CHAPTER 7
ENVIRONMENTAL CONSEQUENCES AND MITIGATION DISCUSSION

Chapter 7 discusses environmental consequences that would occur due to implementation of the reasonable alternatives for each of the following: (1) tank waste retrieval, treatment, and disposal and single-shell tank system closure at the Hanford Site (i.e., tank closure); (2) decommissioning of the Fast Flux Test Facility and auxiliary facilities and disposition of the inventory of radioactively contaminated bulk sodium (i.e., Fast Flux Test Facility decommissioning); and (3) management of waste resulting from other Hanford Site activities and limited volumes from other U.S. Department of Energy sites (i.e., waste management). Chapter 4 presents more-detailed analysis of short-term impacts; Chapter 5, of long-term impacts. As previously discussed in Chapter 4, Section 4.4, three representative scenarios, or combinations of alternatives, were selected to facilitate comparison of the alternatives and discussion of the analyses.

Section 7.1 discusses mitigation measures that could be implemented to reduce or avoid environmental impacts on each resource area or discipline (e.g., geology and soils) and identifies resource areas that could be affected such that consideration of additional mitigation measures may be warranted. Section 7.2 discusses adverse impacts that are unavoidable and would occur even after implementation of all of the reasonable mitigation measures discussed in Section 7.1. Section 7.3 discusses the major irreversible and irretrievable resource commitments that would be made under all alternatives. Section 7.4 discusses the relationship between short-term uses of the environment and the maintenance and enhancement of its long-term productivity. Section 7.5 provides an expanded discussion of the groundwater sensitivity analyses and potential long-term groundwater mitigation strategies.

Detailed analyses and discussions of environmental justice concerns, that is, potential high and disproportionate impacts on minority and low-income populations, are provided in Chapter 4, Sections 4.1.13, 4.2.13, and 4.3.13, and are not repeated in this chapter. The discussion presented in this chapter on public health and occupational safety includes impacts estimated under the alternatives related to normal operations, facility accidents, and waste transportation.

7.1 MITIGATION

This section describes the mitigation measures that could be used to avoid or reduce environmental impacts resulting from implementation of the alternatives described in previous chapters. As specified in Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) regulations (40 CFR 1508.20), mitigation includes the following:

- Avoiding the impact altogether by not taking a certain action or parts of an action
- Minimizing the impact by limiting the degree or magnitude of the action and its implementation
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment
- Reducing or eliminating the impact over time by preserving and maintaining the affected environment during the life of the action
- Compensating for the impact by replacing or providing substitute resources or environments

All of the *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* alternatives, including the No Action Alternative, have the potential to impact one or more resource areas or disciplines over the timeframes analyzed in this environmental impact statement (EIS). Resource areas that could be negatively impacted include land resources, infrastructure, noise and vibration, air quality, geology and soils, water resources, ecological resources, cultural and paleontological resources, socioeconomics, public and occupational health and safety (human health), and waste management. To mitigate impacts on resource areas, activities associated with the *TC & WM EIS* proposed action alternatives would follow standard procedures and best management practices for facility construction and would consider incorporating, where applicable, the best demonstrated available technologies for facility operations and closure. The

U.S. Department of Energy (DOE) is already applying best management practices to minimize environmental impacts in association with ongoing Waste Treatment Plant (WTP) construction. These practices are required by Federal and state licensing and permitting requirements, as described in Chapter 8.

The 1996 *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement (TWRS EIS)* (DOE and Ecology 1996) described possible mitigation measures for the projected short- and long-term impacts of the proposed action alternatives for tank waste retrieval and treatment. DOE committed to these mitigation measures, as documented in the 1997 *TWRS EIS* Record of Decision (ROD) (62 FR 8693).

The 1999 *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement (Hanford Comprehensive Land-Use Plan EIS)* (DOE 1999a) identified specific mitigation measures, policies, and management controls that direct land use at the Hanford Site (Hanford). DOE committed to these mitigation measures, as documented in the 1999 *Hanford Comprehensive Land-Use Plan EIS* ROD (64 FR 61615). These commitments were reaffirmed in the 2008 *Supplement Analysis, Hanford Comprehensive Land-Use Plan Environmental Impact Statement (Hanford Comprehensive Land-Use Plan EIS SA)* (DOE 2008) and in the associated ROD (73 FR 55824).

The mitigation measures associated with the *TWRS EIS*, *Hanford Comprehensive Land-Use Plan EIS*, and *Hanford Comprehensive Land-Use Plan EIS SA* would continue to be implemented, as applicable, in coordination with the tank waste retrieval and treatment activities discussed in this EIS.

Following completion of this *TC & WM EIS* and its associated ROD, DOE would be required to prepare a mitigation action plan that explains mitigation commitments expressed in the ROD (10 CFR 1021.331). This mitigation action plan would be prepared before DOE would implement any *TC & WM EIS* alternative actions that are the subject of a mitigation commitment expressed in the ROD.

Following completion of the mitigation action plan and before implementing any closure actions, DOE will develop a tank farm system closure plan that will be implemented for each of the waste management areas. The State of Washington "Dangerous Waste Regulations" (WAC 173-303) implement the Hazardous Waste Management Act of 1976, as amended. These regulations provide the requirements for decisionmaking regarding the cleanup and permitting of dangerous wastes. The regulations define the state closure standards for the owners and operators of all dangerous waste facilities (WAC 173-303-610(2)) and include references to requirements for tank systems (WAC 173-303-640). Requirements for a response to a leak or spill and unfit-for-use tank systems are also described (WAC 173-303-640(7)). The regulations describe specific requirements for closure of the tank system (WAC 173-303-640(8)(a) and (b)). This part of the regulations provides a requirement for DOE to "remove or decontaminate all waste residues, contaminated soils, and structures and equipment contaminated with waste" for the tank system. If DOE "demonstrates that not all contaminated soils can be practically removed or decontaminated," then closure is required (WAC 173-303-640(8)(b)). The closure plan will include a preliminary performance assessment. The plan will be reviewed to ensure regulatory compliance by the Washington State Department of Ecology and presented for public comment before approval as a modification to the Hanford sitewide permit. This process is described in Appendix I of the Hanford Federal Facility Agreement and Consent Order, also known as the Tri-Party Agreement (TPA). A closure plan will be submitted for each waste management area that meets the compliance schedule and requirements of the TPA, as well as those of the state closure standards (WAC 173-303-610(2)) and the *TC & WM EIS* ROD. The Washington State Department of Ecology will consider all EIS mitigation information and any additional, relevant information when developing the closure plan. As an example of the current process, the TPA has milestones for the completion of a soil investigation for Waste Management Area C (Milestone M-45-61), submittal of a closure plan (Milestone M-45-82), and completion of Waste Management Area C closure (Milestone M-45-83). DOE will complete the soil investigation to determine the nature and extent of the contamination. To inform the decision process for closure, DOE will complete a Waste Management Area C performance assessment and risk assessment. Following completion of the tank waste retrievals and data collection activities for residuals in the pipelines, ancillary equipment, and soil, the performance assessment will be revised to include all data. This revised performance assessment and closure plan will be presented for public review and comment, and the Waste Management Area C closure plan will be modified and incorporated into the Hanford sitewide permit.

DOE has incorporated several mitigation measures into the alternatives proposed in this EIS to prevent or reduce their short- and long-term environmental impacts. Some mitigation measures were incorporated into all of the alternatives, and some represent variations in one or more of the elements or technologies used to construct the alternatives. Table 7–1 summarizes the potential mitigation measures by resource area; these mitigation measures are discussed in more detail in the sections that follow. The table is divided into three groups: the first group presents mitigation measures that would normally be considered regardless of impact severity; the second group presents additional mitigation measures that may be necessary for cases in which specific short-term impacts are projected to approach or exceed existing capacities, regulatory thresholds, or other guidelines; and the third group presents additional mitigation measures for cases in which specific long-term impacts may require special consideration.

While some mitigation measures have already been incorporated into the actions proposed under the *TC & WM EIS* alternatives, some may have not yet been identified; these would be implemented after issuance of the ROD. Furthermore, because of the relatively long timeframes required to conclude each alternative's life cycle, additional and more-effective mitigation measures may become available in the future that could reduce the environmental impacts associated with a proposed action. DOE will continue to identify and incorporate new technologies or practices that could potentially reduce the impacts throughout the life cycle of a selected alternative.

As discussed in Chapter 5 of this *TC & WM EIS*, DOE acknowledges that benchmark standards could be exceeded in groundwater at the Core Zone Boundary and/or the Columbia River nearshore on various dates. In response to comments received on the *Draft TC & WM EIS* concerning these potential long-term impacts on groundwater resources, additional sensitivity analyses were performed and are included in this final EIS. The additional analyses focus on factors perceived to have a substantial influence on the magnitude of long-term groundwater impacts. The factors evaluated in this final EIS include (1) reduction in the availability of constituents of potential concern (COPCs) for discharge into the environment (e.g., flux reduction) that might mimic remedial actions conducted at some of the more-prominent waste sites on the Central Plateau and along the river corridor or restrictions on the receipt and disposal of offsite waste at Hanford; (2) modification of treatment processes (e.g., iodine-129 recycle, technetium-99 removal); and (3) improvements in Integrated Disposal Facility (IDF) performance (e.g., infiltration rates) and in secondary- and supplemental-waste-form performance (e.g., release rates). Section 7.5 was added to this final EIS and provides a more detailed discussion of this topic and summarizes the results of these analyses. The results of these analyses will aid DOE in formulating an appropriate mitigation action plan subsequent to this final EIS and its associated ROD(s) and in prioritizing future Hanford remedial actions that would be protective of human health and the environment and would reduce long-term impacts on groundwater.

Table 7–1. Summary of Potential Mitigation Measures

Resource Area	Mitigation Measures
	Potential Mitigation Measures
Land resources	• Locate facilities in proximity to related activities. • Maintain and coordinate land use as described in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824). • Use existing buildings or disturbed land. • Use existing permitted facilities to supplement activities. • Use existing infrastructure and rights-of-way. • Expedite restoration of land upon completion of mission, and when appropriate, emphasize long-term reclamation versus interim site stabilization.
Infrastructure	• Incorporate high-efficiency motors, pumps, lights, and other energy conservation measures into the design of new facilities. • Schedule operations during offpeak times. • Sequence operations to minimize peak use of utilities.
Noise and vibration	• Limit construction to daylight hours. • Maintain equipment mufflers. • Restrict use of horns and use appropriately sized heavy equipment. • Plan truck routes and timing of traffic.
Air quality	• Implement dust suppression techniques, such as application of water or surfactants. • Use low-sulfur fuels or alternative fuel vehicles. • Maintain equipment in peak working condition. • Implement zone ambient air monitoring to monitor effectiveness of engineering controls. • Sequence and schedule construction and/or operations of activities. • Limit the amount of disturbed land areas and revegetate land as soon as possible. • Incorporate best available air pollution control technologies into design of new facilities. • Use containment structures for excavation activities, whenever appropriate.
Geology and soils	• Manage borrow materials as described in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824) to address requirements such as contouring and revegetating the landscape to match the natural surroundings. • Use disturbed land areas whenever possible. • Limit the time disturbed soils are exposed and/or use protective covers over denuded areas and stockpiles. • Adhere to best management practices for erosion and sedimentation control (e.g., dust suppression, soil fixation). • Restore and recontour disturbed areas to preexisting and culturally relevant conditions to the maximum extent possible.

Table 7–1. Summary of Potential Mitigation Measures *(continued)*

Resource Area	Mitigation Measures
Potential Mitigation Measures *(continued)*	
Water resources	• Continue to operate or deploy groundwater remediation technologies such as a pump-and-treat system, temporary or reactive barriers, or other groundwater extraction and treatment methods. • Implement spill prevention and control and stormwater pollution prevention plans. • Incorporate water conservation practices into routine operations. • Adhere to strict waste acceptance criteria for burial at one of the proposed or existing waste disposal facilities. • Consider higher levels of tank waste retrieval to mitigate impacts on groundwater (e.g., 90 percent, 99 percent, 99.9 percent). • Implement groundwater-quality monitoring programs. • Construct engineered surface barriers with liners and leachate collections systems. • Extend duration of postclosure care or administrative control period.
Ecological resources	• Implement mitigation measures similar to those listed for land. • Provide compensatory mitigation of sagebrush habitat or other sensitive plant species encountered. • Demarcate construction and land disturbance zones clearly to limit intrusion into non-work areas. • Avoid special status plant and animal species whenever possible. • Implement spill prevention and control plans. • Avoid interfering with animal breeding or nesting areas or periods.
Cultural and paleontological resources	• Assign an archaeological monitor during construction and other earth-disturbing activities. • Perform surveys to identify prehistoric or cultural resources prior to initiating earth-disturbing activities, and avoid any discovered resources. Visual aspects: • Stockpile borrow material or coordinate the timing of excavation activities (e.g., at night) in Borrow Area C to avoid interfering with tribal ceremonial and religious activities that could be affected visually from Rattlesnake Mountain. • Remove unnecessary facilities or infrastructure when no longer needed. • Consolidate facilities or infrastructure where appropriate. • Restore and/or revegetate disturbed areas in a culturally relevant manner. • Provide minimal maintenance to exterior of buildings, equipment, and roads to reduce disturbed areas.
Socioeconomics	• Construct and operate new facilities in sequence, rather than concurrently, whenever possible, to reduce the demand on employment resources and associated public services. • Upgrade select traffic routes or intersections. • Use alternate work schedules or expand the existing carpool and commuter program in accordance with Washington's commute trip reduction policy. • Coordinate shipment of materials and waste with heavy commute or public traffic timeframes.

Table 7–1. Summary of Potential Mitigation Measures *(continued)*

Resource Area	Mitigation Measures
Potential Mitigation Measures *(continued)*	
Public and occupational health and safety	• Incorporate best available demonstrated technologies for reducing release of radioactive emissions. • Maintain acceptable worker doses by implementing ALARA techniques (e.g., reducing time of exposure, increasing number of workers, using shielding, implementing remote operations). • Prepare shipments of waste in containers certified for the intended purpose, and train and license handlers and transporters.
Waste management	• Implement pollution prevention and waste minimization techniques. • Investigate technologies that have the potential to increase WTP melter life and increase waste loading (e.g., sulfate removal).
Additional Considerations for Short-Term Mitigation Measures	
Infrastructure	WTP operations would place a high demand on Hanford's electrical grid for an extended amount of time and are projected to approach or, under some alternatives, exceed existing peak capacity. To mitigate this impact, the following steps could be taken: (1) prepare an energy consumption plan, (2) supplement electric power supply from alternative sources, and (3) upgrade Hanford's distribution system.
Air quality	Construction activities are projected to exceed ambient air quality standards for particulate matter under most alternatives, and in some cases, for carbon monoxide or nitrogen dioxide as well. However, the projections do not take into account implementation of all reasonable mitigation measures. Mitigation measures may be necessary to ensure applicable standards are met. A more refined analysis, assuming implementation of reasonable engineering controls, would likely result in a substantial reduction in projected emissions of criteria air pollutants.
Geology and soils	The analysis in this *TC & WM EIS* assumes all borrow material would come from Borrow Area C and no excavation soils from waste management disposal facility or new facility construction would be used. To mitigate this impact, the extraction and management of geologic materials would be executed in a manner consistent with the policies and resource management plans as described in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824).
Public and occupational health and safety	Under *TC & WM EIS* Tank Closure Alternatives 4, 6A, and 6B, which would involve either partial (under Alternative 4) or complete (under Alternatives 6A and 6B) clean closure of the tank farms, the average worker dose would approach and, in some cases, potentially exceed DOE's Administrative Control Level of 500 millirem per year. In these cases, a comprehensive evaluation of worker exposures may be warranted to determine which activities are the largest contributors to worker dose and to implement aggressive ALARA techniques to ensure worker doses remain below the appropriate levels. In addition, public exposure during the peak year of activities, although low, would coincide with the relatively short operation of the cesium and strontium capsule processing campaign in the WTP. The processing of this material could be spread over a longer timeframe, thus mitigating the peak impact on the public.
Waste management	Under *TC & WM EIS* Tank Closure Alternatives 6A, 6B, and 6C, all tank waste would be managed as HLW, representing a significant increase in waste volume managed as HLW by a factor of at least 14 times more than other action alternatives. Under these alternatives, the treated radioactive tank waste would be stored on site. To mitigate potential impacts of storing large quantities of HLW, waste management areas could be modified as necessary.

Table 7–1. Summary of Potential Mitigation Measures *(continued)*

Resource Area	Mitigation Measures
Additional Considerations for Long-Term Mitigation Measures	
Water resources	Several COPCs are predicted to exceed or approach benchmark concentrations in groundwater at the Core Zone Boundary and/or the Columbia River nearshore at various dates. The COPCs resulting in the majority of impacts include the radionuclides hydrogen-3 (tritium), iodine-129, technetium-99, and uranium-238 and the chemicals chromium, nitrate, and total uranium. These COPC drivers are consistent across all *TC & WM EIS* alternatives. Potential mitigation measures that could be considered include the following: • Increase partitioning of COPC drivers into ILAW and/or IHLW forms by recycling secondary-waste streams into primary-waste feeds or adopting pretreatment removal technologies that would target COPCs (e.g., technetium removal). • Continue research and development for more-robust, long-term-performing secondary-waste forms and supplemental-treatment primary-waste forms. • Design and construct more-robust surface barriers or require periodic replacements of engineered barriers. • Restrict the receipt of offsite waste to waste that would have low impacts on groundwater over the long term at Hanford (e.g., limit or restrict receipt of offsite waste containing iodine-129 or technetium-99 at Hanford). Note: For example, DOE evaluated in this final EIS the effect of applying waste acceptance criteria to offsite waste by removing a highly radioactive waste stream (i.e., high inventories of iodine-129 and technetium-99) from the inventory of offsite waste analyzed for disposal at Hanford. • Implement comprehensive groundwater-quality monitoring programs with contingency corrective action plans.
Ecological resources	Long-term impacts on ecological receptors from air emissions and groundwater contamination are expected to be minor; however, because a reduction in impacts on air quality and water resources would result in a corresponding reduction in ecological receptor risk, the mitigation measures discussed under “Air Quality” and “Water Resources” could also reduce impacts on ecological resources. Additionally, periodic monitoring programs for ecological receptors could provide early detection of declining populations and, if necessary, implementation of corrective actions.
Public and occupational health and safety	Impacts on offsite receptors would be negligible when compared with background exposures; however, impacts on onsite receptors that consume groundwater as a drinking water source would exceed dose standards for one or more COPCs. Long-term impacts on human health receptors (e.g., resident farmer) are indirect impacts that would result from long-term impacts on other resources, such as groundwater (e.g., water used for irrigating land, drinking water) or ecological resources (e.g., consumption of animals or fish). As such, any potential mitigation measures that could reduce impacts on water resources and/or ecological resources may also be applicable for mitigation of human health impacts.

Key: ALARA=as low as is reasonably achievable; COPC=constituent of potential concern; DOE=U.S. Department of Energy; EIS=environmental impact statement; Hanford=Hanford Site; *Hanford Comprehensive Land-Use Plan EIS=Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*; *Hanford Comprehensive Land-Use Plan EIS SA=Supplement Analysis, Hanford Comprehensive Land-Use Plan Environmental Impact Statement*; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; ROD=Record of Decision; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*; WTP=Waste Treatment Plant.

DOE has prepared or will potentially prepare a number of area and resource management plans, as described in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824). These plans are either in draft form, have been completed, are being revised, or are waiting on available funds and program prioritization (DOE 2008). These plans and their status are summarized as follows:

- *Hanford Site Ground Water Protection Management Plan*: Final
- *Groundwater Vadose Zone Integration Project Summary Description*: Final
- *Hanford Institutional Control Plan*: Final
- *Ecological Compliance Assessment Management Plan*: Final
- *Hanford Long-Term Stewardship Program and Transition*: *Preparing for Environmental Cleanup Completion*: Final
- *Threatened and Endangered Species Management Plan, Salmon and Steelhead (T&ESMP-SS)*: Final

    Chinook Salmon-Upper Columbia River Spring Run Hanford Management Plan (sub-tier to *T&ESMP-SS*): Final

    Steelhead-Middle Columbia River Run Hanford Management Plan (sub-tier to *T&ESMP-SS*): Final

- *Hanford Cultural Resources Management Plan (HCRMP)*: Final pending revision

    Gable Mountain and Gable Butte Resource Management Plan (sub-tier to *HCRMP*): Final

    Rattlesnake Mountain Cultural Resource Management Plan (sub-tier to *HCRMP*): Draft pending

    Aesthetic and Visual Resources Management Plan (sub-tier to *HCRMP*): Draft pending revision

- *Hanford Site Biological Resources Management Plan (BRMaP)*: Final pending revision

    Hanford Site Biological Resources Mitigation Strategy (sub-tier to *BRMaP*): Final pending revision

    Fire Management Plan (sub-tier to *BRMaP*): Final pending revision

    Noxious Weed Management Plan (sub-tier to *BRMaP*): Final pending revision

- *Hanford Bald Eagle Management Plan*: Final pending revision
- *Facility and Infrastructure Assessment and Strategy*: Draft
- *Industrial Mineral Resources Management Plan*: Draft
- *Fitzner-Eberhardt Arid Lands Ecology Reserve Comprehensive Conservation Plan*: Draft
- *Wahluke Slope Comprehensive Conservation Plan*: Draft
- *Columbia River Corridor Area Management Plan*: Draft
- *Hanford Site Watershed Management Plan*: Pending available funds and program prioritization
- *South 600 Area Management Plan*: Pending available funds and program prioritization

As these management plans become available, special management or mitigation required by the procedures outlined in the plans would be implemented for the proposed *TC & WM EIS* activities, as appropriate.

7.1.1 Land Resources

Land resources would be used to construct facilities for the treatment, storage, or retrieval of tank closure or Fast Flux Test Facility (FFTF) decommissioning and closure waste. The duration and amount of land used would vary depending on the alternative. Land resources would also be used to construct permanent disposal facilities in support of the Waste Management alternatives. Construction of tank waste retrieval, treatment, storage, and permanent disposal facilities would occur primarily within the 200 Areas, which are encompassed by the Central Plateau. In the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a) and associated ROD (64 FR 61615), the Central Plateau was designated Industrial-Exclusive, and the 400 Area was designated for industrial use. There are two exceptions in which new facilities would be constructed outside the Central Plateau. The first exception would be construction of the Remote Treatment Project (RTP) under the FFTF Decommissioning action alternatives; this facility would be built in the existing T Plant complex in Hanford's 400 Area under the Hanford Option. The second exception would be construction of additional Immobilized High-Level Radioactive Waste (IHLW) Interim Storage Modules east of the Central Plateau (covering an area of 86.2 hectares [213 acres]) under Tank Closure Alternative 6A. Under this alternative, all tank waste would be managed as high-level radioactive waste (HLW) and treated to become IHLW.

In addition to the construction of new facilities, land resources would be mined for geologic materials necessary for implementation of the alternatives. Borrow Area C is an approximately 926.3-hectare (2,289-acre) borrow area designated to provide all borrow materials, including rock, riprap (basalt), aggregate (gravel and sand), and soil (silt and loam), for facility construction and associated activities described in this EIS. In the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a) and associated ROD (64 FR 61615), Borrow Area C is designated as Conservation (Mining).

As described in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824), to mitigate impacts, representative locations for new facilities to support tank waste retrieval, treatment, storage, and disposal under each of the alternatives may have been chosen based on the following factors or by taking the following steps:

- Location of all facilities, to the maximum extent practical, within the Central Plateau Industrial-Exclusive land use zone (i.e., the 200-East and 200-West Areas and areas in between).
- Proximity to similar facilities (e.g., landfills near landfills), supporting infrastructure, or the tank farms.
- Proximity of Borrow Area C to the Central Plateau.
- Availability of sufficient uncontaminated space not reserved for use by other Hanford projects.
- Maintenance of proposed land use within the Industrial-Exclusive and Conservation (Mining) land use zones.
- Selection and use of existing buildings whenever possible.
- Collocation of related actions and interdependent facilities to reduce the areal extent of land disturbance (e.g., supplemental treatment facilities and Cesium and Strontium Capsule Processing Facility adjacent to the WTP).

- Use of existing infrastructure and rights-of-way.

- Expedient restoration and re-landscaping of open areas upon completion of construction-related activities or upon termination and closure of a facility at the completion of its mission.

- Restoration of Borrow Area C through activities including regrading; contouring the landscape; revegetating to match the natural landscape using native species; and adhering to best management practices for soil erosion and sediment control in accordance with appropriate resource management plans, such as a final adopted version of the *Draft Industrial Mineral Resources Management Plan* (Reidel, Hathaway, and Gano 2001).

Several Tank Closure alternatives would require the construction of more facilities than others; however, such construction would be designed to make use of options that could help mitigate impacts on other resource areas. For example, Tank Closure Alternatives 3A, 3B, 3C, 4, and 5 all analyze the construction of supplemental treatment facilities for treating tank waste. Supplemental treatment would shorten the length of time required to treat tank waste, which may help reduce impacts on other resource areas. In other cases, the treatment of all tank waste through the WTP under Alternative 2A or the clean closure of all single-shell tank (SST) farms under Alternatives 6A and 6B would require long implementation timeframes. This may lead to better-performing waste forms, but, as a consequence of the longer implementation timeframes, replacement facilities or construction of new double-shell tanks (DSTs) may become a necessity.

Land resources located in the Industrial-Exclusive zone and dedicated to permanent waste management or buffer areas in the long term would not be available for unrestricted use. This particular impact cannot be mitigated and would be considered a long-term impact or commitment of land resources, as discussed in Section 7.3.

7.1.2 Infrastructure

Except for electric power required under Tank Closure Alternative 6A, Base and Option Cases, in which all tank waste would be treated as HLW in the WTP, none of the other *TC & WM EIS* alternatives are expected to consume energy, fuel, or water resources exceeding that which can be provided through existing infrastructure. Existing facilities and infrastructure could be utilized whenever possible to mitigate any necessary changes or upgrades. Necessary and new facilities associated with the *TC & WM EIS* action alternatives could be constructed within areas that have existing infrastructure and rights-of-way whenever possible. If needed, new infrastructure would be constructed consistent with the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824).

To satisfy short-lived demands on utilities (such as those typical during construction), portable generators, temporary work lighting, portable water and fuel storage vessels, and portable sanitary facilities could be used to mitigate the need for upgrades to the existing, permanent infrastructure. This would be especially true for those activities that would occur in locations that do not have readily available tie-ins to the existing infrastructure.

The estimated peak electrical usages under the Tank Closure action alternatives range from 28 percent to 113 percent of available capacity, as discussed in Chapter 4, Section 4.1.2. The high demand for electric power would be largely due to WTP operations, particularly operation of the HLW melters. Under Tank Closure Alternative 6A, Base and Option Cases, in which all tank waste would be vitrified in the WTP HLW melters, demand is projected to exceed the peak electrical capacity of Hanford's electric power distribution system. Even though activities under the other Tank Closure alternatives are not projected to exceed the available peak capacity, electrical consumption is expected to remain near Hanford's peak capacity for the duration of WTP operations analyzed under each alternative. The consumption of electric power during WTP operations may require mitigation or the implementation of an energy consumption plan. The following steps could be taken to mitigate electrical consumption:

- Incorporate high-efficiency motors, pumps, lights, and other energy-saving equipment into the design of new facilities.
- Schedule operations during offpeak times.
- Sequence operations to minimize peak use of utilities.
- Use alternative or supplemental methods to supply electricity that would not disrupt or threaten to disrupt the regional supply grid.

Infrastructure demands under the FFTF Decommissioning and Waste Management alternatives are expected to be relatively low and thus would not require implementation of additional mitigation measures. Pursuant to DOE Order 430.2B, *Departmental Energy, Renewable Energy and Transportation Management*, and Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*, DOE has established agency-wide goals for energy efficiency and water conservation improvements at DOE sites, including reductions in energy and potable water consumption, use of advanced electric metering systems, use of sustainable building materials and practices, and use of innovative renewable and clean energy sources. Consideration given to implementing policies under the Tank Closure, FFTF Decommissioning, and Waste Management alternatives consistent with Executive Order 13514 could reduce impacts on infrastructure.

7.1.3 Noise and Vibration

Generally, noise impacts on residential developments and other offsite public areas under the proposed *TC & WM EIS* alternatives are expected to be negligible because most activities would take place in the interior portion of Hanford (the Central Plateau) and away from these sensitive locations. The noise impacts projected to occur in the Central Plateau areas would not represent a significant increase over current levels. However, noise impacts would affect wildlife near Borrow Area C the most. Activities in Borrow Area C could be limited to daylight hours. Noise impacts during construction would be minimized by maintaining the equipment to ensure that the mufflers and other components are operating properly, by restricting the use of vehicle horns, and by using appropriately sized equipment. Noise from truck traffic coming and going from work sites could be mitigated by planning the routes and timing of truck traffic.

7.1.4 Air Quality

The *TC & WM EIS* action alternatives would involve construction of (1) new facilities over varying timeframes; (2) large permanent disposal facilities; and (3) surface barriers for tank farms, cribs and trenches (ditches), and disposal facilities. Construction activities would generate criteria and hazardous air pollutants. Emissions would be associated with diesel-fueled construction equipment and other fuel-burning equipment (e.g., generators) and vehicles. Construction equipment emissions can be minimized by using more-refined fuels (e.g., low-sulfur diesel fuel) and by maintaining the equipment to ensure that emissions control systems and other components are functioning at peak efficiency. Most notably, fugitive dust emissions would occur as a result of land disturbance by heavy equipment and vehicles, causing suspension of particulate matter from exposed soil in the air. Ambient monitoring and engineering controls may be necessary to maintain pollutants below acceptable levels. Engineering controls could include watering and/or using surfactants to control dust emissions from exposed areas and storage piles, revegetating exposed areas, sequencing and scheduling work, watering roadways, and minimizing construction activity in dry or windy conditions (during late summer and fall). DOE is currently applying these measures in constructing the WTP. For activities that could disturb contaminated dust (e.g., removal of tank farms), excavation work could take place beneath domed containment structures using negative-pressure systems, air locks, and water sprays.

