Case, are detailed in Appendix Q and summarized in Tables 5–72 through 5–77; those related to cribs and trenches (ditches) after CY 1940, in Tables 5–72 and 5–73; to past leaks after CY 1940, in Tables 5–74 and 5–75; and to the combination of cribs and trenches (ditches), past leaks, and other tank farm sources after CY 2050, in Tables 5–76 and 5–77.

Impacts would be slightly less than those under Tank Closure Alternative 6B, Base Case, and standards would be exceeded, as under Tank Closure Alternative 6B, Base Case. The population dose is estimated as 2.44×10^{-1} person-rem per year for the year of maximum impact. This corresponds to 1.57×10^{-5} percent of the annual population dose due to background exposure.

The time series of radiological risk under Tank Closure Alternative 6B, Option Case, is presented in Figure 5–343.

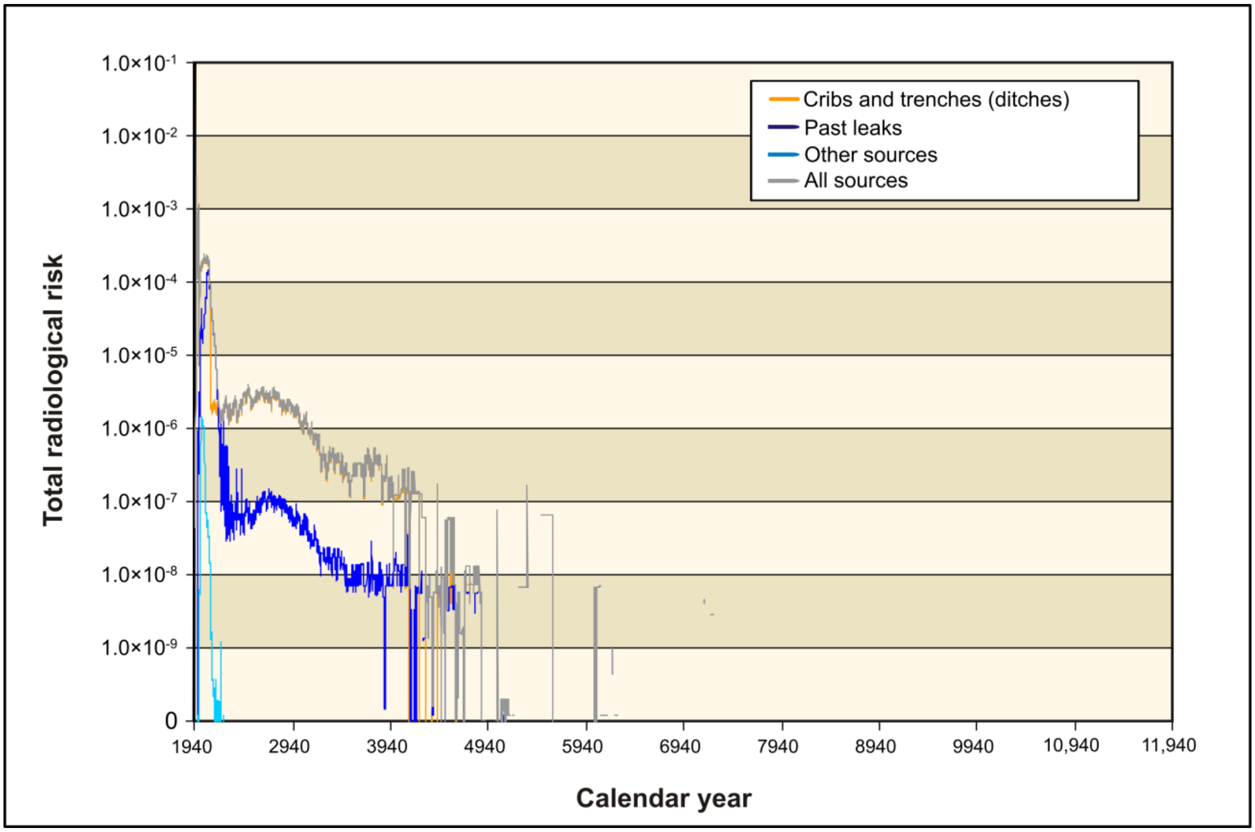


Figure 5–343. Tank Closure Alternative 6B, Option Case, Time Series of Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary

Table 5–72. Tank Closure Alternative 6B, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	1.51×10^{2}	8.99×10^{1}	2.94×10^{-3}	0.00	2.94×10^{-3}	2.61×10^{2}	3.17×10^{2}	7.88×10^{-3}	2.45×10^{-8}	7.88×10^{-3}
T Barrier	8.91×10^{2}	8.80×10^{1}	8.46×10^{-3}	0.00	8.46×10^{-3}	1.04×10^{3}	2.81×10^{2}	1.02×10^{-2}	2.48×10^{-8}	1.02×10^{-2}
Core Zone Boundary	1.51×10^{2}	8.99×10^{1}	2.94×10^{-3}	0.00	2.94×10^{-3}	2.61×10^{2}	3.17×10^{2}	7.88×10^{-3}	2.45×10^{-8}	7.88×10^{-3}
Columbia River nearshore	3.15	2.58	6.93×10^{-5}	0.00	6.93×10^{-5}	5.89	1.12×10^{1}	1.97×10^{-4}	7.60×10^{-10}	1.97×10^{-4}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	3.45×10^{-4}	8.96×10^{-4}	1.11×10^{-8}	7.04×10^{-14}	1.11×10^{-8}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–73. Tank Closure Alternative 6B, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Cribs and Trenches (Ditches)

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
B Barrier	4.44×10^{2}	6.87×10^{2}	1.63×10^{-2}	1.12×10^{-3}	1.68×10^{-2}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.23×10^{3}	5.81×10^{2}	1.30×10^{-2}	1.14×10^{-3}	1.32×10^{-2}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	4.44×10^{2}	6.87×10^{2}	1.63×10^{-2}	1.12×10^{-3}	1.68×10^{-2}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	1.05×10^{1}	2.39×10^{1}	4.13×10^{-4}	3.48×10^{-5}	4.37×10^{-4}	9.99×10^{-2}	4.64	2.80×10^{-6}	3.48×10^{-5}	3.58×10^{-5}
Off Site										
Columbia River	9.83×10^{-4}	4.53×10^{-1}	3.41×10^{-8}	3.23×10^{-9}	3.53×10^{-8}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–74. Tank Closure Alternative 6B, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	2.56	6.96×10^{-1}	8.40×10^{-5}	0.00	8.40×10^{-5}	6.37	9.62×10^{-1}	2.73×10^{-4}	2.72×10^{-10}	2.73×10^{-4}
B Barrier	5.74	6.52×10^{-1}	1.67×10^{-4}	0.00	1.67×10^{-4}	1.30×10^{1}	1.11	5.24×10^{-4}	2.43×10^{-10}	5.24×10^{-4}
S Barrier	5.64	2.47	1.63×10^{-4}	0.00	1.63×10^{-4}	1.27×10^{1}	3.41	5.09×10^{-4}	9.67×10^{-10}	5.09×10^{-4}
T Barrier	2.44×10^{1}	3.29	7.00×10^{-4}	0.00	7.00×10^{-4}	5.48×10^{1}	6.39	2.18×10^{-3}	1.18×10^{-9}	2.18×10^{-3}
U Barrier	2.86×10^{-1}	6.56×10^{-2}	8.76×10^{-6}	0.00	8.76×10^{-6}	6.75×10^{-1}	1.21×10^{-1}	2.79×10^{-5}	2.38×10^{-11}	2.79×10^{-5}
Core Zone Boundary	5.74	8.24×10^{-1}	1.67×10^{-4}	0.00	1.67×10^{-4}	1.30×10^{1}	1.22	5.24×10^{-4}	3.20×10^{-10}	5.24×10^{-4}
Columbia River nearshore	7.48×10^{-1}	8.86×10^{-2}	2.16×10^{-5}	0.00	2.16×10^{-5}	1.69	1.62×10^{-1}	6.77×10^{-5}	3.23×10^{-11}	6.77×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.03×10^{-5}	5.32×10^{-6}	1.62×10^{-9}	1.17×10^{-15}	1.62×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–75. Tank Closure Alternative 6B, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impacts of Past Leaks

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.28×10^{1}	1.65	5.95×10^{-4}	1.25×10^{-5}	5.96×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	2.54×10^{1}	2.04	1.13×10^{-3}	1.11×10^{-5}	1.14×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	2.47×10^{1}	5.85	1.10×10^{-3}	4.44×10^{-5}	1.14×10^{-3}	N/A	N/A	N/A	N/A	N/A
T Barrier	1.06×10^{2}	1.21×10^{1}	4.71×10^{-3}	5.41×10^{-5}	4.76×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.33	2.27×10^{-1}	6.04×10^{-5}	1.09×10^{-6}	6.13×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	2.54×10^{1}	2.20	1.13×10^{-3}	1.47×10^{-5}	1.14×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.28	3.04×10^{-1}	1.46×10^{-4}	1.48×10^{-6}	1.48×10^{-4}	1.21×10^{-2}	6.66×10^{-2}	5.82×10^{-7}	1.48×10^{-6}	2.05×10^{-6}
Off Site										
Columbia River	1.59×10^{-4}	1.50×10^{-3}	5.73×10^{-9}	5.38×10^{-11}	5.78×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–76. Tank Closure Alternative 6B, Option Case, Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	1.99	8.26×10^{-1}	5.79×10^{-5}	0.00	5.79×10^{-5}	4.52	1.85	1.81×10^{-4}	2.93×10^{-10}	1.81×10^{-4}
B Barrier	7.92	5.23	2.41×10^{-4}	0.00	2.41×10^{-4}	1.86×10^{1}	2.97×10^{1}	7.67×10^{-4}	7.70×10^{-10}	7.67×10^{-4}
S Barrier	3.42	1.58	9.87×10^{-5}	0.00	9.87×10^{-5}	7.72	2.20	3.08×10^{-4}	6.19×10^{-10}	3.08×10^{-4}
T Barrier	1.51×10^{1}	4.31	4.31×10^{-4}	0.00	4.31×10^{-4}	3.38×10^{1}	1.22×10^{1}	1.34×10^{-3}	1.32×10^{-9}	1.34×10^{-3}
U Barrier	2.86×10^{-1}	6.18×10^{-2}	8.76×10^{-6}	0.00	8.76×10^{-6}	6.75×10^{-1}	1.13×10^{-1}	2.79×10^{-5}	2.25×10^{-11}	2.79×10^{-5}
Core Zone Boundary	7.92	5.23	2.41×10^{-4}	0.00	2.41×10^{-4}	1.86×10^{1}	2.97×10^{1}	7.67×10^{-4}	7.70×10^{-10}	7.67×10^{-4}
Columbia River nearshore	8.07×10^{-1}	8.30×10^{-1}	2.33×10^{-5}	0.00	2.33×10^{-5}	1.82	2.66	7.28×10^{-5}	2.34×10^{-10}	7.28×10^{-5}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	4.87×10^{-5}	5.40×10^{-5}	1.97×10^{-9}	3.53×10^{-15}	1.97×10^{-9}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–77. Tank Closure Alternative 6B, Option Case, American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
A Barrier	8.80	4.04	3.91×10^{-4}	1.34×10^{-5}	4.02×10^{-4}	N/A	N/A	N/A	N/A	N/A
B Barrier	3.68×10^{1}	6.51×10^{1}	1.66×10^{-3}	3.53×10^{-5}	1.69×10^{-3}	N/A	N/A	N/A	N/A	N/A
S Barrier	1.50×10^{1}	3.78	6.65×10^{-4}	2.84×10^{-5}	6.92×10^{-4}	N/A	N/A	N/A	N/A	N/A
T Barrier	6.55×10^{1}	2.49×10^{1}	2.89×10^{-3}	6.07×10^{-5}	2.95×10^{-3}	N/A	N/A	N/A	N/A	N/A
U Barrier	1.33	2.12×10^{-1}	6.04×10^{-5}	1.03×10^{-6}	6.13×10^{-5}	N/A	N/A	N/A	N/A	N/A
Core Zone Boundary	3.68×10^{1}	6.51×10^{1}	1.66×10^{-3}	3.53×10^{-5}	1.69×10^{-3}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.54	5.53	1.57×10^{-4}	1.07×10^{-5}	1.64×10^{-4}	1.31×10^{-2}	9.21×10^{-1}	6.26×10^{-7}	1.07×10^{-5}	1.11×10^{-5}
Off Site										
Columbia River	1.86×10^{-4}	2.81×10^{-2}	6.81×10^{-9}	1.62×10^{-10}	6.97×10^{-9}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

5.1.2.11 Tank Closure Alternative 6C: All Vitrification with Separations; Landfill Closure

Activities under Tank Closure Alternative 6C would be similar to those under Tank Closure Alternative 2B. Likewise, impacts exceeding dose and risk standards, the estimated population dose for the year of maximum impact, and corresponding percentage of the annual population dose due to background exposure would be the same as those under Tank Closure Alternative 2B for cribs and trenches (ditches), past leaks, and other tank farm sources.

5.1.2.12 Tank Closure Intruder Scenario

Intruders are individuals who enter a tank farm area and engage in activity that could cause direct contact with residual contamination in the stabilized or closed tanks. Two types of receptors and two types of scenarios were considered. The receptor types were the American Indian resident farmer and the resident farmer, and the scenario types were home construction and well drilling. Because the majority of the waste at the tank farms is at a depth greater than that of the foundation for a home, the home construction scenario was screened from the analysis. Also, sensitivity analysis determined that in all cases for residential agriculture, impacts on the American Indian resident farmer exceeded impacts on the resident farmer. Screening analysis also determined that impacts of intrusion were dominated by contact with short-lived radionuclides, strontium-90 and cesium-137. Consequently, impacts of intrusion at the tank farms are represented by the well-drilling scenario, in which a worker inhales dust and receives external radiation while drilling the well and an American Indian resident farmer contacts residual contamination brought to the surface during development of the well. Because complete removal of tanks is proposed under Tank Closure Alternatives 6A, Base and Option Cases, and 6B, Base and Option Cases, no tank farm intruder impacts would occur under these alternatives. In addition, complete removal of tanks is proposed for the BX and SX tank farms under Alternative 4 and intruder impacts would be avoided. Estimates of impact under this intrusion scenario for the eighteen tank farms and Tank Closure Alternatives 1 through 5 and 6C are summarized in Table 5–78 for American Indian resident farmer intruders. For all tank farms and alternatives, resident farmer impacts are dominated by exposure to strontium-90 and cesium-137. Because inhalation and external exposure are the only exposure modes for the well-drilling worker, impacts on the worker involved in well drilling would be the same for resident farmer and American Indian receptors. Estimates of impact on the drilling worker are presented in Table 5–79. For all tank farms and alternatives, drilling worker doses are dominated by external exposure to cesium-137 and inhalation exposure to plutonium-239 and americium-241. For both the resident farmer and drilling worker, impacts are presented as dose for the year of peak dose. Because doses are dominated by radionuclides with short half-lives, the year of peak dose occurs immediately after loss of institutional control. Due to high concentrations of strontium-90 and cesium-137, the DOE intruder dose guideline of 500 millirem (DOE Guide 435.1-1) is exceeded for SST farms under Alternative 1 and 5 and for DST farms under all alternatives.

Table 5–78. Doses to an American Indian Engaged in Residential Agriculture Following Well Drilling at the Tank Farms

Tank Farm	Dose (rem per year)					
	Tank Closure Alternative					
	1	2	3	4	5	6C
A	48.4	0.484	0.484	0.048	4.84	0.484
AX	36.8	0.368	0.368	0.0368	3.68	0.368
B	6.84	0.068	0.068	0.0068	0.68	0.068
BX	5.71	0.0571	0.0571	N/A[a]	0.571	0.0571
BY	27.8	0.278	0.278	0.0278	2.78	0.0278
C	25.0	0.250	0.250	0.0250	2.50	0.250
S	33.2	0.332	0.332	0.0332	3.32	0.332
SX	30.7	0.307	0.307	N/A[a]	3.07	0.0307
T	2.38	0.0238	0.0238	0.0024	0.238	0.0238
TX	19.5	0.195	0.195	0.0195	1.95	0.195
TY	2.23	0.0223	0.0223	0.0022	0.223	0.0223
U	26.8	0.268	0.268	0.0268	2.68	0.268
AN	166	1.66	1.66	0.166	16.6	1.66
AP	90.3	0.903	0.903	0.0903	9.03	0.903
AW	74.1	0.741	0.741	0.0741	7.41	0.741
AY	82.6	0.826	0.826	0.0826	8.26	0.826
AZ	738	7.38	7.38	0.738	73.8	7.38
SY	117	1.17	1.17	0.117	11.7	1.17

[a] N/A=not applicable because the BX and SX tank farms would be clean closed under Tank Closure Alternative 4.

Table 5–79. Doses to a Well-Drilling Worker at the Tank Farms

Tank Farm	Dose (rem per year)					
	Tank Closure Alternative					
	1	2	3	4	5	6C
A	1.38×10^{-1}	1.38×10^{-3}	1.38×10^{-4}	1.38×10^{-4}	1.38×10^{-2}	1.38×10^{-3}
AX	8.78×10^{-2}	8.78×10^{-4}	8.78×10^{-4}	8.78×10^{-5}	8.73×10^{-3}	8.78×10^{-4}
B	1.93×10^{-2}	1.93×10^{-4}	1.93×10^{-4}	1.93×10^{-5}	1.93×10^{-3}	1.92×10^{-4}
BX	2.30×10^{-2}	2.30×10^{-4}	2.30×10^{-4}	N/A[a]	2.30×10^{-3}	2.30×10^{-4}
BY	6.20×10^{-2}	6.20×10^{-4}	6.20×10^{-4}	6.20×10^{-5}	6.20×10^{-3}	6.20×10^{-4}
C	1.95×10^{-1}	1.95×10^{-3}	1.95×10^{-3}	1.95×10^{-4}	1.95×10^{-2}	1.95×10^{-3}
S	9.10×10^{-2}	9.10×10^{-4}	9.10×10^{-4}	9.10×10^{-5}	9.10×10^{-3}	9.10×10^{-4}
SX	8.85×10^{-2}	8.85×10^{-4}	8.85×10^{-4}	N/A[a]	8.85×10^{-3}	8.85×10^{-4}
T	1.22×10^{-2}	1.22×10^{-4}	1.22×10^{-4}	1.22×10^{-5}	1.22×10^{-3}	1.22×10^{-4}
TX	1.33×10^{-1}	1.33×10^{-3}	1.33×10^{-3}	1.33×10^{-4}	1.33×10^{-2}	1.33×10^{-3}
TY	6.99×10^{-3}	6.99×10^{-5}	6.99×10^{-5}	6.99×10^{-6}	6.99×10^{-4}	6.99×10^{-5}
U	7.94×10^{-2}	7.94×10^{-4}	7.94×10^{-4}	7.94×10^{-5}	7.94×10^{-3}	7.94×10^{-4}
AN	3.75×10^{-1}	3.75×10^{-3}	3.75×10^{-3}	3.75×10^{-4}	3.75×10^{-2}	3.75×10^{-3}
AP	1.90×10^{-1}	1.90×10^{-3}	1.90×10^{-3}	1.90×10^{-4}	1.90×10^{-2}	1.90×10^{-3}
AW	1.91×10^{-1}	1.91×10^{-3}	1.91×10^{-3}	1.91×10^{-4}	1.91×10^{-2}	1.91×10^{-3}
AY	4.71×10^{-1}	4.71×10^{-3}	4.71×10^{-3}	4.71×10^{-4}	4.71×10^{-2}	4.71×10^{-3}
AZ	2.43	2.43×10^{-2}	2.43×10^{-2}	2.43×10^{-3}	2.43×10^{-1}	2.43×10^{-2}
SY	6.87×10^{-1}	6.87×10^{-3}	6.87×10^{-3}	6.87×10^{-4}	6.87×10^{-2}	6.87×10^{-3}

[a] N/A=not applicable because the BX and SX tank farms would be clean closed under Tank Closure Alternative 4.

5.1.3 Ecological Risk

This section presents the results of the evaluation of long-term impacts on ecological resources of releases to air and groundwater under the Tank Closure alternatives. Risk indices—Hazard Quotient and Hazard Index—were calculated by comparing the predicted dose to the benchmark dose (see Appendix P). Risk indices could not be calculated for some chemical COPCs and some receptors because exposure parameters or toxicity reference values do not exist for all COPCs and receptors. For each receptor, calculated risk indices are presented for the COPC with the highest Hazard Quotient or Hazard Index.

Releases to air and groundwater are expected under all Tank Closure alternatives. The long-term impacts on terrestrial ecological resources of releases to air at Hanford were evaluated at the onsite maximum-exposure location (Core Zone Boundary) and on terrestrial, riparian, and aquatic resources at the offsite maximum-exposure location (Columbia River). Impacts on ecological resources of releases to groundwater were evaluated at the Columbia River.

5.1.3.1 Tank Closure Alternative 1: No Action

Predicted emissions of COPCs in air under Tank Closure Alternative 1: No Action are unlikely to pose a hazard to ecological receptors. Under Tank Closure Alternative 1, the largest Hazard Quotient (1.16) for any COPC was calculated for the mouse exposed to xylene deposited onto soil at the onsite maximum-exposure location (see Table 5–80). Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The mouse Hazard Quotient for xylene does not indicate that small omnivorous mammals are likely to be adversely impacted (see Appendix P). The largest Hazard Index (0.0098) for radioactive COPCs released to air under Tank Closure Alternative 1 (see Appendix P, Table P–3) is predicted for the mourning dove at the onsite maximum-exposure location. This indicates no risk from radioactive COPCs released to air under Tank Closure Alternative 1.

Hazard Index – (ecological definition) The sum of the individual Hazard Quotients of constituents within a class that exert effects with the same toxicological mechanism or endpoint and are additive in effect.

Hazard Quotient – The value used as an assessment of non-cancer-associated toxic effects of chemicals, e.g., kidney or liver dysfunction. It is a ratio of the estimated exposure to that level of exposure at which it is expected that adverse health effects would begin to be produced. It is independent of a cancer risk, which is calculated for only those chemicals identified as carcinogens.

Long-term impacts on ecological resources as a result of releases to groundwater from past leaks, residuals, ancillary equipment, and cribs and trenches (ditches) were evaluated at the Columbia River (see Appendix P). The largest risk index (a Hazard Quotient of 43) for groundwater releases under Tank Closure Alternative 1 (see Table 5–81) is that calculated for aquatic biota, including salmonids, exposed to chromium at the Columbia River. The uncertainty about the risk that chromium in groundwater releases poses to aquatic biota under the *TC & WM EIS* alternatives is discussed in Appendix P (see Section P.3.2). The next-largest Hazard Quotient (1.36) for a chemical COPC was calculated for the least weasel exposed to nitrate. Hazard Quotients and Hazard Indices less than or equal to 1 indicate no risk. The largest Hazard Index (0.02) for radioactive COPCs released to groundwater under Tank Closure Alternative 1 (see Appendix P, Table P–12) is predicted for benthic invertebrates. This indicates no risk from radioactive COPCs under Tank Closure Alternative 1.

Table 5–80. Tank Closure Alternatives – Long-Term Impacts of Chemical COPC Releases to Air on Terrestrial Resources at the Onsite Maximum-Exposure Location

Tank Closure Alternative	Hazard Quotient of Worst-Case Chemical COPC by Receptor								
	Plants	Soil-Dwelling Invertebrate	Side-Blotched Lizard	Great Basin Pocket Mouse	Coyote	Mule Deer	Meadow-lark	Mourning Dove	Burrowing Owl
	Mercury	Mercury	Mercury	Xylene	Xylene	Formaldehyde	Mercury	Mercury	Mercury
1	0.00	0.00	0.00	**1.16**	1.48×10^{-1}	1.63×10^{-1}	0.00	0.00	0.00
2A	6.46	9.02×10^{-1}	**1.52×10^{2}**	1.21×10^{2}	1.54×10^{1}	1.29×10^{1}	9.12×10^{1}	7.53	6.35
2B	7.05	9.85×10^{-1}	**1.66×10^{2}**	9.79×10^{1}	1.24×10^{1}	1.24×10^{1}	9.95×10^{1}	8.22	6.92
3A	1.67×10^{1}	2.33	**3.92×10^{2}**	1.02×10^{2}	1.30×10^{1}	1.24×10^{1}	2.35×10^{2}	1.94×10^{1}	1.64×10^{1}
3B	4.80	6.70×10^{-1}	1.13×10^{2}	**1.23×10^{2}**	1.57×10^{1}	1.39×10^{1}	6.77×10^{1}	5.59	4.71
3C	1.67×10^{1}	2.33	**3.92×10^{2}**	1.07×10^{2}	1.35×10^{1}	1.26×10^{1}	2.35×10^{2}	1.94×10^{1}	1.64×10^{1}
4	6.67	9.31×10^{-1}	**1.57×10^{2}**	9.06×10^{1}	1.15×10^{1}	1.35×10^{1}	9.41×10^{1}	7.77	6.54
5	6.34	8.85×10^{-1}	**1.49×10^{2}**	**1.49×10^{2}**	1.90×10^{1}	1.79×10^{1}	8.94×10^{1}	7.38	6.22
6A, Base	6.56	9.16×10^{-1}	1.54×10^{2}	**2.70×10^{2}**	3.43×10^{1}	3.49×10^{1}	9.25×10^{1}	7.64	6.44
6A, Option	6.51	9.09×10^{-1}	1.53×10^{2}	**2.74×10^{2}**	3.48×10^{1}	4.26×10^{1}	9.18×10^{1}	7.58	6.39
6B, Base	7.35	1.03	**1.73×10^{2}**	1.51×10^{2}	1.92×10^{1}	2.32×10^{1}	1.04×10^{2}	8.56	7.21
6B, Option	7.30	1.02	**1.71×10^{2}**	1.56×10^{2}	1.98×10^{1}	3.09×10^{1}	1.03×10^{2}	8.50	7.16
6C	7.30	1.02	**1.71×10^{2}**	9.70×10^{1}	1.23×10^{1}	1.04×10^{1}	1.03×10^{2}	8.50	7.16

Note: The maximum Hazard Quotient under each alternative is indicated by **bold** text.

Key: Base=Base Case; COPC=constituent of potential concern; Option=Option Case.

Table 5–81. Tank Closure Alternatives – Long-Term Impacts of Contaminant Releases to Groundwater on Aquatic and Riparian Receptors at the Columbia River

Tank Closure Alternative	Hazard Quotient or Hazard Index of Worst-Case Chemical or Radioactive COPC by Receptor						
	Benthic Invertebrate	Muskrat	Spotted Sandpiper	Raccoon	Least Weasel	Bald Eagle	Aquatic Biota/Salmonids
	Chromium	Nitrate	Chromium	Chromium	Nitrate	Chromium	Chromium
1	1.69×10^{-1}	1.41×10^{-2}	1.15	1.39×10^{-1}	1.36	3.71×10^{-2}	**4.32×10^{1}**
2A	1.62×10^{-1}	1.38×10^{-2}	1.10	1.33×10^{-1}	1.36	3.66×10^{-2}	**4.31×10^{1}**
2B, 3A, 3B, 3C, 6C	1.67×10^{-1}	1.43×10^{-2}	1.13	1.37×10^{-1}	1.37	3.69×10^{-2}	**4.31×10^{1}**
4	1.67×10^{-1}	1.43×10^{-2}	1.13	1.37×10^{-1}	1.37	3.69×10^{-2}	**4.31×10^{1}**
5	1.67×10^{-1}	1.43×10^{-2}	1.13	1.37×10^{-1}	1.37	3.69×10^{-2}	**4.31×10^{1}**
6A, Base	1.67×10^{-1}	1.43×10^{-2}	1.13	1.37×10^{-1}	1.37	3.69×10^{-2}	**4.31×10^{1}**
6A, Option	1.45×10^{-1}	1.37×10^{-2}	9.84×10^{-1}	1.19×10^{-1}	1.37	3.63×10^{-2}	**4.44×10^{1}**
6B, Base	1.67×10^{-1}	1.43×10^{-2}	1.13	1.37×10^{-1}	1.37	3.69×10^{-2}	**4.31×10^{1}**
6B, Option	1.41×10^{-1}	1.38×10^{-2}	9.59×10^{-1}	1.16×10^{-1}	1.36	3.61×10^{-2}	**4.45×10^{1}**

Note: The maximum Hazard Quotient under each alternative is indicated by **bold** text.

Key: Base=Base Case; COPC=constituent of potential concern; Option=Option Case.

5.1.3.2 Tank Closure Alternative 2A: Existing WTP Vitrification; No Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 2A pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 2A. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for mammals (mouse Hazard Quotient is 121) and mercury for lizards and birds (side-blotched lizard Hazard Quotient is 152) at the onsite maximum-exposure location (see Table 5–80). No risk from radioactive COPCs is predicted under Tank Closure Alternative 2A. The largest Hazard Index (0.0167) for radioactive COPCs released to air under Tank Closure Alternative 2A (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. No risk to terrestrial, riparian, or aquatic ecological receptors from COPC releases to air is predicted under Tank Closure Alternative 2A at the offsite maximum-exposure location (Columbia River).

The largest risk index (a Hazard Quotient of 43) for groundwater releases under Tank Closure Alternative 2A is that calculated for aquatic biota, including salmonids, exposed to chromium at the Columbia River, nearly equal to the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–81). No other Hazard Quotients exceed 1.4. Hazard Quotients and Hazard Indices around 1 indicate minimal or no risk. The largest Hazard Index (0.00095) for radioactive COPCs released to groundwater under Tank Closure Alternative 2A (see Appendix P, Table P–12) is predicted for benthic invertebrates, less than half that under Tank Closure Alternative 1. This indicates no risk from radioactive COPCs released to groundwater under Tank Closure Alternative 2A.

5.1.3.3 Tank Closure Alternative 2B: Expanded WTP Vitrification; Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 2B pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location, only slightly larger than under Tank Closure Alternative 2A (see Table 5–80). Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 2B. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for mammals (mouse Hazard Quotient is 98) and mercury for lizards and birds (side-blotched lizard Hazard Quotient is 166) at the onsite maximum-exposure location. No risk from radioactive COPCs is predicted under Tank Closure Alternative 2B. The largest Hazard Index (0.0091) for radioactive COPCs released to air under Tank Closure Alternative 2B (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. No risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air is predicted under Tank Closure Alternative 2B at the offsite maximum-exposure location (Columbia River).

The largest risk index (a Hazard Quotient of 43) for groundwater releases under Tank Closure Alternative 2B is that calculated for aquatic biota, including salmonids, exposed to chromium at the Columbia River, nearly equal to the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–81). No other Hazard Quotients exceed 1.4. Hazard Quotients and Hazard Indices around 1 indicate minimal or no risk. The largest Hazard Index (0.0006) for radioactive COPCs released to groundwater under Tank Closure Alternative 2B (see Appendix P, Table P–12) is predicted for the least weasel, a factor of three smaller than that under Tank Closure Alternative 1. This indicates no risk from radioactive COPCs released to groundwater under Tank Closure Alternative 2B.

5.1.3.4 Tank Closure Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 3A pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Tank Closure

Alternative 3A (and Tank Closure Alternative 3C) poses the highest risk of all alternatives for plants, soil-dwelling invertebrates, and the side-blotched lizard, meadowlark, mourning dove, and owl at the onsite maximum-exposure location (see Table 5–80). Hazard Quotients calculated for plants are between 1 and 20 for toluene and mercury under Tank Closure Alternative 3A. The chemical COPCs with the largest calculated Hazard Quotients for air releases are mercury for soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 392) and xylene for mammals (Great Basin pocket mouse Hazard Quotient is 102) at the onsite maximum-exposure location. No risk from radioactive COPCs is predicted under Tank Closure Alternative 3A. The largest Hazard Index (0.0137) for radioactive COPCs released to air under Tank Closure Alternative 3A (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. No risk to terrestrial, riparian, or aquatic ecological receptors is predicted from releases to air under Tank Closure Alternative 3A at the offsite maximum-exposure location (Columbia River).

The largest risk index (a Hazard Quotient of 43) for groundwater releases under Tank Closure Alternative 3A is that calculated for aquatic biota, including salmonids, exposed to chromium at the Columbia River, nearly equal to the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–81). No other Hazard Quotients exceed 1.4. Hazard Quotients and Hazard Indices around 1 indicate minimal or no risk. The largest Hazard Index (0.0006) for radioactive COPCs released to groundwater under Tank Closure Alternative 3A (see Appendix P, Table P–12) is predicted for the least weasel, a factor of three smaller than that under Tank Closure Alternative 1. This indicates no risk from radioactive COPCs released to groundwater under Tank Closure Alternative 3A.

5.1.3.5 Tank Closure Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 3B pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location (see Table 5–80). Hazard Quotients calculated for plants are between 1 and 5 for toluene and mercury under Tank Closure Alternative 3B. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for mammals (mouse Hazard Quotient is 123) and mercury for lizards and birds (side-blotched lizard Hazard Quotient is 113) at the onsite maximum-exposure location. No risk from radioactive COPCs is predicted under Tank Closure Alternative 3B. The largest Hazard Index (0.0086) for radioactive COPCs released to air under Tank Closure Alternative 3B (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. No risk to terrestrial, riparian, or aquatic ecological receptors from releases to air is predicted under Tank Closure Alternative 3B at the offsite maximum-exposure location (Columbia River).