As discussed in Chapter 4, Sections 4.1.4 and 4.3.4, construction and other earth-disturbing activities associated with all Tank Closure and Waste Management alternatives, including No Action, have the potential to cause particulate matter to exceed standards. The 1-hour average concentrations of carbon monoxide and nitrogen dioxide are also projected to exceed standards under several Tank Closure alternatives. However, the analysis of emissions did not consider the emissions controls described above that could be employed in construction areas to mitigate impacts. Before implementation of any Tank Closure or Waste Management alternative, a more refined analysis of emissions, assuming reasonable control technologies and more-detailed construction activities, would need to be performed; this analysis is expected to result in substantially lower estimates of emissions and ambient concentrations of criteria pollutants under all *TC & WM EIS* alternatives. Concentrations of other hazardous air pollutants are projected to be within acceptable levels under all *TC & WM EIS* alternatives and below any published acceptable source impact levels, except mercury under Tank Closure Alternatives 2B, 6B, and 6C.

New facility process operations (especially operations of the WTP and its supporting facilities) and subsequent deactivation would generate airborne emissions of various pollutants, including radionuclides and nonradioactive organic and inorganic chemicals. Because a variety of air pollutant contributors and processes could be operating under the action alternatives, a variety of air pollutant control technologies could be considered. For example, for removal of airborne particulates and gaseous emissions, the following control technologies could be considered in process design:

- The cyclone precipitator is a common industrial technology used as a precleaning step ahead of more-expensive and -effective control systems for removal of particulates. Because this technology is commonly used at commercial concrete production facilities, it would be a good candidate for precleaning emissions emanating from nonthermal treatment systems, such as the Cast Stone Facility. It would generally not be a useful control technology for thermal waste treatment systems, such as the WTP, and its use in radioactive environments may be limited as well.

- The electrostatic precipitator is another useful technology for control of particulate emissions. The current WTP design calls for installation of wet electrostatic precipitators. This technology would remove particulates and some of the vapor included in the air stream and could provide effective treatment for all of the air emissions generated from all waste treatment systems currently considered in this *TC & WM EIS*.

- Direct filtration can also be effective in controlling particulates. One typical industrial application is a baghouse filter system. Direct filtration via high-efficiency particulate air (HEPA) filters has been shown to be very effective at controlling particulates at Hanford. HEPA filters can be used (and will probably be required) for all of the waste treatment systems analyzed in this EIS as long as the exhaust stream temperature can be properly tempered.

- Scrubber systems are another effective air treatment control technology. Currently, the WTP design includes two kinds of scrubbers: caustic and submerged bed. Scrubbers can be used with all currently planned waste treatment technologies. Submerged bed scrubbers are effective at reducing particulate loading in the airborne emissions stream. They can be used on any of the waste treatment technologies considered in this EIS. Caustic scrubbers are effective in treating acid gases produced as part of the thermal treatment system. They would be an effective control on all of the thermal waste treatment system facilities (e.g., WTP, bulk vitrification) but would not provide any additional reduction to the nonthermal systems (e.g., cast stone).

- Thermal oxidation systems are an important treatment technology for controlling emissions of organic chemicals and vapors because they burn these emissions. The current WTP design calls for inclusion of a thermal catalytic oxidizer.

- Carbon adsorption is another treatment technology that helps remove organics from the air emissions stream. This technology is very effective at removing organics and other vapors with the proper chemical affinity. However, as with HEPA filters, carbon adsorption systems are not very effective with high-temperature or liquid-saturated air streams; therefore, the stream must be properly tempered for this technology to be effective. Current WTP design calls for inclusion of a carbon-bed adsorption unit for removal of mercury vapor from the emissions stream.

- The current WTP plan calls for inclusion of a selective catalytic reduction unit for control of nitrous oxide. This type of system can be designed to treat specific chemicals in the airborne stream by using different catalysts and can help reduce acid gases in the emissions stream. This treatment technology could be an effective addition to most of the waste treatment systems and could be effectively implemented to address specific chemicals of concern.

- Pretreatment of waste streams prior to introduction to the WTP or other supplemental treatment processes could also help reduce airborne contaminants and gaseous emissions. Pretreatment would be employed to remove problematic toxic and radioactive air pollutants from the waste stream prior to treatment, thus eliminating or reducing the potential for emissions of target contaminants from the process stacks.

Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*, makes reduction of greenhouse gas emissions a priority for Federal agencies by establishing agency-wide goals to reduce the energy intensity in buildings, increase the use and generation of renewable energy, and reduce the use of fossil fuels in vehicle fleets. Consideration given to implementing policies under the Tank Closure, FFTF Decommissioning, and Waste Management alternatives consistent with Executive Order 13514 could reduce impacts on air quality, particularly those associated with climate change. For example, DOE could consider the use of cleaner-burning fuels such as natural gas in lieu of diesel fuel for WTP and/or other facility operations.

7.1.5 Geology and Soils

Impacts on geology and soils would generally be proportional to the total area of land disturbed by construction of new treatment, storage, and disposal facilities; the depth and lateral extent of excavations of the tank farms and other contaminated soils; and the total amount of geologic resources that would be mined from Borrow Area C. Excavation depths for new facility construction generally would not exceed about 12 meters (40 feet); however, deep soil excavation ranging from depths of 20 meters (65 feet) to as many as 78 meters (255 feet) below the land surface may be required for clean closure of the SST farms under Tank Closure Alternatives 6A and 6B or for clean closure of the BX and SX tank farms under Tank Closure Alternative 4. The majority of impacts on geology and soils would result from (1) mining materials to backfill tank farm excavations and permanent disposal facilities; (2) providing engineered backfill for construction of the WTP and related facilities; and (3) constructing engineered barriers for closure of the tank farms, cribs and trenches (ditches), River Protection Project Disposal Facility (RPPDF), and one or two IDFs. For analysis purposes, it was assumed that all required geologic resources for the *TC & WM EIS* alternatives would come only from Borrow Area C and would potentially involve disturbance of up to 619 hectares (1,530 acres) of land excavated to a depth of approximately 4.6 meters (15 feet). The greatest impact on Borrow Area C would occur under an alternative combination involving Tank Closure Alternative 6A, Option Case; FFTF Decommissioning Alternative 3; and Waste Management Alternative 2, Disposal Group 3. This potential combination of alternatives is not one of the three selected for analysis in this EIS. The following mitigating factors could possibly reduce the overall impact of mining operations from Borrow Area C:

- Extraction and management of geologic materials would be executed in a manner consistent with the policies and resource management plans described in the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a), the subsequent *Hanford Comprehensive Land-Use Plan EIS SA* (DOE 2008), and their associated RODs (64 FR 61615 and 73 FR 55824).

- Borrow Area C would be restored through activities including regrading; contouring the landscape; revegetating to match the natural landscape; and adhering to best management practices for soil erosion and sediment control in accordance with appropriate resource management plans, such as a final adopted version of the *Draft Industrial Mineral Resources Management Plan* (Reidel, Hathaway, and Gano 2001).

Regardless of the use of borrow materials sources other than Borrow Area C, geologic resources would still be required in large quantities under some alternatives, and the long-term impacts of mining these materials would be realized.

Surface soils and unconsolidated sediments exposed in excavations and cut slopes during new facility construction would be subject to wind and water erosion if left exposed over an extended period of time. In all cases, adherence to standard best management practices for soil erosion and sediment control during construction would serve to minimize soil erosion and loss. Due to the number of construction projects that would be ongoing during the early years of each of the action alternatives, erosion of exposed soils cannot be completely eliminated during construction, but a number of practices could reduce overall impacts. Temporary soil disturbance outside the eventual footprint of new facilities could be limited by using inactive areas within the building footprints for material laydown, storage, and parking, as well as by using narrow access and egress corridors for construction equipment usage. In general, limiting the amount of time soils are exposed, limiting the area disturbed during any phase of a construction project, and applying protective coverings to denuded areas during construction (e.g., mulch, geotextiles) until the disturbed areas can be revegetated or otherwise covered by facilities could reduce the potential for soil loss. Soil loss and offsite transport could be further reduced by appropriate sedimentation and soil erosion and control devices, including sediment traps, sediment fences, staked hay bales, or other methods that Hanford's arid conditions may dictate. Stockpiles of soil removed during construction could be covered with a geotextile or temporary vegetative covering to protect them from erosion. This soil would normally be reclaimed for reuse on site—as backfill for facility excavations, for example. To reduce the risk from exposing contaminated soils, areas in which new facilities would be constructed would be surveyed prior to any ground disturbance, and any contamination could be remediated as necessary.

Mitigation measures, such as controlling the spread of contaminated soil or preventing the recontamination of remediated areas during decommissioning, could be implemented through the use of work sequencing, soil stabilization measures, temporary covers, and exclusion zones. Impacts on soils could also be mitigated by grading the land to create contours consistent with the surrounding environment.

7.1.6 Water Resources

There would be no direct discharge of effluents to either surface waters or groundwater during new facility construction, operations, or subsequent deactivation, and no appreciable impact on water quality is expected to result from routine activities. Nonhazardous process wastewater would be discharged to the Treated Effluent Disposal Facility in the 200-East Area, while radioactive liquid effluents would be discharged to the 200 Area Liquid Effluent Retention Facility prior to treatment in the Effluent Treatment Facility (ETF). It was assumed that these facilities, or their equivalents, would continue to be available to manage process liquids generated under the action alternatives, and that any necessary life extensions or replacements would be completed as needed.

Surface water and groundwater would be protected from hazardous materials spills by development and implementation of spill prevention and contingency plans for instances in which hazardous materials are being handled. These plans to minimize the potential for hazardous materials spills would include provisions for storage of hazardous materials and refueling of construction equipment within the confines of protective berms, as well as cleanup and recovery plans and emergency response notification plans and procedures. Spills would also be reduced by keeping vehicles and equipment in good working order to prevent oil and fuel leaks. Soil erosion and sediment control plans and stormwater pollution prevention plans would be implemented, as required, for any earth-disturbing activity to minimize the transport of suspended sediment or other deleterious materials to surface-water or groundwater bodies.

Portions of the probable maximum flood zone associated with Cold Creek lie within the confines of Borrow Area C. Mining of geologic materials to support tank closure and waste management activities would include consideration of impacts on the watercourse and associated floodplain. Any changes in the extent and nature of predicted mining that could impact the floodplain would be evaluated, and a floodplain assessment would be prepared, as required by Executive Order 11988, *Floodplain Management*, and other Federal regulations (10 CFR 1022).

Water resources requirements under any of the *TC & WM EIS* alternatives would be well below available resources; therefore, no mitigation would be required to provide alternative supplies. However, whenever possible, water conservation practices could be implemented.

Impacts on groundwater would occur over the long term under all of the alternatives. Contaminants from past SST system leaks and releases and other historic waste discharges in the 200 Areas that are already resident in the vadose zone would continue migrating downgradient to the unconfined aquifer and toward the Columbia River. Any future leaks from the SST or DST system and onsite disposal of waste would add to these impacts. The Tank Closure No Action Alternative would make the largest additional incremental contribution to existing contaminant releases over the long term because no tank waste retrieval and treatment or SST system closure would be performed. Even after implementation of corrective action measures to fill deteriorating tanks with grout or gravel, Hanford SSTs, DSTs, and miscellaneous underground storage tanks would fail over time, resulting in the unmitigated release of their entire contents to the vadose zone and unconfined aquifer system. However, elements of the Tank Closure action alternatives for tank waste storage, retrieval, treatment, and disposal and SST system closure that are analyzed in this *TC & WM EIS* incorporate mitigation measures to varying degrees for attenuating long-term groundwater-quality impacts. Under all of the Tank Closure action alternatives, waste residing in the SSTs and DSTs would be retrieved for treatment, leaving residual waste ranging from 0.1 to 10 percent of the waste volume in place. This *TC & WM EIS* assumed leaks from the SST system would occur during retrieval operations. As the analysis shows, even if the tanks were to leak during retrieval, retrieval and treatment of tank waste would reduce the incremental contribution of tank farm actions over the long term.

Waste forms generated as a result of tank waste treatment and from contaminated soil and debris would be disposed of in an onsite, engineered disposal facility (either an IDF or the RPPDF). Liners and leachate collection systems would be used to control infiltration of surface water, prevent effluent releases to the vadose zone, and actively monitor contaminant release levels so that appropriate corrective actions can be implemented. Corrective actions include installation of additional temporary barriers to halt contaminant migration or exhumation of waste for further treatment before redisposal. Temporary barriers have been placed on tank farms and could be applied to other locations. WTP immobilized low-activity waste (ILAW) forms could be formulated to preferentially retain contaminants to retard their release to the subsurface, or pretreatment steps could be employed to remove problematic constituents prior to treatment and disposal. Similarly, grouting of certain mixed low-level radioactive waste (MLLW) streams could prove successful in delaying release of some contaminants. However, in the long term, contaminants would eventually be released as systems fail and would eventually impact the vadose zone and groundwater.

DOE uses a proactive approach to protecting groundwater through the performance assessment process. Disposal facility performance assessments are routinely reviewed to ensure that facilities meet requirements established in DOE Orders 435.1, *Radioactive Waste Management*, and 458.1, *Radiation Protection of the Public and the Environment*. Changes in disposal facility waste acceptance criteria could be enforced if a review indicates that groundwater contamination might exceed applicable requirements. As a result, some waste could require further treatment prior to disposal, additional confinement (such as disposal in high-integrity containers), or the development and use of better long-term-performing waste forms. Waste that does not meet the waste acceptance criteria for immediate disposal could be stored until another treatment or disposal method is found.

Most Tank Closure alternatives would employ landfill closure of the tank farms, which would include placing an engineered surface barrier (either the modified Resource Conservation and Recovery Act [RCRA] Subtitle C barrier or the Hanford barrier design) over the tank farms to minimize water infiltration through the residual tank waste inventories and its subsequent transport through the vadose zone. The surface barrier would be monitored and maintained during a 100-year postclosure care period to ensure its structural integrity. For the Tank Closure alternatives that would employ clean closure of all tank farms (i.e., Alternatives 6A and 6B), the impacts were analyzed without assessment of such barriers. Tank Closure Alternative 4 represents a partial clean closure alternative; the BX and SX tank farms would be excavated and clean-closed, whereas other tank farms would be left in place. In addition, engineered surface barriers would be constructed for FFTF entombment and closure of waste management disposal facilities, such as one or two IDFs and the RPPDF. The Hanford barrier, a more robust surface barrier analyzed under Tank Closure Alternative 5, is a potential mitigating measure that could be incorporated into all alternatives for closure of tank farms, cribs and trenches (ditches), and waste management disposal facilities, depending on its performance compared with the RCRA Subtitle C barrier.

The engineered surface barriers that would be constructed for in-place closure of the tank farms, FFTF entombment, or closure of the waste management disposal facilities would have an extensive groundwater-quality monitoring network of observation wells to detect contaminant releases. Given that releases of contaminants from the closed disposal facilities or tank farms would occur hundreds or thousands of years into the future, groundwater-quality monitoring systems may need to remain in place far beyond the 30- or 100-year periods assumed under current regulations and incorporated into these alternatives. Should the monitoring system detect releases that could lead to significant deterioration of groundwater quality, DOE could implement one or more of the following mitigation measures:

- The same types of technologies that could be implemented to address existing groundwater contamination could be implemented to remediate potential future groundwater contamination under any *TC & WM EIS* alternative.

- The same technologies and actions described under the clean closure alternatives for tank, ancillary equipment, and contaminated soil removal could be implemented to remove the source(s) of all or a portion of the contaminants from the vadose zone on a location-by-location basis.

- Surface controls (e.g., hydraulic barriers, water run-on and runoff management systems, leachate collection systems) implemented to limit and control infiltration through engineered barriers could be replaced by more-robust and -effective systems and/or subsurface contaminant migration control systems (e.g., grout curtains, chemical barriers, injected sequestering agents).

- Postclosure care, associated administrative controls, and monitoring and maintenance of the closure systems (e.g., groundwater monitoring; restriction of access to the surface of the sites; routine repair of remediation systems, including surface barrier lobes), which were assumed to end after 100 years, could be extended and/or implemented to restrict access to groundwater by future site users.

Of particular interest when considering long-term impacts on groundwater, and as discussed in detail in Chapter 5, are hydrogen-3 (tritium), iodine-129, technetium-99, chromium, nitrate, uranium-238, and total uranium. Collectively, these COPCs account for essentially 100 percent of the risk and hazard drivers when analyzing long-term groundwater impacts of the *TC & WM EIS* alternatives. Tritium is a short-lived radionuclide (with a half-life of 12.7 years) that is projected to decay to below benchmark concentrations before reaching the Columbia River. Iodine-129, technetium-99, chromium, and nitrate are referred to as "conservative tracers" due to their mobility and because they are long-lived or persistent in the environment. Under Tank Closure Alternatives 6A and 6B, in which the SST farms would be clean-closed, the peak concentrations of conservative tracers at the Core Zone Boundary were projected to have occurred during the past-practice period due to past leaks from SST farms and discharges to cribs and trenches (ditches). Under Tank Closure Alternatives 1 and 2A, in which tank farm closure would not be achieved, the peak concentrations at the Core Zone Boundary would occur shortly after the post–administrative control period ends, when any residual waste in the SSTs or DSTs would be released into the vadose zone. The end of the post–administrative control period ranges from calendar year (CY) 2107 under Tank Closure Alternative 1 to CY 2193 under Tank Closure Alternative 2A. Uranium-238 and total uranium are characterized by limited mobility and are projected to reach peak concentrations at the Core Zone Boundary at a much later date than the other, more-mobile COPCs (i.e., after CY 5000).

Under the FFTF Decommissioning alternatives, tritium and technetium-99 are the risk drivers; however, neither of these COPCs is projected to exceed benchmark standards within the 400 Area Property Protected Area or at the Columbia River.

The same COPCs as discussed above in regard to the Tank Closure alternatives are also the risk and hazard drivers under the Waste Management action alternatives. However, the performance of an IDF in the 200-East Area (IDF-East), an IDF in the 200-West Area (IDF-West) under Waste Management Alternative 3, and the RPPDF and their related impacts on groundwater would be largely influenced by waste form performance and the partitioning of COPCs between the various waste forms. Generally, ILAW (e.g., vitrified waste) forms perform better than supplemental- and secondary-waste forms. A major contributing factor to the groundwater-related impacts of the Waste Management alternatives is disposal of offsite waste from other DOE facilities. Under the Waste Management action alternatives, iodine-129 and technetium-99 that leach from an IDF would be the largest contributors to groundwater impacts when compared with other *TC & WM EIS* sources (i.e., Tank Closure and FFTF Decommissioning action alternatives).

This *TC & WM EIS* shows that receipt of offsite waste streams that contain specific amounts of certain isotopes, specifically iodine-129 and technetium-99, could cause an adverse impact on the environment. As evaluated in this EIS, 2.3 curies of iodine-129 from offsite waste streams could cause impacts above benchmark standards, regardless of whether this waste stream is disposed of in the 200-East Area under Waste Management Alternative 2 or in the 200-West Area under Waste Management Alternative 3. The technetium-99 inventory of 1,460 curies from offsite waste streams evaluated in this EIS could cause impacts that are less significant than those of iodine-129. However, considering the combined impacts of technetium-99 from offsite waste streams and from past leaks and cribs and trenches (ditches), DOE believes it may not be prudent to add significant additional technetium-99 to the existing environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of offsite waste streams containing iodine-129 or technetium-99 at Hanford. For example, DOE evaluated the effect of applying waste acceptance criteria to offsite waste by removing a highly radioactive waste stream (i.e., high inventories of iodine-129 and technetium-99) from the inventory of offsite waste analyzed for disposal at Hanford in this final EIS. The removal of this waste stream from the offsite inventories presented in Appendix D, Section D.3.6, Tables D–86, D–87, and D–88 significantly reduces the radionuclide inventory used in groundwater analyses, particularly for iodine-129 and technetium-99. This *Final TC & WM EIS* considers the receipt of offsite waste containing 2.3 curies of iodine-129 and 1,460 curies of technetium-99, whereas the *Draft TC & WM EIS* evaluated approximately 15 curies of iodine-129 and 1,790 curies of technetium-99.

Appendix D provides detailed discussion and assumptions regarding the partitioning of COPCs between the various waste form products. One of the assumptions of the *TC & WM EIS* analysis is that approximately 20 percent of iodine-129 would be captured in primary-waste forms (e.g., ILAW, bulk vitrification glass, steam reforming waste); the volatilized balance would be recovered in secondary-waste forms. The only exception would be under Tank Closure Alternatives 3B, 4, and 5, in which cast stone would capture a higher percentage of iodine-129 due to the nonthermal nature of this treatment technology. As mentioned above, iodine-129 is a conservative tracer with a half-life of approximately 17 million years and is projected to exceed benchmark concentrations. As such, reasonable mitigation measures could be considered that would recycle secondary-waste streams into the primary-waste-stream feeds within the WTP to increase iodine-129 capture in ILAW and bulk vitrification glass, which are considered more-stable waste forms than those associated with secondary waste. The current WTP design supports the ability to recycle. For example, one method would involve the recycling of iodine within the WTP by capturing it in the submerged bed scrubber and returning it to pretreatment. This recycling could theoretically concentrate the iodine in the feed stream, which, in turn, could put more iodine in a specific volume of glass product. Also, the development of more-robust, longer-performing waste forms, particularly in regard to cast stone waste, steam reforming waste, and other grouted waste (i.e., ETF-generated secondary waste), could be pursued.

Another assumption detailed in Appendix D of this *TC & WM EIS* is partitioning of technetium-99 in IHLW, ILAW, and supplemental treatment primary-waste forms. Without technetium-99 removal as a pretreatment step in the WTP, the analysis assumes that roughly 97 to 98 percent of the technetium-99 from treated tank waste would be captured in ILAW or supplemental-waste products, 1 to 2 percent would be captured in secondary-waste forms, and less than 1 percent would be captured in IHLW. The further partitioning of technetium-99 among ILAW and supplemental-waste forms would be generally proportional to the volume of waste that would be treated in each of the facilities. For example, under Tank Closure Alternative 3A, technetium-99 was assumed to partition in primary-waste forms at 28 percent, 38 percent, and 32 percent between ILAW processed in the WTP, bulk vitrification glass processed in the 200-East Area Bulk Vitrification Facility, and bulk vitrification glass processed in the 200-West Area Bulk Vitrification Facility, respectively. However, under Tank Closure Alternative 2B, in which technetium-99 removal would be incorporated as a pretreatment step in the WTP, 97.5 percent of technetium-99 is expected to be captured in IHLW and only 1 percent in ILAW. In addition, under Tank Closure Alternative 3B, in which technetium-99 removal would be employed in the WTP, 99 percent of the technetium-99 in the waste treated in the 200-East Area would be incorporated in IHLW. Similar to iodine-129 above, technetium-99 is a conservative tracer with a long half-life (211,000 years) and is projected to exceed benchmark standards. Potential mitigation measures that could be considered include technetium-99 removal as a pretreatment option in the WTP. Also, the development of more-robust, longer-performing waste forms, particularly for supplemental treatment technologies and other grouted waste (i.e., ETF-generated secondary waste), could be pursued.

In response to comments received on the *Draft TC & WM EIS* concerning these potential long-term impacts on groundwater resources, additional sensitivity analyses were performed and are included in this final EIS. The additional analyses focus on factors perceived to have a substantial influence on the magnitude of long-term groundwater impacts. Section 7.5 summarizes the results of these analyses and their relative importance to mitigation planning.

7.1.7 Ecological Resources

Short-term impacts on ecological resources could potentially upset terrestrial habitats and compromise threatened and endangered species. The significance of these impacts would largely depend on the amount of new land disturbance that would occur under each *TC & WM EIS* alternative. Disturbance of new land could be minimized by employing the same mitigation measures discussed in Section 7.1.1.

Ecological resources in the Industrial-Exclusive zone of the Central Plateau have been adversely affected from previous disturbances of the area, including the 24 Command and Wautoma Fires (see Chapter 3, Section 3.2.7). However, the fires did not affect the 200-East Area. New facility construction under the Tank Closure and Waste Management alternatives would impact sagebrush habitat to varying degrees, depending on the alternative. Chapter 4, Sections 4.1.7 and 4.3.7, discuss the total area of sagebrush habitat that would be affected under each alternative. This loss may be subject to compensatory mitigation at a ratio of 1:1 to 3:1, as prescribed in the *BRMaP* (DOE 2001) and the *Hanford Site Biological Resources Mitigation Strategy* (DOE 2003a). In addition, some habitats and species that have repopulated the burned areas could also be subject to mitigation under existing biological conditions and current mitigation guidelines. Within the Central Plateau, several state-listed, special status species of plants and wildlife have been observed or have the potential for inhabiting the areas of disturbance. The noted species include two state watch plant species, the stalked-pod milkvetch and crouching milkvetch, which would not require mitigation, although they could be considered in project planning. Other, more-protected species that are considered Level III resources under the *BRMaP* (DOE 2001) would potentially require active mitigation (e.g., Piper's daisy [state sensitive]; loggerhead shrike and northern sagebrush lizard [Federal species of concern and state candidates]; black-tailed jackrabbit, sage sparrow, striped whipsnake, and sage thrasher [state candidates]). No significant ecological impacts, and therefore no mitigation activities, are expected to occur in the 400 Area under any of the FFTF Decommissioning alternatives.

The extent of ecological impacts on Borrow Area C would depend on the amount of geologic materials that would need to be mined to support backfilling needs, construction of new facilities, and construction of engineered surface barriers. The maximum impacts would occur under the Tank Closure alternatives that involve clean closure of the tanks and cribs and trenches (ditches) (i.e., Alternatives 6A and 6B, Option Cases) and under Waste Management Alternatives 2 and 3, Disposal Groups 2 and 3 (in which one or two IDFs and the RPPDF would be sized for the largest capacities). Vegetation communities located within Borrow Area C include cheatgrass/bluegrass and needle-and-thread grass/Indian ricegrass. The latter represents an unusual and relatively pristine community type at Hanford and is more highly valued. In addition to Piper's daisy, stalked-pod milkvetch, and crouching milkvetch, which are also found in the Central Plateau, as discussed above, the long-billed curlew (state monitor) has been identified in Borrow Area C.

Biological surveys of areas potentially affected under the action alternatives have been completed (Sackschewsky 2003a, 2003b). While current biological conditions and mitigation guidelines are appropriate for determining mitigation requirements for near-term impacts, they are not suitable for judging long-term mitigation requirements because habitats and species assemblages may change over time. Consequently, actual mitigation requirements for later activities that would occur under the alternatives considered would depend on the results of field surveys conducted just prior to initiating ground-disturbing activities and the mitigation guidelines in effect at Hanford at that time.

In addition to preparation of a comprehensive mitigation action plan to address the impacts on Level III resources (Piper's daisy, black-tailed jackrabbit, loggerhead shrike, and sage sparrow) and sagebrush habitat, the following mitigation measures could be implemented to minimize short-term impacts on terrestrial resources and threatened and endangered species:

- Conduct proper maintenance of heavy equipment, and clearly mark construction zones to prevent intrusion into sensitive areas or outside work areas.
- Implement noise-reduction measures, as discussed in Section 7.1.3.
- Implement spill prevention and control plans, as discussed in Section 7.1.6.
- Avoid, to the maximum extent possible, disturbance of the needle-and-thread grass/Indian ricegrass communities in Borrow Area C.
- Avoid performing land-disturbing activities during animal breeding and nesting periods.

The long-term impacts of air emissions and groundwater contamination on ecological receptors are correlated with the amount and timing of air emissions and releases of contaminants to the vadose zone and underlying aquifers. As discussed in Chapter 5, radioactive COPCs from air emissions are not projected to be a risk to ecological receptors. Groundwater impacts at the Columbia River associated with nonradioactive and radioactive COPCs are also not projected to be a significant risk; however, chromium would pose a slightly elevated risk to aquatic biota at the Columbia River under most Tank Closure and Waste Management alternatives. In some cases, moderate risks associated with nonradioactive COPCs from air emissions are projected. The majority of impacts are associated with mercury and xylene under the Tank Closure alternatives and with xylene alone under the FFTF Decommissioning and Waste Management alternatives. However, as presented in Appendix D, for conservative analysis, the mercury inventory was assumed both to be captured in waste forms and to be emitted into the air. The assumption under most action alternatives that essentially 100 percent of the mercury inventory should be included in air emission analysis (i.e., almost 100 percent of the mercury inventory was assumed to be captured in waste-form products) suggests that the risk from mercury is conservatively overstated. Implementing any of the mitigation measures discussed in Sections 7.1.4 and 7.1.6, which would reduce air and groundwater impacts, would also serve to reduce impacts on ecological receptors. Other mitigation measures could include performing periodic ecological surveys to monitor trends in terrestrial, riparian, and aquatic populations.

7.1.8 Cultural and Paleontological Resources

Although no alternative is expected to impact any prehistoric or other significant cultural resource, the potential for inadvertent discovery of prehistoric resources exists. Avoidance of identified resources would be the primary form of mitigation, wherever practical. To avoid loss of cultural resources during new facility construction, cultural resource surveys have been and may in the future be conducted in areas of interest. An archaeological monitor could be assigned to oversee any highly sensitive areas during ground-disturbing activities to ensure that, whenever possible, construction impacts are limited to the project area. If any cultural resources are discovered during construction, construction would be halted, and procedures set forth in the *HCRMP* (DOE 2003b) would be implemented.

The construction of new facilities in the Central Plateau would increase the industrial profile of the area from higher elevations. Likewise, excavation of Borrow Area C would alter the view of this area from higher elevations, such as Rattlesnake Mountain, which is of cultural interest to local American Indian tribes. To mitigate potential visual impacts on, or interference with, tribal and religious ceremonies on Rattlesnake Mountain, borrow material could be stockpiled or the timing of excavation activities could be coordinated with the tribes. For example, excavation could be conducted at night to avoid affecting certain ceremonies that might be performed during the day. The consolidation of existing activities or facilities and the removal of unnecessary facilities or infrastructure on Rattlesnake Mountain would tend to improve the visual profile of the mountain, allow restoration of the natural habitat, and enhance tribal religious and cultural experiences. The restoration of land used for *TC & WM EIS* activities, as well as restoration of Borrow Area C in accordance with the appropriate resource management plans, such as a final adopted version of the *Draft Industrial Mineral Resources Management Plan* (Reidel, Hathaway, and Gano 2001), would lessen these visual impacts. DOE will continue its ongoing practice of consulting with American Indian tribes concerning potential impacts that may affect traditional cultural properties, including visual impacts. Where needed, measures to restore disturbed land or to avoid or minimize these impacts would be developed and implemented in coordination with area tribes in a culturally relevant manner consistent with the *BRMaP* (DOE 2001).

7.1.9 Socioeconomics

The potential exists for substantial impacts on regional socioeconomic conditions under all of the *TC & WM EIS* alternatives. Under the Tank Closure No Action Alternative, termination of WTP construction would lead to a noticeable and immediate short-term effect on the regional economy due to loss of employment and revenue. This loss of jobs could not be easily mitigated, as workers with certain skill sets could find it difficult to find comparable employment in the region. In contrast, implementation of any of the action alternatives would significantly increase the demand for professional, skilled, and unskilled labor. This would affect the regional economy, demographic characteristics, and housing and community services in the socioeconomic region of influence for the foreseeable future. Construction activities would cause short-term spikes in employment and demands on the regional economy. These short-term spikes could place a strain on the availability of housing and could cause large upward and downward swings in housing prices. These spikes could also strain local school districts and other public services. Secondary effects on housing and community services would be somewhat mitigated by the fact that the spike in employment would be associated with construction. The long duration of some alternatives during the operations phase would lead to a more stable, long-term demand on regional socioeconomics. Data indicate that vacant permanent housing for sale and rent in the region may be insufficient to meet the demand under some action alternatives (see Chapter 3, Section 3.2.9.3, and Chapter 4, Section 4.1.9). It is anticipated that additional demand would stimulate construction of permanent and other forms of housing to meet the influx of construction workers, thereby producing a positive effect on the regional economy. Similarly, the direct and indirect income associated with procurement of equipment and supplies for completion of the WTP and associated new facility construction would be another economic benefit. Nevertheless, school enrollments associated with the influx of construction and operations workers and their families are expected to increase, and utility, community safety, and police and fire services may need to be expanded to meet demand.

Careful scheduling of activities, particularly during the construction phases, could reduce the severity of short-term spikes. Certain facilities could be built in sequence, rather than concurrently, although this could cause some small delays in initiation or completion of the projects and increases in project cost.

Implementing any action alternative could impact local transportation infrastructure, especially during commuting periods. The local transportation system has additional capacity during noncommuting periods, but has no additional capacity during the morning and evening peaks (see Chapter 4, Sections 4.1.9, 4.2.9, and 4.3.9). As also described in these subsections, employee commuter traffic and truck traffic would peak at various times, depending on the nature and intensity of the activities being conducted under each alternative. This combined effect would decrease the available capacity of site access roads during the morning and evening rush hours. Possible measures that could be used to mitigate traffic volume impacts are physical improvements to local and onsite roads to increase capacity, including construction of additional vehicle lanes throughout road segments; construction of passing lanes in certain locations; or realignment of roadways to reduce points of congestion. Employee programs that provide flexible hours or staggered work shifts to reduce peak traffic volumes also could reduce local transportation impacts. In addition, employee programs and incentives encouraging ridesharing could be established, and existing bus and/or vanpool programs could be expanded. Under Washington State law (Washington State 2006), major employers in Benton and Franklin Counties and the cities of Kennewick, Pasco, Richland, and West Richland must adopt commute trip reduction plans. The intent of the commute trip reduction policy is to reduce commutes by workers from their homes to major work sites during the peak period of 6:00 A.M. to 9:00 A.M. on weekdays. Construction work sites are generally excluded under the law, provided the construction duration is less than 2 years. The ongoing construction of the Hanford WTP would likely not be exempt.

Transport of geologic materials from Borrow Area C across State Route 240 to the 200 Areas presents a particular concern for its potential to cause traffic congestion and accidents and may require specific mitigation measures. Safety measures could include dust control; restrictions on crossings to non-shift-change hours; signs and warning lights along State Route 240 to the north, south, and well in advance of the crossing; and a traffic control light at the crossing itself.

7.1.10 Public and Occupational Health and Safety

Current and anticipated design, construction, and operations of waste treatment and disposal facilities would incorporate the best available technology and engineering controls to limit the discharge of potentially hazardous materials to the environment. The peak annual dose to both the on- and offsite maximally exposed individual through the inhalation pathway is projected to be well below the regulatory limit of 10 millirem per year (40 CFR 61, Subpart H) under all alternatives analyzed.

Although doses are expected to remain below any regulatory limits, the years of peak radiological impacts on the public would coincide with strontium and cesium processing. One option for mitigating this impact could be to alter the treatment strategy by distributing the treatment of strontium and cesium capsules over a longer period of time or by incorporating more-aggressive air pollution control technology designed to target strontium and cesium emissions.

Workers would receive radiation doses under the *TC & WM EIS* alternatives. For all work activities involving radiation, the principle of maintaining doses as low as is reasonably achievable (ALARA) would be followed. This principle would involve formal analysis by workers, supervisors, and radiation and/or chemical protection personnel of the work in a hazardous environment to reduce exposure of workers to the lowest practicable level. Examples of ALARA measures could include minimizing time spent in the field of radiation, maximizing distances from sources of radiation, using shielding whenever possible, and/or reducing the radioactive source. Mitigation measures also would be used to protect workers from radiological and chemical exposure hazards during construction, operations, and demolition activities. These mitigation measures would be derived from formal radiation protection programs and chemical hazards management programs. Examples of specific measures could include using personal protective equipment (e.g., Tyvek suits, face masks), shielding (e.g., earth berms, concrete walls, steel plates, lead bricks), and remotely operated robotic machinery; training workers; and spreading the work across a larger number of workers. All activities that affect the handling, treatment, storage, or disposal of radioactive waste would be performed within the limits of a DOE-approved safety basis. The safety basis would be established by evaluating potential accidents and defining appropriate controls to ensure that accident impacts are below required levels.

The regulatory limit for a worker dose is 5,000 millirem per year (10 CFR 835). The recommended DOE Administrative Control Level for a worker dose is 500 millirem per year (DOE Standard 1098-2008). The analysis of worker dose presented in Chapter 4, Sections 4.1.10, 4.2.10, and 4.3.10, calculated an aggregated average dose for a full-time-equivalent (FTE) worker over all activities included under each alternative. For example, an average annual dose reported to be 500 millirem per year would indicate that, unless mitigation measures were taken, a portion of an alternative's activities would exceed DOE's administrative control level and a portion would be below this level. Under Tank Closure Alternatives 4 and 6B, the average annual dose would exceed 500 millirem per year without mitigation measures. Under Tank Closure Alternative 6A, the average annual dose would approach 500 millirem per year. The high average FTE worker dose incurred in these cases would be primarily due to the exhumation of tank farms and underlying radioactively contaminated soils. In these cases, a comprehensive evaluation of worker exposures may be warranted and, whenever possible, applicable ALARA techniques or other mitigation measures similar to those discussed above may be necessary to ensure the worker dose is reduced and maintained below 500 millirem per year. Under all other *TC & WM EIS* alternatives, the FTE worker dose would be sufficiently low that the probability of any worker dose exceeding 500 millirem per year would be low.

Long-term impacts on human health were analyzed using a variety of receptors and receptor locations, as discussed in Chapter 5 and detailed further in Appendix K. In summary, the offsite receptor locations are the Columbia River itself and downstream population centers. One receptor is an American Indian hunter-gatherer, who, like people living in the downstream population centers, would consume water from the Columbia River. In contrast, the onsite receptors (i.e., the drinking-water well user, resident farmer, and American Indian resident farmer) would directly consume groundwater for drinking water, and, in some cases, would use groundwater to irrigate crops. The exposure scenarios for onsite receptors involve several locations within the Core Zone Boundary and at the Columbia River nearshore. The COPCs that are drivers for groundwater impacts, briefly discussed in Section 7.1.6, are also the drivers for human health impacts.

Because of the substantial dilution that would take place as groundwater seeps into the Columbia River, impacts on downstream population centers and the American Indian hunter-gatherer, both of whom would use surface water as a source of drinking water or might consume fish from the Colombia River, would be negligible compared with background exposures. However, impacts on any receptor that consumes groundwater as a drinking water source and uses groundwater to irrigate crops within the Core Zone Boundary would exceed dose standards and Hazard Indices for either one or multiple COPCs. These impacts on receptors at onsite locations could not be directly mitigable because the underlying assumption is that access to the site and its groundwater resources would be attainable at some future date after all institutional controls are no longer in force. However, implementing any of the mitigation measures discussed in Section 7.1.6, which would reduce groundwater impacts, may also reduce impacts on human health.

All shipments of radioactive or hazardous materials on public roads would be performed within applicable regulatory requirements that address the following:

- Waste packaging in containers certified for use in waste transport
- Training and licensing requirements for transporters
- Notification of potentially affected organizations

Potential mitigation measures to reduce impacts on workers and the public could include packaging the waste to reduce radiation doses below regulatory limits, selecting transportation routes to minimize exposure to populations along the route, and scheduling transport to avoid high-traffic times and locations. The latter could also reduce congestion and transportation delays, thereby reducing radiological exposure and the potential for traffic accidents.

7.1.11 Waste Management

This *TC & WM EIS* analyzes the construction, operations, and closure of permanent disposal facilities to support the disposal of the waste that would be generated under each of the Tank Closure, FFTF Decommissioning, and Waste Management alternatives. These permanent disposal facilities would include IDF-East, IDF-West, and the RPPDF, which would be located in an area between the 200-East and 200-West Areas. A more detailed description of the IDF and RPPDF is provided in Chapter 2 and Appendix E. This *TC & WM EIS* analyzes several configurations of the IDF and RPPDF, depending on the capacity and duration of operations required; these configurations are referred to as "disposal groups." A disposal group is designed to conservatively provide disposal capacity to multiple Tank Closure alternatives; thus, under some Tank Closure alternatives, the full capacity of the disposal facilities, as analyzed in this EIS, may not be used. Chapter 2 provides a more detailed description of the disposal groups, including an explanation of how they were determined and which Tank Closure alternatives would be supported under each disposal group.

Permanent disposal facilities (i.e., one or two IDFs and the RPPDF) would be constructed with an RCRA-compliant liner and leachate collection system to manage infiltration and prevent the release of contaminants into the vadose zone. Each permanent disposal area would be closed and covered with an engineered modified RCRA Subtitle C barrier. The emplacement of a more robust Hanford barrier design, which may further mitigate infiltration of surface water and extend the lifetime of the structural integrity of the barrier, is analyzed under Tank Closure Alternative 5. These engineered surface barriers, constructed for in-place closure of the tank farms, entombment of FFTF, or closure of the waste management disposal facilities, could have an extensive groundwater-quality monitoring network of observation wells to detect contaminant releases.

Except for the Tank Closure No Action Alternative, HLW would be generated under all of the Tank Closure alternatives. Under Tank Closure Alternative 6A, all tank waste would be treated and formed into IHLW in the WTP. Under Tank Closure Alternatives 6A, 6B, and 6C, all treated tank waste would be managed as HLW. In addition to the IHLW, HLW melters, which are used to vitrify HLW as part of WTP operations, would be taken out of service and would require disposal. The amount of treated tank waste managed as HLW under Tank Closure Alternative 6A, 6B, or 6C would be at least 14 times more than that of any other action alternative. Under these alternatives, the treated tank waste would be stored on site. The increase in the volume of waste managed as HLW under Tank Closure Alternatives 6A, 6B, and 6C would also result in a corresponding reduction in the volume of ILAW glass that would require onsite disposal in an IDF.

Sulfate removal is a WTP pretreatment step analyzed under Tank Closure Alternative 5. Sulfate removal has the potential to mitigate impacts on the waste management system (see Appendix E, Section E.1.2.3.9). This technology would remove sulfates from the tank waste stream, thereby reducing corrosivity and potentially extending melter life. This may lead to a reduction in melters taken out of service that would otherwise require disposal. The removal of sulfates may also enable increased waste loading from 14 weight-percent sodium oxide loading to 20 weight-percent sodium oxide loading, thereby potentially reducing the number of IHLW and/or ILAW canisters that would be produced (CEES 2007). However, sulfate grout waste would be generated and would require disposal in an IDF.

DOE has a longstanding policy to minimize waste generation. DOE is implementing Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*, by conducting its environmental, transportation, and energy-related activities under the law in an environmentally, economically, and fiscally sound, integrated, continuously improving, efficient, and sustainable manner. Hanford has a pollution prevention program that was formalized in the *Hanford Site Waste Minimization and Pollution Prevention Awareness Program Plan* (DOE 1999b). Program components include waste minimization, recycling, source reduction, and buying practices that give preference to products made from recycled materials. Implementation of the pollution prevention and waste minimization plans could minimize the generation of secondary waste.

7.1.12 Alternative Combinations

Generally, potential mitigation measures for each resource area would remain the same regardless of the selected combination of alternatives; therefore, additional discussion of mitigation measures across the three alternative combinations would be redundant. However, wherever appropriate in the previous subsections of Section 7.1, mitigation measures may be specifically discussed for a particular alternative (e.g., Tank Closure) when analysis suggests that a specific impact of that alternative may need more emphasis. The alternative combinations and their effects on short-term impacts are discussed in more detail in Chapter 4, Section 4.4.

7.2 UNAVOIDABLE, ADVERSE ENVIRONMENTAL IMPACTS

Unavoidable, adverse environmental impacts are those that would occur after implementation of all feasible mitigation measures, including those design elements incorporated in and analyzed under the individual *TC & WM EIS* alternatives. Implementing any of the alternatives considered in this *TC & WM EIS* would result in unavoidable, adverse impacts on the human environment. A summary discussion of these impacts is included in this section; however, a more detailed impacts discussion can be found for each resource area in the appropriate sections in Chapter 4 for short-term impacts and in Chapter 5 for long-term impacts.

Unavoidable, adverse environmental impacts may occur in either the short or long term. For analysis purposes in this EIS, "short-term" denotes the complete project life cycle under each alternative, during which construction, operations, decommissioning, deactivation, and closure activities would take place. All of the *TC & WM EIS* alternatives require either a 100-year administrative control or postclosure care period or storage of HLW for a significant period of time, either of which would contribute very little to impacts. Thus, the most significant unavoidable, adverse environmental impacts would occur in the earlier years of the short-term timeframes of the *TC & WM EIS* alternatives, during which all construction, operations, and deactivation activities would be completed and only postclosure care or storage activities would remain. A Tank Closure, FFTF Decommissioning, and Waste Management alternative would be implemented concurrently as an alternative combination, so while the short-term impacts under one *TC & WM EIS* alternative may end, they may continue under another.

"Long term" denotes the timeframe that extends beyond conclusion of the short-term project life-cycle period of each alternative. Under any viable alternative, it is expected that an increase in short-term adverse impacts would lead to an overall decrease in long-term adverse impacts (see Section 7.4).

7.2.1 Land Resources

Construction, consolidation, operations, maintenance, and deactivation of new or existing facilities would be required to support the action alternatives and would result in short-term adverse impacts on land and visual resources, including the development or use of undisturbed land. Visual impacts of existing structures and maintenance activities on Rattlesnake and Gable Mountains and land use for construction of new facilities are considered short-term impacts because, after a facility's mission has been completed, that facility would be deactivated and demolished, and vegetation and habitat would be reestablished to recreate the natural condition. Many of the facilities currently reside on or would be constructed on land that has been disturbed; thus, while this would be considered a short-term commitment of land, it would not necessarily be considered an adverse impact. Except for facilities associated with the FFTF Decommissioning alternatives, the IHLW Interim Storage Modules constructed under Tank Closure Alternative 6A, and Borrow Area C, new and existing facilities would be situated in the area designated

Industrial-Exclusive in the *Hanford Comprehensive Land-Use Plan EIS*. This area has been set aside for waste management activities. FFTF decommissioning activities at Hanford would take place within the 400 Area Property Protected Area, which is in an industrial use designated area (DOE 1999a). Borrow Area C is located at the end of Beloit Avenue, just south of State Route 240. Other land resource impacts are presented and discussed in Chapter 4, Sections 4.1.1, 4.2.1, and 4.3.1.

The amount of new land disturbance required for construction of facilities to support the Tank Closure alternatives ranges from 3.2 hectares (8 acres) under Alternative 2B to 186 hectares (460 acres) under Alternative 6A, Option Case. Under Tank Closure Alternatives 6A, 6B, and 6C, in which all tank waste would be managed as HLW and would require substantial facility storage space, the disturbance of new land would be very high compared with that of the remainder of the Tank Closure alternatives. Under the Tank Closure No Action Alternative, construction of the WTP and the Canister Storage Building would be terminated, and no new disturbance of land would be required. New land disturbance would not be necessary under any of the FFTF Decommissioning alternatives. Under the Waste Management No Action Alternative, no new land areas would be disturbed; only existing disposal facilities would be used. The amount of new land disturbance under the Waste Management action alternatives ranges from 63 hectares (155 acres) under Alternative 2, Disposal Group 1, to 240 hectares (594 acres) under Alternative 3, Disposal Group 3. All newly disturbed land under the Tank Closure alternatives would be used to construct treatment and storage facilities; because these facilities would eventually be deactivated and demolished, this disturbance would be considered a short-term adverse impact. The vast majority of newly disturbed land under the Waste Management alternatives would be used for construction of permanent disposal facilities, which would be considered a long-term impact. Less than 1 percent of the new land disturbed under the Waste Management alternatives, or 0.4 hectares (1 acre), would be used for construction of new treatment facilities.

Borrow Area C is the designated source of the geologic materials that would be used for construction, operations, deactivation, and closure activities. Geologic materials from Borrow Area C would be used for concrete and grout, backfill, and construction of engineered barriers. The unavoidable, adverse impacts would be the areal extent of land disturbance and the mining of geologic materials to a maximum depth of 4.6 meters (15 feet) in some locations. Despite any restoration efforts, the land contours and visual references would be unavoidably altered for the long term; however, the potential use of the land would remain as Conservation (Mining), as designated by the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a). Borrow Area C land disturbance required to support tank closure would range from 2 hectares (5 acres) under the Tank Closure No Action Alternative to 458 hectares (1,131 acres) under Tank Closure Alternative 6A, Option Case. The FFTF Decommissioning No Action Alternative would not require any geologic materials, but FFTF Decommissioning Alternative 3 would require disturbance of up to 3.2 hectares (8 acres) of Borrow Area C. Geologic materials would not be required under the Waste Management No Action Alternative, but Waste Management Alternative 2, Disposal Groups 2 and 3, would require disturbance of up to 159 hectares (392 acres) of Borrow Area C. The areal extent of land disturbance impacts would be commensurate with the total amount of geologic resources consumed, as discussed in more detail in Section 7.2.5.

7.2.2 Infrastructure

Implementation of the *TC & WM EIS* alternatives would not adversely affect the current infrastructure's long-term ability to provide energy, fuel, or water resources to support future actions. In the short term, under Tank Closure Alternative 6A, Base and Option Cases, in which all tank waste would be vitrified in WTP HLW melters, demand is projected to exceed the peak electrical capacity of Hanford's electric power distribution system. Even though the available peak capacity is not projected to be exceeded under other tank closure activities, electrical consumption is expected to remain near Hanford's peak capacity for the duration of the WTP operations analyzed under each alternative. However, this short-term adverse impact on electrical distribution can be mitigated, as discussed in Section 7.1.2.

7.2.3 Noise and Vibration

Increases in noise levels would be relatively low outside the immediate areas of construction; however, the combination of construction noise and associated human activity would likely displace small numbers of animals surrounding the work areas. Heavy diesel equipment used for construction under most of the alternatives is expected to result in the highest noise levels. The most obvious reaction of wildlife would be a startle or fright response resulting from transient, unexpected noise. Such noise could cause animals to flee the area. Lower, more-constant noise levels may cause wildlife to temporarily avoid the construction zone. None of the construction activities are located near residential areas. Noise impacts would be considered short-term impacts that would occur mainly during the construction phases of an alternative. Noise impacts are presented and discussed in Chapter 4, Sections 4.1.3, 4.2.3, and 4.3.3.

7.2.4 Air Quality

Implementation of the *TC & WM EIS* alternatives would cause unavoidable, adverse impacts on air quality resulting from the release of various criteria and toxic chemical constituents. Peak impacts of the release of criteria pollutants are expected to occur during construction activities. Under select Tank Closure alternatives, unmitigated air pollutant emissions could result in exceedance of standards for particulate matter, and in some cases, for carbon monoxide and nitrogen dioxide. The FFTF Decommissioning alternatives are not projected to exceed standards for criteria pollutants. All Waste Management alternatives except the No Action Alternative are projected to exceed standards for particulate matter and 1-hour standards for nitrogen dioxide and carbon monoxide. Under Waste Management Alternatives 2 and 3, Disposal Groups 1 and 2, the 1-hour standard for sulfur dioxide also projected to be exceeded.

All toxic air pollutants are projected to be below acceptable source impact levels, except for mercury under Tank Closure Alternatives 2B; 6B, Base and Option Cases; and 6C.

Even after employing the best available technology and management practices to bring air contaminants down to acceptable levels, complete elimination of criteria and toxic air pollutants would not be possible, and some unavoidable, adverse impacts would still occur. Nonradiological air quality impacts are presented and discussed in Chapter 4, Sections 4.1.4, 4.2.4, and 4.3.4.

In addition to nonradioactive air pollutants, unavoidable, adverse impacts on air quality would occur as a result of radioactive emissions. Unavoidable impacts on ecological receptors and human health due to radioactive air emissions are discussed in Sections 7.2.7 and 7.2.10, respectively.

7.2.5 Geology and Soils

Large volumes of geologic resource materials would be required for constructing facilities, backfilling excavations, constructing engineered barriers for closure of tank systems, entombing facilities, and closing landfill disposal sites. Such geologic resource materials would include rock, gravel, sand, clays, and soil. Under Tank Closure Alternatives 3A, 4, and 5, in which bulk vitrification would be employed as a supplemental treatment option, geologic resources would also be consumed. Section 7.3 and Chapter 4, Sections 4.1.5, 4.2.5, and 4.3.5, discuss impacts on geology and soils in more detail. Borrow Area C is the designated source of geologic materials for all activities discussed in this *TC & WM EIS*. This *TC & WM EIS* assumes that all geologic materials would be supplied from Borrow Area C.

The utilization of geologic materials would be the most significant under Tank Closure Alternatives 6A and 6B, in which the SST farms would be clean-closed, and Waste Management Alternatives 2 and 3, Disposal Groups 2 and 3, in which the disposal facilities would be designed and built to contain the largest disposal capacities.

7.2.6 Water Resources

Adverse impacts on subsurface soils and groundwater, which flow into and thus would subsequently affect the Columbia River, would be unavoidable over the long term under all of the *TC & WM EIS* alternatives due to historical releases of contaminants and the ongoing presence of onsite disposal areas. The greatest impact on water resources would occur under the No Action Alternative for tank closure, FFTF decommissioning, and waste management, in which the following would occur, respectively: (1) the storage tanks would be left to degrade over time, leading to the eventual release of untreated tank waste into the subsurface; (2) the remote-handled special components (RH-SCs) and bulk sodium would not be properly disposed of; and (3) construction of modern landfill facilities would not be completed. All of the action alternatives are designed to enhance waste-form and disposal area performance. Discussions of the long-term performance assessment, the projected impacts, and whether these impacts would exceed existing health- and risk-based standards are found in Chapter 4, Sections 4.1.6, 4.2.6, and 4.3.6, as well as in Chapter 5.

The unavoidable, adverse impacts on groundwater that would result from implementation of any of the *TC & WM EIS* action alternatives would be proportional to the amount of tank waste that would be retrieved for treatment and the performance of the primary- and secondary-waste forms. Even the high-performing ILAW that would be disposed of on site would eventually leach some COPCs into the subsurface. During any post–administrative control period, the eventual failure of engineered barriers, followed by infiltration of water through the permanent disposal facilities or in-place closure of other facilities, would facilitate migration of contaminants into the groundwater.

In addition to waste generated under the *TC & WM EIS* alternatives, the onsite non–Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) waste and any offsite waste that would be received and disposed of in an IDF or the RPPDF would contribute to any unavoidable impacts on groundwater.

7.2.7 Ecological Resources

Unavoidable, adverse impacts on ecological resources would be commensurate with the amount of new land disturbance that would occur as a result of a particular action, as previously discussed in Section 7.2.1. This would cause short-term unavoidable impacts on the natural habitat in these areas, affecting both plant and wildlife ecosystems. Microbiotic crusts, which are expected to occur only on undisturbed sites within the 200 Areas and Borrow Area C, would be destroyed by new construction and excavation activities. Ground disturbance would also result in the loss of less-mobile species, such as small mammals, reptiles, and amphibians. Larger, more-mobile species, including many mammals and birds, would be displaced to similar surrounding habitat. Their ultimate survival would depend on whether the areas into which they move are at their carrying capacity (i.e., whether they already contain the maximum number of individual animals that the habitat is capable of supporting). Over the long term, except for areas used for waste disposal, vegetation and wildlife would be reestablished to re-create the natural condition on land disturbed for construction of treatment facilities, including Borrow Area C.

Federally or state-listed threatened or endangered species have not been observed within or in the immediate vicinity of the 200 Areas or Borrow Area C; therefore, long-term impacts on these groups of plants and animals are not expected. However, there are several state-listed species of interest that may be adversely affected in newly disturbed land areas; these include the stalked-pod milkvetch, crouching milkvetch, Piper's daisy, black-tailed jackrabbit, loggerhead shrike, sage sparrow, and long-billed curlew.

The five ponds associated with the Liquid Effluent Retention Facility and Treated Effluent Disposal Facility, located within and adjacent to the 200-East Area, would receive effluent discharges. Although the Liquid Effluent Retention Facility ponds are covered by a floating membrane constructed of very low-density polyethylene (Poston, Duncan, and Dirkes 2011:6.24), the Treated Effluent Disposal Facility ponds are not covered and, therefore, are accessible to wildlife. Potential long-term indirect impacts on wildlife that depend on Columbia River aquatic resources are discussed in Chapter 4, Sections 4.1.7, 4.2.7, and 4.3.7.

In addition to new land disturbance, air and groundwater impacts over the long term would cause limited unavoidable, adverse impacts on ecological receptors. Even after implementation of air pollution control technologies, radioactive and nonradioactive COPCs would be deposited into area soils and the Columbia River as a result of emissions from facility operations. Furthermore, under all *TC & WM EIS* alternatives, some COPCs would eventually migrate to and seep into the Columbia River. However, as discussed in Chapter 5, most of these impacts are not projected to be a risk to ecological receptors. In a few cases, the impacts would represent a very small risk. Implementing the mitigation measures discussed in Section 7.1.7 would further reduce these impacts.

7.2.8 Cultural and Paleontological Resources

None of the *TC & WM EIS* alternatives or ongoing maintenance and operational activities are expected to significantly impact any prehistoric, historic, cultural, paleontological, or visual resources. Given that ground disturbance would be required under most alternatives, the potential for inadvertent discovery of prehistoric resources exists. If discovered, the mitigation steps described in Section 7.1.8 of this chapter would be implemented. Excavation of Borrow Area C would alter the view of this area from higher elevations, such as Rattlesnake Mountain, which is of cultural interest to local American Indians, even after restoration efforts have been completed. The consolidation of existing activities or facilities, removal of unnecessary facilities or infrastructure on Rattlesnake Mountain, and maintenance of firebreaks and access roads on Rattlesnake and Gable Mountains would constitute unavoidable, adverse short-term impacts, but over the long term would tend to improve the visual profiles on or from these natural features and allow restoration of natural habitat, thus enhancing tribal religious and cultural experiences.

7.2.9 Socioeconomics

The potential exists for substantial impacts on regional socioeconomic conditions under all of the *TC & WM EIS* alternatives. Under the Tank Closure No Action Alternative, termination of WTP construction would lead to a noticeable and immediate short-term effect on the regional economy due to the loss of employment and revenue. In contrast, implementation of any of the action alternatives would result in a significant increase in demand for professional, skilled, and unskilled labor. This would affect the regional economy, demographic characteristics, and housing and community services in the socioeconomic region of influence for the foreseeable future. Construction activities would cause short-term spikes in employment and demands on the regional economy. These short-term spikes could strain the availability of housing and cause large upward and downward swings in housing prices. These spikes could also strain local school districts and other public services. Additionally, the influx of people to the region would strain the local transportation system. These unavoidable impacts could not be easily mitigated; however, implementing the mitigation measures discussed in Section 7.1.9 of this chapter could reduce their effect on the region.

7.2.10 Public and Occupational Health and Safety

Normal facility operations and deactivation, including some closure activities, would result in unavoidable radiological exposure to workers and the general public. The general public would be exposed to radiation from facility air emissions. Impacts on the general population and maximally exposed individuals are discussed in Chapter 4, Sections 4.1.10, 4.2.10, and 4.3.10. Workers would be exposed to radiation from routine operations dealing with the processing of radioactive waste. Workers would have the highest levels of exposure due to proximity and length of exposure, but doses would be administratively controlled to ensure radiological exposure levels would not exceed occupational health and safety standards. In addition to radiological exposures, workers would be exposed to chemical hazards and would also incur injuries, possibly even fatalities, while performing routine work-related tasks. Except for Tank Closure Alternative 6A, Base and Option Cases, in which about three fatalities are projected, projected fatalities for routine work-related accidents were calculated to be less than one under all *TC & WM EIS* alternatives. Work-related accidents are discussed in Sections 4.1.15, 4.2.15, and 4.3.15.

The human health risk from transportation of radioactive materials is categorized as either radiological or nonradiological. Radiological risk is that associated with the release of radioactive materials during an accident or the effects of low levels of radiation emitted during normal, or incident-free, transportation. Nonradiological risk is that associated with transportation itself, regardless of the nature of the cargo being transported, such as accidents resulting in injury or death when there is no release of radioactive material. Shipping packages containing radioactive materials emit low levels of radiation during incident-free transportation. The amount of radiation emitted depends on the kinds and amounts of materials being transported. U.S. Department of Transportation regulations require that shipping packages containing radioactive materials have sufficient radiation shielding to limit the radiation to an acceptable level of 10 millirem per hour at 2 meters (6.6 feet) from the transporter. Incident-free exposure and accident-related fatalities while shipping both radioactive waste and nonradioactive materials are discussed in Chapter 4, Sections 4.1.12, 4.2.12, and 4.3.12.