The largest risk index (a Hazard Quotient of 43) for groundwater releases under Tank Closure Alternative 3B is that calculated for aquatic biota, including salmonids, exposed to chromium at the Columbia River, nearly equal to the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–81). No other Hazard Quotients exceed 1.4. Hazard Quotients and Hazard Indices around 1 indicate minimal or no risk. The largest Hazard Index (0.0006) for radioactive COPCs released to groundwater under Tank Closure Alternative 3B (see Appendix P, Table P–12) is predicted for the least weasel, a factor of three smaller than that under Tank Closure Alternative 1. This indicates no risk from radioactive COPCs released to groundwater under Tank Closure Alternative 3B.

5.1.3.6 Tank Closure Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 3C pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Tank Closure Alternative 3C risk indices are similar to those under Tank Closure Alternative 3A, posing the highest risk of all alternatives for plants, soil-dwelling invertebrates, and the side-blotched lizard, meadowlark, mourning dove, and owl at the onsite maximum-exposure location (see Table 5–80). Hazard Quotients calculated for plants are between 1 and 20 for toluene and mercury under Tank Closure Alternative 3C. The chemical COPCs with the largest calculated Hazard Quotients for air releases are mercury for soil-dwelling invertebrates, lizards, birds, and the Great Basin pocket mouse (side-blotched lizard Hazard Quotient is 392) and xylene for mammals (mouse Hazard Quotient is 107) at the onsite maximum-exposure location. No risk from radioactive COPCs is predicted under Tank Closure Alternative 3C. The largest Hazard Index (0.0146) for radioactive COPCs released to air under Tank Closure Alternative 3C (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. No risk to terrestrial, riparian, or aquatic ecological receptors from releases to air is predicted under Tank Closure Alternative 3C at the offsite maximum-exposure location (Columbia River).

The largest risk index (a Hazard Quotient of 43) for groundwater releases under Tank Closure Alternative 3C is that calculated for aquatic biota, including salmonids, exposed to chromium at the Columbia River, nearly equal to the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–81). No other Hazard Quotients exceed 1.4. Hazard Quotients and Hazard Indices around 1 indicate minimal or no risk. The largest Hazard Index (0.0006) for radioactive COPCs released to groundwater under Tank Closure Alternative 3C (see Appendix P, Table P–12) is predicted for the least weasel, a factor of three smaller than that under Tank Closure Alternative 1. This indicates no risk from radioactive COPCs released to groundwater under Tank Closure Alternative 3C.

5.1.3.7 Tank Closure Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 4 pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 4. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for mammals (mouse Hazard Quotient is 91) and mercury for lizards and birds (side-blotched lizard Hazard Quotient is 157) at the onsite maximum-exposure location (see Table 5–80). No risk from radioactive COPCs is predicted under Tank Closure Alternative 4. The largest Hazard Index (0.01) for radioactive COPCs released to air under Tank Closure Alternative 4 (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. No risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air is predicted under Tank Closure Alternative 4 at the offsite maximum-exposure location (Columbia River).

The largest risk index (a Hazard Quotient of 43) for groundwater releases under Tank Closure Alternative 4 is that calculated for aquatic biota, including salmonids, exposed to chromium at the Columbia River, nearly equal to the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–81). No other Hazard Quotients exceed 1.4. Hazard Quotients and Hazard Indices around 1 indicate minimal or no risk. The largest Hazard Index (0.0006) for radioactive COPCs released to groundwater under Tank Closure Alternative 4 (see Appendix P, Table P–12) is predicted for the least weasel, a factor of three smaller than that under Tank Closure Alternative 1. This indicates no risk from radioactive COPCs released to groundwater under Tank Closure Alternative 4.

5.1.3.8 Tank Closure Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 5 pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 5. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for mammals (mouse Hazard Quotient is 149) and mercury for lizards and birds (side-blotched lizard Hazard Quotient is 149) at the onsite maximum-exposure location (see Table 5–80). No risk from radioactive COPCs is predicted under Tank Closure Alternative 5. The largest Hazard Index (0.0098) for radioactive COPCs released to air under Tank Closure Alternative 5 (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. No risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air is predicted under Tank Closure Alternative 5 at the offsite maximum-exposure location (Columbia River).

The largest risk index (a Hazard Quotient of 43) for groundwater releases under Tank Closure Alternative 5 is that calculated for aquatic biota, including salmonids, exposed to chromium at the Columbia River, nearly equal to the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–81). No other Hazard Quotients exceed 1.4. Hazard Quotients and Hazard Indices around 1 indicate minimal or no risk. The largest Hazard Index (0.0006) for radioactive COPCs released to groundwater under Tank Closure Alternative 5 (see Appendix P, Table P–12) is predicted for the least weasel, a factor of three smaller than that under Tank Closure Alternative 1. This indicates no risk from radioactive COPCs released to groundwater under Tank Closure Alternative 5.

5.1.3.9 Tank Closure Alternative 6A: All Vitrification/No Separations; Clean Closure

5.1.3.9.1 Base Case

Predicted emissions of COPCs in air under Tank Closure Alternative 6A, Base Case, pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 6A, Base Case. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for mammals (mouse Hazard Quotient is 270) and mercury for lizards and birds (side-blotched lizard Hazard Quotient is 154) at the onsite maximum-exposure location (see Table 5–80). No risk from radioactive COPCs is predicted under Tank Closure Alternative 6A, Base Case. The largest Hazard Index (0.023) for radioactive COPCs released to air under Tank Closure Alternative 6A, Base Case (see Appendix P, Table P–3), is predicted for the mouse at the onsite maximum-exposure location. No risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air is predicted under Tank Closure Alternative 6A, Base Case, at the offsite maximum-exposure location (Columbia River).

The largest risk index (a Hazard Quotient of 43) for groundwater releases under Tank Closure Alternative 6A, Base Case, is that calculated for aquatic biota, including salmonids, exposed to chromium at the Columbia River, nearly equal to the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–81). No other Hazard Quotients exceed 1.4. Hazard Quotients and Hazard Indices around 1 indicate minimal or no risk. The largest Hazard Index (0.0006) for radioactive COPCs released to groundwater under Tank Closure Alternative 6A, Base Case (see Appendix P, Table P–12), is predicted for the least weasel, a factor of three less than that under Tank Closure Alternative 1. This indicates no risk from radioactive COPCs released to groundwater under Tank Closure Alternative 6A, Base Case.

5.1.3.9.2 Option Case

Predicted emissions of COPCs in air under Tank Closure Alternative 6A, Option Case, pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 6A, Option Case. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for mammals (mouse Hazard Quotient is 274) and mercury for soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 153) at the onsite maximum-exposure location (see Table 5–80). No risk from radioactive COPCs is predicted under Tank Closure Alternative 6A, Option Case. The largest Hazard Index (0.024) for radioactive COPCs released to air under Tank Closure Alternative 6A, Option Case (see Appendix P, Table P–3), is predicted for the mouse at the onsite maximum-exposure location. No risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air is predicted under Tank Closure Alternative 6A, Option Case, at the offsite maximum-exposure location (Columbia River).

The largest risk index (a Hazard Quotient of 44) for groundwater releases under Tank Closure Alternative 6A, Option Case, is that calculated for aquatic biota, including salmonids, exposed to chromium at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–81). No other Hazard Quotients exceed 1.4. Hazard Quotients and Hazard Indices around 1 indicate minimal or no risk. The largest Hazard Index (0.0006) for radioactive COPCs released to groundwater under Tank Closure Alternative 6A, Option Case (see Appendix P, Table P–12), is predicted for the least weasel, a factor of three less than the maximum Hazard Index under Tank Closure Alternative 1 (Hazard Index is 0.002). This indicates no risk from radioactive COPCs released to groundwater under Tank Closure Alternative 6A, Option Case.

5.1.3.10 Tank Closure Alternative 6B: All Vitrification with Separations; Clean Closure

5.1.3.10.1 Base Case

Predicted emissions of COPCs in air under Tank Closure Alternative 6B, Base Case, pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 6B, Base Case. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for mammals (mouse Hazard Quotient is 151) and mercury for soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 173) at the onsite maximum-exposure location (see Table 5–80). No risk from radioactive COPCs is predicted under Tank Closure Alternative 6B, Base Case. The largest Hazard Index (0.024) for radioactive COPCs released to air under Tank Closure Alternative 6B, Base Case (see Appendix P, Table P–3), is predicted for the mouse at the onsite maximum-exposure location. No risk to terrestrial, riparian, or aquatic ecological receptors is predicted from releases of COPCs to air under Tank Closure Alternative 6B, Base Case, at the offsite maximum-exposure location (Columbia River).

The largest risk index (a Hazard Quotient of 43) for groundwater releases under Tank Closure Alternative 6B, Base Case, is that calculated for aquatic biota, including salmonids, exposed to chromium at the Columbia River, nearly equal to the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–81). No other Hazard Quotients exceed 1.4. Hazard Quotients and Hazard Indices around 1 indicate minimal or no risk. The largest Hazard Index (0.0006) for radioactive COPCs released to groundwater under Tank Closure Alternative 6B, Base Case (see Appendix P, Table P–12), is predicted for the least weasel, a factor of three less than the maximum Hazard Index under Tank Closure Alternative 1. This indicates no risk from radioactive COPCs released to groundwater under Tank Closure Alternative 6B, Base Case.

5.1.3.10.2 Option Case

Predicted emissions of COPCs in air under Tank Closure Alternative 6B, Option Case, pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 6B, Option Case. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for mammals (mouse Hazard Quotient is 156) and mercury for soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 171) at the onsite maximum-exposure location (see Table 5–80). No risk from radioactive COPCs is predicted under Tank Closure Alternative 6B, Option Case. The largest Hazard Index (0.024) for radioactive COPCs released to air under Tank Closure Alternative 6B, Option Case (see Appendix P, Table P–3), is predicted for the mouse at the onsite maximum-exposure location. No risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air is predicted under Tank Closure Alternative 6B, Option Case, at the offsite maximum-exposure location (Columbia River).

The largest risk index (a Hazard Quotient of 44.5) for groundwater releases under Tank Closure Alternative 6B, Option Case, is that calculated for aquatic biota, including salmonids, exposed to chromium at the Columbia River, only slightly greater than the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–81). No other Hazard Quotients exceed 1.4. Hazard Quotients and Hazard Indices around 1 indicate minimal or no risk. The largest Hazard Index (0.0006) for radioactive COPCs released to groundwater under Tank Closure Alternative 6B, Option Case (see Appendix P, Table P–12), is predicted for the least weasel, a factor of three less than the maximum Hazard Index under Tank Closure Alternative 1 (Hazard Index is 0.002). This indicates no risk from radioactive COPCs released to groundwater under Tank Closure Alternative 6B, Option Case.

5.1.3.11 Tank Closure Alternative 6C: All Vitrification with Separations; Landfill Closure

Predicted emissions of COPCs in air under Tank Closure Alternative 6C pose a small probability of adverse impact on ecological receptors at the onsite maximum-exposure location. Hazard Quotients calculated for plants are between 1 and 10 for toluene and mercury under Tank Closure Alternative 6C. The chemical COPCs with the largest calculated Hazard Quotients for air releases are xylene for mammals (mouse Hazard Quotient is 97) and mercury for soil-dwelling invertebrates, lizards, and birds (side-blotched lizard Hazard Quotient is 171) at the onsite maximum-exposure location (see Table 5–80). No risk from radioactive COPCs is predicted under Tank Closure Alternative 6C. The largest Hazard Index (0.009) for radioactive COPCs released to air under Tank Closure Alternative 6C (see Appendix P, Table P–3) is predicted for the mouse at the onsite maximum-exposure location. No risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air is predicted under Tank Closure Alternative 6C at the offsite maximum-exposure location (Columbia River).

The largest risk index (a Hazard Quotient of 43) for groundwater releases under Tank Closure Alternative 6C is that calculated for aquatic biota, including salmonids, exposed to chromium at the Columbia River, nearly equal to the Hazard Quotient under Tank Closure Alternative 1 (see Table 5–81). No other Hazard Quotients exceed 1.4. Hazard Quotients and Hazard Indices around 1 indicate minimal or no risk. The largest Hazard Index (0.0006) for radioactive COPCs released to groundwater under Tank Closure Alternative 6C (see Appendix P, Table P–12) is predicted for the least weasel, a factor of three smaller than that under Tank Closure Alternative 1. This indicates no risk from radioactive COPCs released to groundwater under Tank Closure Alternative 6C.

5.1.4 Environmental Justice

Sections 5.1.1 and 5.1.2 evaluate groundwater impacts and associated potential long-term human health effects under the Tank Closure 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 minority or 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. (See Appendix Q, Section Q.2.4.1, for assumed consumption levels for the different receptors.) The American Indian hunter-gatherer was assumed to have a subsistence consumption pattern that differs from that of the American Indian resident farmer. The American Indian hunter-gatherer would not cultivate crops, but rather would gather food from indigenous plants and harvest a larger amount of fish from the Columbia River, drink no milk, consume no eggs, and drink a larger amount of water (water that would be gathered from potentially contaminated surface-water sources); thus, this receptor is assumed to be 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.2.2. Due to dependence on surface water, the American Indian hunter-gatherer is only reported at the Columbia River nearshore location.

Long-term human health impacts of tank closure actions would be greatest under Tank Closure Alternative 1. Radionuclide releases under this alternative would result in doses at the A, B, and S Barriers and the Core Zone Boundary that would exceed regulatory limits for the resident farmer and the American Indian resident farmer. None of the hypothetical receptors at the Columbia River nearshore or surface-water locations would be exposed to a dose in excess of regulatory limits, including the American Indian hunter-gatherer. Chemical releases under this alternative would result in exceedance of the Hazard Index for chromium and nitrate at the A, B, S, T, and U Barriers and the Core Zone Boundary for the resident farmer and American Indian resident farmer and an exceedance of the Hazard Index for nitrate at the Columbia River nearshore for the resident farmer and the American Indian resident farmer. The American Indian hunter-gatherer at the Columbia River nearshore would be exposed to a collective Hazard Index in excess of regulatory limits due to acetonitrile, chromium, nitrate, and uranium releases. None of the receptors at the Columbia River surface-water location would experience a Hazard Index in excess of regulatory limits due to chemical releases.

The analysis determined that the greatest impact of any alternative on long-term human health could result in radiation doses in excess of regulatory limits and chemical exposures with a Hazard Index greater than 1 for receptors located on site at the A, B, S, T, or U Barriers; Core Zone Boundary; or Columbia River nearshore. There are no such onsite receptors currently at Hanford. The onsite exposure scenarios do not currently exist and have never existed during Hanford operations. Therefore, the estimated high health risks for past years are hypothetical risks only; no persons were ever exposed at these levels. While it is possible for these receptor scenarios to develop in the future, none are expected for the foreseeable future because the Core Zone is designated for Industrial-Exclusive land use, the Columbia River nearshore is designated for Preservation (Hanford Reach National Monument), and the area between them is designated for Conservation (Mining) (DOE 1999). It is unlikely, therefore, that any of the Tank Closure alternatives would pose a disproportionately high and adverse long-term human health risk to the offsite American Indian population. The greatest risk would be to the American Indian resident farmer at the Core Zone Boundary. During the year of peak dose, this receptor would receive a radiation dose of 2.6×10^2 millirem. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index greater than 1. The adverse impacts would also be applicable to non–American Indian receptors at the same locations, but to a lesser extent, because non–American Indian receptors are not expected to consume as much potentially contaminated food, e.g., fish, meat, milk.

5.2 FFTF DECOMMISSIONING ALTERNATIVES

This section describes the potential long-term environmental and human health impacts associated with implementation of alternatives considered to decommission FFTF and auxiliary facilities at Hanford; to manage waste from the decommissioning process, including waste designated as remote-handled special components (RH-SCs); and to manage the disposition of the Hanford inventory of radioactively contaminated bulk sodium from FFTF, as well as other onsite facilities. Three FFTF Decommissioning alternatives were considered and analyzed: (1) FFTF Decommissioning Alternative 1: No Action, in which only certain deactivation activities at FFTF would be conducted, consistent with previous DOE National Environmental Policy Act actions, and two action alternatives: (2) FFTF Decommissioning Alternative 2: Entombment, and (3) FFTF Decommissioning Alternative 3: Removal. FFTF Decommissioning Alternative 2 would involve removing all above-grade structures within the 400 Area Property Protected Area (PPA), with minimal removal of below-grade structures, equipment, and materials as necessary to comply with regulatory standards. The FFTF reactor vessel and other below-grade equipment would remain. FFTF Decommissioning Alternative 3 would consist of removing all above-grade structures within the 400 Area PPA, with additional removal of contaminated below-grade structures, including the FFTF reactor vessel, equipment, and materials. Associated construction, operations, deactivation, closure, and decommissioning activities are assessed, as applicable, for each alternative.