In addition to the human health risk associated with facilities and transportation, any unavoidable impact on groundwater that occurs (see Section 7.2.6) despite mitigation measures (see Section 7.1.6), even if contamination is below benchmark standards, would affect human health. This human health risk would exist even if impacts are deemed acceptable from a dose perspective or are predicted to be negligible compared with background exposure levels.

7.2.11 Waste Management

Secondary waste, including low-level radioactive waste (LLW), MLLW, and hazardous waste, would be an unavoidable byproduct generated during construction, operations, deactivation, and closure activities. Examples of secondary waste include personal protective equipment, rags, tools, filters, and empty containers. This secondary waste would be in addition to the primary-waste forms produced as a result of tank waste treatment or FFTF decommissioning activities. Secondary-waste generation would be greatest during the operations and deactivation phases of each alternative. Secondary waste would be managed, treated, and/or stored for eventual recycling or disposal in accordance with applicable Federal and State of Washington regulations. Waste management impacts are discussed in Chapter 4, Sections 4.1.14, 4.2.14, and 4.3.14.

Primary waste is generally not considered an unavoidable, adverse environmental impact because this waste already exists in one form or another and, consequently, would require management and disposal. However, depending on the treatment method implemented, the volumes of primary waste may increase. This could result from the addition of binding agents (e.g., glass formers, grout), treatment by acid wash, or WTP and/or Preprocessing Facility (PPF) melters that are taken out of service. The increased volumes of waste would lead to a larger demand for landfill space. The increase in landfill loading would be considered an unavoidable consequence, although not necessarily an adverse consequence, because the overall performance of the final waste form would be enhanced.

7.2.12 Alternative Combinations

This section presents a comparison of the unavoidable, adverse environmental impacts that are projected to occur under the three alternative combinations selected for analysis in this EIS. A summary of overall projected unavoidable, adverse impacts under these alternative combinations is presented in Table 7–2. A detailed discussion of short-term impacts under the alternative combinations is presented in Chapter 4, Section 4.4. Long-term impacts under the alternative combinations are presented in Chapter 5, Section 5.4.

Alternative Combinations Analyzed in This Environmental Impact Statement

Alternative Combination 1: All No Action Alternatives for tank closure, Fast Flux Test Facility (FFTF) decommissioning, and waste management

Alternative Combination 2: Tank Closure Alternative 2B, FFTF Decommissioning Alternative 2 with the Idaho Option for disposition of remote-handled special components (RH-SCs) and the Hanford Reuse Option for disposition of bulk sodium, and Waste Management Alternative 2 with Disposal Group 1

Alternative Combination 3: Tank Closure Alternative 6B, Base Case; FFTF Decommissioning Alternative 3 with the Idaho Option for disposition of RH-SCs and the Hanford Reuse Option for disposition of bulk sodium; and Waste Management Alternative 2 with Disposal Group 2

Alternative Combination 1, which represents all the No Action Alternatives, would have the least unavoidable impacts on most resource areas in the short term, but conversely would also have the greatest overall adverse impacts on the environment over the long term. Until construction of the WTP and Canister Storage Building could be terminated under the Tank Closure No Action Alternative, some land disturbance and mining of geologic materials would occur in Borrow Area C. This would result in relatively small but unavoidable short-term impacts on land, noise, air, and ecological resources. Approximately 2 hectares (5 acres) of new land disturbance would take place solely in Borrow Area C. Because of the limited disturbance of land in Borrow Area C, it is expected that native vegetation and natural species habitat would reclaim the disturbed areas relatively quickly, especially after restoration efforts are completed. Noise impacts would remain in the general vicinity of construction zones, but are not projected to exceed guidelines at receptor locations. Air quality would be adversely affected, with the possibility that particulate matter and nitrogen dioxide could exceed existing standards. Noise and air impacts would end with the cessation of construction activities. Over the long term, untreated tank waste would eventually be released from all the tank systems, migrate through the subsurface into groundwater, and unavoidably and adversely impact the Columbia River and the Hanford Reach ecosystem.

Alternative Combination 2 represents a midrange set of alternatives. The majority of short-term impacts would occur between 2006 and 2052, after which most activities would have been completed and the 100-year postclosure care and monitoring period for this set of alternatives would collectively begin. In the short term, not including Borrow Area C, 68 hectares (167 acres) of new land would be disturbed at Hanford, disrupting mostly sagebrush habitat and potentially several species of interest. In Borrow Area C, 140 hectares (345 acres) of new land would be permanently disturbed, altering the aesthetic quality of this area from several vantage points. Most of the 6.5 million cubic meters (8.5 million cubic yards) of geologic resources utilized would come from Borrow Area C. Electricity demand for WTP operations would approach site capacities and would need to be sustained for the duration of WTP operations. Noise impacts from construction activities would not necessarily increase in acuteness, but the effects would be distributed over a prolonged period of time, compared with Alternative Combination 1. Particulate matter, nitrogen dioxide, carbon monoxide, sulfur dioxide, and mercury could exceed air quality standards or guidelines at times. Vitrification of tank waste would eliminate the threat of untreated tank waste being released into the subsurface, but subsequent burial in an onsite disposal facility would be an unavoidable consequence of such treatment. Additional waste would be generated as a result of tank waste treatment, including secondary waste and low-activity waste (LAW) melters taken out of service, thereby increasing the need for onsite disposal capacity. The transportation risk assessment projected two fatalities due to accidents that involve fatal radiation doses to workers and three fatalities due to accidents that do not involve radiological exposure (e.g., fatalities resulting from impact of crash). The majority of projected transportation risks are associated with the receipt of offsite LLW and MLLW from other DOE facilities, an activity that is not associated with tank closure.

Alternative Combination 3 represents the set of alternatives that would produce the greatest impacts on most resource areas; therefore, it most closely resembles a scenario in which the maximum reasonably foreseeable unavoidable consequences would occur in the short term. The duration of short-term impacts resulting from construction, operations, and deactivation would extend through 2102. Unavoidable impacts on land and ecological resources would be similar to those under Alternative Combination 2, but would be magnified. Not including Borrow Area C, new land disturbance at Hanford would increase to 350 hectares (865 acres), while disturbance in Borrow Area C would increase to 401 hectares (992 acres). Geologic material consumption would increase to 18.7 million cubic meters (24.5 million cubic yards). Depending on the timing of construction activities, particulate matter, nitrogen dioxide, carbon monoxide, sulfur dioxide, and mercury emissions could exceed air quality standards or guidelines. The management of all treated tank waste as HLW would balance the reduction in the need for onsite LLW disposal capacity with an increase in demand for onsite HLW storage facilities. Secondary waste would be generated in greater quantities due to the significant increase in waste treatment associated with clean closure of the tank systems. WTP LAW melters that are taken out of service would be managed as HLW and would not require onsite disposal, but would be replaced with PPF melters, which would require onsite disposal when taken out of service. Transportation risks would increase for tank closure activities, but the majority of the projected risk would still be from receipt of offsite LLW and MLLW. The transportation risk assessment projected two worker fatalities due to accidents involving radiation doses and four fatalities due to nonradiological accidents.

Table 7–2. Alternative Combinations Unavoidable, Adverse Environmental Impacts

Resource Area	Alternative Combination 1	Alternative Combination 2	Alternative Combination 3
Land resources	2 hectares of new land would be disturbed in Borrow Area C only.	Not including Borrow Area C, 68 hectares of new land would be disturbed at Hanford. 140 hectares would be disturbed in Borrow Area C.	Not including Borrow Area C, 350 hectares of new land would be disturbed at Hanford. 401 hectares would be disturbed in Borrow Area C.
Infrastructure	Demand would remain well below capacities; therefore, no adverse impacts are expected.	Demand would remain well below capacities, except electrical demand would be approximately 68 percent of site capacities during WTP operations. This impact would not be permanent, but would require infrastructure upgrades or supplemental electrical supply to prevent a potential disruption in the local electrical supply grid.	Demand would remain well below capacities, except electrical demand would be approximately 73 percent of site capacities during WTP operations. This impact would not be permanent, but would require infrastructure upgrades or supplemental electrical supply to prevent a potential disruption in the local electrical supply grid.
Noise and vibration	Increases in noise levels would be relatively low outside immediate areas of construction and would be barely discernible at the Hanford site boundaries. Noise levels at these boundaries under all combinations of alternatives are projected to be below the Washington State standard daytime maximum noise level limitation of 60 dBA for industrial sources impacting residential receptors. Noise levels are expected to be the highest during the construction phase. Since the activities undertaken in support of each scoping area of this *TC & WM EIS* (tank closure, FFTF decommissioning, and waste management) would occur in different geographic areas, the impacts on noise levels would not be additive.		
Air quality	Particulate matter and nitrogen dioxide emissions may require additional analysis or engineering controls.	Particulate matter, nitrogen dioxide, carbon monoxide, sulfur dioxide, and mercury emissions may require additional analysis or engineering controls.	Particulate matter, nitrogen dioxide, carbon monoxide, sulfur dioxide, and mercury emissions may require additional analysis or engineering controls.
Geology and soils	99,000 cubic meters of geologic resources would be consumed for partial construction of the WTP and Canister Storage Building until terminated.	6,470,000 cubic meters of geologic resources would be consumed.	18,700,000 cubic meters of geologic resources would be consumed.
Water resources	All tank waste would eventually leak into the subsurface, adversely affecting groundwater quality and the Columbia River. The majority of long-term impacts would be from the eventual release of tank waste. Tank Closure Alternative 1 would account for more than 99 percent of impacts on groundwater under this alternative combination.	All tank waste would be vitrified in the WTP and disposed of in 200 Area disposal facilities or stored on site until disposition decisions are made and implemented. Some leaching of contaminants would occur prior to decay. The majority of long-term impacts would be from tank farm sources of hydrogen-3 (tritium), uranium-238, chromium, nitrate, and total uranium. The largest contributors of iodine-129 and technetium-99 would be waste management sources, particularly offsite waste disposed of in the 200-East Area Integrated Disposal Facility.	All tank waste would be vitrified and managed as HLW, requiring long-term, onsite storage in aboveground storage facilities. PPF glass and deep soil that has been removed would be disposed of in 200 Area disposal facilities. Some leaching of contaminants would occur prior to decay, although less than under Alternative Combination 2, due to aboveground storage of vitrified tank waste. Long-term impacts would be similar to those under Alternative Combination 2.

Table 7–2. Alternative Combinations Unavoidable, Adverse Environmental Impacts *(continued)*

Resource Area	Alternative Combination 1	Alternative Combination 2	Alternative Combination 3
Ecological resources	Negligible ecological impacts on grasslands and state-listed species within Borrow Area C would occur. However, long-term impacts could occur along the Columbia River due to release of untreated tank waste. Negligible long-term ecological impacts would occur from air emissions. Due to unmitigated release of tank waste into the subsurface, impacts on ecological resources in the Columbia River might occur from migration of contaminants through groundwater.	Grassland and sagebrush habitat would be adversely impacted, along with several state-listed species. Some long-term impacts on ecological resources would occur from air emissions associated mainly with WTP operations. Less, but more prolonged, than under Alternative Combination 1, impacts on ecological resources in the Columbia River might occur from releases from tank farm sources and waste management sources into the groundwater. Overall, ecological resource impacts would be the greatest, although very low, under this alternative combination.	Grassland and sagebrush habitat would be adversely impacted along with several state-listed species. This alternative combination's impact on grassland and sagebrush habitat would be greater due to the length of short-term activities and the amount of new land disturbance when compared with Alternative Combination 2. Some long-term impacts on ecological resources would occur from air emissions associated with WTP, PPF, and clean closure operations. Overall, long-term impacts on groundwater would be similar to those under Alternative Combination 2, although somewhat less due to offsite disposal of more treated tank waste, which would be managed as HLW.
Cultural and paleontological resources	No impacts are expected to occur under this alternative combination.	Excavation of Borrow Area C would alter the view of this area from higher elevations, such as Rattlesnake Mountain, which is of cultural interest to local American Indians, even after completion of restoration efforts.	
Socioeconomics	With the termination of WTP construction, the loss of jobs in the short term would negatively impact the local economy and could possibly suppress growth within the ROI. At its peak, and prior to termination of construction, the workforce would be approximately 1,840 FTEs and would represent 1.5 percent of the projected 2008 labor force within the ROI.	Significant growth in the workforce would be necessary and would fuel regional growth. The peak workforce would represent approximately four to five times the peak workforce under Alternative Combination 1, although the peak would occur around 2040. The number of daily commuter vehicles would be correlated with the increase in the workforce and could affect commute times.	Major growth in the workforce would be necessary and would fuel regional growth. The peak workforce would represent approximately seven times the peak workforce under Alternative Combination 1, although the peak would occur around 2021. The number of daily commuter vehicles would be correlated with the increase in the workforce and could affect commute times.

Table 7–2. Alternative Combinations Unavoidable, Adverse Environmental Impacts *(continued)*

Resource Area	Alternative Combination 1	Alternative Combination 2	Alternative Combination 3
Public and occupational health and safety	Normal facility operations and deactivation, including some closure activities, would result in unavoidable radiological exposure to workers and the general public; nevertheless, no latent fatal cancers are expected among the workers or the general public. Any increase in transportation risks would be negligible because they would be limited to continued operation of the low-level radioactive waste burial grounds, and because no tank waste would be treated and/or transported. No transportation-related fatalities are projected. Comparatively, this alternative combination would lead to the maximum potential for long-term impacts on the public due to unmitigated releases of radioactive contaminants from the storage tanks. Impacts on groundwater from releases of tank inventories within the Core Zone Boundary would potentially increase risks to onsite receptors that attempt to use groundwater as a source of drinking water or for irrigation of crops. Negligible impacts on downstream populations are projected.	Normal facility operations and deactivation, including some closure activities, would result in unavoidable radiological exposure to workers and the general public. Nine latent fatal cancers could occur among workers due to radiological exposure, and one is expected among the general public. The majority of transportation risks would be associated with receipt of offsite waste. Impacts on groundwater within the Core Zone Boundary from waste management areas would potentially increase risks to onsite receptors that attempt to use groundwater as a source of drinking water or for irrigation of crops. Negligible impacts on downstream populations are projected.	Normal facility operations and deactivation, including some closure activities, would result in unavoidable radiological exposure to workers and the general public. The number of latent fatal cancers among workers due to radiological exposure could increase to 53 as a result of clean closure activities and one latent fatal cancer is expected among the general public. The majority of transportation risks would be associated with the receipt of offsite waste, with a minor increase due to the local transportation of additional waste associated with clean closure of the tanks. Comparatively, this alternative combination would have a lower potential for long-term impacts on the public due to the management of treated tank waste as HLW. Although less than those under Alternative Combination 2, impacts on groundwater within the Core Zone Boundary and waste management areas would potentially increase risks to onsite receptors that attempt to use groundwater as a source of drinking water or for irrigation of crops. Negligible impacts on downstream populations are projected.
Waste management	Any increase in secondary-waste generation is expected to be negligible during ongoing administrative activities related to maintaining existing tank systems. In time, as efforts to maintain existing tank systems would likely intensify, the rate of secondary-waste generation would also increase.	WTP operations would yield secondary-waste and low-activity-waste melters that would be taken out of service.	All tank waste would be managed as HLW. A possible long-term consequence would be the requirement for long-term care and management of large quantities of HLW in onsite, aboveground storage facilities. PPF operations in support of clean closure activities would yield secondary-waste and PPF melters that would be taken out of service. WTP melters taken out of service would also be managed as HLW.

Note: To convert cubic meters to cubic yards, multiply by 1.308; hectares to acres, by 2.471.

Key: dBA=decibels A-weighted; FFTF=Fast Flux Test Facility; FTE=full-time equivalent; Hanford=Hanford Site; HLW=high-level radioactive waste; PPF=Preprocessing Facility; ROI=region of influence; *TC & WM EIS*=*Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*; WTP=Waste Treatment Plant.

7.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

This section describes the major irreversible and irretrievable commitments of resources that have been identified under each alternative considered in this *TC & WM EIS*. A commitment of resources is irreversible when future options for a resource are limited due to primary or secondary impacts of the commitment. A commitment of resources is irretrievable when a resource is neither renewable nor recoverable for future use once it has been used or consumed under the commitment. In general, the commitments of capital, land, energy, labor, and materials during implementation of the activities in support of the Tank Closure, FFTF Decommissioning, and Waste Management alternatives would be irreversible or irretrievable. This section discusses the commitments of four major categories of resources that would be required to implement the proposed actions and alternatives: land, materials, utilities, and labor.

Implementation of any of the alternatives considered in this *TC & WM EIS*, including the No Action Alternatives, would entail the irreversible and irretrievable commitments of land; construction materials (e.g., steel, concrete), chemicals, and geologic resources; utility resources (electricity, fossil fuels, and water); and labor. These resources would be committed over the entire life cycle of the alternatives described in this *TC & WM EIS* and would essentially be irrecoverable. The life cycle of an alternative includes construction, operations, decommissioning, and closure of facilities used to accomplish the objectives included in the scope of this *TC & WM EIS*.

Based on the analysis in this *Final TC & WM EIS*, some portion of the land, extending to the soil, may not be available for use and may be subject to access or use restrictions. For example, under certain Tank Closure alternatives where landfill closure of tank structures would occur, the land and underlying vadose zone would be covered by an engineered barrier and may be subject to access or use restrictions. A similar situation would exist under FFTF Decommissioning Alternative 2, where below-grade structures, such as the reactor vessel, piping, and other components, would be entombed and covered by an engineered barrier. Under the Waste Management action alternatives, waste that is disposed of (e.g., ILAW glass), would remain in place, and the disposal areas would be covered by an engineered barrier and be subject to access and use restrictions. Potential long-term land use commitments and associated timeframes are discussed in more detail in Section 7.4. The 2010 groundwater monitoring report (DOE 2010a) identifies current exceedances for the following radionuclides: tritium, technetium-99, iodine-129, strontium-90, and uranium. Cesium-137, cobalt-60, and plutonium exceed the standards in a number of wells. Exceedances were also identified for the following chemicals: nitrates, carbon tetrachloride, chromium, and trichloroethylene (DOE 2010a). Corrective actions and remedial activities are ongoing planned for all of the Hanford areas. Appendix U provides the status of remedial activities identified to date. As additional cleanup work still has to be done, the full extent of access or use restrictions will not be known until the scope of *TC & WM EIS* activities and CERCLA cleanup have been completed. Previously, in Section 7.2.6, potential unavoidable adverse impacts on groundwater that would result from implementation of any of the *TC & WM EIS* alternatives are discussed.

7.3.1 Tank Closure Alternatives

Under the Tank Closure No Action Alternative, both ongoing partial construction of new facilities and routine tank operations would continue until these activities are terminated, followed by administrative controls for 100 years. Under Tank Closure Alternatives 2 through 6C, construction, operations, and deactivation of new facilities would be required to support tank waste retrieval, treatment, and disposal and SST system closure. (Tank Closure Alternative 2A does not address SST system closure.) For some facilities, construction of multiple replacements would be necessary because the life cycle of a particular alternative would exceed the design life of the facility.

7.3.1.1 Land Resources

Land use commitments under the Tank Closure alternatives for (1) construction of new facilities on undisturbed land, (2) permanent in-place closure of existing facilities, and (3) borrow areas that would be used to supply geologic materials (e.g., sand, gravel, and soil) would be irreversible and irretrievable (see Table 7–3).

Land use commitments under the Tank Closure No Action Alternative include the area currently occupied by the SST farms and the B and T Area cribs and trenches (ditches) that would not be closed. Under Tank Closure Alternatives 2A through 5 and 6C, land use commitments would include new treatment and storage facilities constructed on undisturbed land. Under Tank Closure Alternative 2A, land use commitments would also include the SST farms and cribs and trenches (ditches), where waste would be left in place. Under Tank Closure Alternatives 2B through 5 and 6C, land use commitments would also include those areas where engineered barriers would be placed over the SST farms and cribs and trenches (ditches). Under Tank Closure Alternatives 6A and 6B, clean closure of the SST farms would be achieved, thereby eliminating the need for engineered barriers. However, management and subsequent storage of all tank waste as IHLW under these alternatives would require a substantial amount of land until permanent waste disposal could be realized. Tank Closure Alternatives 6A and 6B, Base Cases, however, would still require the emplacement of an engineered barrier over the cribs and trenches (ditches). Tank Closure Alternatives 6A and 6B, Option Cases, would achieve clean closure of the SST farms and the B and T Area cribs and trenches (ditches).

Table 7–3. Tank Closure Alternatives Irreversible and Irretrievable Commitments of Land Resources[a]

Alternative	Land Resource (hectares)	
	Permanently Committed and Newly Disturbed Land[b]	Borrow Area C (Disturbed Land)
1	17	2
2A	33	29
2B	107	95
3A	110	100
3B	111	92
3C	111	93
4	87	102
5	111	117
6A, Base Case	209	381
6A, Option Case	186	458
6B, Base Case	128	240
6B, Option Case	104	316
6C	153	104

[a] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure. Does not include land area already committed for construction of the original Waste Treatment Plant.

[b] This includes (1) land area where facilities would be closed in place or where engineered barriers would be constructed; (2) new disturbance of land for facility construction; and (3) new disturbance of land for construction of engineered barriers beyond the boundary of the barrier itself. Does not include Borrow Area C.

Note: To convert hectares to acres, multiply by 2.471.

Source: SAIC 2010a.

New disturbance of land for construction of facilities would be considered an irreversible impact. The in-place closure of SST farms and cribs and trenches (ditches), with or without the emplacement of engineered barriers, would be considered an irreversible and irretrievable commitment of land. Section 7.4 discusses the relationship between short-term uses of the environment and the maintenance and enhancement of its long-term productivity.

Construction of new facilities, emplacement of engineered surface barriers, and/or partial or complete clean closure of the SST system would require relatively large volumes of geologic materials from Borrow Area C for backfilling of excavations. While this land would not be irreversibly or irretrievably committed to some use, the area would be irreversibly altered. The consumption of geologic materials, including soil, gravel, sand, and rock or basalt, is covered in Section 7.3.1.2 below.

The estimated areas of land that may be permanently committed or newly disturbed while supporting the Tank Closure alternatives are presented in Table 7–3. Except for Borrow Area C and the construction of IHLW Interim Storage Modules under Tank Closure Alternative 6A, all land commitments would be within the Central Plateau (200 Areas). This area has been designated Industrial-Exclusive by the *Hanford Comprehensive Land-Use Plan EIS* (DOE 1999a) and has been set aside for *TC & WM EIS* activities. For a detailed discussion of land use impacts of construction of new and existing facilities and Borrow Area C operations under the Tank Closure alternatives, see Chapter 4, Section 4.1.1. Table 7–3 may differ from the presentation of analysis in Section 4.1.1 because Table 7–3 does not include committed land for construction of new facilities where the land is known to have already been disturbed.

7.3.1.2 Material Resources

The irreversible and irretrievable commitment of material resources would include process chemicals used during operations of facilities, materials used for construction that cannot be recovered or recycled, materials that would be rendered radioactive and could not be decontaminated, raw materials consumed or reduced to irrecoverable waste forms, and geologic borrow materials. Projected demands for primary material resources under each of the Tank Closure alternatives are shown in Table 7–4 for construction and in Table 7–5 for nonconstruction-related activities.

Principal construction materials would include steel; asphalt; and concrete and grout constituents such as cement, gravel, and sand. Although other materials, including wood, plastics, and other metals, would be used, these quantities are not considered a primary demand. Concrete, steel, and other materials incorporated into the framework of new facilities, such as the WTP and supplemental treatment facilities, would be irretrievably lost, regardless of whether operations would result in direct contamination of the materials. Cement would be used to formulate concrete for construction of new facilities and in the grouting of SSTs and ancillary equipment in the tank farms. Concrete would be manufactured in batch plants located throughout the 200 Areas. The management of all tank waste as HLW under Tank Closure Alternatives 6A and 6B would require construction of additional IHLW Shipping/Transfer Facilities and Interim Storage Facilities, as well as ILAW Interim Storage Facilities, which would increase the steel, asphalt, and concrete commitments. Significant quantities of grout would be utilized under Tank Closure Alternatives 2B through 6C to fill the SSTs in place or the ancillary equipment associated with the tank system and/or cribs and trenches (ditches). The Tank Closure No Action Alternative and Alternative 2A would not utilize comparable amounts of grout because the SSTs would not be closed under these alternatives.

Geologic materials would include sand, gravel, soil, and rock mined from Borrow Area C for the construction of engineered barriers and for specification and nonspecification backfill (e.g., other borrow materials). Specification backfill has been designated for construction of the WTP due to the sensitivity of the melters to facility settling. Under the appropriate alternatives, nonspecification backfill would be used to replenish voids resulting from excavation and removal of the SST farms and cribs and trenches (ditches). For example, Tank Closure Alternatives 6A and 6B, in which deep soil removal would be required for the tank systems and/or cribs and trenches (ditches), would require a notable increase in soil commitments (shown under "Other Borrow Materials" in Table 7–4) for backfilling the excavation. In addition, construction of shipping/transfer facilities and interim storage facilities under Tank Closure Alternative 6A to manage the additional IHLW that would be produced specifically requires 'rock' as a backfill for facility construction. Except for the Tank Closure No Action Alternative; Alternative 2A; and Alternatives 6A and 6B, Option Cases, engineered barriers would be constructed and emplaced. Tank Closure Alternatives 6A and 6B, Base Cases, would not require engineered barriers for the SST farms; however, these alternatives would still require placement of engineered barriers over the cribs and trenches (ditches).

The consumption of various materials would be necessary to support nonconstruction-related activities under the Tank Closure alternatives. Under the Tank Closure No Action Alternative, there would be no retrieval or treatment of tank waste; therefore, the consumption of materials would be below notable quantities. The WTP, which would be required under Tank Closure Alternatives 2A through 6C, as well as the PPF, which would be required under Tank Closure Alternatives 4, 6A, and 6B, would utilize glass formers for the vitrification of tank waste into a high-performing waste form. Operations of the WTP LAW melters would require the use of ion exchange resins to remove cesium-137 from the waste feed prior to treatment, except under Tank Closure Alternative 6A, in which all tank waste would be treated as HLW. To achieve 99.9 percent tank waste retrieval under Tank Closure Alternatives 4, 6A, and 6B, chemical washing would be employed, requiring the use of miscellaneous retrieval chemicals (e.g., oxalic acid). The consumption of nitric acid (3 percent and 57 percent solution) and caustics (50 percent solution) would support operations of the PPF under Tank Closure Alternatives 4, 6A, and 6B. Under Tank Closure Alternatives 3A through 5, transuranic (TRU) waste would be separated from other tank waste using dedicated Contact-Handled and Remote-Handled Mixed TRU Waste Facilities. The TRU waste processing facilities required under these alternatives would use appreciable quantities of sorbent materials and sodium hydroxide.

The various supplemental treatment technologies (i.e., bulk vitrification, cast stone, steam reforming, and sulfate removal) would all consume additional materials to expedite treatment of tank waste. The bulk vitrification technology, implemented under Tank Closure Alternatives 3A, 4, and 5, would utilize soil and sand as an insulator in the large bulk vitrification containers during the melt process. The cast stone technology, implemented under Tank Closure Alternatives 3B, 4, and 5, would utilize fly ash, slag, and cement to encapsulate the waste feed and produce a solid-waste form. The steam reforming technology, implemented under Tank Closure Alternative 3C, would consume sucrose (sugar), kaolin clay, iron oxide, oxygen, and nitrogen as chemical additives at various stages of the treatment process. Finally, sulfate removal, implemented under Tank Closure Alternative 5, would consume nitric acid (12.2 molar), strontium nitrate (41.5 weight-percent), sodium hydroxide (30 weight-percent), and grout. The chemicals would be used to react and precipitate sulfates from the waste feed, and the grout would be used to stabilize the sulfate precipitate after it is removed from the waste stream. Appendix E provides a more detailed analysis of the operations and chemical uses of each of the tank waste treatment technologies.

Table 7–4. Tank Closure Alternatives Irreversible and Irretrievable Commitments of Construction Materials[a, b]

Resource (× 1,000)	Tank Closure Alternative												
	1	2A	2B	3A	3B	3C	4	5	6A, Base Case	6A, Option Case	6B, Base Case	6B, Option Case	6C
Construction Materials (metric tons)													
Steel	4	88	73	62	61	69	168	63	1,240	1,740	534	1,030	143
Asphalt	0	5	5	4	4	4	5	4	125	125	5	5	5
Concrete (cubic meters)[c]													
Cement	8	162	102	84	83	85	120	88	1,500	1,530	346	374	195
Sand	16	327	206	168	167	172	240	178	3,010	3,070	685	742	388
Gravel	21	427	268	219	218	224	312	233	3,920	4,000	889	965	507
Fly ash	0	0	0	0	0	0	0	0	0	0	0	0	0
Grout (cubic meters)[c]													
Cement	0	0.01	13	13	13	13	20	13	28	93	28	93	13
Sand	0	0.05	774	774	774	774	661	772	116	384	116	384	774
Fly ash	0	0.04	166	166	166	166	182	163	140	463	140	463	166
Bentonite clay	0	0	6	6	6	6	7	6	7	9	7	9	6
Water-reducing agent	0	0	0.22	0.22	0.22	0.22	0.19	0.22	0.04	0.14	0.04	0.14	0.22
Engineered Barrier (cubic meters)													
Sand	0	0	1,060	1,060	1,060	1,060	591	1,760	317	0	317	0	1,060
Gravel	0	0	253	253	253	253	141	421	76	0	76	0	253
Soil	0	0	849	849	849	849	475	1,420	255	0	255	0	849
Asphalt	0	0	138	138	138	138	77	230	41	0	41	0	138
Other Borrow Materials (cubic meters)													
Rock	0	14	14	10	10	10	13	10	350	350	14	14	14
Sand	0.2	1	4	4	4	4	4	4	1	1	1	1	4
Gravel	0.3	6	8	8	8	8	11	8	11	11	9	9	8
Soil	0.2	1	529	529	529	529	1,800	1	8,300	12,100	8,300	12,100	529
Specification backfill	55	549	254	220	220	220	220	220	1,020	1,020	254	254	254

[a] Resources listed were calculated as total life-cycle requirements for construction-related activities.
[b] Values presented in this table are in thousands; multiply by 1,000 to obtain actual value of resource commitment.
[c] Concrete and grout are presented as premixed constituents.
Note: To convert cubic meters to cubic yards, multiply by 1.308.
Source: SAIC 2010a.