For each action alternative (i.e., FFTF Decommissioning Alternatives 2 and 3), two options (a Hanford and an Idaho option) were evaluated for disposition of RH-SCs and processing of bulk sodium. For RH-SCs, the Hanford Option would involve treating the waste in a new, onsite treatment facility, followed by disposal of the treated components and residuals along with other Hanford waste in the 200 Areas. Under the Idaho Option, RH-SCs would be shipped to the Remote Treatment Project (RTP) at the Idaho National Laboratory's (INL's) Idaho Nuclear Technology and Engineering Center (INTEC). Following treatment at the RTP, the FFTF components and residuals would be disposed of with other INL waste at an offsite facility or returned to Hanford for disposal. For processing of bulk sodium under the Hanford Reuse Option, the bulk sodium would be stored in its current locations until it is shipped to a new onsite facility for processing. The bulk sodium would be converted to a caustic sodium hydroxide solution, which would then be transferred to the WTP for reuse. Under the Idaho Reuse Option, the bulk sodium would be stored in its current locations until it is shipped to the INL Materials and Fuels Complex (MFC) for processing in the existing Sodium Processing Facility (SPF). Following processing, the caustic would be returned to Hanford for reuse in the WTP. These alternatives and options are described further in Chapter 2, Section 2.5.

5.2.1 Groundwater

The focus of this section is on the impacts of FFTF disposition (sodium processing and remote-handled treatment should not have a groundwater impact); the waste removed from FFTF or resulting from removal will be discussed under the Waste Management alternatives.

5.2.1.1 FFTF Decommissioning Alternative 1: No Action

This section describes the groundwater analysis results for FFTF Decommissioning Alternative 1: No Action, including long-term groundwater impacts of contaminant sources within the FFTF barrier. Impacts of sources removed from within the FFTF barrier and disposed of in an IDF are presented in Section 5.3, which discusses waste management impacts.

5.2.1.1.1 Actions and Timeframes Influencing Groundwater Impacts

Under FFTF Decommissioning Alternative 1, after a period of administrative control, no further actions would be taken to remove radionuclides or chemicals from within the FFTF barrier. Summaries of the proposed actions and timelines for this alternative are provided in Chapter 2, Section 2.5. For the long-term groundwater impacts analysis, two major periods were identified for FFTF Decommissioning Alternative 1, as follows:

- The administrative control period was assumed to start in CY 2008 and end in CY 2107 (100-year duration). It was assumed that during this administrative control period, corrective action or emergency response measures would preclude releases of contaminants from FFTF to the environment.

- The post–administrative control period was assumed to start in CY 2108 and continue through the 10,000-year period of analysis until CY 11,940. During this post–administrative control period, all remaining contaminants at FFTF would be available for release to the environment.

5.2.1.1.2 COPC Drivers

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

- Radiological risk drivers: tritium and technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: total uranium

The COPC drivers for FFTF Decommissioning Alternative 1 were selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the FFTF barrier during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Total uranium becomes a contributor toward the end of the period of analysis. Tritium was added to the list of COPC drivers because of its contribution to risk during the early part of the period of analysis. The radiological risk drivers account for essentially all of the radiological risk associated with FFTF Decommissioning Alternative 1. Even though there is no chemical risk predicted, there is a chemical hazard. Total uranium accounts for essentially all of the chemical hazard risk associated with FFTF Decommissioning Alternative 1.

The COPC drivers that are discussed in detail in this section fall into three categories. Technetium-99 is mobile (i.e., moves with groundwater) and long lived (relative to the 10,000-year period of analysis). It is essentially a conservative tracer. Tritium is also mobile, but short-lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Total uranium is long-lived, or stable, but not as mobile as the other COPC drivers. This constituent moves about seven times more slowly than groundwater.

The other COPCs that were analyzed do not significantly contribute to drinking water risk or hazard at the FFTF barrier during the period of analysis because of low inventories, low release rates, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.2.1.1.3 Analysis of Release and Mass Balance

This section presents the impacts of FFTF Decommissioning 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 (see Figures 5–344 through 5–346). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over eight orders of magnitude within the same series of figures.

Figure 5–344 shows the estimated release to the vadose zone of the radiological risk drivers. The total release to the vadose zone is controlled by the combination of decay at the source and available inventory (i.e., 100 percent of the inventory is either decayed at the source or released during the period of analysis). About 0.4 curies of tritium, about 27 curies of technetium-99, and about 37,000 kilograms of total uranium are released to the vadose zone over the period of analysis.

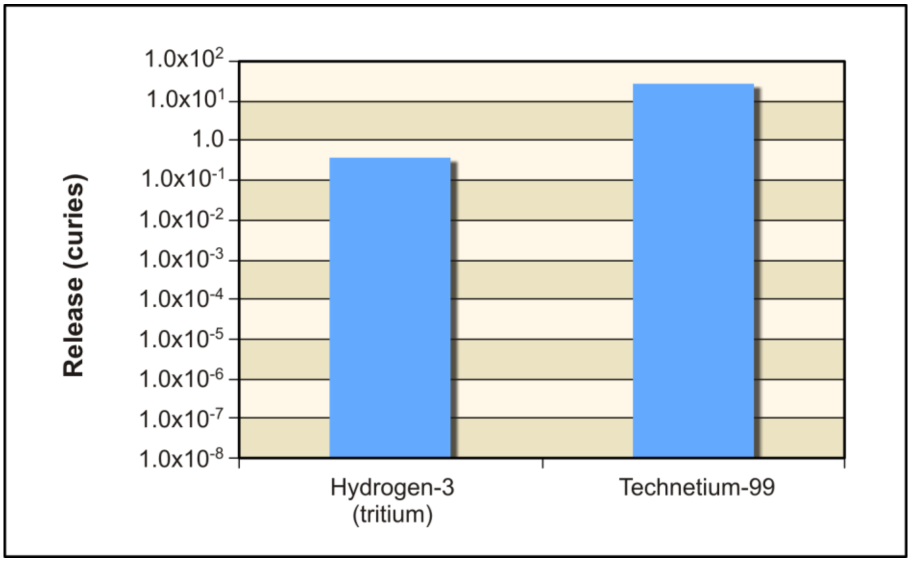


Figure 5–344. FFTF Decommissioning Alternative 1 Releases of Radioactive Constituents of Potential Concern to Vadose Zone from Sources Inside the Fast Flux Test Facility Barrier

Figure 5–345 shows the release to groundwater of the radiological risk drivers. In addition to the inventory considerations, 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, the amount released to groundwater is essentially equal to the amount released to the vadose zone. For tritium, the amount released to groundwater is strongly attenuated by radioactive decay. Less than 1 percent of the tritium released in the analysis into the vadose zone reaches groundwater. For total uranium, the amount released to groundwater is less than that released to the vadose zone because of vadose zone retention. Only about 11 percent of the total uranium released in the analysis into the vadose zone reaches groundwater. This result suggests that total uranium is not a factor until the end of the 10,000-year period of analysis because of the long travel times for this COPC in the vadose zone.

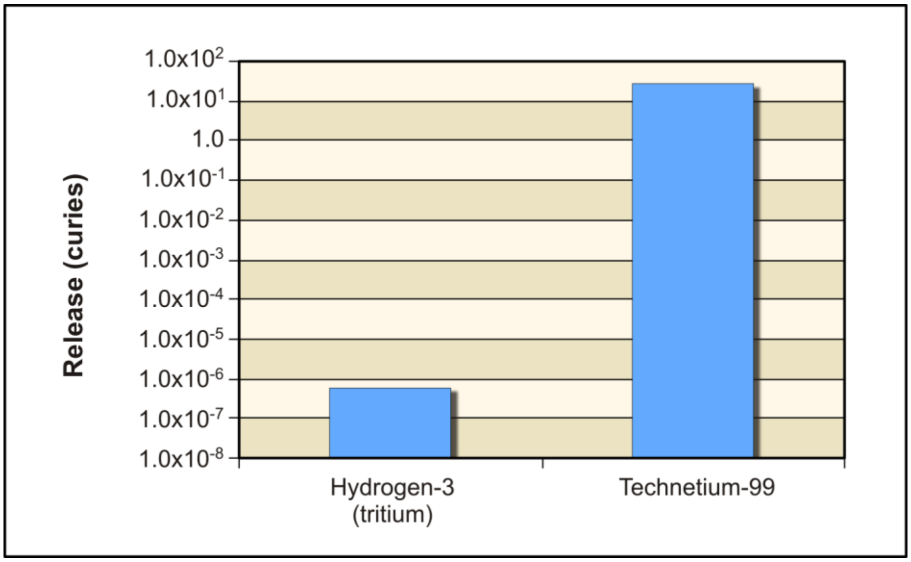


Figure 5–345. FFTF Decommissioning Alternative 1 Releases of Radioactive Constituents of Potential Concern to Groundwater from Sources Inside the Fast Flux Test Facility Barrier

Figure 5–346 shows the release to the Columbia River of the radiological risk drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For technetium-99, the amount released to the Columbia River is essentially equal to the amount released to groundwater. For tritium, the amount released to the Columbia River is strongly attenuated by radioactive decay. Overall, only about 4 percent of the tritium released to groundwater reaches the Columbia River in the analysis. For total uranium, the amount released to the Columbia River is strongly attenuated by retardation; only about 63 percent of the total uranium released to groundwater reaches the Columbia River in the analysis.

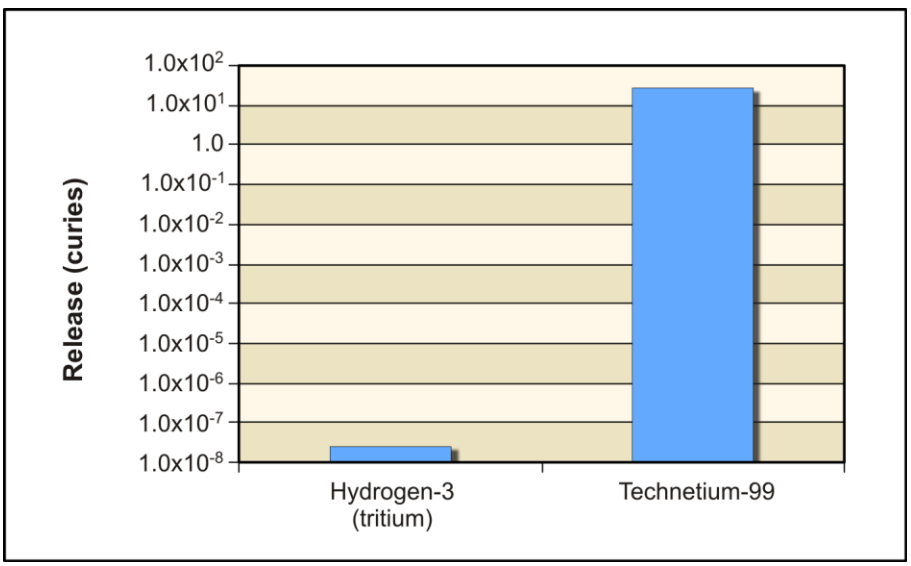


Figure 5–346. FFTF Decommissioning Alternative 1 Releases of Radioactive Constituents of Potential Concern to Columbia River from Sources Inside the Fast Flux Test Facility Barrier

5.2.1.1.4 Analysis of Concentration Versus Time

This section presents the analysis of FFTF Decommissioning Alternative 1 impacts in terms of groundwater concentration versus time at the FFTF barrier and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter (see Table 5–82 and Figures 5–347 and 5–348). The benchmark concentration of each radionuclide is also shown (900 and 20,000 picocuries per liter for technetium-99 and tritium, respectively). Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over two orders of magnitude.

Figure 5–347 shows concentration versus time for technetium-99. The concentration of technetium-99 at the FFTF barrier peaks at about 45 percent of the benchmark around CY 2790. During this time, groundwater concentrations at the Columbia River nearshore peak at about two orders of magnitude below the benchmark concentration. Technetium-99 is essentially not a factor at times later than CY 3890.

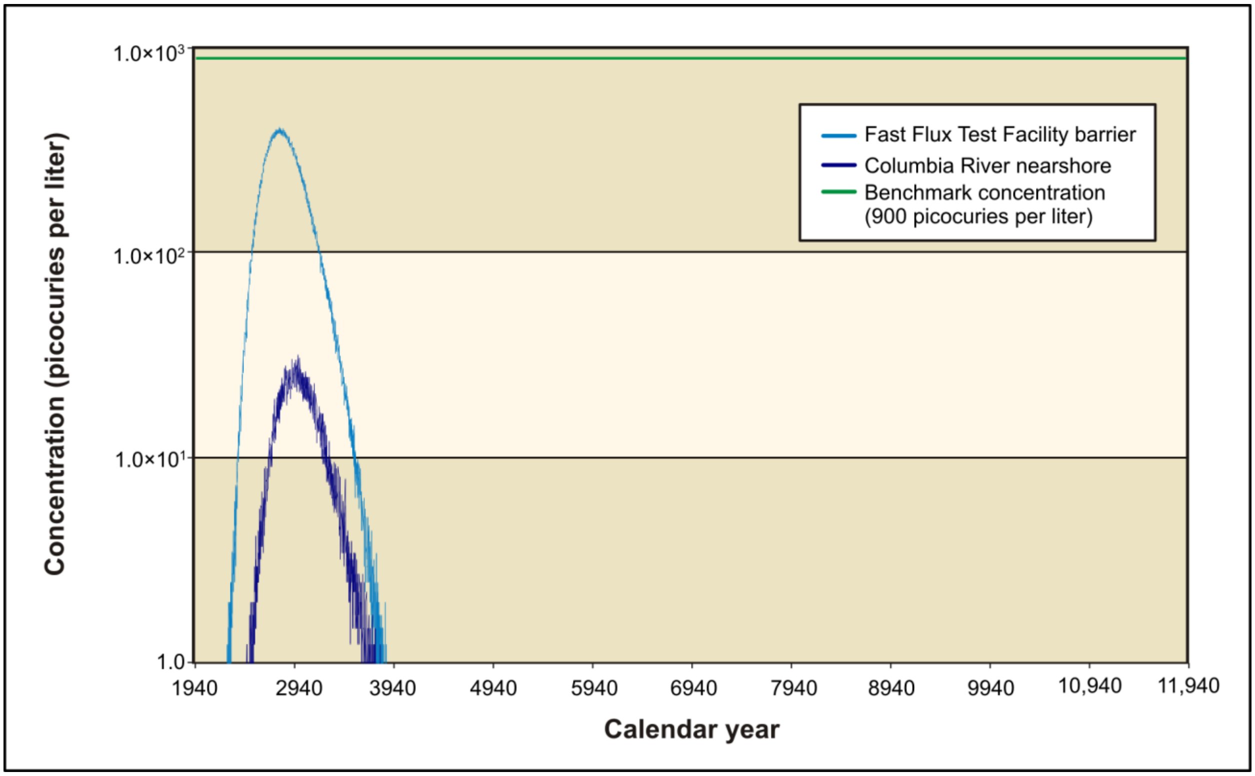


Figure 5–347. FFTF Decommissioning Alternative 1 Technetium-99 Concentration Versus Time

Figure 5–348 shows concentration versus time for tritium. Note that for visual clarity, the time period shown in this figure is from CYs 1940 through 2440 (500 years), rather than the full 10,000-year period of analysis. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor. Releases from FFTF do not cause groundwater concentrations to exceed the benchmark concentration throughout the period of analysis. The concentrations at the FFTF barrier peak at about 8 orders of magnitude below the benchmark concentration. During this time, groundwater concentrations at the Columbia River nearshore peak at about 11 orders of magnitude below the benchmark concentration.

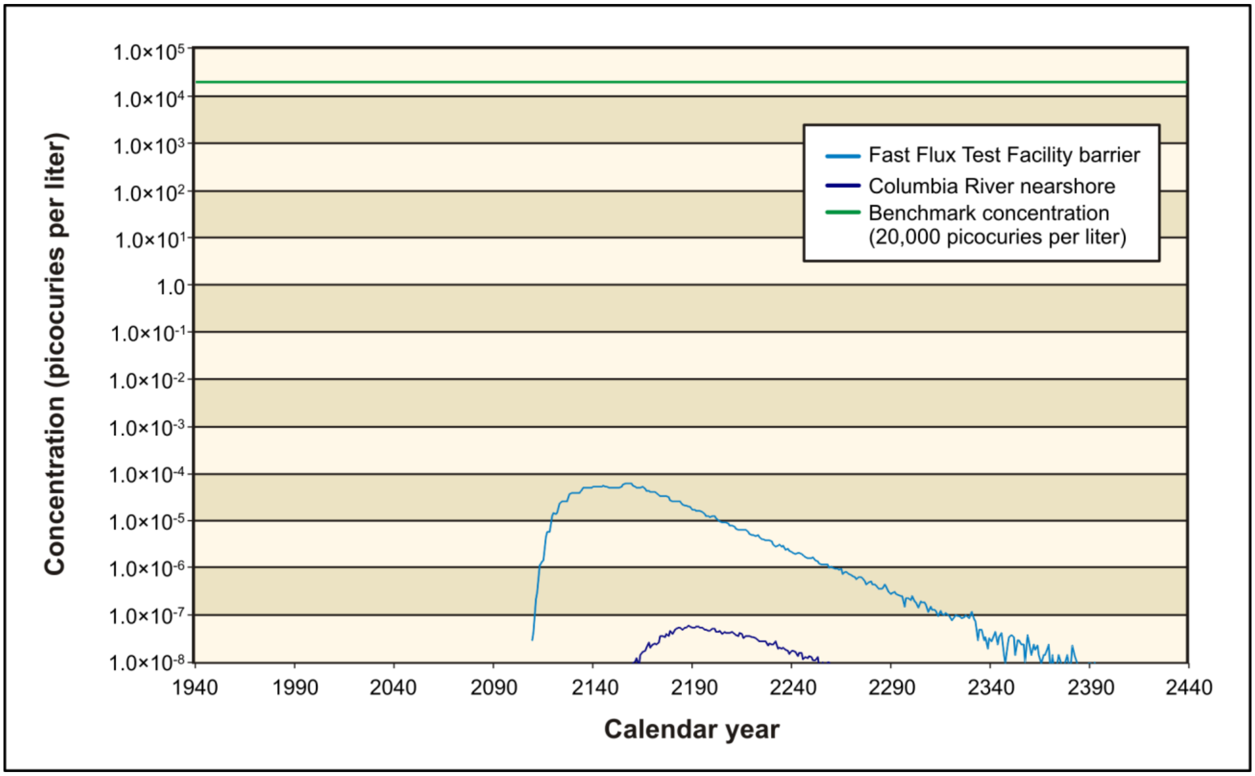


Figure 5–348. FFTF Decommissioning Alternative 1 Hydrogen-3 (Tritium) Concentration Versus Time

For total uranium, releases do not occur until well into the post–administrative control period, around CY 5000. The concentration of total uranium at the FFTF barrier peaks at about 66 percent of the benchmark concentration near the end of the analysis period, around CY 11,840. Groundwater concentrations at the Columbia River nearshore peak at about two orders of magnitude below the benchmark concentration at this time.

Table 5–82 lists the estimated maximum concentrations of technetium-99 and total uranium in the peak year at the FFTF barrier and Columbia River nearshore. The COPC concentrations never exceed the respective benchmark concentrations at the FFTF barrier or Columbia River nearshore during the 10,000-year analysis period.

Table 5–82. FFTF Decommissioning Alternative 1 Maximum COPC Concentrations in the Peak Year at the FFTF Barrier and Columbia River Nearshore

Contaminant	FFTF Barrier	Columbia River Nearshore	Benchmark Concentration
Radionuclide (picocuries per liter)			
Technetium-99	411 (2790)	32 (2978)	900
Chemical (micrograms per liter)			
Total uranium	20 (11,842)	1 (11,788)	30

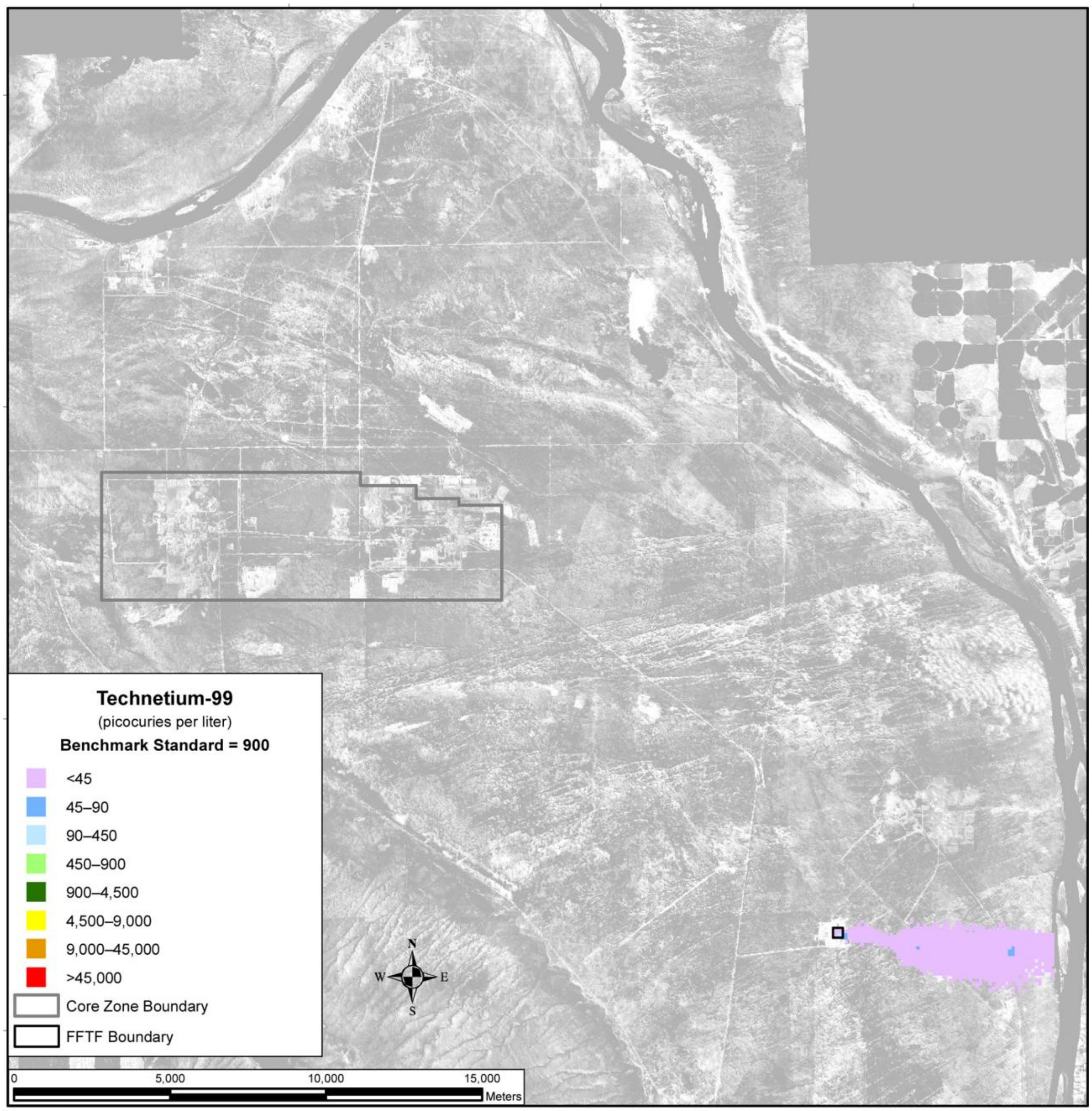
Note: Corresponding calendar years shown in parentheses.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

5.2.1.1.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of FFTF Decommissioning Alternative 1 in terms of the spatial distribution of COPC driver concentrations in groundwater at selected times. Concentrations of radionuclides are in picocuries per liter (see Figures 5–349 and 5–350). Concentrations of each radionuclide are indicated by a color scale that is relative to the benchmark concentration (900 and 20,000 picocuries per liter for technetium-99 and tritium, respectively). 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.

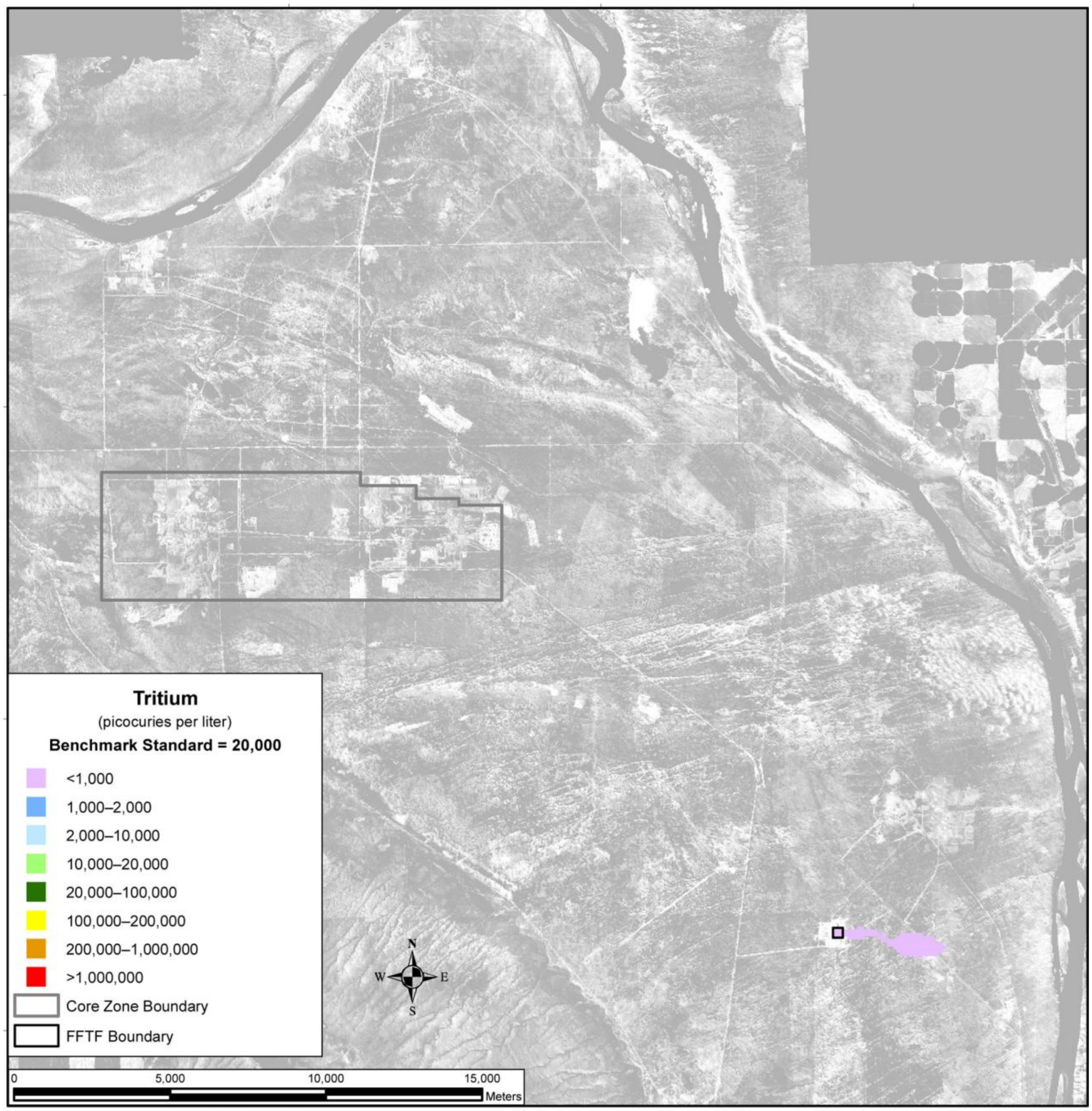
Figure 5–349 shows the spatial distribution of technetium-99 concentrations in groundwater in CY 2590, roughly the time of greatest development of the groundwater plume. For ease of presentation, the FFTF barrier is represented by a polygon surrounding FFTF. Releases from FFTF result in a groundwater concentration plume that extends east from the facility to the Columbia River nearshore. Peak concentrations in this plume are less than one-hundredth of the benchmark in CY 2590.



Note: To convert meters to feet, multiply by 3.281.

Figure 5–349. FFTF Decommissioning Alternative 1 Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 2590

Figure 5–350 shows the spatial distribution of tritium concentrations in groundwater in CY 2135, roughly the time of greatest development of the groundwater plume. For ease of presentation, the FFTF barrier is represented by a polygon surrounding FFTF. Analysis releases from FFTF result in a groundwater concentration plume that extends from the facility east to the Columbia River nearshore. Peak concentrations in this plume are less than one-twentieth of the benchmark concentration in CY 2135.



Note: To convert meters to feet, multiply by 3.281.

Figure 5–350. FFTF Decommissioning Alternative 1 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration, Calendar Year 2135

5.2.1.1.6 Summary of Impacts

Under FFTF Decommissioning Alternative 1, none of the COPCs exceed the benchmark concentrations at the FFTF barrier or the Columbia River nearshore during the 10,000-year period of analysis. Tritium concentrations are strongly attenuated by radioactive decay and are essentially negligible, peaking at about eight orders of magnitude below the benchmark standard at the FFTF barrier. Technetium-99 impacts are greatest around CY 2600 to 2800, when the associated groundwater plume is most developed and peak concentrations reach about 400 picocuries per liter at the FFTF barrier, about 45 percent of the benchmark. Total uranium is not a factor until near the end of the analysis, around CY 11,800, when peak concentrations reach about 20 micrograms per liter at the FFTF barrier, about 66 percent of the benchmark concentration.

5.2.1.2 FFTF Decommissioning Alternative 2: Entombment

This section describes the groundwater analysis results for FFTF Decommissioning Alternative 2: Entombment, including long-term groundwater impacts of contaminant sources within the FFTF barrier. Impacts of sources removed from within the FFTF barrier and disposed of in an IDF are presented in Section 5.3, which discusses waste management impacts.

5.2.1.2.1 Actions and Timeframes Influencing Groundwater Impacts

Under FFTF Decommissioning Alternative 2, all above-grade structures and minimal below-grade structures, equipment, and materials would be removed. An RCRA-compliant barrier would be constructed over the Reactor Containment Building and any other remaining below-grade structures (including the reactor vessel). Summaries of the proposed actions and timelines for this alternative are provided in Chapter 2, Section 2.5. For the long-term groundwater impacts analysis, two major periods were identified for FFTF Decommissioning Alternative 2, as follows:

- The entombment period was assumed to start in CY 2013, when decommissioning activities would begin, and end in CY 2121, following the completion of decommissioning and entombment activities and a 100-year postclosure period. It was assumed that there would be no releases from FFTF during this entombment period.

- The post-entombment period was assumed to start in CY 2122 and continue through the 10,000-year period of analysis until CY 11,940. During this post-entombment period, all remaining constituents at FFTF would be available for release to the environment, over time, as the barrier degrades and any remaining COPCs are released from the underground, grouted components.

5.2.1.2.2 COPC Drivers

A total of 40 COPCs were analyzed for FFTF Decommissioning Alternative 2. Complete results for all 40 COPCs are provided in Appendices M, N, and O, but this discussion of long-term impacts associated with FFTF Decommissioning Alternative 2 is focused on the following COPC drivers:

- Radiological risk drivers: technetium-99
- Chemical risk drivers: none
- Chemical hazard drivers: none

The COPC driver for FFTF Decommissioning Alternative 2 was selected by evaluating the risk or hazard associated with all 40 COPCs during the year of peak risk or hazard at the FFTF barrier during the 10,000-year period of analysis and selecting the major contributor. This process is described in Appendix Q. The radiological risk driver accounts for essentially all of the radiological risk. No chemical risk is predicted. The peak chemical hazard to a drinking-water well user at the FFTF barrier is essentially negligible.

The COPC driver that is discussed in detail in this section is technetium-99. Technetium-99 is mobile (i.e., moves with groundwater) and long-lived (relative to the 10,000-year period of analysis). It is essentially a conservative tracer. The other COPCs that were analyzed do not significantly contribute to drinking water risk or hazard at the FFTF barrier during the period of analysis because of low inventories, low release rates, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.2.1.2.3 Analysis of Release and Mass Balance

This section presents the impacts of FFTF Decommissioning Alternative 2 in terms of the total amount of radioactive 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 (see Figures 5–351 through 5–353). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over seven orders of magnitude.

Figure 5–351 shows the estimated release of technetium-99 to the vadose zone, about 27 curies. This is the same inventory estimate for FFTF Decommissioning Alternative 1 because the source of the technetium-99 is not removed under this alternative. Figure 5–352 shows the technetium-99 release to groundwater, which is essentially the same as that released to the vadose zone. This is due to technetium-99's lack of retardation and long half-life. Figure 5–353 shows the technetium-99 release to the Columbia River, which also is about 27 curies.