Table 7–5. Tank Closure Alternatives Irreversible and Irretrievable Commitments of Nonconstruction Materials[a, b]

Resource (× 1,000)	Tank Closure Alternative											
	1	2A	2B	3A	3B	3C	4	5	6A, Base Case	6A, Option Case	6B, Base Case	6B, Option Case	6C
Materials													
Glass formers (metric tons)[c]	0	195	202	197	197	197	199	181	194	264	206	276	202
Ion exchange resins (liters)[d]	0	1,580	2,440	1,590	1,590	1,590	1,960	1,600	0	0	2,440	2,440	2,440
Retrieval chemicals, (e.g., oxalic acid) (liters)[e]	0	0	0	0	0	0	189,000	0	244,000	244,000	189,000	189,000	0
Nitric acid (3 percent and 57 percent solution) (liters)[e]	0	0	0	0	0	0	5,680	0	1,790	62,700	1,790	62,700	0
Caustic (50 percent solution) (liters)[e]	0	0	0	0	0	0	2,430	0	61	2,120	61	2,120	0
Sorbent (liters)	0	0	0	984	984	984	1,010	894	0	0	0	0	0
Sodium hydroxide (kilograms)	0	0	0	22	22	22	22	22	0	0	0	0	0
Soil (cubic meters)[f]	0	0	0	187	0	0	63	63	0	0	0	0	0
Sand (cubic meters)[f]	0	0	0	148	0	0	50	50	0	0	0	0	0
Fly ash (cubic meters)[g]	0	0	0	0	233	0	149	149	0	0	0	0	0
Slag (cubic meters)[g]	0	0	0	0	233	0	149	149	0	0	0	0	0
Cement (cubic meters)[g]	0	0	0	0	28	0	18	18	0	0	0	0	0
Sucrose (metric tons)[h]	0	0	0	0	0	1,130	0	0	0	0	0	0	0
Kaolin clay (metric tons)[h]	0	0	0	0	0	207	0	0	0	0	0	0	0
Oxygen (metric tons)[h]	0	0	0	0	0	1,070	0	0	0	0	0	0	0
Nitrogen (metric tons)[h]	0	0	0	0	0	460	0	0	0	0	0	0	0
Nitric acid (12.2 molar) (liters)[i]	0	0	0	0	0	0	0	91,600	0	0	0	0	0
Strontium nitrate (41.5 weight-percent) (liters)[i]	0	0	0	0	0	0	0	42,800	0	0	0	0	0
Grout mix (kilograms)[i]	0	0	0	0	0	0	0	28,000	0	0	0	0	0
Sodium hydroxide (30 weight-percent) (liters)	0	0	0	0	0	0	0	3,820	0	0	0	0	0

[a] Resources listed were calculated as total life-cycle requirements for nonconstruction-related activities.
[b] Values presented in this table are in thousands; multiply by 1,000 to obtain actual value of resource commitment.
[c] The Waste Treatment Plant and Preprocessing Facility utilize glass formers for the vitrification process. These values do not include materials for processing cesium and strontium capsules. The values under Tank Closure Alternatives 3A through 5 do not reflect a reduction due to treatment of some tank waste using supplemental treatment.
[d] Cesium removal pretreatment.
[e] Used in chemical washing, which is needed to achieve 99.9 percent retrieval of tank waste.
[f] Bulk vitrification insulating materials.
[g] Cast stone materials.
[h] Steam reforming materials (table does not include small amount of iron oxide that would also be consumed in this process).
[i] Sulfate removal materials.

Note: To convert cubic meters to cubic yards, multiply by 1.308; kilograms to pounds, by 2.2046; liters to gallons, by 0.26417.
Source: SAIC 2010a.

7.3.1.3 Utility Resources

Key utility infrastructure resources include the projected activity demands for water, electricity, and fuel over the life cycle of each Tank Closure alternative. Projected demands for key utility infrastructure resources under each Tank Closure alternative are shown in Table 7–6.

Table 7–6. Tank Closure Alternatives Utility Resource Commitments[a, b]

Alternative	Resource (× 1,000,000)			
	Water (liters)	Electricity (kilowatt-hours)	Fuel (liters)	
			Diesel	Gasoline
1	3,300	115	36	5
2A	208,000	35,600	4,960	221
2B	86,300	17,900	4,040	156
3A	77,000	14,100	1,860	116
3B	77,000	12,100	1,860	116
3C	77,300	20,100	1,980	116
4	82,200	14,800	2,050	133
5	92,500	12,200	4,110	124
6A, Base Case	643,000	186,000	22,900	715
6A, Option Case	643,000	188,000	23,000	711
6B, Base Case	92,600	21,100	4,360	216
6B, Option Case	92,800	23,800	4,440	212
6C	86,300	17,900	4,040	156

[a] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.

[b] Values presented in this table are in millions; multiply by 1,000,000 to obtain actual value of resource commitment.

Note: To convert liters to gallons, multiply by 0.26417.

Source: SAIC 2010a.

Water would be required during construction for soil compaction, dust control, and possibly for work surface and equipment washdown. Concrete and grout would be produced in onsite batch plants that would require large volumes of water. During operations, water would be required to support process makeup requirements and facility cooling, as well as the potable and sanitary needs of the operations workforce and other uses. Water would also be consumed during facility deactivation activities to stabilize and partially decontaminate waste retrieval, treatment, and disposal facilities.

Energy expended would be in the form of electricity for construction equipment and facility operations and fuel for equipment, vehicles, and process operations. The energy required to support the activities under each alternative would be a large fraction of the total energy used at Hanford. The high demand for electricity under Tank Closure Alternatives 2A through 6C would largely be attributable to operations of the WTP and PPF melters, and the demand under Tank Closure Alternatives 3A, 3C, 4, and 5 would also be attributable to operations of the bulk vitrification or steam reforming supplemental treatment processes. Electricity and fuels would be purchased from commercial sources.

For a detailed discussion of the impacts on the existing infrastructure of implementing the Tank Closure alternatives, see Chapter 4, Section 4.1.2.

7.3.1.4 Labor Resources

Labor resources associated with the Tank Closure alternatives would be required over the entire life cycle of the alternatives, although more would be required during the construction and operations phases. Under Tank Closure Alternative 6A, the treatment and management of all tank waste as HLW and the duration of all life-cycle phases (156 years) would require a substantially larger commitment of labor compared with other Tank Closure action alternatives. The labor requirements of all of the Tank Closure alternatives are shown in Table 7–7. These labor requirements have the potential to generate economic impacts that may affect the need for housing units, public services, and local transportation in the region. For a detailed analysis of the labor impacts associated with the Tank Closure alternatives, see Chapter 4, Section 4.1.9.

Table 7–7. Tank Closure Alternatives Labor Resource Commitments[a]

Alternative	Labor Hours	Labor (FTEs)
1	16,300,000	7,840
2A	708,000,000	340,000
2B	388,000,000	187,000
3A	349,000,000	168,000
3B	344,000,000	165,000
3C	357,000,000	172,000
4	450,000,000	216,000
5	325,000,000	156,000
6A, Base Case	2,060,000,000	990,000
6A, Option Case	2,130,000,000	1,020,000
6B, Base Case	515,000,000	248,000
6B, Option Case	572,000,000	275,000
6C	389,000,000	187,000

[a] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.

Note: To convert FTEs to labor hours, multiply by 2,080.

Key: FTE=full-time equivalent.

Source: SAIC 2010a.

7.3.2 FFTF Decommissioning Alternatives

Implementation of the FFTF Decommissioning No Action Alternative would involve completion of deactivation activities and site monitoring under administrative controls for 100 years. The deactivation activities would include removal and storage of the four FFTF RH-SCs and bulk sodium. A complete description of the four FFTF RH-SCs is provided in Appendix E, Section E.2.4.4. FFTF Decommissioning Alternative 2 would involve demolition of structures to grade and in-place entombment. FFTF Decommissioning Alternative 3 would involve complete removal of all above- and below-grade structures. Both FFTF Decommissioning Alternatives 2 and 3 would require disposition of the four RH-SCs in an RTP at either Hanford or the Idaho National Laboratory (INL), as well as bulk sodium processing in a new Sodium Reaction Facility (SRF) at Hanford or in the existing Sodium Processing Facility (SPF) at INL. As a result of the proposed locations of these facilities at either Hanford or INL, FFTF Decommissioning Alternatives 2 and 3 have four different scenarios depending on the potential location combinations.

7.3.2.1 Land Resources

Land use commitments under the FFTF Decommissioning alternatives for (1) construction of new facilities on undisturbed land, (2) permanent in-place closure of existing facilities, and (3) borrow areas that would be used to supply geologic materials (e.g., sand, gravel, and soil) would be irreversible and irretrievable (see Table 7–8).

Table 7–8. FFTF Decommissioning Alternatives Irreversible and Irretrievable Commitments of Land Resources[a]

Alternative (with Options)	Land Resource (hectares)	
	Permanently Committed and Newly Disturbed Land[b]	Borrow Area C (Disturbed Land)
1–No Action	18	0
2–Hanford RTP and SRF	0.7	2.8
2–Hanford RTP and INL SPF	0.7	2.8
2–INL RTP and Hanford SRF	0.7	2.8
2–INL RTP and SPF	0.7	2.8
3–Hanford RTP and SRF	0	3.2
3–Hanford RTP and INL SPF	0	3.2
3–INL RTP and Hanford SRF	0	3.2
3–INL RTP and SPF	0	3.2

[a] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.

[b] This includes (1) land area where facilities would be closed in place or where engineered barriers would be constructed; (2) new disturbance of land for facility construction; and (3) new disturbance of land for construction of engineered barriers beyond the boundary of the barrier itself. Does not include Borrow Area C.

Note: To convert hectares to acres, multiply by 2.471.

Key: FFTF=Fast Flux Test Facility; Hanford=Hanford Site; INL=Idaho National Laboratory; RTP=Remote Treatment Project; SPF=Sodium Processing Facility; SRF=Sodium Reaction Facility.

Source: SAIC 2010b.

FFTF is located in Hanford's 400 Area. None of the FFTF Decommissioning alternatives involve new disturbance of land for construction of an RTP at Hanford or INL, construction of an SRF at Hanford, or construction of an SPF at INL. Construction of these facilities would be within existing buildings or on disturbed land. The area where engineered barriers would be placed over the Reactor Containment Building (RCB) and Buildings 491E and 491W would be considered an irreversible and irretrievable commitment of land as a permanent waste management area. Section 7.4 discusses the relationship between short-term uses of the environment and the maintenance and enhancement of its long-term productivity.

The construction of new facilities, backfilling of subgrade void spaces, and emplacement of engineered surface barriers would require relatively large volumes of geologic materials from Borrow Area C. While this land would not be irreversibly or irretrievably committed to some use, the area would be irreversibly altered. The consumption of geologic materials, including soil, gravel, sand, and rock or basalt, is covered in Section 7.3.2.2.

The estimated areas of land that may permanently be committed or newly disturbed while supporting the FFTF Decommissioning alternatives are presented in Table 7–8. Except for Borrow Area C, all land use would occur within the FFTF Property Protected Area (i.e., 400 Area). For a detailed discussion of land use impacts of construction of new and existing facilities and Borrow Area C operations under the FFTF Decommissioning alternatives, see Chapter 4, Section 4.2.1. Table 7–8 may differ from the presentation of analysis in Chapter 4, Section 4.2.1, because Table 7–8 does not include committed land for construction of new facilities where the land is known to have already been disturbed.

7.3.2.2 Material Resources

The irreversible and irretrievable commitment of material resources would include process chemicals used during operations of facilities, construction materials that would not be recovered or recycled, materials that would be rendered radioactive and could not be decontaminated, raw materials consumed or reduced to irrecoverable waste forms, and geologic borrow materials. Projected demands for primary material resources under each FFTF Decommissioning alternative are shown in Table 7–9. The commitment of material resources would be for the entire life cycle of each FFTF Decommissioning alternative, including construction, operations, deactivation, and closure.

Regardless of whether the SRF is built at Hanford or INL's SPF is reactivated, modified, and used, some nitrogen would be necessary for the operations of either bulk sodium processing facility. Principal construction materials would include steel, as well as concrete and grout constituents, such as cement, gravel, and sand. Although other materials, including wood, plastics, and other metals, would be used, the use of these materials would be minor. For practical purposes, concrete, steel, and other materials incorporated into the framework of new facilities, such as the RTP and SRF at Hanford, would be irretrievably lost, regardless of whether operations would result in the direct contamination of the materials. In general, the RTP and SRF would be of comparable size and complexity; therefore, similar quantities of construction materials would be required for their respective construction.

Geologic materials, including sand, gravel, and soil, would be mined from Borrow Area C for the construction of engineered barriers and for nonspecification backfill, as presented in Table 7–9 under "Other Borrow Materials." The amount of nonspecification backfill required for filling subgrade void spaces would be higher under FFTF Decommissioning Alternative 3, in which the structures would be completely removed. Under all of the FFTF Decommissioning Alternative 2 scenarios, entombment would require the construction of an engineered barrier.

Table 7–9. FFTF Decommissioning Alternatives Irreversible and Irretrievable Commitments of Materials[a, b]

Resource (× 1,000)	FFTF Decommissioning Alternative								
	1	2–Entombment (with Options)				3–Removal (with Options)			
	No Action	Hanford RTP and SRF	Hanford RTP and INL SPF	INL RTP and Hanford SRF	INL RTP and SPF	Hanford RTP and SRF	Hanford RTP and INL SPF	INL RTP and Hanford SRF	INL RTP and SPF
Process Chemicals (metric tons)									
Nitrogen	0.14	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Construction Materials (metric tons)									
Steel	0	1	1	0.02	0.004	1	1	0.02	0.004
Asphalt	0	0	0	0	0	0	0	0	0
Concrete (cubic meters)[c]									
Cement	0	1	1	0.02	0.006	1	1	0.02	0.006
Sand	0	1	1	0.02	0.04	1	1	0.02	0.04
Gravel	0	2	2	0.05	0.02	2	2	0.05	0.02
Fly ash	0	0	0	0	0	0	0	0	0
Grout (cubic meters)[c]									
Cement	0	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Sand	0	23	23	23	23	23	23	23	23
Fly ash	0	12	12	12	12	12	12	12	12
Bentonite clay	0	0	0	0	0	0	0	0	0
Water-reducing agent	0	0	0	0	0	0	0	0	0
Engineered Barrier (cubic meters)									
Sand	0	9	9	9	9	0	0	0	0
Gravel	0	2	2	2	2	0	0	0	0
Soil	0	7	7	7	7	0	0	0	0
Asphalt	0	1	1	1	1	0	0	0	0
Other Borrow Materials (cubic meters)									
Rock	0	0	0	0	0	0	0	0	0
Sand	0	0	0	0	0	0	0	0	0
Gravel	0	2	1	0.1	0	0	0	0.1	0
Soil	0	0.04	0.04	0	0	0.04	0.04	0	0
Specification backfill	0	80	80	80	80	120	120	120	120

[a] Values presented in this table are in thousands; multiply by 1,000 to obtain actual value of resource commitment.
[b] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.
[c] Concrete and grout are presented as premixed constituents.

Note: To convert cubic meters to cubic yards, multiply by 1.308.

Key: FFTF=Fast Flux Test Facility; Hanford=Hanford Site; INL=Idaho National Laboratory; RTP=Remote Treatment Project; SPF=Sodium Processing Facility; SRF=Sodium Reaction Facility.

Source: SAIC 2010b.

7.3.2.3 Utility Resources

Key utility infrastructure resources would include projected activity demands for water, electricity, and fuel over the life cycle considered under each FFTF Decommissioning alternative. Projected demands for key utility infrastructure resources under each FFTF Decommissioning alternative are shown in Table 7–10.

Table 7–10. FFTF Decommissioning Alternatives Utility Resource Commitments[a, b]

Alternative (with Options)	Resource (× 1,000)			
	Water (liters)	Electricity (kilowatt-hours)	Fuel (liters)	
			Diesel	Gasoline
1–No Action	795,000	600,000	0	114
2–Hanford RTP and SRF	31,100	4,600	5,350	872
2–Hanford RTP and INL SPF	30,900	4,500	4,380	466
2–INL RTP and Hanford SRF	23,600	4,600	5,110	780
2–INL RTP and SPF	23,400	4,500	4,140	372
3–Hanford RTP and SRF	30,400	7,800	5,090	880
3–Hanford RTP and INL SPF	30,200	7,700	4,120	474
3–INL RTP and Hanford SRF	22,900	7,800	5,110	790
3–INL RTP and SPF	22,700	7,700	3,880	382

[a] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.
[b] Values presented in this table are in thousands; multiply by 1,000 to obtain actual value of resource commitment.
Note: To convert liters to gallons, multiply by 0.26417.
Key: FFTF=Fast Flux Test Facility; Hanford=Hanford Site; INL=Idaho National Laboratory; RTP=Remote Treatment Project; SPF=Sodium Processing Facility; SRF=Sodium Reaction Facility.
Source: SAIC 2010b.

The consumption of water and electricity under the FFTF Decommissioning No Action Alternative would be relatively high compared with that under the action alternatives due to the long-term management requirements of 100 years of administrative controls. Conversely, to effect entombment or complete removal under FFTF Decommissioning Alternatives 2 and 3, fuel consumption would increase. Essentially, the differences in utility consumption between FFTF Decommissioning Alternatives 2 and 3 are negligible.

For a detailed discussion of impacts on the existing infrastructure of implementing the FFTF Decommissioning alternatives, see Chapter 4, Section 4.2.2.

7.3.2.4 Labor Resources

Labor resources associated with the FFTF Decommissioning alternatives would be required over the entire life cycle of each alternative. The FFTF Decommissioning No Action Alternative would require a smaller commitment of labor resources than the action alternatives, but the labor would be needed over an extended period of time. FFTF Decommissioning Alternatives 2 and 3 would require much greater short-term commitments of labor resources to achieve either entombment or removal of the FFTF structures. To achieve removal under FFTF Decommissioning Alternative 3, a slight increase in construction labor would be required compared with FFTF Decommissioning Alternative 2. These labor requirements are shown in Table 7–11. Labor requirements have the potential to generate economic impacts that may affect the need for housing units, public services, and local transportation in the region. For a detailed analysis of the labor impacts associated with the FFTF Decommissioning alternatives, see Chapter 4, Section 4.2.9.

Table 7–11. FFTF Decommissioning Alternatives Labor Resource Commitments[a]

Alternative (with Options)	Labor Hours	Labor (FTEs)
1–No Action	41,600	20
2–Hanford RTP and SRF	1,860,000	894
2–Hanford RTP and INL SPF	1,540,000	740
2–INL RTP and Hanford SRF	1,510,000	726
2–INL RTP and SPF	1,200,000	577
3–Hanford RTP and SRF	2,000,000	962
3–Hanford RTP and INL SPF	1,690,000	813
3–INL RTP and Hanford SRF	1,660,000	798
3–INL RTP and SPF	1,340,000	644

[a] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.

Note: To convert FTEs to labor hours, multiply by 2,080.

Key: FFTF=Fast Flux Test Facility; FTE=full-time equivalent; Hanford=Hanford Site; INL=Idaho National Laboratory; RTP=Remote Treatment Project; SPF=Sodium Processing Facility; SRF=Sodium Reaction Facility.

Source: SAIC 2010b.

7.3.3 Waste Management Alternatives

Expansion of Hanford's waste disposal capacity would be necessary to support implementation of the Tank Closure, FFTF Decommissioning, and Waste Management alternatives, as well as to receive and dispose of offsite waste. Under the Waste Management No Action Alternative, the current disposal capacity at Hanford would not be expanded. Burial in low-level radioactive waste burial ground (LLBG) 218-W-5, trenches 31 and 34, would continue until 2035, followed by 100 years of administrative controls. Construction of IDF-East would be terminated; the site would be backfilled with native soils. Under Waste Management Alternatives 2 and 3, disposal groups were developed to support particular Tank Closure alternatives based on needed disposal capacities and operational timeframes. Three disposal groups were developed as a subset of both Waste Management Alternatives 2 and 3; all involve construction, operations, deactivation, closure, and postoperational monitoring of additional disposal facilities (i.e., one or two IDFs and the RPPDF). Additionally, Waste Management Alternatives 2 and 3 would require new facility construction, operations, and deactivation to expand the T Plant and Waste Receiving and Processing Facility (WRAP) and to provide storage capacities for processing and handling TRU waste, LLW, and MLLW.

7.3.3.1 Land Resources

Land use commitments under the Waste Management alternatives for (1) construction of new facilities on undisturbed land, (2) permanent land disposal facilities, and (3) borrow areas that would be used to supply geologic materials would be irreversible and irretrievable (see Table 7–12). Geologic materials (e.g., sand, gravel, soil, rock) would be used to construct disposal areas and to emplace engineered barriers over disposal areas.

The Waste Management No Action Alternative would not require construction of any new facilities or disposal facilities. In addition, construction of IDF-East would cease without burial of waste and the site would be backfilled with native soils. Waste Management Alternatives 2 and 3 would require expansion or new construction of the T Plant, WRAP, and waste processing and storage facilities within the 200-West Area. The only new disturbance of land that would be required under both Waste Management Alternatives 2 and 3 would be the construction of a portion of the WRAP Remote-Handled Mixed

TRU/TRU waste facility in the 200-West Area. Waste Management Alternatives 2 and 3 would also involve construction of additional disposal facilities: IDF-East would be built under Waste Management Alternative 2 and two IDFs, IDF-East and IDF-West, under Waste Management Alternative 3. The RPPDF would be built between the 200-East and 200-West Areas regardless of the alternative selected.

Table 7–12. Waste Management Alternatives Irreversible and Irretrievable Commitments of Land Resources[a]

Alternative (with Disposal Group)	Land Resource (hectares)	
	Permanently Committed and Newly Disturbed Land[b]	Borrow Area C (Disturbed Land)
1–No Action	0	0
2–Disposal Group 1	65	41
2–Disposal Group 2	248	158
2–Disposal Group 3	248	158
3–Disposal Group 1	65	37
3–Disposal Group 2	253	157
3–Disposal Group 3	253	157

[a] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.

[b] This includes (1) land area where facilities would be closed in place or where engineered barriers would be constructed; (2) new disturbance of land for facility construction; and (3) new disturbance of land for construction of engineered barriers beyond the boundary of the barrier itself. Does not include Borrow Area C.

Note: To convert hectares to acres, multiply by 2.471.

Source: SAIC 2010c.

New disturbance of land for construction of facilities would be considered an irreversible impact. Land used for permanent disposal facilities would be considered an irreversible and irretrievable commitment of land. Section 7.4 discusses the relationship between short-term uses of the environment and the maintenance and enhancement of its long-term productivity.

The construction of new facilities and emplacement of engineered surface barriers over disposal areas would require relatively large volumes of geologic materials from Borrow Area C. While this land would not be irreversibly or irretrievably committed to some use, the area would be irreversibly altered. The consumption of geologic materials, including soil, gravel, sand, and rock or basalt, is covered in Section 7.3.3.2.

The estimated areas of land that may be permanently committed or newly disturbed while supporting the Waste Management alternatives are presented in Table 7–12. Except for Borrow Area C, all land use would occur within the Central Plateau. For a detailed discussion of land use impacts of construction of new and existing facilities and Borrow Area C operations under the Waste Management alternatives, see Chapter 4, Section 4.3.1. Table 7–12 may differ from the presentation of analysis in Chapter 4, Section 4.3.1, because Table 7–12 does not include committed land for construction of new facilities where the land is known to have already been disturbed.

7.3.3.2 Material Resources

The irreversible and irretrievable commitment of material resources would include process chemicals used during operations of facilities, construction materials that could not be recovered or recycled, materials that would be rendered radioactive and could not be decontaminated, raw materials consumed or reduced to irrecoverable waste forms, and geologic borrow materials. Projected demands for primary material resources under each Waste Management alternative are shown in Table 7–13. The commitment of material resources would be for the entire life cycle of each Waste Management alternative, including construction, operations, deactivation, and closure.

Geologic materials would include sand, gravel, and soil mined from Borrow Area C for the construction of disposal areas and engineered barriers for one or two IDFs and the RPPDF, as presented in Table 7–13 under "Other Borrow Materials." The gravel listed under "Other Borrow Materials" would be used to construct a drain layer as part of the disposal area liners. For Disposal Groups 2 and 3 under both Waste Management action alternatives, the collective size of the IDF(s) and RPPDF would increase significantly to accommodate clean closure of the tank farms and cribs and trenches (ditches), resulting in a proportional increase in the consumption of geologic resources necessary to construct the engineered barriers.

Nitrogen would be used for operations of the expanded WRAP. Principal construction materials would include steel, as well as concrete and grout constituents, such as cement, gravel, and sand. Although other materials, including wood, plastics, and other metals, would be used, the use of these materials would be minor. For practical purposes, concrete, steel, and other materials incorporated into the framework of new facilities, such as the T Plant, WRAP, and waste storage facilities, would be irretrievably lost, regardless of whether operations would result in direct contamination of the materials.

Table 7–13. Waste Management Alternatives Irreversible and Irretrievable Commitments of Materials[a, b]

Resource (× 1,000)	Waste Management Alternative						
	1	2–IDF-East Only			3–IDF-East and IDF-West		
	No Action	Disposal Group 1	Disposal Group 2	Disposal Group 3	Disposal Group 1	Disposal Group 2	Disposal Group 3
Process Chemicals (metric tons)							
Nitrogen	0	1	1	1	1	1	1
Construction Materials (metric tons)							
Steel	2	8	8	8	8	8	8
Asphalt	0	0	0	0	0	0	0
Concrete (cubic meters)[c]							
Cement	1	4	4	4	4	4	4
Sand	3	9	9	9	9	9	9
Gravel	4	11	11	11	11	11	11
Fly ash	0	0	0	0	0	0	0
Grout (cubic meters)[c]							
Cement	0	0	0	0	0	0	0
Sand	0	0	0	0	0	0	0
Gravel	0	0	0	0	0	0	0
Fly ash	0	0	0	0	0	0	0
Bentonite clay	2	5	20	20	5	20	20
Water-reducing agent	0	0	0	0	0	0	0
Engineered Barrier (cubic meters)							
Sand	0	814	3,150	3,150	599	3,070	3,070
Gravel	0	195	755	755	195	755	755
Soil	0	651	2,520	2,520	649	2,520	2,520
Asphalt	0	98	377	377	101	382	382
Other Borrow Materials (cubic meters)							
Rock	0	0	0	0	0	0	0
Sand	0	0	0	0	0	0	0
Gravel	0.034	209	808	808	208	809	809
Soil	0	0	0	0	0	0	0

[a] Values presented in this table are in thousands; multiply by 1,000 to obtain actual value of resource commitment.
[b] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.
[c] Concrete and grout are presented as premixed constituents.
Note: To convert cubic meters to cubic yards, multiply by 1.308.
Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility.
Source: SAIC 2010c.

7.3.3.3 Utility Resources

Key utility infrastructure resources include projected activity demands for water, electricity, and fuel over the life cycle considered under each Waste Management alternative and respective disposal group. Projected demands for key utility infrastructure resources under each Waste Management alternative are shown in Table 7–14.

Table 7–14. Waste Management Alternatives Utility Resource Commitments[a, b]

Alternative (with Disposal Group)	Resource (× 1,000)			
	Water (liters)	Electricity (kilowatt-hours)	Fuel (liters)	
			Diesel	Gasoline
1–No Action	35,700	5,630	13,900	1,230
2–Disposal Group 1	3,050,000	559,000	257,000	21,700
2–Disposal Group 2	21,200,000	559,000	1,460,000	83,100
2–Disposal Group 3	37,200,000	559,000	2,220,000	109,000
3–Disposal Group 1	3,040,000	559,000	257,000	21,200
3–Disposal Group 2	21,100,000	569,000	1,450,000	83,100
3–Disposal Group 3	36,900,000	569,000	2,210,000	108,000

a Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.

b Values presented in this table are in thousands; multiply by 1,000 to obtain actual value of resource commitment.

Note: To convert liters to gallons, multiply by 0.26417.

Source: SAIC 2010c.

The consumption of utility resources under the Waste Management No Action Alternative would be relatively low compared with that under the action alternatives as new waste processing, storage, and disposal facilities would not be constructed. Disposal Group 1 under both Waste Management action alternatives would involve increased consumption of utility resources. Compared with utility demands for Disposal Group 1, consumption of water and fuel would increase significantly under Disposal Groups 2 and 3 in proportion to the large increase in disposal area capacities required. However, electricity consumption would remain constant among the three disposal groups because its use would not correspond to construction and operations of the disposal areas, but rather with operations of the new T Plant, WRAP, and waste storage facilities that would be built and operated regardless of the disposal group selected.

For a detailed discussion of impacts on the existing infrastructure of implementing the Waste Management alternatives, see Chapter 4, Section 4.3.2.

7.3.3.4 Labor Resources

Labor resources associated with the Waste Management alternatives would be required over the entire life cycle of the alternatives. The Waste Management No Action Alternative would require a smaller commitment of labor resources than the action alternatives due to the lack of additional waste processing, storage, and disposal facilities to be constructed and operated. The labor requirements would be proportionally influenced by the size of the disposal areas and the length of operations. The difference in labor requirements between Waste Management Alternatives 2 and 3, which only differ in respective locations of each alternative's disposal areas, would be very minor. The labor requirements of the Waste Management alternatives are shown in Table 7–15. Labor requirements have the potential to generate economic impacts that may affect the need for housing units, public services, and local transportation in the region. For a detailed analysis of the labor impacts associated with the Waste Management alternatives, see Chapter 4, Section 4.3.9.

Table 7–15. Waste Management Alternatives Labor Resource Commitments[a]

Alternative (with Disposal Group)	Labor Hours	Labor (FTEs)
1–No Action	1,010,000	486
2–Disposal Group 1	57,800,000	27,800
2–Disposal Group 2	166,000,000	79,800
2–Disposal Group 3	242,000,000	116,000
3–Disposal Group 1	59,300,000	28,500
3–Disposal Group 2	167,000,000	80,300
3–Disposal Group 3	243,000,000	117,000

[a] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.