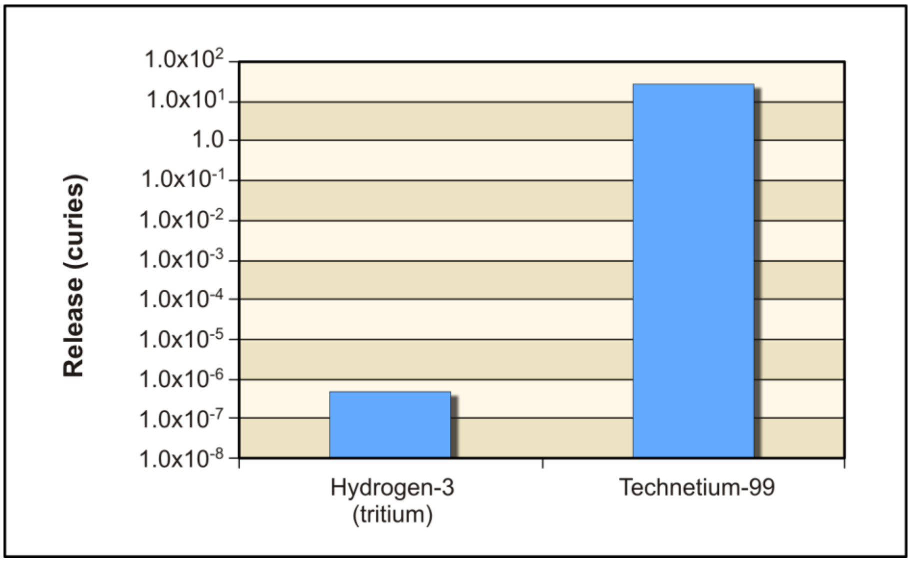


Figure 5–351. FFTF Decommissioning Alternative 2 Releases of Radioactive Constituents of Potential Concern to Vadose Zone from Sources Inside the Fast Flux Test Facility Barrier

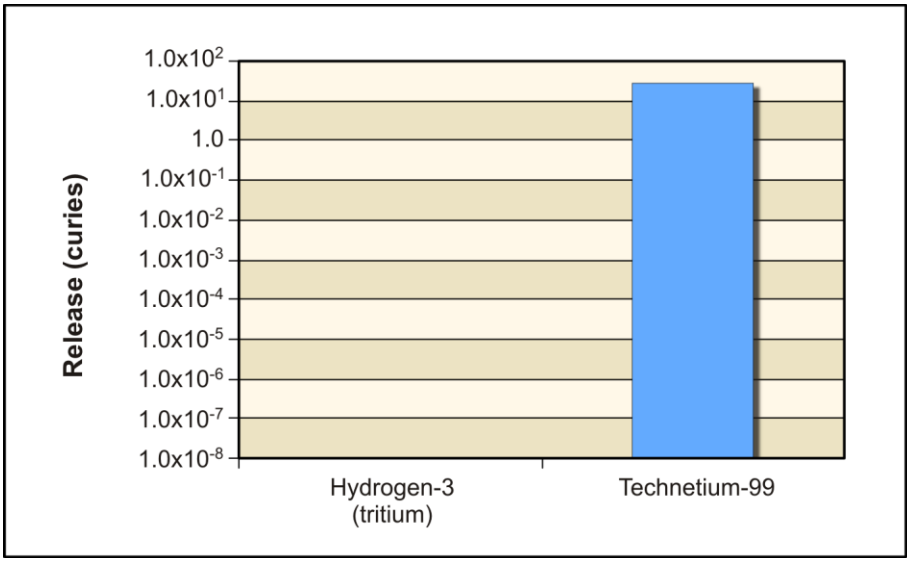


Figure 5–352. FFTF Decommissioning Alternative 2 Releases of Radioactive Constituents of Potential Concern to Groundwater from Sources Inside the Fast Flux Test Facility Barrier

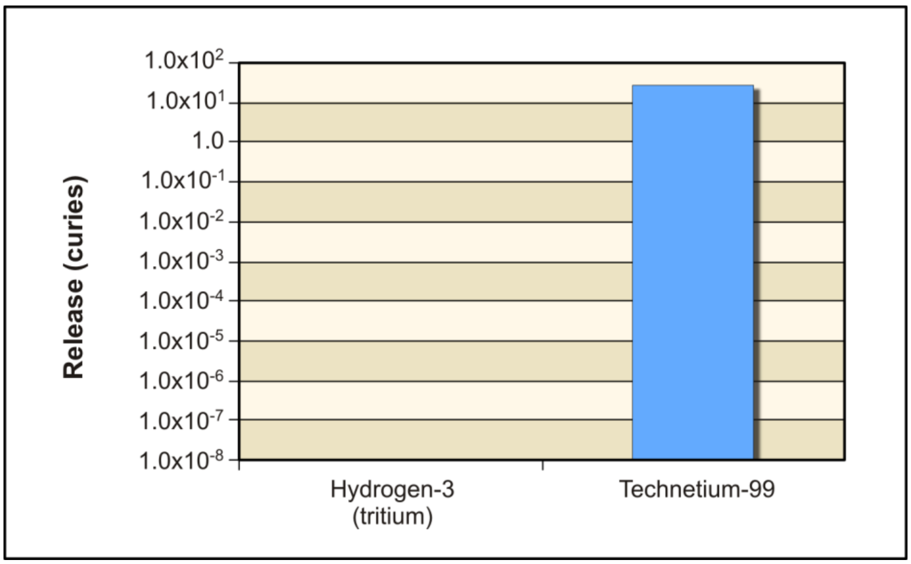


Figure 5–353. FFTF Decommissioning Alternative 2 Releases of Radioactive Constituents of Potential Concern to Columbia River from Sources Inside the Fast Flux Test Facility Barrier

5.2.1.2.4 Analysis of Concentration Versus Time

This section presents the analysis of FFTF Decommissioning Alternative 2 impacts in terms of groundwater concentration versus time at the FFTF barrier and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter (see Figure 5–354). The benchmark concentration of technetium-99 is also shown (900 picocuries per liter). Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over an order of magnitude.

Figure 5–354 shows concentration versus time for technetium-99. The concentration of technetium-99 at the FFTF barrier peaks at about 45 percent of the benchmark around CY 3100. During this time, groundwater concentrations at the Columbia River nearshore peak at about two orders of magnitude below the benchmark concentration. Technetium-99 is essentially not a factor at times later than CY 4200.

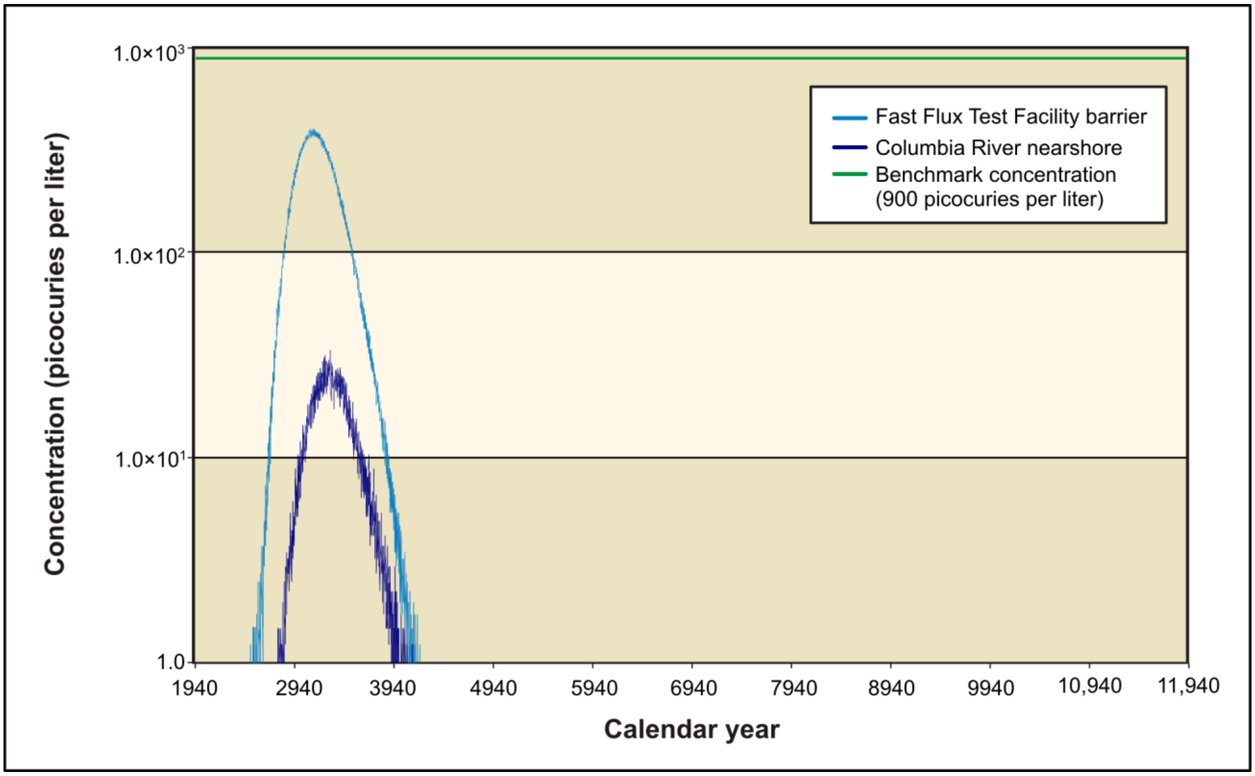


Figure 5–354. FFTF Decommissioning Alternative 2 Technetium-99 Concentration Versus Time

Table 5–83 lists the estimated maximum concentrations of technetium-99 in the peak year at the FFTF barrier and Columbia River nearshore. Technetium-99 concentrations never exceed the benchmark concentration at the FFTF barrier or the Columbia River nearshore during the 10,000-year analysis period.

Table 5–83. FFTF Decommissioning Alternative 2 Maximum COPC Concentrations in the Peak Year at the FFTF Barrier and Columbia River Nearshore

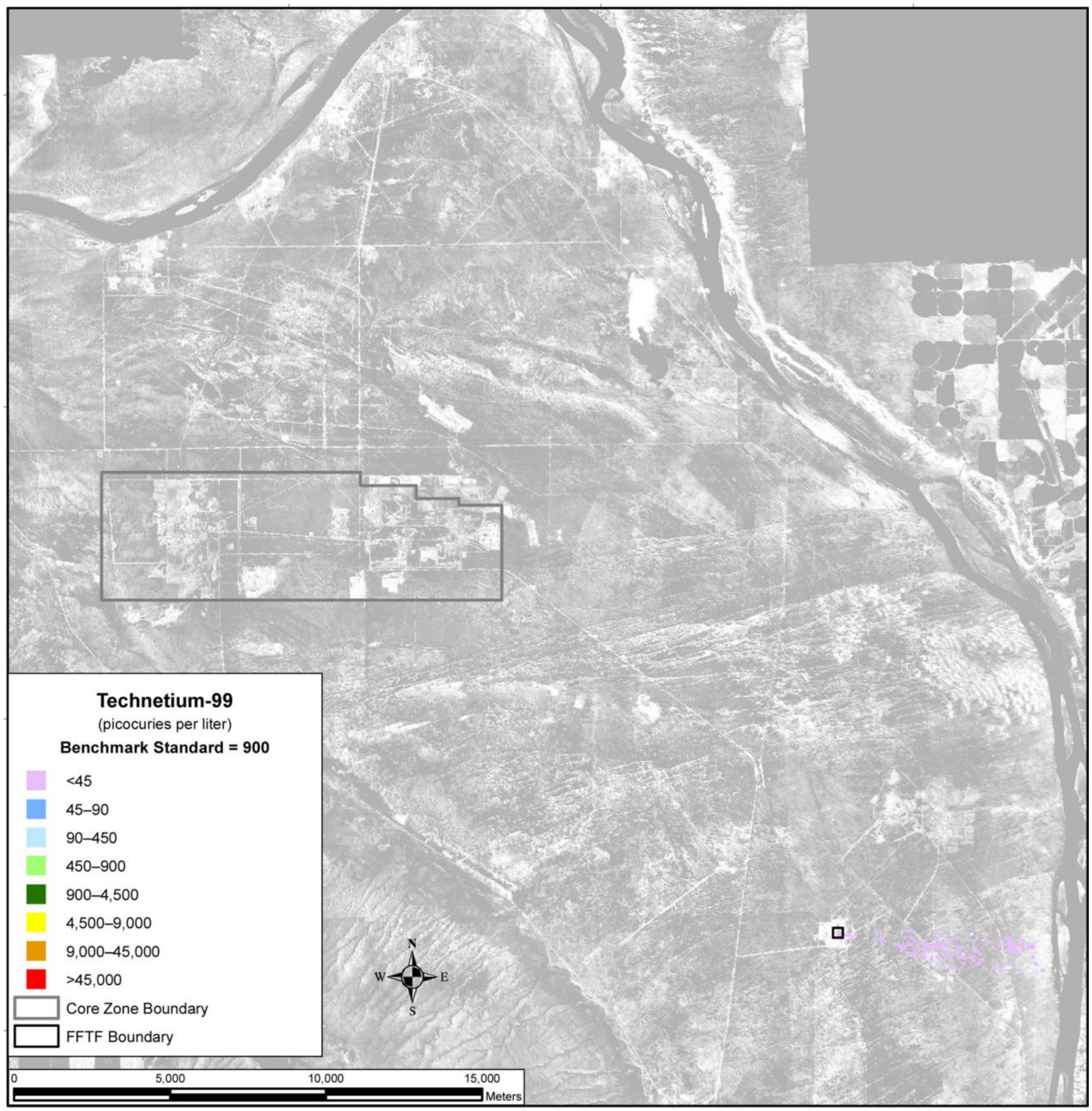
Contaminant	FFTF Barrier	Columbia River Nearshore	Benchmark Concentration
Radionuclide (picocuries per liter)			
Technetium-99	401 (3137)	34 (3307)	900

Note: Corresponding calendar years shown in parentheses.
Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

5.2.1.2.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of FFTF Decommissioning Alternative 2 in terms of the spatial distribution of the COPC driver concentrations in groundwater at selected times. Concentrations are in picocuries per liter (see Figure 5–355). Concentrations of technetium-99 are indicated by a color scale that is relative to the benchmark concentration (900 picocuries per liter). 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.

Figure 5–355 shows the spatial distribution of the technetium-99 plume in CY 2590, before the time of greatest development of the groundwater plume. Analysis releases from FFTF result in a groundwater concentration plume that extends east from the facility to the Columbia River nearshore. Peak concentrations in this plume are less than one-twentieth of the benchmark in CY 2590.



Note: To convert meters to feet, multiply by 3.281.

Figure 5–355. FFTF Decommissioning Alternative 2 Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 2590

5.2.1.2.6 Summary of Impacts

Under FFTF Decommissioning Alternative 2, the impacts of technetium-99 on groundwater are similar to those under FFTF Decommissioning Alternative 1. Technetium-99 concentrations do not exceed benchmark standards at the FFTF barrier or the Columbia River nearshore during the 10,000-year period of analysis. The impacts are greatest around CY 3200.

5.2.1.3 FFTF Decommissioning Alternative 3: Removal

This section describes the groundwater analysis results for FFTF Decommissioning Alternative 3: Removal, including long-term groundwater impacts of contaminant sources within the FFTF barrier. Impacts of sources removed from within the FFTF barrier and disposed of in an IDF are presented in Section 5.3, which discusses waste management impacts.

5.2.1.3.1 Actions and Timeframes Influencing Groundwater Impacts

Under FFTF Decommissioning Alternative 3, all above-grade structures within the 400 Area PPA would be removed; additionally, contaminated below-grade structures, equipment, and materials would be removed. Summaries of the proposed actions and timelines for this alternative are provided in Chapter 2, Section 2.5. For the long-term groundwater impacts analysis, two major periods were identified for FFTF Decommissioning Alternative 3, as follows:

- The removal period was assumed to start in CY 2013, when decommissioning activities would begin, and end in CY 2121, following the completion of decommissioning and removal activities and a 100-year postclosure period. It was assumed that there would be no releases from FFTF during this removal period.

- The post-removal period was assumed to start in CY 2122 and continue through the 10,000-year period of analysis until CY 11,940. During this post-removal period, all remaining constituents at FFTF would be available for release to the environment.

5.2.1.3.2 COPC Drivers

A total of 40 COPCs were analyzed for FFTF Decommissioning Alternative 3. These COPCs would become available for release to the environment at the end of the post-removal period in 2121. The total amount of each COPC released to the aquifer would be limited first by the inventory remaining after removal. The removal activities would limit the residual inventories to a much greater extent under FFTF Decommissioning Alternative 3 than under FFTF Decommissioning Alternatives 1 and 2. The maximum residual inventory calculated under FFTF Decommissioning Alternative 3 is for carbon-14, which is approximately 8×10^{-4} curies. The second factor that would limit release to the aquifer is attenuation by retardation and/or radioactive decay. Accounting for both factors, the calculated maximum total release to the aquifer of all COPCs is for technetium-99, which is 4×10^{-6} curies. For all COPCs, the calculated peak rate of release to the aquifer is less than 10^{-8} curies per year, the threshold for evaluating long-term groundwater impacts (see Appendix O). Thus, the analysis predicts no long-term groundwater impacts associated with FFTF Decommissioning Alternative 3 above *de minimis* values.

5.2.2 Human Health Impacts

Potential human health impacts due to release of radionuclides are estimated as dose and as lifetime risk of incidence of cancer (i.e., radiological risk). For long-term performance assessment, radiological dose and risk are estimated consistent with the recommendations of *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, Federal Guidance Report No. 13 (Eckerman et al. 1999), including use of radionuclide-specific dose factors and risk coefficients. Potential human health effects due to release of chemical constituents include both carcinogenic effects and other forms of toxicity. Impacts of carcinogenic chemicals are estimated as lifetime risk of incidence of cancer. Noncarcinogenic effects are estimated as a Hazard Quotient, the ratio of the long-term intake of a single chemical to intake that produces no observable effect, and as a Hazard Index, the sum of the Hazard Quotients of a group of chemicals. Further information on the nature of human health effects in response to exposure to radioactive and chemical constituents is provided in Appendix K, Section K.1. Screening analysis identified 14 radioactive and 26 chemical constituents as contributing the greatest risk of adverse impacts. Appendix Q provides more information on the screening analysis and on results of detailed analysis, including time of occurrence of peak impacts and constituent- and location-specific impacts under each Tank Closure, FFTF Decommissioning, and Waste Management alternative.

The four measures of human health impacts considered in this analysis—lifetime risks of developing cancer from radioactive and chemical constituents, dose from radioactive constituents, and Hazard Index from chemical constituents—were calculated for each year for 10,000 years for each receptor at three specific locations (i.e., the FFTF barrier, Columbia River nearshore, and Columbia River surface water). This is a large amount of information that must be summarized to allow interpretation of results. The method chosen is to present dose for the year of maximum dose, risk for the year of maximum risk, and Hazard Index for the year of maximum Hazard Index. This choice is based on regulation of radiological impacts expressed as dose and the observation that peak risk and peak noncarcinogenic impacts expressed as Hazard Index may occur at times other than that of peak dose. Also, to summarize time dependence of impacts, time series of lifetime risk are presented only for locations of likely maximum impact, that is, near field barriers and the Core Zone Boundary.

Impacts on human health over the long period following decommissioning of FFTF would be due primarily to the materials left in place following no action, entombment, or removal. Onsite analysis locations comprise the FFTF boundary and the Columbia River nearshore. Offsite analysis locations comprise access points to Columbia River surface water near the site and population centers downstream of the site. Estimates of constituent concentrations in Columbia River surface water are used to calculate the impacts for both offsite location points of analysis. The total population of downstream water users was assumed to be 5 million people for the entire 10,000-year period of analysis (DOE 1987). Four types of receptors are considered. The first type, a drinking-water well user, uses groundwater as a source of drinking water. The second type, a resident farmer, uses either groundwater or surface water for drinking water consumption and irrigation of crops. Garden size and crop yield are adequate to produce approximately 25 percent of average requirements for crops and animal products. The third type, an American Indian resident farmer, also uses either groundwater or surface water for drinking water consumption and irrigation of crops. Garden size and crop yield are adequate to produce the entirety of average requirements of crops and animal products. The fourth type, an American Indian hunter-gatherer, is impacted by both groundwater and surface water because he uses surface water for drinking water consumption and consumes both wild plant materials, which use groundwater, and game, which use surface water. Members of the offsite population are assumed to have the activity pattern of a residential farmer, using surface water to meet the total annual drinking water requirement and to irrigate a garden that provides approximately 25 percent of annual crop and animal product requirements. These receptors are also assumed to consume fish harvested from the river. Impacts on an individual of the offsite population are the same as those reported in tables in this chapter for the resident farmer at the Columbia River surface-water location.

The significance of dose impacts is evaluated by comparison against the 100-millirem-per-year all-exposure-modes standard specified for protection of the public and the environment in DOE Order 458.1, *Radiation Protection of the Public and the Environment*. The level of protection provided for the drinking water pathway is evaluated by comparison with the applicable drinking water standards presented in Section 5.2.1. Population doses are compared against total effective dose equivalent from natural background sources of 311 millirem per year for a member of the population of the United States

(NCRP 2009). The significance of noncarcinogenic chemical impacts is evaluated by comparison against a guideline value of unity for Hazard Index. Estimation of Hazard Index less than unity (1) indicates that observable effects would not occur.

5.2.2.1 FFTF Decommissioning Alternative 1: No Action

This section contains the results for FFTF Decommissioning Alternative 1: No Action. The section includes analysis of long-term human health impacts from sources within the FFTF barrier. Impacts from sources removed from the FFTF barrier and disposed of in an IDF are discussed in Section 5.3, which deals with waste management issues.

Under FFTF Decommissioning Alternative 1, only those actions consistent with previous DOE actions under the National Environmental Policy Act would be completed. Final decommissioning of FFTF would not occur. For analysis purposes, the remaining waste would be available for release to the environment after an institutional control period of 100 years.

Potential human health impacts of this alternative are detailed in Appendix Q and summarized in Tables 5–84 and 5–85. The key radioactive constituent contributor to human health risk would be technetium-99. The chemical risk and hazard drivers were essentially negligible. Neither the dose standards nor the Hazard Index guideline would be exceeded at any location. Population dose is estimated as 1.15×10^{-2} person-rem per year for the year of peak dose. This corresponds to 7.43×10^{-7} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the FFTF barrier is presented in Figure 5–356.

Table 5–84. FFTF Decommissioning Alternative 1 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

Location	Receptor									
	Drinking-Water Well User					Resident Farmer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
Fast Flux Test Facility barrier	7.19×10^{-1}	1.91×10^{-1}	2.47×10^{-5}	0.00	2.47×10^{-5}	1.85	1.95×10^{-1}	8.14×10^{-5}	3.87×10^{-16}	8.14×10^{-5}
Columbia River nearshore	5.57×10^{-2}	7.99×10^{-3}	1.91×10^{-6}	0.00	1.91×10^{-6}	1.43×10^{-1}	8.14×10^{-3}	6.30×10^{-6}	0.00	6.30×10^{-6}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	2.31×10^{-6}	2.09×10^{-7}	1.01×10^{-10}	0.00	1.01×10^{-10}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–85. FFTF Decommissioning Alternative 1 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

Location	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
Fast Flux Test Facility barrier	3.79	2.03×10^{-1}	1.78×10^{-4}	1.77×10^{-11}	1.78×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	2.93×10^{-1}	8.50×10^{-3}	1.38×10^{-5}	0.00	1.38×10^{-5}	9.58×10^{-4}	3.72×10^{-4}	5.12×10^{-8}	0.00	5.12×10^{-8}
Off Site										
Columbia River	5.33×10^{-6}	2.90×10^{-7}	2.53×10^{-10}	0.00	2.53×10^{-10}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

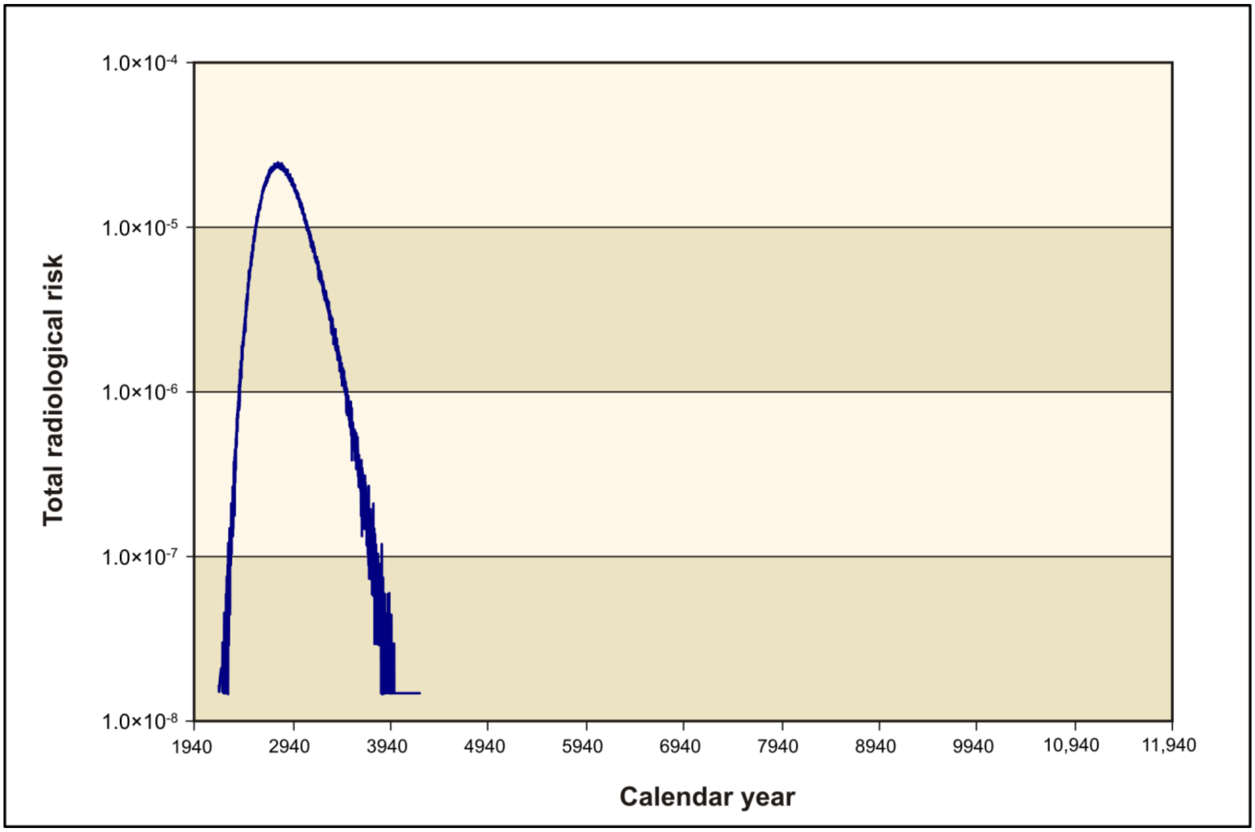


Figure 5–356. FFTF Decommissioning Alternative 1 Time Series of Radiological Risk for the Drinking-Water Well User at the Fast Flux Test Facility Barrier

5.2.2.2 FFTF Decommissioning Alternative 2: Entombment

Under FFTF Decommissioning Alternative 2: Entombment, all aboveground structures and minimal below-grade structures, equipment, and materials would be removed. An RCRA-compliant barrier would be constructed over the Reactor Containment Building and any other remaining below-grade structures, including the reactor vessel. Impacts from sources removed from the FFTF barrier and disposed of in an IDF are discussed in Section 5.3, which discusses waste management issues.

Potential human health impacts of this alternative are summarized in Tables 5–86 and 5–87 and are detailed in Appendix Q. The key radioactive constituent contributor to human health risk would be technetium-99. The chemical risk and hazard drivers would be essentially negligible. Neither dose standards nor the Hazard Index guideline would be exceeded at any location. Population dose is estimated as 1.15×10^{-2} person-rem per year for the year of peak dose. This corresponds to 7.40×10^{-7} percent of the annual population dose due to background exposure. The time series of radiological risk for the drinking-water well user at the FFTF barrier is presented in Figure 5–357.

Table 5–86. FFTF Decommissioning Alternative 2 Drinking-Water Well User and Resident Farmer Long-Term Human Health Impact Summary

	Receptor									
	Drinking-Water Well User					Resident Farmer				
Location	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
Fast Flux Test Facility barrier	7.02×10^{-1}	0.00	2.42×10^{-5}	0.00	2.42×10^{-5}	1.81	0.00	7.94×10^{-5}	0.00	7.94×10^{-5}
Columbia River nearshore	5.86×10^{-2}	0.00	2.02×10^{-6}	0.00	2.02×10^{-6}	1.51×10^{-1}	0.00	6.63×10^{-6}	0.00	6.63×10^{-6}
Off Site										
Columbia River	N/A	N/A	N/A	N/A	N/A	2.30×10^{-6}	0.00	1.01×10^{-10}	0.00	1.01×10^{-10}

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

Table 5–87. FFTF Decommissioning Alternative 2 American Indian Resident Farmer and American Indian Hunter-Gatherer Long-Term Human Health Impact Summary

	Receptor									
	American Indian Resident Farmer					American Indian Hunter-Gatherer				
Location	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk	Dose at Year of Peak Dose (mrem/yr)	Hazard Index at Year of Peak Hazard Index	Rad. Risk at Year of Peak Rad. Risk	Nonrad. Risk at Year of Peak Nonrad. Risk	Total Risk at Year of Peak Total Risk
On Site										
Fast Flux Test Facility barrier	3.70	0.00	1.74×10^{-4}	0.00	1.74×10^{-4}	N/A	N/A	N/A	N/A	N/A
Columbia River nearshore	3.09×10^{-1}	0.00	1.45×10^{-5}	0.00	1.45×10^{-5}	1.01×10^{-3}	0.00	5.39×10^{-8}	0.00	5.39×10^{-8}
Off Site										
Columbia River	5.30×10^{-6}	0.00	2.52×10^{-10}	0.00	2.52×10^{-10}	N/A	N/A	N/A	N/A	N/A

Key: mrem=millirem; N/A=not applicable; Nonrad.=nonradiological; Rad.=radiological; yr=year.

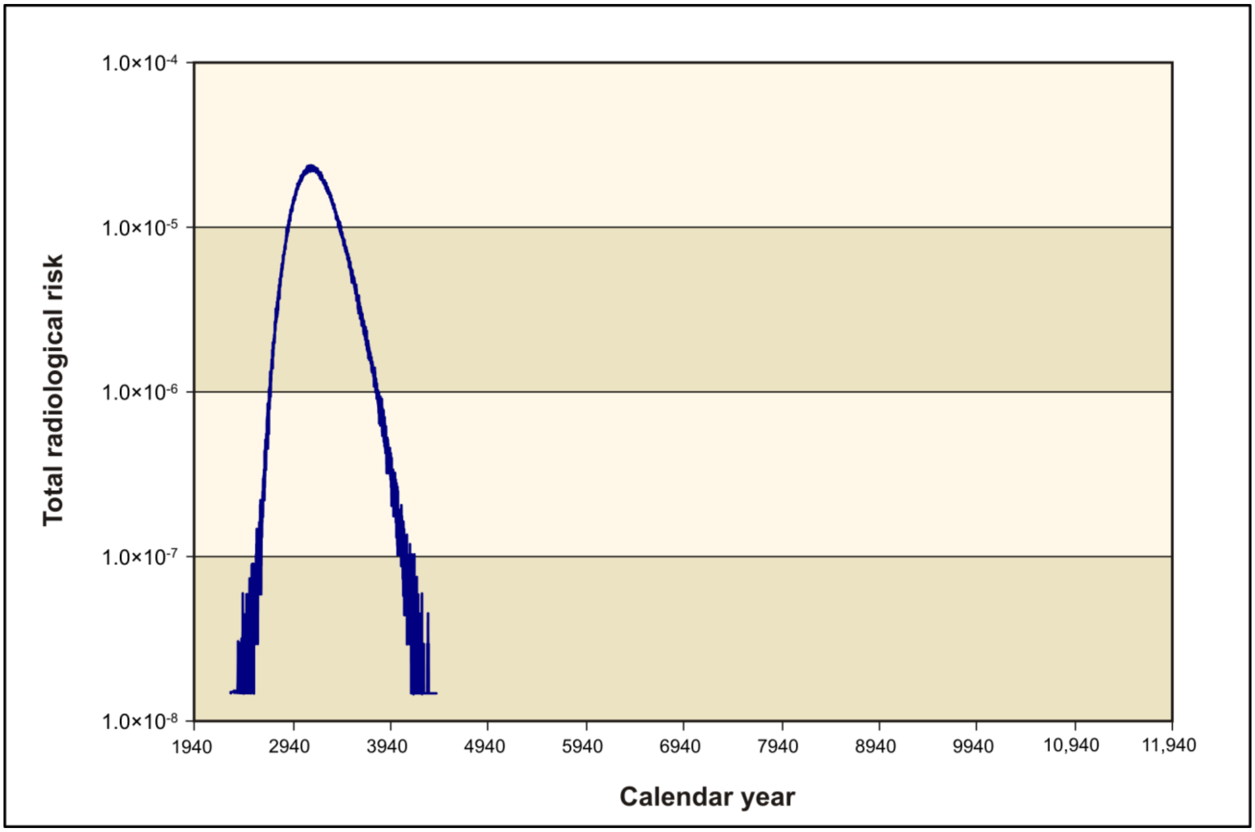


Figure 5–357. FFTF Decommissioning Alternative 2 Time Series of Radiological Risk for the Drinking-Water Well User at the Fast Flux Test Facility Barrier

5.2.2.3 FFTF Decommissioning Alternative 3: Removal

Under FFTF Decommissioning Alternative 3: Removal, nearly all aboveground structures, as well as contaminated below-grade structures, equipment, and materials, would be removed. As a result of the removal of contaminated material, negligible impacts on groundwater, surface water, and human health are predicted.