Note: To convert FTEs to labor hours, multiply by 2,080.

Key: FTE=full-time equivalent.

Source: SAIC 2010c.

7.3.4 Alternative Combinations

This section presents a comparison of the irreversible and irretrievable commitments of resources that are projected under the three alternative combinations selected for analysis in this EIS. The alternative combinations are described in detail in Chapter 4, Section 4.4.

7.3.4.1 Land Resources

Land use commitments under the alternative combinations for construction of new facilities on undisturbed land, permanent land disposal facilities, and borrow areas that would be used to supply geologic materials would be irreversible and irretrievable. The estimated areas of land that may be permanently committed or newly disturbed while supporting the representative alternative combinations are presented in Table 7–16. The values presented in Table 7–16 do not include the commitment of land for construction of new facilities where the land is known to have already been disturbed.

Table 7–16. Alternative Combinations Irreversible and Irretrievable Commitments of Land Resources[a]

Alternative Combination	Land Resource (hectares)	
	Permanently Committed and Newly Disturbed Land[b]	Borrow Area C (Disturbed Land)
1	35	2
2	173	140
3	376	401

[a] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.

[b] This includes (1) land area where facilities would be closed in place or where engineered barriers would be constructed; (2) new disturbance of land for facility construction; and (3) new disturbance of land for construction of engineered barriers beyond the boundary of the barrier itself. Does not include Borrow Area C.

Note: To convert hectares to acres, multiply by 2.471.

Source: SAIC 2010a, 2010b, 2010c.

7.3.4.2 Material Resources

The irreversible and irretrievable commitment of material resources would include process chemicals used during operations of facilities, construction materials that cannot be recovered or recycled, materials that would be rendered radioactive and could not be decontaminated, raw materials consumed or reduced to irrecoverable waste forms, and geologic borrow materials. Projected demands for primary material resources under each representative combination of alternatives are presented in Table 7–17.

Table 7–17. Alternative Combinations Irreversible and Irretrievable Commitments of Materials[a, b]

Resource (× 1,000)	Alternative Combination 1	Alternative Combination 2	Alternative Combination 3
Materials			
Glass formers (metric tons)	0	202	206
Ion exchange resins (liters)	0	2,440	2,440
Retrieval chemicals (e.g., oxalic acid) (liters)	0	0	189,000
Nitric acid (3 percent and 57 percent solution) (liters)	0	0	1,790
Caustic (50 percent solution) (liters)	0	0	61
Nitrogen (metric tons)	0.14	1.05	1.05
Construction Materials (metric tons)			
Steel	6	81	538
Asphalt	0	5	5
Concrete (cubic meters)[c]			
Cement	9	106	350
Sand	19	214	694
Gravel	25	280	901
Grout (cubic meters)[c]			
Cement	0	13.4	28.2
Sand	0	797	138
Fly ash	0	178	152
Bentonite clay	2	11	27
Water-reducing agent	0	0.22	0.04
Engineered Barriers (cubic meters)			
Sand	0	1,880	3,470
Gravel	0	450	831
Soil	0	1,510	2,770
Asphalt	0	237	419
Other Borrow Materials (cubic meters)			
Rock	0	14	14
Sand	0.19	4	1
Gravel	0.28	218	817
Soil	0.17	529	8,300
Specification backfill	55	334	374

[a] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.

[b] Values presented in this table are in thousands; multiply by 1,000 to obtain actual value of resource commitment.

[c] Concrete and grout are presented as premixed constituents.

Note: To convert cubic meters to cubic yards, multiply by 1.308; liters to gallons, by 0.26417.

Source: SAIC 2010a, 2010b, 2010c.

7.3.4.3 Utility Resources

Key utility infrastructure resources would include projected activity demands for water, electricity, and fuel over the life cycle considered under each alternative combination. The irreversible and irretrievable commitments of utility resources under each representative alternative combination are presented in Table 7–18.

Table 7–18. Alternative Combinations Utility Resource Commitments[a, b]

Alternative Combination	Resource (× 1,000,000)			
	Water (liters)	Electricity (kilowatt-hours)	Fuel: Diesel (liters)	Fuel: Gasoline (liters)
1	11,300	721	50	6
2	89,400	18,500	4,300	179
3	114,000	21,700	5,820	300

[a] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.
[b] Values presented in this table are in millions; multiply by 1,000,000 to obtain actual value of resource commitment.
Note: To convert liters to gallons, multiply by 0.26417.
Source: SAIC 2010a, 2010b, 2010c.

7.3.4.4 Labor Resources

Labor resources associated with the alternative combinations would be required over the entire life cycle of each combination, although more labor resources would be required during the construction and operations phases. Labor requirements have the potential to generate economic impacts that may affect the need for housing units, public services, and local transportation in the region. The labor requirements of the representative alternative combinations are shown in Table 7–19.

Table 7–19. Alternative Combinations Labor Resource Commitments[a]

Alternative Combination	Labor Hours	Labor (FTEs)
1	17,400,000	8,370
2	447,000,000	215,000
3	683,000,000	328,000

[a] Calculated as total alternative life-cycle requirements, encompassing construction, operations, deactivation, and closure.
Note: To convert FTEs to labor hours, multiply by 2,080.
Key: FTE=full-time equivalent.
Source: SAIC 2010a, 2010b, 2010c.

7.4 RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

Pursuant to NEPA regulations (40 CFR 1502.16), an EIS must consider the relationship between local short-term uses of the environment and the maintenance and enhancement of its long-term productivity. Potential short-term impacts related to the Tank Closure, FFTF Decommissioning, and Waste Management alternatives are presented in Chapter 4. For analysis purposes, "short term" encompasses the active project phases of each alternative, during which construction, operations, deactivation, and closure activities would take place. Short-term timeframes include any administrative control, postclosure care, or onsite storage activities for treated waste pending final disposition. "Long term" is defined as the timeframe that extends beyond conclusion of the short-term activities proposed under each alternative. Long-term impacts are discussed in Chapter 5.

In making a decision regarding various alternatives for accomplishing a proposed action, an agency's objective is to demonstrate and implement the alternative(s) that, on balance, would result in the least overall adverse impact on the environment. Under the evaluated *TC & WM EIS* action alternatives, an increase in worker and public exposure under controlled circumstances (i.e., tank waste retrieval, treatment, and disposal) and in compliance with applicable legal requirements over the short term would lead to a decrease in exposure of the unprotected public to unmitigated releases of contaminants into the environment over the long term.

Under certain *TC & WM EIS* alternatives, in addition to short-term use of the environment, the emplacement of engineered barriers over tank farm systems, cribs and trenches (ditches), the FFTF RCB, and/or permanent waste disposal sites would be considered a long-term use of the environment, and thus would decrease the long-term productivity of these locations. Short- and long-term uses of the environment in the broader context would include elements of unavoidable, adverse impacts and irreversible and irretrievable commitments of resources to enhance the long-term productivity of the environment. Unavoidable, adverse environmental impacts are discussed in Section 7.2; irreversible and irretrievable commitments of resources are discussed in Section 7.3.

7.4.1 Tank Closure Alternatives

The short-term duration of each Tank Closure alternative is presented in Table 7–20. The short-term durations are broken into two groups: (1) the construction, operations, and deactivation phase, when most activities would take place, and (2) the closure phase, when administrative controls or postclosure care would be performed and/or long-term storage would continue. Most impacts and short-term uses of the environment would occur during the construction, operations, and deactivation phase. Under the Tank Closure No Action Alternative and Tank Closure Alternative 2A, administrative controls would be required because tank farm closure would not be achieved. Under Tank Closure Alternatives 2B through 5, the SST farms would be closed and covered with an engineered barrier, followed by postclosure care. Under Tank Closure Alternatives 6A and 6B, Base Cases, an engineered barrier would be emplaced over the cribs and trenches (ditches). Under Tank Closure Alternatives 6A and 6B, Option Cases, all tank farms and cribs and trenches (ditches) would be clean-closed and, therefore, would not require construction of an engineered barrier or postclosure care. In contrast, Tank Closure Alternative 6C would require an engineered barrier over the tank farms and cribs and trenches (ditches) and, as a result, would require postclosure care. Under Tank Closure Alternatives 6A through 6C, all tank waste would be managed as HLW, which would require construction and operations of long-term, onsite storage facilities.

Table 7–20. Tank Closure Alternatives Short-Term Life Cycles

Alternative	Construction, Operations, and Deactivation Phase	Closure Phase (Activity Type)[a]
1	2006–2008	2008–2107 (AC)
2A	2006–2094	2094–2193 (AC)
2B	2006–2046	2046–2145 (PM)
3A	2006–2043	2042–2141 (PM)
3B	2006–2043	2042–2141 (PM)
3C	2006–2043	2042–2141 (PM)
4	2006–2046	2045–2144 (PM)
5	2006–2039	2040–2139 (PM)
6A, Base Case	2006–2168	2151–2250 (PM) Until 2262 (ST)
6A, Option Case	2006–2168	Until 2262 (ST)
6B, Base Case	2006–2101	2102–2201 (PM) Until 2199 (ST)
6B, Option Case	2006–2101	Until 2199 (ST)
6C	2006–2046	2046–2145 (PM) Until 2145 (ST)

[a] Activity types: AC=administrative controls; PM=postclosure care and monitoring; ST=onsite storage.

Source: SAIC 2010a.

Short-term commitments of resources would include the space and materials required for construction of new facilities and support facilities; for transportation infrastructure; and for waste storage, retrieval, treatment, and disposal, as well as tank closure. Certain resource commitments would be substantially greater under Tank Closure Alternatives 2B through 6C than under the Tank Closure No Action Alternative or Tank Closure Alternative 2A because construction of an engineered surface barrier for landfill closure and/or partial or complete clean closure of the SST system would be required. Tank Closure Alternative 2A would involve a commitment of resources to treat and stabilize the tank waste, but would not follow through with closure of the SST farms. Depending on the alternative, workers, the public, and the environment would be exposed to various amounts of hazardous and radioactive materials over the short term from tank waste retrieval, treatment, and disposal activities and from SST system closure operations.

Table 7–21 presents the amounts of land that would be committed in the short term to accomplish the objectives of each Tank Closure alternative. The areas given include land for existing facilities and new facilities that would be constructed to support a particular alternative. The land use amounts are presented as aggregate values over the entire short-term life cycles of the alternatives; however, in practice, most facilities would operate during various timeframes. Table 7–21 also presents the long-term land commitments that would continue indefinitely under each alternative, including all permanent disposition areas where engineered barriers would preclude the use of the site for other productive purposes and all areas where tank farms and cribs and trenches (ditches) would not be closed under certain alternatives. Borrow Area C is not included in the short-term commitments of land. While excavation activities conducted in Borrow Area C would take place in the short term, they could be terminated at any time. The amount of land disturbance required in Borrow Area C to support each Tank Closure alternative was previously discussed in Section 7.3.1.1.

Table 7–21. Tank Closure Alternatives Short- and Long-Term Commitments of Land

Alternative	Land Commitment (hectares)	
	Short-Term Use[a]	Long-Term Use[b]
1	0	17
2A	33	17
2B	17	84
3A	16	84
3B	17	84
3C	17	84
4	20	61
5	20	84
6A, Base Case	210	25
6A, Option Case	212	0
6B, Base Case	119	25
6B, Option Case	121	0
6C	62	84

[a] Land use commitments over the short term encompass the total alternative life cycle, including construction, operations, deactivation, and closure. Short-term land use under Alternative 1 does not include partial construction of the Waste Treatment Plant because this action has already been initiated.

[b] Land use commitments over the long term encompass the period following completion of each alternative's scheduled activities. Long-term land use under Alternatives 1 through 3C, 5, and 6C comprises the footprints of the single-shell tank farms and B and T Area cribs and trenches (ditches), with or without engineered barriers, as applicable; that under Alternative 4 does not include the BX and SX tank farms, which would be clean-closed; that under Alternatives 6A and 6B, Base Cases, comprises only the footprints of the B and T Area cribs and trenches (ditches); and that under Alternatives 6A and 6B, Option Cases, does not include any tank farms or cribs and trenches (ditches), which would be clean-closed.

Note: To convert hectares to acres, multiply by 2.471.

Source: SAIC 2010a.

Although this EIS considers only facility deactivation and not decontamination and decommissioning of waste treatment, storage, and disposal facilities, DOE could decontaminate and decommission major facilities at the end of their life cycles and restore adjacent area brownfield sites, which would then be available for future industrial use. However, it is unlikely that any of the facility sites would be restored to their original predevelopment states or natural, terrestrial habitats.

The Tank Closure No Action Alternative would likely incur additional and indefinite commitments of land over the long term, when degradation of tank farms would lead to eventual release of unmitigated contaminants into the subsurface environment, potentially impacting the Columbia River. Except for Tank Closure Alternatives 6A and 6B, under which clean closure of all SST farms would occur, as well as Tank Closure Alternative 4, under which clean closure of the BX and SX tank farms would occur, the remaining action alternatives would leave SST system components and residual tank waste (ranging from 0.01 to 10 percent by volume) in place. Any land areas where tank farms would be left in place would represent a long-term commitment of land and terrestrial resources for waste management. In addition, except for Tank Closure Alternatives 6A and 6B, Option Cases, the areas occupied by the cribs and trenches (ditches) would represent a long-term commitment of land. Therefore, these areas would be removed from long-term productivity considerations. However, these areas would likely be reclaimed by native vegetation and wildlife in the absence of human intervention over the very long term following the end of any administrative control or postclosure care period.

Air emissions associated with waste retrieval, treatment, and disposal and SST system closure would introduce radioactive and nonradioactive constituents into the regional airshed around Hanford. Over time, these emissions would result in additional loading and exposure, but would not impair the long-term productivity of the environment at Hanford.

Chemical and radioactive contamination of the vadose zone and groundwater below and downgradient of the 200 Areas would occur over time under all of the Tank Closure alternatives due to the release of residual tank contaminants and the disposal of treated tank waste and contaminated soil. The long-term performance of waste forms and their impacts on the vadose zone and groundwater receptors are discussed in detail in Chapter 5. Depending on the extent and magnitude of resultant groundwater contaminant plumes, it may be necessary to place land use or other institutional controls on the overlying land areas for an indefinite period, thereby reducing the overall long-term productivity of the affected areas.

Radiation and chemical doses to aquatic and terrestrial receptors at seeps along the Columbia River and in the receiving water were evaluated as part of the ecological risk portion of the analysis. Under all scenarios and alternatives, results indicated that calculated absorbed doses to referenced organisms would be below regulatory limits and/or reference standards and, therefore, would likely have no impact on the long-term productivity of the Columbia River ecosystem.

Continued employment, expenditures, and tax revenues generated during implementation of any of the action alternatives would directly benefit local, regional, and state economies over the short term. Local governments investing project-generated tax revenues into infrastructure and other required services could facilitate economic productivity. Nearby townships and geographic provinces have experienced a recent surge in growth, and the availability of employment opportunities would further sustain and foster regional development.

Management and disposal of LLW, MLLW, mixed TRU waste, IHLW, ILAW, and secondary waste generated as a result of waste retrieval, treatment, and disposal and SST system closure would increase energy demand and consume space at treatment, storage, and disposal facilities. Regardless of the location, a longer-term commitment of terrestrial resources would be required to meet waste management needs. Primary waste (e.g., IHLW canisters) and HLW melters taken out of service would be stored on site. All treated tank waste under Tank Closure Alternatives 6A, 6B, and 6C would be managed as HLW and would require storage at Hanford until disposition decisions are made and implemented.

The short-term use of the environment would be evaluated against the maintenance and enhancement of its long-term productivity, as demonstrated by the performance assessment for untreated and treated tank waste forms. This relationship between short-term uses of the environment and its long-term productivity under the Tank Closure alternatives corresponds to the relationship between commitments of resources now to their use in the future under the Waste Management alternatives (see Section 7.3.3). In a simple sense, the Tank Closure alternatives represent most of the short-term uses of the environment, while the Waste Management alternatives represent most of the resultant long-term commitments of tank closure. These two proposed actions are mutually dependent.

7.4.2 FFTF Decommissioning Alternatives

The short-term duration of each FFTF Decommissioning alternative is presented in Table 7–22. The short-term durations are broken into two groups: (1) the construction, operations, and deactivation phase, when most activities would take place, and (2) the closure phase, when administrative controls or postclosure care would be performed. Most impacts and short-term uses of the environment would occur during the construction, operations, and deactivation phase. Under the FFTF Decommissioning No Action Alternative, administrative controls would be required to maintain the facility in its existing state for 100 years. FFTF Decommissioning Alternatives 2 and 3 would require 100 years of postclosure care, although fewer activities would be required during this period under FFTF Decommissioning Alternative 3 because it does not require emplacement of an engineered barrier.

Table 7–22. FFTF Decommissioning Alternatives Short-Term Life Cycles

Alternative	Construction, Operations, and Deactivation Phase	Closure Phase (Activity Type)[a]
1	Not applicable	2008–2107 (AC)
2[b]	2013–2021	2022–2121 (PM)
3[b, c]	2012–2021	2022–2121 (PM)

[a] Activity types: AC=administrative controls; PM=postclosure care and monitoring.

[b] Life-cycle durations are the same for all Hanford Site and Idaho options.

[c] Alternative 3 includes a 100-year postclosure care period even though this alternative does not have an engineered barrier.

Key: FFTF=Fast Flux Test Facility.

Source: SAIC 2010b.

Short-term commitments of resources would include the space and materials required to expand or construct facilities for treatment of the four FFTF RH-SCs and processing of bulk sodium at Hanford or INL. The only facility under the FFTF Decommissioning alternatives that would require new construction is the SRF at Hanford, although construction would occur within disturbed areas. The RTP at either Hanford or INL and the SPF at INL would be located within or adjacent to existing facilities. Depending on the alternative, workers, the public, and the environment would be exposed to various amounts of hazardous and radioactive materials over the short term due to FFTF decommissioning activities such as decontamination, demolition, and excavation.

Table 7–23 presents the amounts of land that would be committed in the short term to accomplish the objectives of each of the FFTF Decommissioning alternatives, including land use at both Hanford and INL. The SPF at INL is an existing facility and is not included as a short-term commitment under FFTF Decommissioning Alternative 2 or 3. Table 7–23 also presents the long-term land commitments that would continue indefinitely under each alternative, including (1) all permanent disposition areas where engineered barriers would preclude the use of the site for other productive purposes, (2) all areas where buildings would not be decommissioned, and (3) all bulk sodium storage areas. Borrow Area C is not included in the short-term commitments of land. While excavation activities conducted in Borrow Area C would take place in the short term, they could be terminated at any time. The amount of land disturbance required in Borrow Area C to support each FFTF Decommissioning alternative was previously discussed in Section 7.3.2.1.

The FFTF Decommissioning No Action Alternative would likely incur additional and indefinite long-term commitments of land because, after the end of the 100-year administrative control period, contaminants would be released into the environment. Under FFTF Decommissioning Alternative 2, some facilities would be completely removed and others would be entombed (e.g., the RCB, Buildings 491E and 491W). Long-term commitments of land under FFTF Decommissioning Alternative 2 represent an engineered barrier that would be placed over the RCB and Buildings 491E and 491W. Therefore, the FFTF Decommissioning No Action Alternative, and, to a lesser extent, FFTF Decommissioning Alternative 2, would remove land areas within the 400 Area from consideration for long-term productivity. However, these areas would likely be reclaimed by native vegetation and wildlife in the absence of human intervention over the very long term following the end of any administrative control or postclosure care period. FFTF Decommissioning Alternative 3 represents removal of all buildings, including the RCB and Buildings 491E and 491W, except for the RCB's subgrade concrete shell. In this case, an engineered barrier would not be constructed; however, a limited-scope postclosure care period would still be necessary, after which the land could be returned to productive use.

Table 7–23. FFTF Decommissioning Alternatives Short- and Long-Term Commitments of Land

Alternative (with Options)	Land Commitment (hectares)	
	Short-Term Use[a]	Long-Term Use[b]
1–No Action	0	18
2–Hanford RTP and SRF	0.2	0.7
2–Hanford RTP and INL SPF	0.1	0.7
2–INL RTP and Hanford SRF	0.2	0.7
2–INL RTP and SPF	0.1	0.7
3–Hanford RTP and SRF	0.2	0
3–Hanford RTP and INL SPF	0.1	0
3–INL RTP and Hanford SRF	0.2	0
3–INL RTP and SPF	0.1	0

[a] Land use commitments over the short term encompass the total alternative life cycle, including construction, operations, deactivation, and closure.

[b] Land use commitments over the long term encompass the period following completion of each alternative's scheduled activities. Long-term land use under Alternative 1: No Action comprises the footprint of the existing FFTF Property Protected Area; that under Alternative 2, the engineered barrier over the FFTF Reactor Containment Building and Buildings 491E and 491W; and that under Alternative 3, removal of FFTF and all associated support structures.

Note: To convert hectares to acres, multiply by 2.471.

Key: FFTF=Fast Flux Test Facility; Hanford=Hanford Site; INL=Idaho National Laboratory; RTP=Remote Treatment Project; SPF=Sodium Processing Facility; SRF=Sodium Reaction Facility.

Source: SAIC 2010b.

Air emissions associated with building demolition, closure, and site restoration activities, as well as emissions associated with construction, operations, and deactivation of an RTP and SRF or SPF would introduce small amounts of radioactive and nonradioactive constituents to the regional airshed around Hanford. If the RTP is constructed at INL and INL's SPF is reactivated and modified for bulk sodium processing, air emissions from these two facilities would contribute to cumulative impacts, along with air emissions from other sources at INL. Over time, these emissions would result in additional loading and exposure, but would not impact air quality or radiological exposure standards to the extent that long-term productivity of the environment would be impaired at either Hanford or INL.

Chemical and radioactive contamination of the vadose zone and groundwater below and downgradient from the 400 Area would occur over time under FFTF Decommissioning Alternatives 1 and 2; this contamination would not occur under FFTF Decommissioning Alternative 3, in which removal of all of the structures would take place. Impacts would be the most significant under FFTF Decommissioning Alternative 1. Under FFTF Decommissioning Alternative 2, in which the four FFTF RH-SCs and bulk sodium would be removed, long-term impacts on the vadose zone and groundwater would be reduced. The long-term performance of waste forms and their impacts on the vadose zone and groundwater receptors are discussed in detail in Chapter 5. Depending on the extent and magnitude of resultant groundwater contaminant plumes, it may become necessary for land use or other institutional controls to be placed on the overlying land areas for an indefinite period, thereby reducing overall long-term productivity of the affected areas.

No additional short- or long-term impacts on ecological receptors are projected to occur as a result of implementing any of the FFTF Decommissioning alternatives.

Any impacts on socioeconomic factors are expected to be negligible in the context of activities occurring across Hanford and would be confined within the short-term construction, operations, and deactivation phase, ending no later than 2021 under all alternatives.

Management and disposal of LLW, MLLW, and secondary waste would be required under all FFTF Decommissioning alternatives. The FFTF Decommissioning No Action Alternative would require indefinite storage of the four FFTF RH-SCs within the 400 Area and of bulk sodium within the 200-West and 400 Areas, removing these areas from consideration for other long-term productive uses. Under both action alternatives, the specialized components would be decontaminated and repackaged for disposal in an IDF, and the bulk sodium would be processed to produce a caustic sodium hydroxide solution for treating tank waste in the WTP, thereby eliminating the requirement for long-term operations and maintenance of storage facilities. FFTF Decommissioning Alternative 2 would result in the entombment of LLW and MLLW within the subgrade void spaces of the RCB, which would essentially constitute a land use commitment of the RCB and Buildings 491E and 491W over the long term. Comparatively, under FFTF Decommissioning Alternative 3, all internal reactor core components would be extricated, all buildings would be demolished, and all decommissioning debris would be disposed of as LLW or MLLW in an IDF, potentially enabling future productive use of land in the 400 Area.

Short-term use of the environment for removing and processing the four FFTF RH-SCs and the bulk sodium would be evaluated against the potential adverse impacts on long-term productivity that could result from the eventual release of contaminants into the environment. Under the action alternatives, the increase in short-term impacts of removal of all FFTF structures would be evaluated against the emplacement of an engineered barrier and long-term lost productivity of the FFTF land areas. An additional long-term consideration is assessment of waste-form performance and the effect of additional waste loading on an IDF resulting from the generation of decommissioning waste and secondary waste under the action alternatives.

7.4.3 Waste Management Alternatives

The short-term duration of each Waste Management alternative is presented in Table 7–24. The short-term durations are broken into two groups: (1) the construction, operations, and deactivation phase, when most activities would take place, and (2) the closure phase, when administrative controls or postclosure care would be performed. Most impacts and short-term uses of the environment would occur during the construction, operations, and deactivation phase. The Waste Management No Action Alternative would not include construction or operations of any new disposal facilities; however, it would require a 100-year administrative control period. Under the remaining Waste Management alternatives and their associated disposal groups, permanent disposal facilities would be constructed in the 200 Areas that would ultimately be closed under engineered barriers followed by postclosure care.

Short-term commitments of resources under the Waste Management action alternatives would include the space and materials required to construct facility expansions for processing high-dose LLW and MLLW in the T Plant; processing, packaging, and certifying TRU waste in WRAP; and storing waste in the Central Waste Complex. Other short-term uses of resources would be limited to those required for constructing and operating the disposal facilities.

Table 7–24. Waste Management Alternatives Short-Term Life Cycles

Alternative (with Disposal Group)	Construction, Operations, and Deactivation Phase	Closure Phase (Activity Type)[a]
1–No Action	2007–2035	2036–2135 (AC)
2–Disposal Group 1	2006–2052	2053–2152 (PM)
2–Disposal Group 2	2006–2102	2103–2202 (PM)
2–Disposal Group 3	2006–2167	2168–2267 (PM)
3–Disposal Group 1	2006–2052	2053–2152 (PM)
3–Disposal Group 2	2006–2102	2103–2202 (PM)
3–Disposal Group 3	2006–2167	2168–2267 (PM)

[a] Activity types: AC=administrative controls; PM=postclosure care and monitoring.
Source: SAIC 2010c.

Table 7–25 presents the amounts of land that would be committed in the short term to accomplish the objectives of each of the Waste Management alternatives. This short-term use of land would be for expansion of the T Plant, WRAP, and Central Waste Complex facilities under the action alternatives. Table 7–25 also presents the long-term land commitments that would occur indefinitely under each of the action alternative's disposal groups. All areas where permanent disposal facilities would be located would be indefinitely removed from consideration for long-term productive use. Under the Waste Management action alternatives, engineered barriers would be constructed over the RPPDF and IDF(s). Trenches 31 and 34 in LLBG 218-W-5 are not included in long-term commitments of land in this *TC & WM EIS* due to previous long-term commitments consistent with an existing permit. Borrow Area C is not included in the short-term commitments of land. While excavation activities in Borrow Area C would be conducted in the short term, they could be terminated at any time. The amount of land disturbance required in Borrow Area C to support each Waste Management alternative was previously discussed in Section 7.3.3.1.

Table 7–25. Waste Management Alternatives Short- and Long-Term Commitments of Land

Alternative (with Disposal Group)	Land Commitment (hectares)	
	Short-Term Use[a]	Long-Term Use[b]
1–No Action	0	0
2–Disposal Group 1	2.7	65
2–Disposal Group 2	2.7	248
2–Disposal Group 3	2.7	248
3–Disposal Group 1	2.7	65
3–Disposal Group 2	2.7	253
3–Disposal Group 3	2.7	253

[a] Land use commitments over the short term encompass the total alternative life cycle, including construction, operations, deactivation, and closure. Under Alternatives 2 and 3, the land use requirements for the Waste Receiving and Processing Facility, T Plant, and Central Waste Complex construction and operations would be equivalent; under Alternative 1, short-term use does not include partial construction of the 200-East Area Integrated Disposal Facility because this action has already been initiated.

[b] Land use commitments over the long term include the permanent disposal sites (e.g., one or both of the Integrated Disposal Facilities and the River Protection Project Disposal Facility) after closure by emplacement of engineered barriers.

Note: To convert hectares to acres, multiply by 2.471.
Source: SAIC 2010c.

The waste management disposal groups were developed and the waste disposal facilities (the RPPDF and IDF[s]) were sized to primarily support the Tank Closure alternatives and to accept some offsite waste for disposal. The Waste Management No Action Alternative would only be implemented if the corresponding Tank Closure No Action Alternative is selected for implementation. Under Waste Management Alternative 2, only IDF-East would be constructed. Under Waste Management Alternative 3, disposal capacity would be divided between IDF-East and -West. The RPPDF would be constructed between the 200-East and -West Areas, regardless of the action alternative selected. Closure of the RPPDF and IDF(s) would be accomplished with the emplacement of an engineered barrier. Therefore, the land areas associated with each of the permanent waste disposal facilities would be removed from consideration for long-term productivity. However, these areas would likely be reclaimed by native vegetation and wildlife in the absence of human intervention over the very long term following the end of any administrative control or postclosure care period.

Air emissions associated with the Waste Management alternatives would introduce small amounts of radioactive and nonradioactive constituents to the regional airshed around Hanford. Radioactive air emissions would result from expanded operations of the T Plant and WRAP. Nonradioactive air emissions would be the greatest during initial construction of the waste disposal facilities, and then again during closure of the facilities and the construction of engineered barriers. Over time, these emissions would result in additional loading and exposure, but would not impact air quality or radiological exposure standards at Hanford to the extent that long-term productivity of the environment would be impaired.

Chemical and radioactive contamination of the vadose zone and groundwater below and downgradient of the 200 Areas would occur over time under all of the alternatives due to release of contaminants from tank closure waste; FFTF decommissioning waste; and offsite waste disposed of in the LLBGs, IDF(s), and the RPPDF. The amounts and timing of contaminants that would leach from the waste disposal sites would largely depend on long-term waste form performance, as dictated by the waste treatment methodologies analyzed under the Tank Closure alternatives. Long-term performance of waste forms and their impacts on the vadose zone and groundwater receptors are discussed in detail in Chapter 5. Depending on the extent and magnitude of resultant groundwater contaminant plumes, it may become necessary for land use or other institutional controls to be placed on the overlying land areas for an indefinite period, thereby reducing the overall long-term productivity of the affected areas.