5.2.2.4 FFTF Decommissioning Intruder Scenario

Intruders are individuals who enter the FFTF area and engage in activity that could cause direct contact with residual contamination in the abandoned or stabilized structures. As in the case of Tank Closure alternatives, two types of receptors and two types of scenarios were considered. The receptor types were the American Indian resident farmer and the resident farmer, and the scenario types were home construction and well drilling. Because the majority of radionuclides in the FFTF area are in hardware at a depth greater than that of the foundation for a home, the home construction scenario was screened from the analysis. Also, sensitivity analysis determined that in all cases for residential agriculture, impacts on the American Indian resident farmer exceeded impacts on the resident farmer. Because inhalation and external exposure are the only exposure modes for the well-drilling worker, impacts on the worker involved in well drilling would be the same for the resident farmer and American Indian resident farmer. For the FFTF area, estimates of inventory indicate that the greatest hazard is due to quantities of the long-lived radionuclides carbon-14, technetium-99, and isotopes of uranium remaining at the site. Relatively small amounts of short-lived radionuclides are estimated to remain at the site. Consequently, impacts of intrusion in the FFTF area are represented by the well-drilling scenario, in which a worker inhales dust and receives external radiation while drilling the well and an American Indian resident farmer contacts residual contamination brought to the surface during development of the well. The impacts under this intrusion scenario for the three FFTF Decommissioning alternatives are summarized in Table 5–88 for the drilling worker and American Indian resident farmer intruders. Resident farmer impacts are dominated by exposure to carbon-14, while for the worker, carbon-14, technetium-99, and uranium isotopes contribute to dose through the direct external and inhalation pathways. For both the resident farmer and drilling worker, impacts are presented as dose for the year of peak dose. Because radionuclides appearing due to decay and ingrowth did not have major contributions to dose, the year of peak dose occurs immediately after loss of institutional control. The DOE intruder dose guideline of 500 millirem is not exceeded under any alternative.

Table 5–88. Doses to a Well-Drilling Worker and an American Indian Engaged in Residential Agriculture Following Well Drilling at the FFTF Area

	Dose (rem per year)		
	FFTF Decommissioning Alternative		
Receptor	**1**	**2**	**3**
Worker	4.5×10^{-6}	4.5×10^{-6}	2.7×10^{-14}
Resident farmer	1.1×10^{-3}	1.1×10^{-3}	1.4×10^{-8}

Key: FFTF=Fast Flux Test Facility.

5.2.3 Ecological Risk

This section presents the results of the evaluation of long-term impacts on ecological resources of releases to air and groundwater under the FFTF Decommissioning alternatives. Risk indices—Hazard Quotient and Hazard Index—were calculated by comparing the predicted dose with the benchmark dose (see Appendix P). Risk indices could not be calculated for lizards, toads, or birds exposed to organic compound COPCs released under the FFTF Decommissioning alternatives because there are no toxicity reference values for such receptors for these COPCs. Risk indices for air emissions were calculated for FFTF Decommissioning Alternative 1 and for the Hanford Option and Hanford Reuse Option and the Idaho Option and Idaho Reuse Option (also referred to as "Hanford Option/Reuse Option" and "Idaho Option/Reuse Option") under FFTF Decommissioning Alternatives 2 and 3. Although the disposition of RH-SCs and bulk sodium could occur at either Hanford or INL under FFTF Decommissioning Alternatives 2 and 3 (e.g., Hanford Option and Idaho Reuse Option, Idaho Option and Hanford Reuse Option), risk indices were calculated only for the Hanford Option/Reuse Option, the scenario with the greatest impact on ecological resources from releases to air at Hanford, and for the Idaho Option/Reuse Option, the scenario with the least impact on ecological resources from releases to air at Hanford. Releases to air would still occur at Hanford under the Idaho Option/Reuse Option due to activities that would occur at FFTF regardless of where the RH-SCs or bulk sodium is sent for disposition. Separate risk indices for air emissions were not calculated for the three components of each alternative: disposition of facilities, RH-SCs, and bulk sodium. Calculated risk indices for the COPC with the highest Hazard Quotient or Hazard Index for each receptor are presented.

Releases to air are expected from leaving the deactivated FFTF and associated facilities and components in place under the No Action Alternative (FFTF Decommissioning Alternative 1) and facility disposition under FFTF Decommissioning Alternatives 2 and 3. Releases to air associated with the disposition of RH-SCs and bulk sodium are expected under FFTF Decommissioning Alternatives 2 and 3 at Hanford under the Hanford Option/Reuse Option and the Idaho Option/Reuse Option and under FFTF Decommissioning Alternatives 2 and 3 at INL under the Idaho Option/Reuse Option. The impacts on ecological resources were evaluated for the combined releases to air from the disposition of RH-SCs and bulk sodium. The estimated impacts are identical under FFTF Decommissioning Alternatives 2 and 3 because the options for RH-SC disposition and bulk sodium disposition are identical under the two alternatives. Releases to groundwater are expected under all FFTF Decommissioning alternatives—No Action, Entombment, and Removal.

The long-term impacts on terrestrial ecological resources of releases to air at Hanford were evaluated at the onsite maximum-exposure location (Core Zone Boundary) and on terrestrial, riparian, and aquatic resources at the offsite maximum-exposure location (Columbia River). Impacts on ecological resources due to releases to groundwater were evaluated at the Columbia River.

5.2.3.1 FFTF Decommissioning Alternative 1: No Action

The FFTF Decommissioning No Action Alternative is not expected to result in releases of radionuclides to air. Releases of chemicals to air are expected due to deactivation activities under FFTF Decommissioning Alternative 1 (see Section 5.2 and Chapter 2, Section 2.3). The calculated risks to plants, the Great Basin pocket mouse, and the coyote from air releases under FFTF Decommissioning Alternative 1 (and Alternative Combination 1) are the highest of all Tank Closure, FFTF Decommissioning, and Waste Management alternatives. Predicted emissions of COPCs to air under FFTF Decommissioning Alternative 1 pose a small risk to plants (Hazard Quotient is 47) and a moderate risk to mammals at the onsite maximum-exposure location (see Table 5–89). The chemical COPCs released to air with the largest calculated Hazard Quotients for the Great Basin pocket mouse are xylene (2120), toluene (338), formaldehyde (79), and benzene (17) at the onsite maximum-exposure location. The coyote has the next-largest calculated Hazard Quotient for the chemical COPC xylene (269).

Table 5–89. FFTF Decommissioning Alternatives – Long-Term Impacts of Chemical COPC Releases to Air on Terrestrial Resources at the Onsite Maximum-Exposure Location

FFTF Decommissioning Alternative	Hazard Quotient of Worst-Case Chemical COPC by Receptor			
	Plants	Great Basin Pocket Mouse	Coyote	Mule Deer
	Toluene	Xylene	Xylene	Formaldehyde
1	4.68×10^{1}	$\mathbf{2.12\times10^{3}}$	2.69×10^{2}	4.79×10^{1}
2, Hanford Option/Reuse Option	1.64×10^{-1}	**7.63**	9.69×10^{-1}	6.13×10^{-1}
2, Idaho Option/Reuse Option	7.81×10^{-2}	**3.71**	4.71×10^{-1}	4.17×10^{-1}
3, Hanford Option/Reuse Option	1.65×10^{-1}	**7.68**	9.75×10^{-1}	5.84×10^{-1}
3, Idaho Option/Reuse Option	7.96×10^{-2}	**3.76**	4.78×10^{-1}	3.88×10^{-1}

Note: The maximum Hazard Quotient under each alternative is indicated by **bold** text. Results are not available for other terrestrial receptors: side-blotched lizard, mourning dove, western meadowlark, and burrowing owl.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

No risk to terrestrial, riparian, or aquatic ecological receptors from releases to air is predicted under FFTF Decommissioning Alternative 1 at the offsite maximum-exposure location (Columbia River). The only estimated Hazard Quotient exceeding 1 is xylene for the mouse (2.4).

Predicted emissions of chemical and radioactive COPCs in groundwater discharging at the Columbia River do not pose a risk to ecological receptors. The largest risk index (a Hazard Quotient of 0.029) for groundwater releases under FFTF Decommissioning Alternative 1 (see Table 5–90) is that calculated for exposure to uranium for mammals eating fish (the raccoon) at the Columbia River. This indicates no risk to ecological receptors from chemical or radioactive COPCs released to groundwater at Hanford under FTFF Decommissioning Alternative 1.

Table 5–90. FFTF Decommissioning Alternatives – Long-Term Impacts of Contaminant Releases to Groundwater on Aquatic and Riparian Receptors at the Columbia River

FFTF Decommissioning Alternative	Hazard Quotient of Highest-Value COPC by Receptor						
	Benthic Invertebrate	Muskrat	Spotted Sandpiper	Raccoon	Least Weasel	Bald Eagle	Aquatic Biota/Salmonids
	Technetium-99	Uranium[a]					
1	2.20×10^{-7}	2.73×10^{-5}	1.30×10^{-2}	2.91×10^{-2}	1.28×10^{-3}	8.07×10^{-5}	5.46×10^{-3}
2	2.32×10^{-7}	0	0	0	0	0	0
3	8.78×10^{-14}	0	0	0	0	0	0

a Uranium as chemical.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility; Rad.=radioactive.

5.2.3.2 FFTF Decommissioning Alternative 2: Entombment

Under FFTF Decommissioning Alternative 2, long-term impacts on ecological resources were evaluated for releases relative to air and groundwater at Hanford and releases to air at INL associated with the disposition of FFTF and associated facilities, RH-SCs, and bulk sodium.

Predicted emissions of COPCs in air at Hanford under FFTF Decommissioning Alternative 2 (Hanford Option/Reuse Option or Idaho Option/Reuse Option) do not pose a risk to ecological receptors. The chemical COPC with the largest calculated Hazard Quotient for air releases is xylene for the mouse (7.6) at the onsite maximum-exposure location under the Hanford Option/Reuse Option (see Table 5–89). Hazard Quotients calculated for chemical COPCs released to air under FFTF Decommissioning Alternative 2, Idaho Option/Reuse Option, are about half as large as those under the Hanford Option/Reuse Option. The largest Hazard Index (2.0×10^{-4}) for radioactive COPCs released to air under FFTF Decommissioning Alternative 2, Hanford Option/Reuse Option (see Appendix P, Table P–3), is predicted for the coyote at the onsite maximum-exposure location, with sodium-22 as the primary contributor. This Hazard Index, much smaller than 1, indicates no risk from radioactive COPCs released to air at Hanford under FFTF Decommissioning Alternative 2 for either the Hanford Option/Reuse Option or the Idaho Option/Reuse Option. Also, no risk to terrestrial, riparian, or aquatic ecological receptors from releases to air is predicted under FFTF Decommissioning Alternative 2 at the offsite maximum-exposure location (Columbia River) under both the Hanford Option/Reuse Option and Idaho Option/Reuse Option.

Although risk indices were not calculated for ecological receptors at INL, the relative magnitude of emissions there suggests little to no risk. For the disposition of RH-SCs and bulk sodium under FFTF Decommissioning Alternative 2, Idaho Option/Reuse Option, the predicted peak annual emissions of tritium (5.72 curies per year), cesium-137 (3.3×10^{-4} curies per year), and uranium (9.5×10^{-8} curies per year) at INL are orders of magnitude smaller than the maximum emissions at Hanford under any *TC & WM EIS* alternative (1.22×10^{3} curies per year for tritium, 2.5×10^{2} curies per year for cesium-137, and 3.7×10^{-2} curies per year for uranium) (see Table 5–91). Because predicted emissions of COPCs do not pose a risk to ecological receptors at Hanford, the smaller rates at INL are unlikely to pose a risk to similar ecological receptors with similar exposure pathways.

Predicted emissions of chemical and radioactive COPCs in groundwater discharging at the Columbia River do not pose a risk to ecological receptors. The largest risk index (Hazard Index of 0.000007) for groundwater releases under FFTF Decommissioning Alternative 2 (see Table 5–90) is that calculated for total internal and external exposure to all radioactive COPCs for mammals eating fish (the least weasel) at the Columbia River. This indicates no risk to ecological receptors from chemical or radioactive COPCs released to groundwater at Hanford under FTFF Decommissioning Alternative 2.

5.2.3.3 FFTF Decommissioning Alternative 3: Removal

Under FFTF Decommissioning Alternative 3, long-term impacts on ecological resources were evaluated for releases relative to air and groundwater at Hanford and releases to air at INL associated with the disposition of FFTF and associated facilities, RH-SCs, and bulk sodium.

Predicted emissions of COPCs in air at Hanford under FFTF Decommissioning Alternative 3 (Hanford Option/Reuse Option or Idaho Option/Reuse Option) are similar to those under FFTF Decommissioning Alternative 2 and do not pose a risk to ecological receptors. The chemical COPC with the largest calculated Hazard Quotient (xylene, 7.68) is for the mouse at the onsite maximum-exposure location (see Table 5–89). Hazard Quotients calculated for chemical COPCs released to air under FFTF Decommissioning Alternative 3, Idaho Option/Reuse Option, are about half as large as those under the Hanford Option/Reuse Option. The largest Hazard Index (2.0×10^{-4}) for radioactive COPCs released to air under FFTF Decommissioning Alternative 3, Hanford Option/Reuse Option (see Appendix P,

Table P–3), is predicted for the coyote at the onsite maximum-exposure location, primarily from sodium-22. This indicates no risk from radioactive COPCs released to air at Hanford under FFTF Decommissioning Alternative 3, either Hanford Option/Reuse Option or Idaho Option/Reuse Option. No risk to terrestrial, riparian, or aquatic ecological receptors from releases of COPCs to air is predicted under FFTF Decommissioning Alternative 3 at the offsite maximum-exposure location (Columbia River).

Although risk indices were not calculated for ecological receptors at INL, the relative magnitude of emissions there suggests little to no risk. For the disposition of RH-SCs and bulk sodium under FFTF Decommissioning Alternatives 2 and 3, Idaho Option/Reuse Option, the predicted peak annual emissions of tritium (5.72 curies per year), cesium-137 (3.30×10^{-4} curies per year), and uranium (9.5×10^{-8} curies per year) at INL are orders of magnitude smaller than the maximum emissions at Hanford under any *TC & WM EIS* alternative (2.02×10^{3} curies per year for tritium, 2.50×10^{2} curies per year for cesium-137, and 3.7×10^{-2} curies per year for uranium). The emissions of COPCs at INL would be smaller than the maximum emissions at Hanford under the Tank Closure, FFTF Decommissioning, and Waste Management alternatives (see Table 5–91). Because predicted emissions of COPCs under FFTF Decommissioning Alternative 3 do not pose a risk to ecological receptors at Hanford, the smaller rates at INL are unlikely to pose a risk to similar ecological receptors with similar exposure pathways.

Table 5–91. Comparison of Peak Annual Emission Rates at INL Under FFTF Decommissioning Alternatives 2 and 3 and at Hanford Under Tank Closure, FFTF Decommissioning, and Waste Management Alternatives

Constituent of Potential Concern	INL	Hanford	Alternative
Radionuclide (curies per year)			
Hydrogen-3 (tritium)	5.72	2.02×10^{3}	Tank Closure 1 and 2A
Cesium-137	3.30×10^{-4}	2.50×10^{2}	Tank Closure 6B
Uranium (all isotopes)	9.51×10^{-8}	3.69×10^{-2}	Tank Closure 1 and 2A
Chemical (grams per year)			
Sulfur dioxide	1.19×10^{4}	2.23×10^{7}	Waste Management 2 (Disposal Groups 2 and 3)
Toluene	1.71×10^{4}	2.85×10^{7}	Waste Management 2 (Disposal Groups 2 and 3)
Xylene	4.87×10^{3}	8.45×10^{6}	Waste Management 2 (Disposal Groups 2 and 3)
1,3-Butadiene	1.55×10^{1}	1.07×10^{5}	Waste Management 2 (Disposal Groups 2 and 3)
Mercury	0	N/A	N/A
Formaldehyde	0	N/A	N/A

Note: To convert grams to ounces, multiply by 0.03527.

Key: FFTF=Fast Flux Test Facility; Hanford=Hanford Site; INL=Idaho National Laboratory; N/A=not applicable because constituent not released at INL.

Predicted emissions of chemical and radioactive COPCs in groundwater discharging at the Columbia River do not pose a risk to ecological receptors. The largest risk index (a Hazard Index of 0.000000000002) for groundwater releases under FFTF Decommissioning Alternative 3 is that calculated for total internal and external exposure to all radioactive COPCs for mammals eating fish (the least weasel) at the Columbia River. This indicates no risk to ecological receptors from chemical or radioactive COPCs released to groundwater at Hanford under FTFF Decommissioning Alternative 3.

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 minority or 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. (See Appendix Q, Section Q.2.4.1, for assumed consumption levels for the different receptors.) The American Indian hunter-gatherer was assumed to have a subsistence consumption pattern that differs from that of the American Indian resident farmer. The American Indian hunter gatherer would not cultivate crops, but rather would gather food from indigenous plants and harvest a larger amount of fish from the Columbia River, drink no milk, consume no eggs, and drink a larger amount of water (water that would be gathered from potentially contaminated surface-water sources); thus, the receptor was assumed to be 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.2.2.

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 radiation 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 radiation dose of 3.8 millirem, compared with 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.