Radiation and chemical doses to aquatic and terrestrial receptors at seeps along the Columbia River and in the receiving water were evaluated as part of the ecological risk portion of the analysis. Under all scenarios and alternatives, results indicated that calculated absorbed doses to referenced organisms would be below regulatory limits and/or reference standards and, therefore, would have no impact on the long-term productivity of the Columbia River ecosystem.

Continued employment, expenditures, and tax revenues generated during implementation of any of the action alternatives would directly benefit local, regional, and state economies over the short term. Local governments investing project-generated tax revenues into infrastructure and other required services could facilitate economic productivity. Nearby townships and geographic provinces have experienced a recent surge in growth, and the availability of employment opportunities would further sustain and foster regional development.

In addition to the waste generated under the Tank Closure and FFTF Decommissioning alternatives, some quantities of LLW and MLLW would be generated from expanded T Plant operations and would be disposed of in an IDF. TRU waste processed at the expanded WRAP would be stored on site until it could be transported off site for disposal at the Waste Isolation Pilot Plant near Carlsbad, New Mexico. A certain amount of offsite waste would be received under Waste Management Alternatives 2 and 3 and disposed of in an IDF, a long-term commitment at Hanford that would result in comparable enhancement of long-term productivity at other DOE facilities.

The short-term use of the environment for treating waste would be evaluated against the maintenance and enhancement of the long-term productivity of the environment, as demonstrated by the performance assessment for the final waste forms that would be disposed of in an IDF and the RPPDF.

7.4.4 Alternative Combinations

This section presents a comparison of the relationship between short-term uses of the environment and maintenance and enhancement of its long-term productivity under the three alternative combinations selected for analysis in this EIS. The alternative combinations are described in detail in Chapter 4, Section 4.4.

The short-term durations of the three alternative combinations analyzed in this EIS are presented in Table 7–26. The short-term durations are broken into two groups: (1) the construction, operations, and deactivation phase, when most activities would take place, and (2) the closure phase, when administrative controls or postclosure care would be performed and/or long-term storage would continue. Under Alternative Combination 1, construction of the WTP, Canister Storage Building, and IDF-East would be terminated. The only activity that would continue would be disposal of waste in LLBG 218-W-5, trenches 31 and 34, until 2035, followed by a 100-year administrative control period. Expanded WTP vitrification under Alternative Combination 2 would significantly reduce the duration of short-term actions, which would end in 2052. Short-term activities would be extended until 2102 under Alternative Combination 3 to accommodate clean closure of the SST farms, followed by a 100-year postclosure care and monitoring period.

Table 7–26. Alternative Combinations Short-Term Life Cycles

Alternative Combination	Alternative	Construction, Operations, and Deactivation Phase	Closure Phase (Activity Type)[a]
1	Tank Closure Alternative 1	2006–2008	2008–2107 (AC)
	FFTF Decommissioning Alternative 1	Not applicable	2008–2107 (AC)
	Waste Management Alternative 1	2007–2035	2036–2135 (AC)
2	Tank Closure Alternative 2B	2006–2046	2046–2145 (PM)
	FFTF Decommissioning Alternative 2	2013–2021	2022–2121 (PM)
	Waste Management Alternative 2, Disposal Group 1	2006–2052	2053–2152 (PM)
3	Tank Closure Alternative 6B, Base Case	2006–2101	2102–2201 (PM) Until 2199 (ST)
	FFTF Decommissioning Alternative 3	2012–2021	2022–2121 (PM)
	Waste Management Alternative 2, Disposal Group 2	2006–2102	2103–2202 (PM)

[a] Activity types: AC=administrative controls; PM=postclosure care and monitoring; ST=onsite storage.
Key: FFTF=Fast Flux Test Facility.
Source: SAIC 2010a, 2010b, 2010c.

Table 7–27 presents the amounts of land that would be committed in the short term under each of the three representative alternative combinations, including the land area required for existing facilities and construction of new facilities to support a particular alternative combination. The land use amounts are presented as aggregate values over the entire short-term life cycles of the alternatives; however, in practice, most facilities would operate during various timeframes. Borrow Area C is not included in the short-term commitments of land. While excavation activities conducted in Borrow Area C would take place in the short term, they could be terminated at any time. The amount of land disturbance required in Borrow Area C to support each alternative combination was previously discussed in Section 7.3.4.1.

Table 7–27 also presents the long-term land commitments that would continue indefinitely under the alternatives, including all permanent disposition areas where engineered barriers would preclude the use of the site for other productive purposes and all areas where the tank farms and cribs and trenches (ditches) or facilities within the FFTF Property Protected Area would not be closed under certain alternatives. No new facilities would be constructed or operated in the short term under Alternative Combination 1; however, a commitment of 35 hectares (86.5 acres) of land would be made to provide waste management areas for the SST farms, cribs and trenches (ditches), and FFTF Property Protected Area. Under Alternative Combination 2, short- and long-term land commitments would be greater due to construction of new disposal facilities and emplacement of engineered barriers over the SST farms and cribs and trenches (ditches). The increase in the long-term commitment of land under Alternative Combination 2 over that under Alternative Combination 1 would occur due to retrieval, treatment, and disposal of all tank waste under Alternative Combination 2. Treating the tank waste and disposing of it in an engineered disposal facility would reduce the long-term effects of radioactive and chemical contaminants leaching into the subsurface and groundwater. Under Alternative Combination 3, short- and long-term land commitments would increase even further. In this case, the increase in short- and long-term land use would be due to SST clean closure activities and requirements for deep soil excavation and disposition. Treated tank waste under Alternative Combination 3 would be managed as HLW and stored on site until disposition decisions are made and implemented.

Table 7–27. Alternative Combinations Short- and Long-Term Commitments of Land

Alternative Combination	Land Commitment (hectares)		
	Alternative	**Short-Term Use[a]**	**Long-Term Use[b]**
1	Tank Closure Alternative 1	0	17
	FFTF Decommissioning Alternative 1	0	18
	Waste Management Alternative 1	0	0
	Total Combined	**0**	**35**
2	Tank Closure Alternative 2B	17	84
	FFTF Decommissioning Alternative 2	0.2	0.7
	Waste Management Alternative 2, Disposal Group 1	2.7	65
	Total Combined	**20**	**150**
3	Tank Closure Alternative 6B, Base Case	119	25
	FFTF Decommissioning Alternative 3	0.2	0
	Waste Management Alternative 2, Disposal Group 2	2.7	248
	Total Combined	**122**	**273**

[a] Land use commitments over the short term encompass the total alternative life cycle, including construction, operations, deactivation, and closure.

[b] Land use commitments over the long term encompass the period following completion of each alternative's scheduled activities.

Note: To convert hectares to acres, multiply by 2.471.

Key: FFTF=Fast Flux Test Facility.

Source: SAIC 2010a, 2010b, 2010c.

Long-term impacts of the alternative combinations would be associated with water resources, ecological resources, and human health. Long-term impacts on ecological resources would result from air emissions and groundwater contamination. A number of onsite and offsite receptors would be affected by human health impacts; these impacts would depend on the acuteness and duration of groundwater contamination due to linkage of exposure pathways to consumption of surface water or the use of groundwater for drinking water or crop irrigation. Thus, impacts on ecological resources and human health would correlate strongly with groundwater impacts. Water resources would be impacted the most under Alternative Combination 1, in which unmitigated releases from tank inventories would occur and would cause the majority of long-term impacts. Inevitable releases from tank inventories would overcome past-practice groundwater impacts and tank system leaks. Conversely, impacts on air quality would be least under Alternative Combination 1 because no new facilities would be constructed or operated.

Under Alternative Combination 2, retrieval and treatment of tank waste in the WTP would have short-term impacts on air quality. Air emissions would not be sufficient to produce significant long-term impacts on ecological resources. By the time groundwater reaches and is diluted by the Columbia River, impacts on ecological resources would also be negligible. The majority of impacts on groundwater resources would no longer be from tank inventories, as most of this waste would be immobilized through WTP operations, but rather from past discharges to the cribs and trenches (ditches), past leaks from tank systems, and new waste management areas. Ultimately, Alternative Combination 2 is projected to result in a reduction in concentrations of conservative tracers by one or two orders of magnitude at the Core Zone Boundary versus those that would occur under Alternative Combination 1. However, Alternative Combination 2 would require construction of IDF-East and the RPPDF in new locations. The receipt and disposal of offsite waste in IDF-East would also contribute to eventual groundwater impacts in this area, particularly associated with iodine-129 and technetium-99.

Under Alternative Combination 3, air quality impacts similar to those described above under Alternative Combination 2 would occur from treatment of tank waste; however, to accomplish excavation and clean closure of the tank farms, air quality impacts would increase significantly. Still, long-term impacts on ecological resources due to air emissions would be minor. Conversely, long-term impacts on ecological resources due to groundwater contamination would decrease when compared with those impacts under Alternative Combination 2. Under Alternative Combination 3, the SST farms would be clean-closed, and any future releases and contributions of residual tank inventories to groundwater would be eliminated. Similar to Alternative Combination 2, past discharges to the cribs and trenches (ditches) and past leaks from tank systems would still be the major source of impacts on groundwater. Under Alternative Combination 3, all treated tank waste would be managed as HLW and stored in onsite storage facilities. As a result, long-term groundwater impacts would be slightly lower under Alternative Combination 3, but generally similar to those under Alternative Combination 2. Treated tank waste requiring disposal in IDF-East would be reduced; however, there would be an increase in need for onsite storage capacity and in disposal requirements for clean closure waste in IDF-East and tank debris in the RPPDF. As under Alternative Combination 2, receipt and disposal of offsite waste in IDF-East would contribute to eventual groundwater impacts in this area, particularly related to iodine-129 and technetium-99.

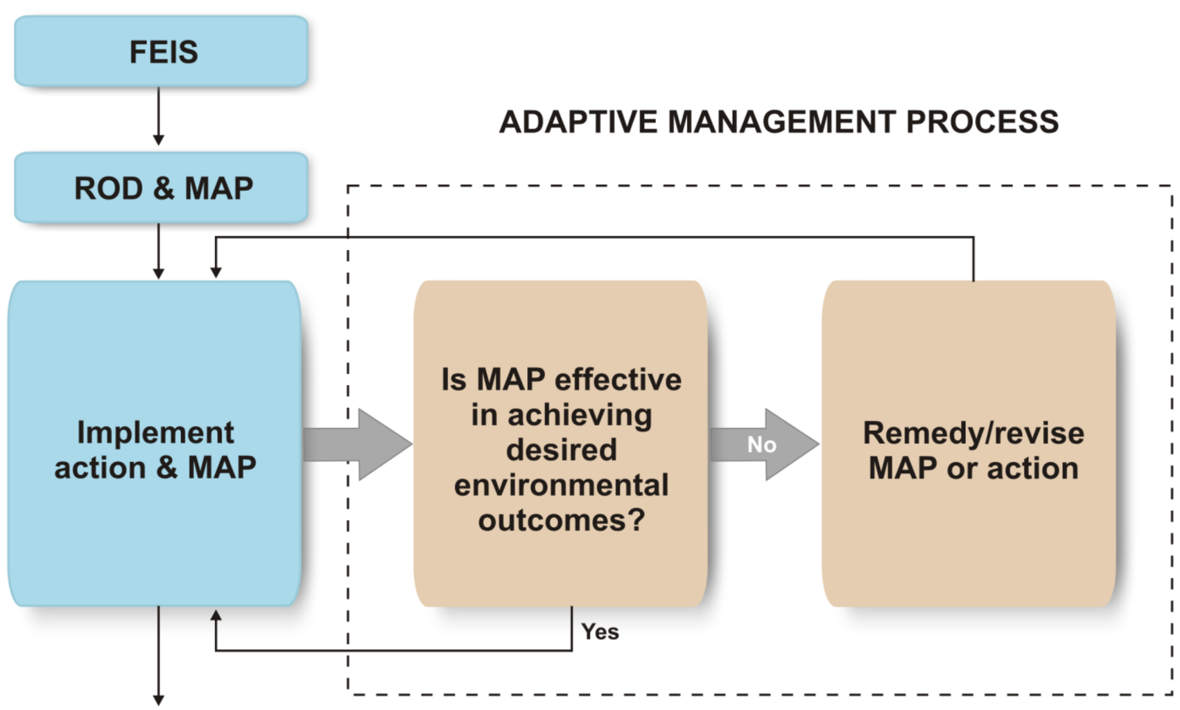
Under all of the alternative combinations, the human health dose standards for one or more COPCs within the Core Zone Boundary would be exceeded if groundwater is used as a source of drinking water and crop irrigation. The impacts on the health of human receptors within the Core Zone Boundary are predicated on each receptor's ability to access groundwater; this ability would be delayed or made more difficult under Alternative Combinations 2 and 3, in which engineered barriers would be constructed in various locations. These engineered barriers would be constructed over the tank farms, cribs and trenches (ditches), or permanent disposal areas, as applicable under Alternative Combination 2 or 3.

7.5 LONG-TERM MITIGATION STRATEGIES

This *Final TC & WM EIS* discussed potential long-term mitigation measures for reducing impacts on groundwater resources in Section 7.1.6; this section presents a more indepth discussion on this topic. DOE acknowledges that several COPCs are predicted to approach or exceed benchmark standards at the Core Zone Boundary and/or Columbia River nearshore at various dates, although such predictions carry a degree of uncertainty. Several commentors on the *Draft TC & WM EIS* expressed concerns about the predicted magnitude of impacts on groundwater under various closure scenarios. DOE conducted a series of sensitivity analyses to help identify additional long-term mitigation actions that may have the potential to reduce long-term groundwater impacts. The sensitivity analyses conducted as part of this *Final TC & WM EIS* are examples of those areas that could be investigated; there may be other areas that might warrant further study. More than one mitigation action may be warranted in the near, mid-, and long term depending on the details of a particular waste management area unit or concern. This section attempts to clarify and discuss some of the uncertainties associated with groundwater impact analyses and to summarize the approach and results of the additional sensitivity analyses that were conducted and incorporated in various sections of this *Final TC & WM EIS*.

DOE intends to select a combination of Tank Closure, FFTF Decommissioning, and Waste Management alternatives and to develop and implement a Mitigation Action Plan that addresses mitigation commitments expressed in the ROD.

Recently, the CEQ issued final guidance on the *Appropriate Use of Mitigation and Monitoring and Clarifying the Appropriate Use of Mitigated Findings of No Significant Impact* (Sutley 2011). DOE's approach to mitigation strategies, as discussed in this *Final TC & WM EIS*, is consistent with the CEQ's new guidance. The new guidance clarifies the appropriate use of performance-based mitigation. The new guidance encourages the use of internal processes for postdecision monitoring to ensure the implementation and effectiveness of mitigation actions and stresses that mitigation is an ongoing and ever-evolving process that should continue well after an action is selected and implemented to ensure mitigation commitments are fully met. A conceptual model of the CEQ's mitigation and adaptive management process is illustrated in Figure 7–1.



Note: Conceptual flowchart adapted from CEQ Guidance (Sutley 2011).
Key: CEQ=Council on Environmental Quality; FEIS=Final Environmental Impact Statement; MAP=Mitigation Action Plan; ROD=Record of Decision.

Figure 7–1. Mitigation and Adaptive Management Processes

7.5.1 Effects of Uncertainty on Long-Term Groundwater Predictions

As stated above, there is a degree of uncertainty associated with the prediction of long-term groundwater impacts. This is in part due to the limitations of the vadose zone and groundwater flow models, the technical data used as inputs to the models, or the difficulty predicting the fate and transport of COPCs over large geographical areas and for very long periods of time. The following section introduces some general information related to uncertainty and its relationship to long-term groundwater performance. Specific ways in which issues or concerns identified in this *Final TC & WM EIS* are or could be mitigated are discussed.

As shown in Figure 7–2, groundwater impacts may be plotted as concentration versus time at a specific receptor location (e.g., the Core Zone Boundary, Columbia River nearshore). As explained in Appendix O, Section O.2, these concentration plots can exhibit large fluctuations and appear erratic due to the stochastic nature of the model, resolution factors, and use of tracking objects for receptors. The best way to view these plots is to look for overall trends. Uncertainty causes potential variance in predicting the concentrations of COPCs at a receptor location. This variance could result in the actual concentration at some future date being more or less than that predicted. Furthermore, uncertainty, or variance, can also be magnified the further into the future a prediction is made. As we are evaluating impacts over considerable timeframes (e.g., 10,000 years), the resultant range of potential concentrations (predicted plus or minus variances) that could actually occur at a particular receptor location could be rather wide. Figure 7–3 illustrates the concept of a range of potential concentrations, also known as a variance band.

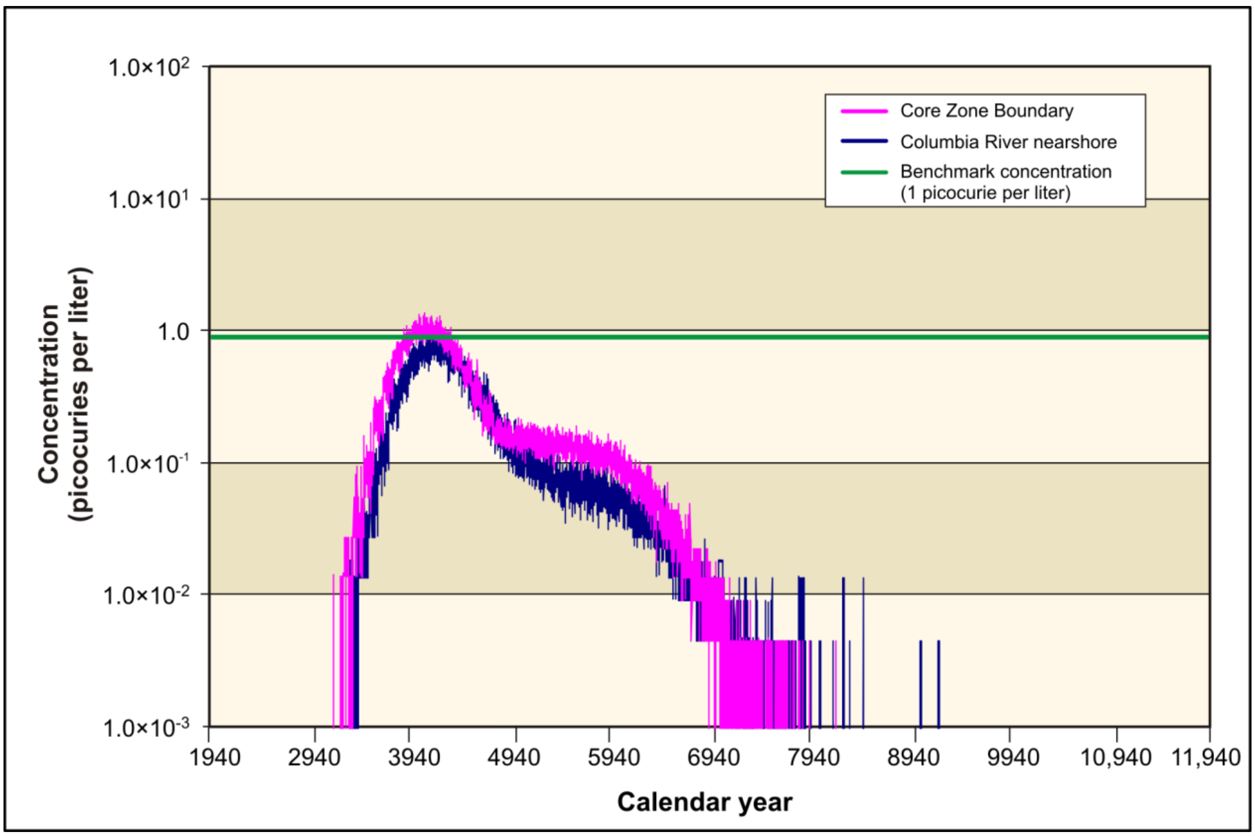


Figure 7–2. Typical Concentration-Versus-Time Plot

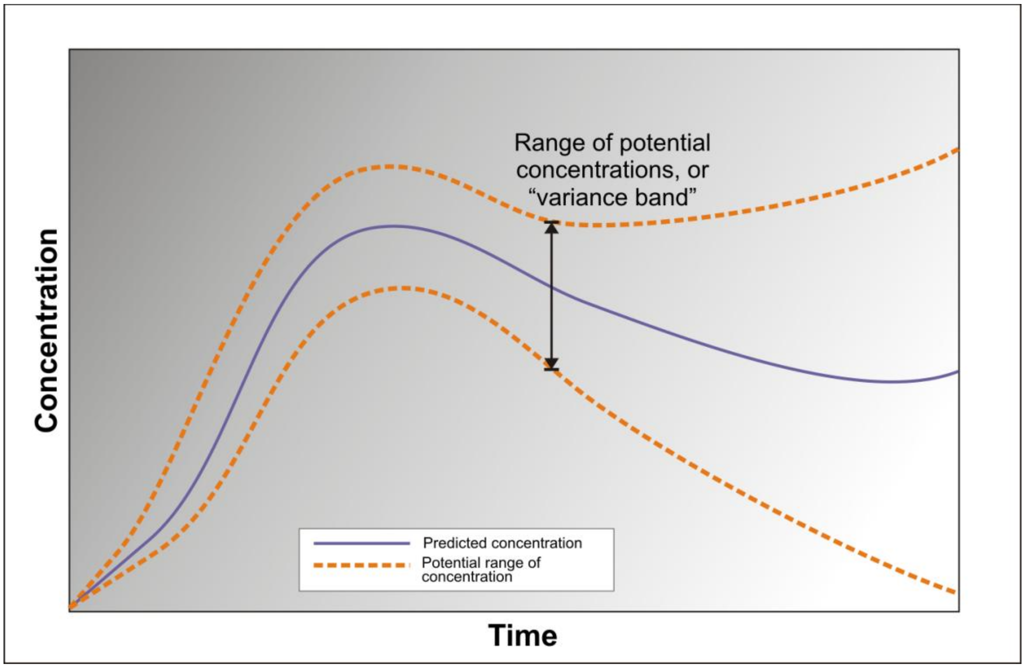


Figure 7–3. Conceptual Range of Potential Concentrations with Variance Band

This discussion might lead someone to ask the question "How can we reduce uncertainty?" This is relevant because reducing uncertainty is important to developing and implementing an effective mitigation strategy. By reducing uncertainty in the analysis, we can more precisely predict groundwater impacts and, thus, how these impacts compare to benchmark standards and how aggressive mitigation strategies need to be to meet those benchmark standards. There are two types of uncertainties: those that can be influenced (e.g., waste forms used, acceptance criteria for offsite waste) and those that generally cannot be influenced (e.g., geology and hydrogeology, infiltration rates, inventories of COPCs). Some uncertainties can be influenced by setting performance standards (e.g., allowable release rates for waste forms, waste acceptance criteria, cleanup standards), resulting in predicted long-term groundwater impacts that would remain below benchmark standards. The uncertainties that cannot be influenced are typically related to physical or chemical data, where little or disputed information is available. While these uncertainties cannot be influenced, they can be understood better by understanding their importance. By reducing uncertainties associated with environmental impacts analysis or implementation of mitigation strategies, the predicted concentrations of COPCs over time at a receptor location can be affected in the following three general ways (also illustrated in Figure 7–4):

1. Narrowing the overall variance band by reducing the uncertainties associated with the physical and chemical data or assumptions. For example, if more-precise and -accepted information on IDF infiltration were known, this would result in less magnification of the variance band over time.
2. Horizontally shifting the concentration plot to the right (later release of COPCs) or left (earlier release of COPCs). For example, barrier failure later than 500 years would shift the plot to the right, and an earlier barrier failure might shift the plot to the left.
3. Vertically shifting the concentration plot up (increase in COPCs) or down (decrease in COPCs). For example, if the Best-Basis Inventory were revised upward (or downward), the receipt and disposal of offsite waste at Hanford were restricted, or waste were shipped from Hanford to an offsite disposal facility, then the amounts of COPCs available for release would be higher (or lower), resulting in a corresponding vertical shift in the concentration plot or a decrease in the predicted peak concentration.

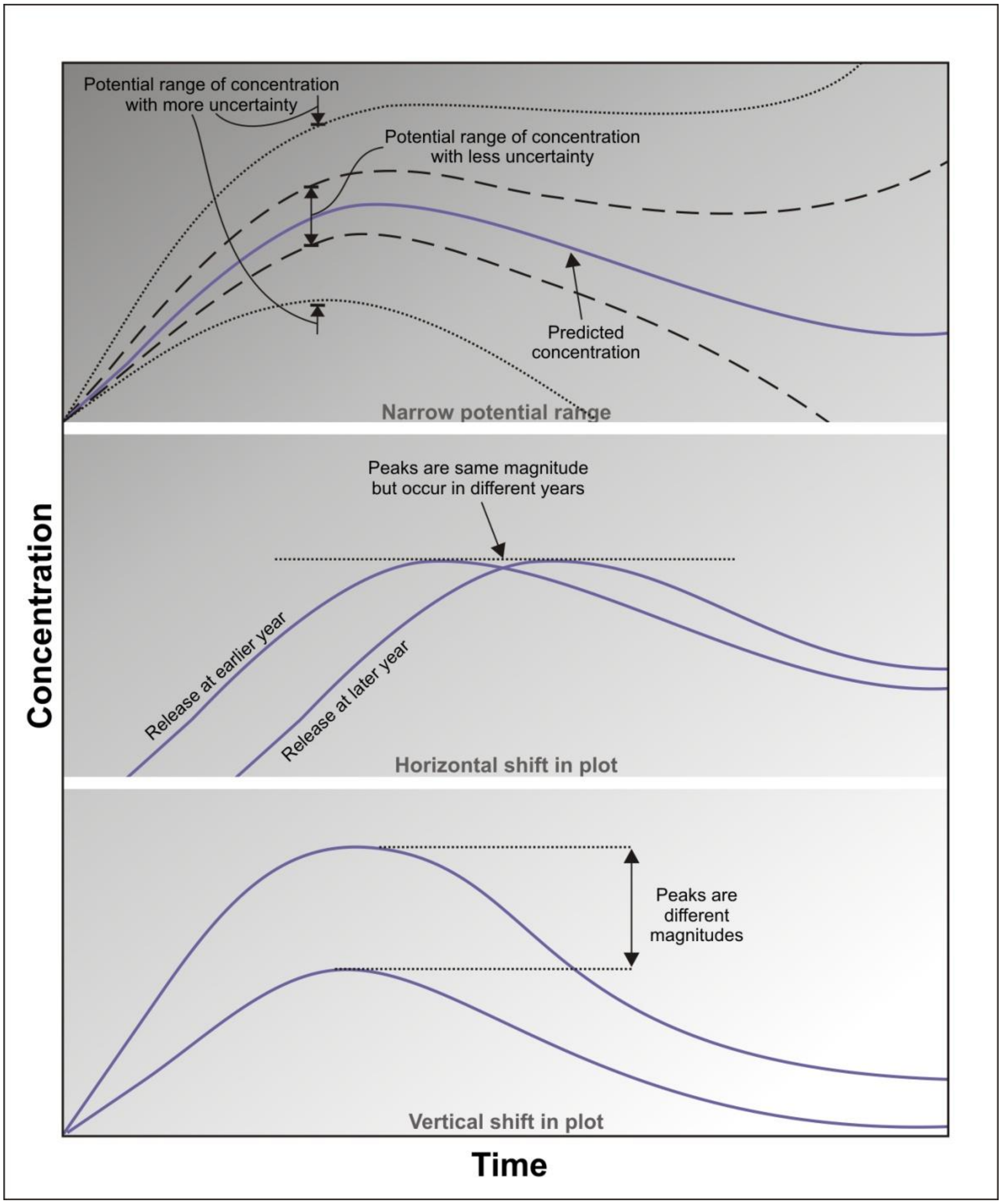


Figure 7–4. Effects of Reducing Uncertainty on Concentration Plots

Another example would be vadose zone remediation at one or more of the prominent waste sites in the Central Plateau, where COPCs could be treated and placed into a more stable waste form and subsequently disposed of in an IDF or in the RPPDF, the Environmental Restoration Disposal Facility, or another onsite permitted disposal facility. This scenario might affect the concentration plot simultaneously in two ways: (1) by delaying the release of COPCs and shifting the peak horizontally and (2) by changing the waste form that contains the COPCs and flattening the peak vertically.

An important note is that the groundwater impacts on a receptor presented in this final EIS as a concentration plot are actually an aggregation of impacts of many potential sources. Figure 7–5 provides an example concentration plot of the individual sources and the final aggregated plot after combining the effects of all the potential sources considered. Thus, reducing the uncertainty associated with a single source may or may not have an appreciable effect on the aggregated concentration plot for many sources. For example, vadose zone remediation at one site out of many across the Central Plateau may or may not reduce the flux of COPCs such that the concentration at the receptor location changes in a meaningful way. Another example might be that improvements in the performance of one waste form would not likely have an effect on the aggregated concentration unless that particular waste form is a major contributor to, or "driver" of, groundwater impacts. As mentioned above, waste form performance is one of many uncertainties. The key to determining which uncertainties, or to what extent changes to an uncertainty, might have more potential for mitigating groundwater impacts is the subject of the sensitivity analyses discussed in the following sections.

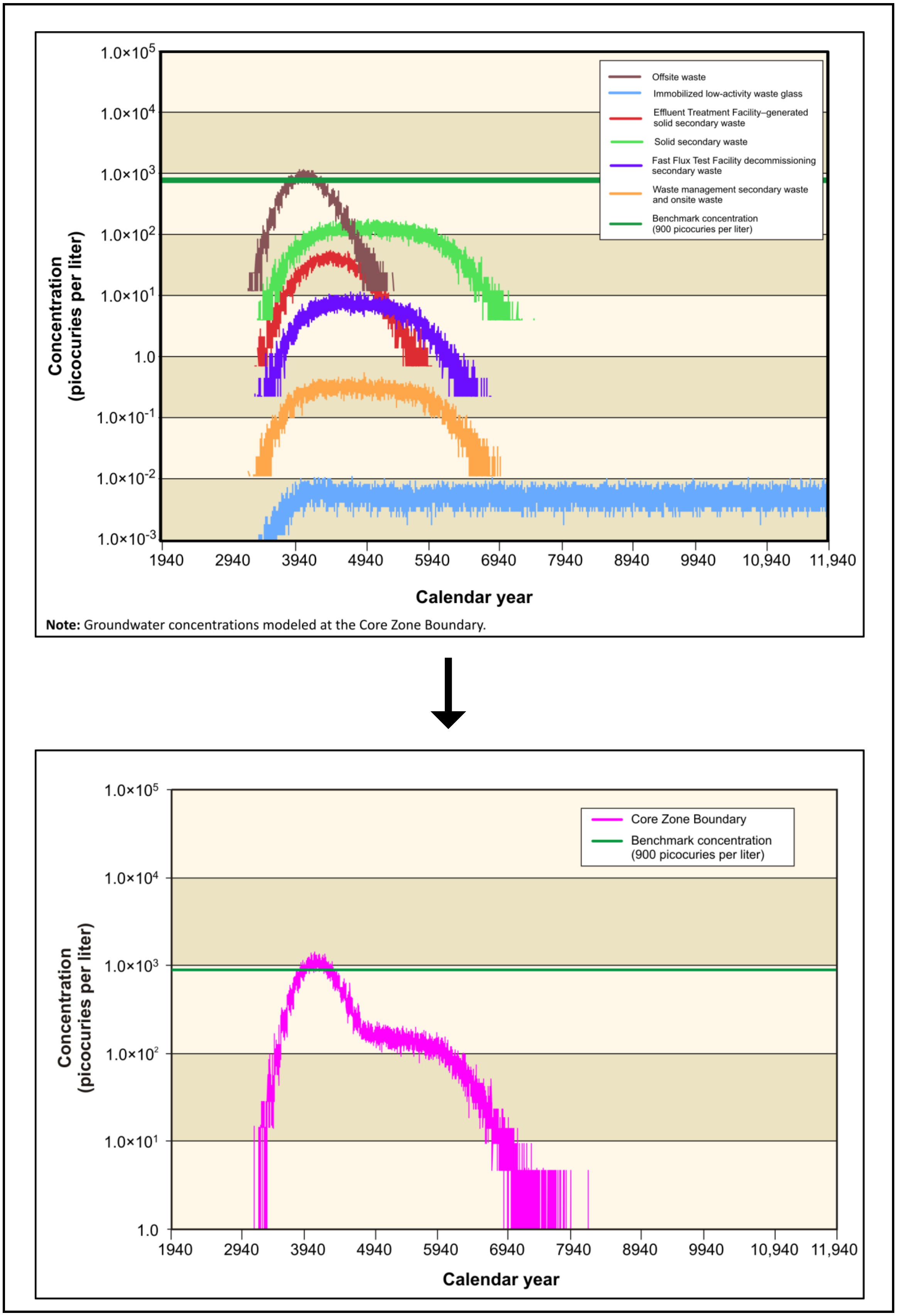


Figure 7–5. Example of Individual Contributors and Aggregation of Multiple Sources

7.5.2 Sensitivity Analyses Discussion

The sensitivity analyses conducted as part of this *Final TC & WM EIS* were used to determine which factors may contribute the most to groundwater impacts and where mitigation strategies might yield the most benefit. These sensitivity analyses are examples of factors that could be investigated.

In considering strategies for mitigating groundwater impacts in this EIS, various sensitivity analyses were conducted under the three following general areas:

- Reduce the inventory of COPCs available for discharge into the environment.
  - Flux reduction
  - Offsite-waste acceptance
  - Capture-and-removal scenario
  - Cribs and trenches (ditches) partial clean closure
- Modify processes for retrieval and treatment of tank waste.
  - Iodine recycle
  - Technetium removal
  - Leak loss of 15,142 liters (4,000 gallons) per tank
- Understand and manage the fate and transport of COPCs.
  - Waste form performance (e.g., ILAW glass, bulk vitrification glass, steam reforming waste, grouted waste)
  - Infiltration rates
  - Climate change and recharge assumptions

The sensitivity analyses were conducted on several COPCs that are considered hazard drivers (e.g., iodine-129, technetium-99, uranium-238); however, the same general principles and conclusions discussed in this section could apply to most COPCs, as would any mitigation planning and monitoring. The results of the sensitivity analyses are summarized in this section and presented in detail in various appendices of this final EIS, as indicated in Section 7.5.3. The results are also discussed in the context of what it means to the development of successful mitigation strategies for activities that will take place several years in the future.

7.5.2.1 Sensitivity Analysis: Flux Reduction

The purpose of the flux-reduction sensitivity analysis was to evaluate the effect on predicted long-term groundwater impacts if certain remediation activities were conducted at some of the more prominent waste sites on the Central Plateau and along the river corridor. A portion of the analysis results is summarized in this section, and additional details and analysis can be found in Appendix U, Section U.1.3.4.1. When conducting the flux-reduction analysis, the following parameters were defined:

- Flux reductions of 50, 75, and 99 percent were applied to cumulative and tank closure sources (e.g., sites) included in the sensitivity analyses, as described below.
- Flux reductions were applied at CY 2035, representing an assumed date when remediation might be completed at a particular site.

- The sources evaluated ranged between low-, moderate-, and heavy-discharge sites.
- Iodine-129 (high mobility) and uranium-238 (low mobility) were modeled.

The flux-reduction sensitivity analysis evaluated cumulative impact sites in the Central Plateau and along the river corridor, as well as tank farm sources from Tank Closure Alternative 2B (landfill closure). The following cumulative impacts sites were included in the analysis:

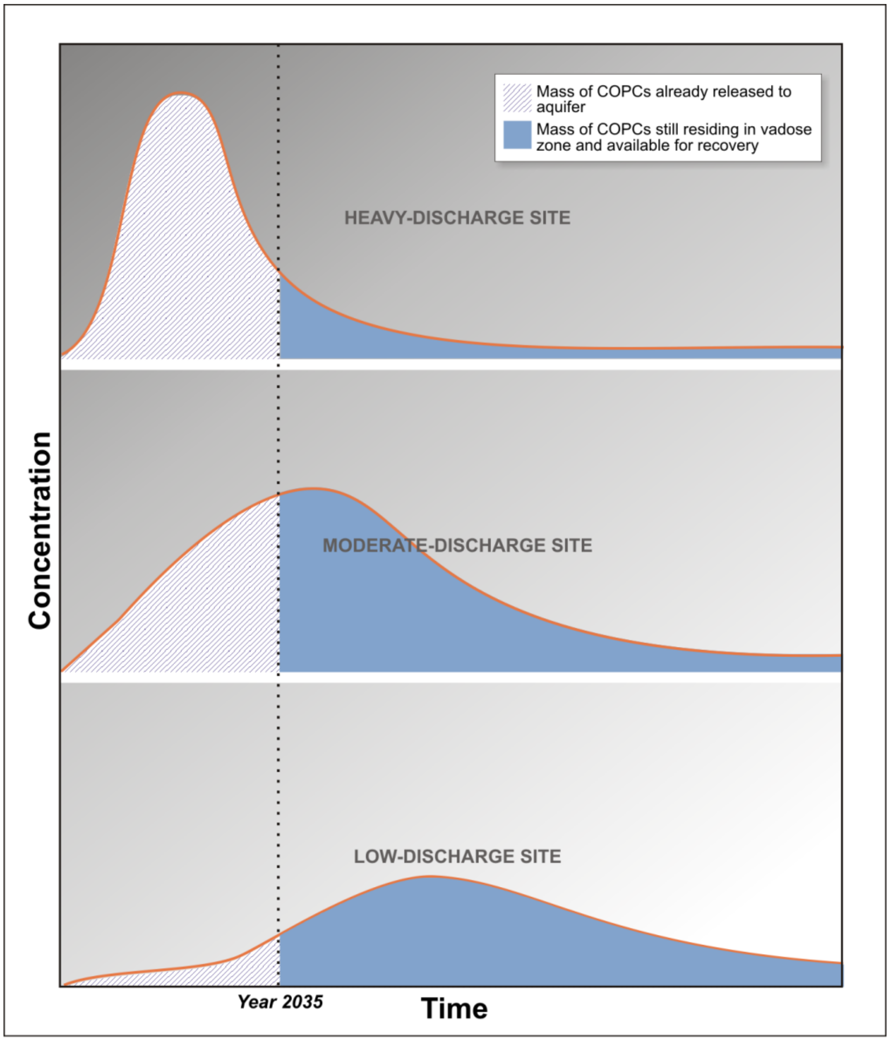
- Ponds (B, S, T, U, and Gable Mountain)
- River corridor sources (1301-N, 100-K Mile Long Trench, and 300 Area Process Ponds)
- BC Cribs (and trenches)
- REDOX [reduction-oxidation] sources (216-U-8, 216-S-7, 216-S-8)
- PUREX [plutonium-uranium extraction] sources (216-A-9, 216-A-10, 216-A-30, 216-B-12)

Tank Closure Alternative 2B (landfill closure) was the basis for the alternative sources that were analyzed in the flux-reduction sensitivity analysis. Those sources included the following:

- Tank farm past leaks (A, AX, B, BX, BY, C, S, SX, T, TX, TY, and U)
- Ancillary equipment (A, AN, AP, AW, AX, AY, AZ, B, BY, C, S, SY, T, TX, TY, and U)
- Retrieval leaks (A, AX, B, BX, BY, C, S, SX, T, TX, TY, and U)
- Tank residuals (A, AN, AP, AW, AX, AY, AZ, B, BX, BY, C, S, SX, SY, T, TX, TY, and U)
- Cribs and trenches (ditches) (B, BX, BY, T, TX, and TY)

For analysis purposes in this *TC & WM EIS*, aqueous sources of contamination were examined based on the amount of discharge. Sources with an aqueous discharge of less than 1 meter (3 feet) per year were categorized as moderate-discharge sources. Sources with aqueous releases of greater than 1 meter (3 feet) per year were categorized as heavy-discharge sources. Solid sources were categorized as low-discharge sources. The sources along the Columbia River primarily fall within the heavy- and moderate-discharge categories and include releases associated with the nuclear reactors. The sources in the central portion of the site include heavy-, moderate-, and low-discharge sites and were associated with plutonium processing and storage of waste generated from plutonium production. The sources in the 300 Area include heavy-, moderate-, and low-discharge sites and are associated with manufacturing work and experiments that were carried out during operations.

The concept behind flux reduction is to recognize the benefits of vadose zone remediation before COPCs are released into the underlying aquifers. Vadose zone remediation can only be effective if a majority of COPCs are recoverable before they can impact the groundwater and if the mass of COPCs available for removal is significant in terms of the overall mass of COPCs from the multitude of sites across the Central Plateau. Once COPCs have been released into the underlying aquifer, vadose zone remediation will have only a limited benefit in reducing the long-term impacts on groundwater concentrations because very little of the COPC mass would remain in the vadose zone where it would be available for remediation. By the time the majority of COPCs have impacted groundwater, remediation actions such as using reactive barriers or pump-and-treat systems would be the only options remaining. Figure 7–6 conceptually illustrates the proportion of COPCs that might be available for remediation for heavy-, moderate-, and low-discharge sites, as discussed below, and assuming remediation would be completed in CY 2035.



Key: COPC=constituent of potential concern.

Figure 7–6. Availability of COPCs for Recovery from Vadose Zone

Heavy-discharge sites are characterized by high volumes of liquid disposal occurring on site for short periods of time. Examples of heavy-discharge sites include the 216-A-9 crib and TY cribs. Concentration plots for heavy-discharge sites typically exhibit a sharp high peak, followed by a tapering shoulder.

For most heavy-discharge sites, flux reduction applied in CY 2035 would occur on the downward side of the peak after a majority of the COPCs have already been released into the groundwater system. Flux reduction as a mitigating measure would generally lower only the shoulder. Consequently, a small portion of the overall COPC mass would be remediated, and long-term concentration reductions at receptor locations would be minimal.

Moderate-discharge sites experience less liquid disposal than a heavy-discharge site, but also for relatively shorter periods of time. Examples of moderate-discharge sites include past tank leaks such as those that occurred at the C and U tank farms. Concentration plots for moderate-discharge sites typically exhibit a rounded peak, followed by a tapering shoulder.

For most moderate-discharge sites, flux reduction applied in CY 2035 would occur somewhere within the peak of COPC release to the groundwater system. Flux reduction as a mitigating measure would generally lower both the rounded peak and the shoulder of the concentration plot. Therefore, vadose zone remediation would generally be more effective for moderate-discharge sites than for heavy-discharge sites; however, depending on the site, the percentage of COPC mass available for remediation may not be large enough for such remediation to result in a corresponding reduction in long-term concentrations at receptor locations. Moderate-discharge sites have a more finite time in which actions need to occur in the vadose zone before the beneficial impact would be realized.

Low-discharge sites experience much less liquid disposal than other heavy- or moderate-discharge sites and might also experience discharge over longer periods of time. An example of a low-discharge site could be the longer-term release from tank residuals, such as that from the C and U tank farms after in situ closure. Typical concentration plots for these sites might exhibit little to no peak with a long, steady, but gradually increasing or decreasing shoulder.

For low-discharge sites, flux reduction applied in CY 2035 might occur prior to the peak of COPC release to the groundwater system. Flux reduction as a mitigating measure would affect the entire duration of release. Low-discharge sites are more likely to have a high percentage of COPC mass still available for remediation in the vadose zone. Therefore, vadose zone remediation would generally be effective in recovering a large percentage of COPC mass and, thus, result in a corresponding reduction in long-term concentrations in the groundwater system. Low-discharge sites may have a longer window of opportunity in which vadose zone actions would be effective, if needed at all.

In summary, flux reduction is more likely to be effective in reducing predicted long-term impacts on groundwater for moderate- to low-discharge sites. However, the specific target COPC is equally important when determining whether flux reduction might be effective. For example, iodine-129 is a COPC that will migrate into the groundwater system more quickly than uranium-238, which migrates comparatively slowly. In most cases, iodine-129 may be available for remediation at most low- and some moderate-discharge sites; however, uranium-238 may be available for remediation at most low- to moderate-discharge sites and potentially at some heavy-discharge sites. Generally, flux reduction at heavy-discharge sites is not likely to be favorable. Flux reduction at moderate-discharge sites might be considered in the near term (e.g., before the peak dissipates), and flux reduction at low-discharge sites might be considered in the near to mid-term as an effective strategy. Additional sensitivity analyses might be needed to determine the overall impact of potential vadose zone remediation for a site at a particular receptor location; this information could subsequently assist DOE in prioritizing the remediation of sites across the Central Plateau. In circumstances where COPCs have already “fluxed” to the groundwater system, remediation strategies might include interceptor, pump-and-treat, or other groundwater extraction and remediation technologies, but would not include technologies that target the vadose zone.

Tank Closure Alternative 4 includes clean closure of the BX and SX tank farms as part of the EIS base case analysis for this alternative, which represents a very specific example of the flux-reduction concept. This example of flux reduction is limited in scope to two source areas, versus a blanket flux reduction for all sources, as was done for the flux-reduction sensitivity analysis, and is limited to remediation by excavation. Appendix U, Section U.1.3.4.1.4, discusses the relative difference in flux reduction in terms of curies of technetium-99, iodine-129, and uranium-238 analyzed under Tank Closure Alternative 4 compared with the analysis performed for the 50 percent, 75 percent, and 99 percent sensitivity cases. On the surface, flux reduction offers some interesting and potentially beneficial outcomes. The prospect of achieving results similar to those of Tank Closure Alternative 4 without the issues of worker exposure, waste generation, technical issues associated with tank exhumation, and increased accidents is certainly worth consideration. Flux reduction is not an easy or simple solution and presents a different set of technical challenges, as discussed below.

An important caveat to the flux-reduction sensitivity analysis is that “hot spot” remediation, partial clean closure analyzed under Tank Closure Alternative 4, or clean closure analyzed under Tank Closure

Alternatives 6A and 6B are complicated remediation activities that require more than simple flux reduction. In most of these cases, the COPCs that could be remediated from the "hot spots" would simply be moved to another location at Hanford (i.e., an IDF, the RPPDF, or the Environmental Restoration Disposal Facility) and may or may not be treated. The risk associated with these COPCs would not necessarily be eliminated, but rather may only be moved to another location or changed in some way. Therefore, flux reduction in one area of Hanford could mean a flux increase in another area of Hanford. Remediation of "hot spots" also might involve increased risk and exposure to workers, which ultimately would need to be evaluated against the potential benefits associated with any flux-reduction action.

DOE published the *Long-Range Deep Vadose Zone Program Plan* in October 2010 (DOE 2010a). This program plan summarizes the current knowledge regarding deep vadose zone remediation challenges beneath the Central Plateau of Hanford and DOE's approach to solving those challenges. The challenges faced are the result of contaminant depth and spread; the presence of multiple contaminants and comingled waste chemistries; the physical, chemical, and biological fate and transport mechanisms; uncertain contaminant behavior; unknown limited availability and effectiveness of cleanup remedies; and the efficacy of remediation performance over the periods and spatial scales needed to make decisions. Remediation of the deep vadose zone is central to Hanford cleanup because the vadose zone provides an ongoing source of contamination to the underlying aquifer and the Columbia River unless permanent solutions are developed and implemented (DOE 2010a). The sensitivity analysis related to flux reduction that was conducted for this final EIS could be expanded and integrated with DOE vadose zone remediation programs to coordinate and prioritize the near-term remediation of some sites while providing for the timely development and availability of technologies for remediating and treating waste from candidate sites in the mid-term.

7.5.2.2 Sensitivity Analysis: Offsite-Waste Acceptance

Previously, in Section 7.1.6, the mitigating measure limiting the receipt of offsite waste for disposal at Hanford was discussed, particularly for those waste streams that contain higher concentrations of iodine-129 and technetium-99. For example, DOE evaluated the effect of applying waste acceptance criteria to offsite waste by removing a highly radioactive waste stream (i.e., high inventories of iodine-129 and technetium-99) from the inventory of offsite waste analyzed for disposal at Hanford in this final EIS. Elimination of this single waste stream removes approximately 13 curies of iodine-129 (a reduction of almost 85 percent) and 338 curies of technetium-99 (a reduction of almost 20 percent) from the offsite inventories that were considered for disposal at Hanford in the *Draft TC & WM EIS*. This *Final TC & WM EIS* considers the receipt of offsite waste containing 2.3 curies of iodine-129 and 1,460 curies of technetium-99.

The purpose of this sensitivity analysis was to evaluate the potential contribution to predicted long-term groundwater impacts resulting from accepting offsite-waste disposal at Hanford. A portion of the results are summarized in this section, and additional details and analysis can be found in Appendix M, Section M.5.7.6. After removing the waste stream mentioned above, the offsite-waste sensitivity analysis applied the following additional parameters:

- Zero to 3 curies of iodine-129 and 0 to 1,500 curies of technetium-99 were established as offsite waste inventories that could be disposed of in IDF-East and representing a potential range of offsite-waste disposal at Hanford.

- IDF-East's configuration was consistent with Waste Management Alternative 2 and Tank Closure Alternative 2B.

- Offsite waste would be received "as is" for disposal with no pretreatment or stabilization steps taken; thus, the waste form performance was assumed to be convective flow with partition-limited release.

- Iodine-129 and technetium-99 were modeled with a background IDF-East infiltration rate of 0.9 millimeters per year.

Figure 7–7 shows the predicted concentration of iodine-129 at the Core Zone Boundary and Columbia River receptor locations if no offsite waste is accepted for disposal at Hanford (i.e., 0 curies). Figure 7–8 shows the predicted concentrations of iodine-129 if 3 curies were disposed of in IDF-East at Hanford. As shown, the disposal of offsite waste with 3 curies of iodine-129 in IDF-East at Hanford results in a peak groundwater concentration at the Core Zone Boundary and Columbia River in approximately CY 8000; this peak is 10 times greater than the concentration predicted for no importation of offsite waste.

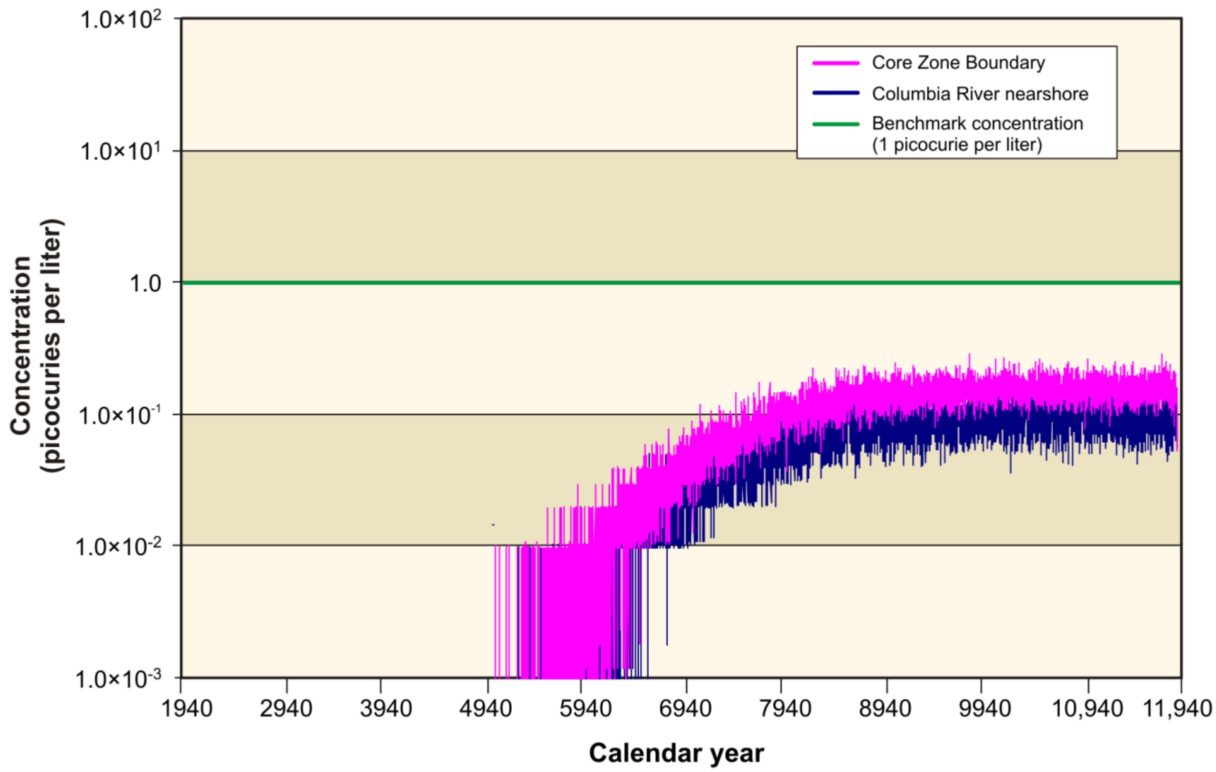


Figure 7–7. Tank Closure Alternative 2B Groundwater Iodine-129 Concentration Without Offsite Waste

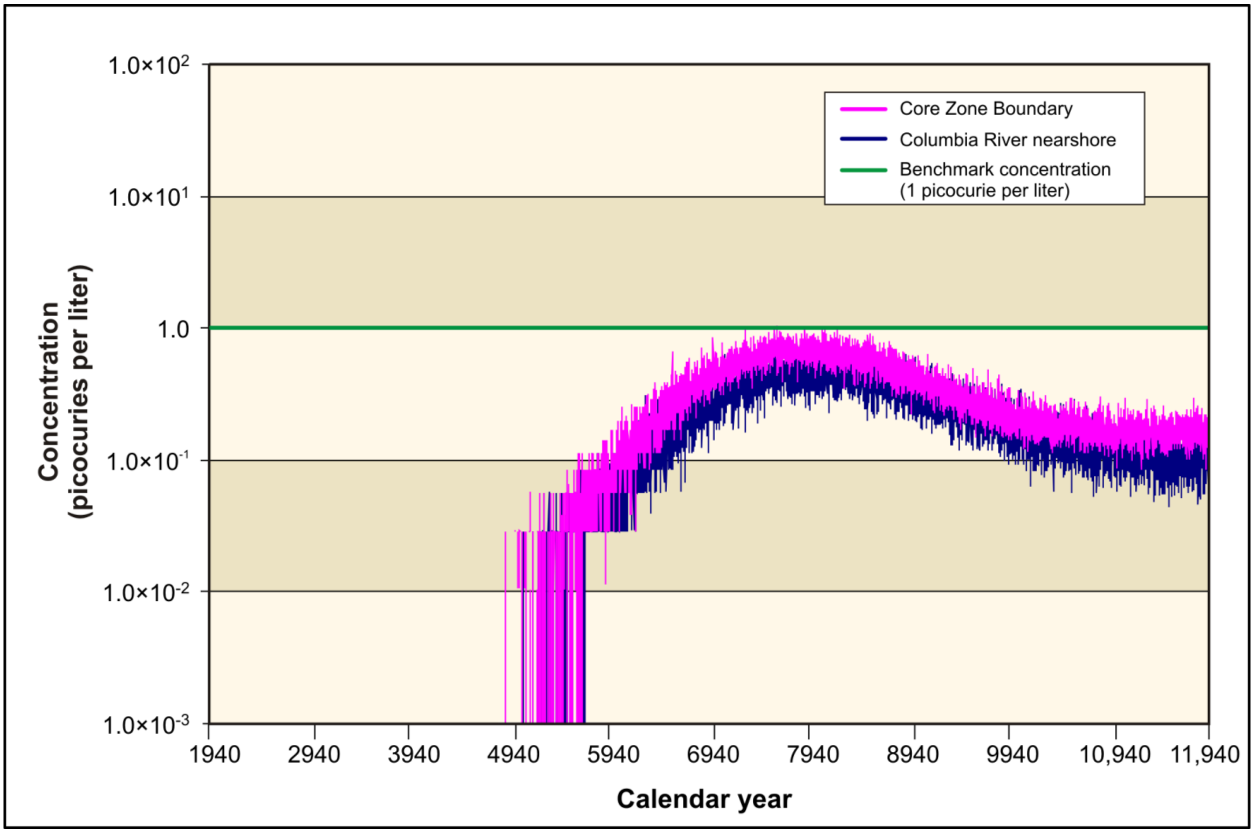


Figure 7–8. Tank Closure Alternative 2B Groundwater Iodine-129 Concentration with 3 Curies of Iodine-129 in Offsite Waste

Figure 7–9 shows the predicted concentrations of technetium-99 at the Core Zone Boundary and Columbia River receptor locations if no offsite waste is accepted for disposal at Hanford (i.e., 0 curies). Figure 7–10 shows the predicted concentrations of technetium-99 if 1,500 curies were disposed of in IDF-East at Hanford. As shown, the disposal of offsite waste with 1,500 curies of technetium-99 in IDF-East at Hanford results in a peak in groundwater concentration at the Core Zone Boundary and Columbia River in approximately CY 8000; this peak is 10 times greater than the concentrations predicted for no importation of offsite waste.

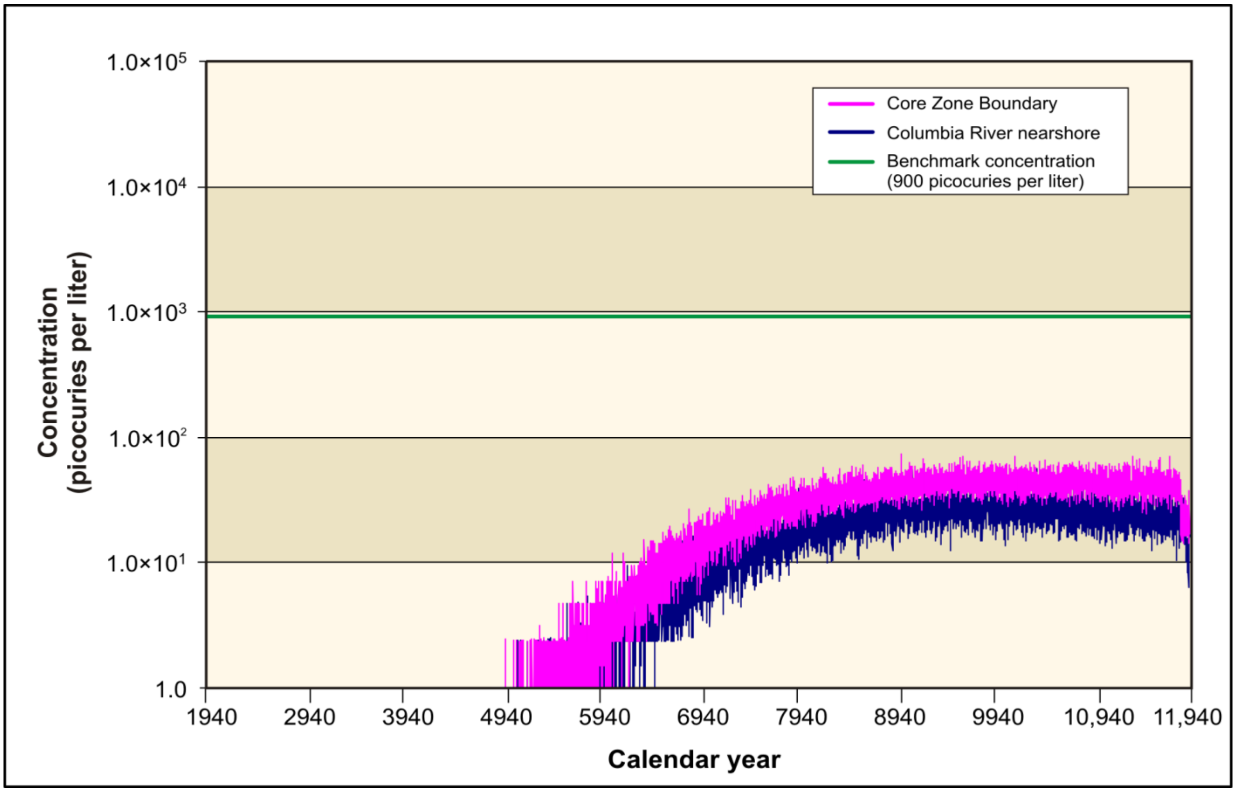


Figure 7–9. Tank Closure Alternative 2B Groundwater Technetium-99 Concentration Without Offsite Waste

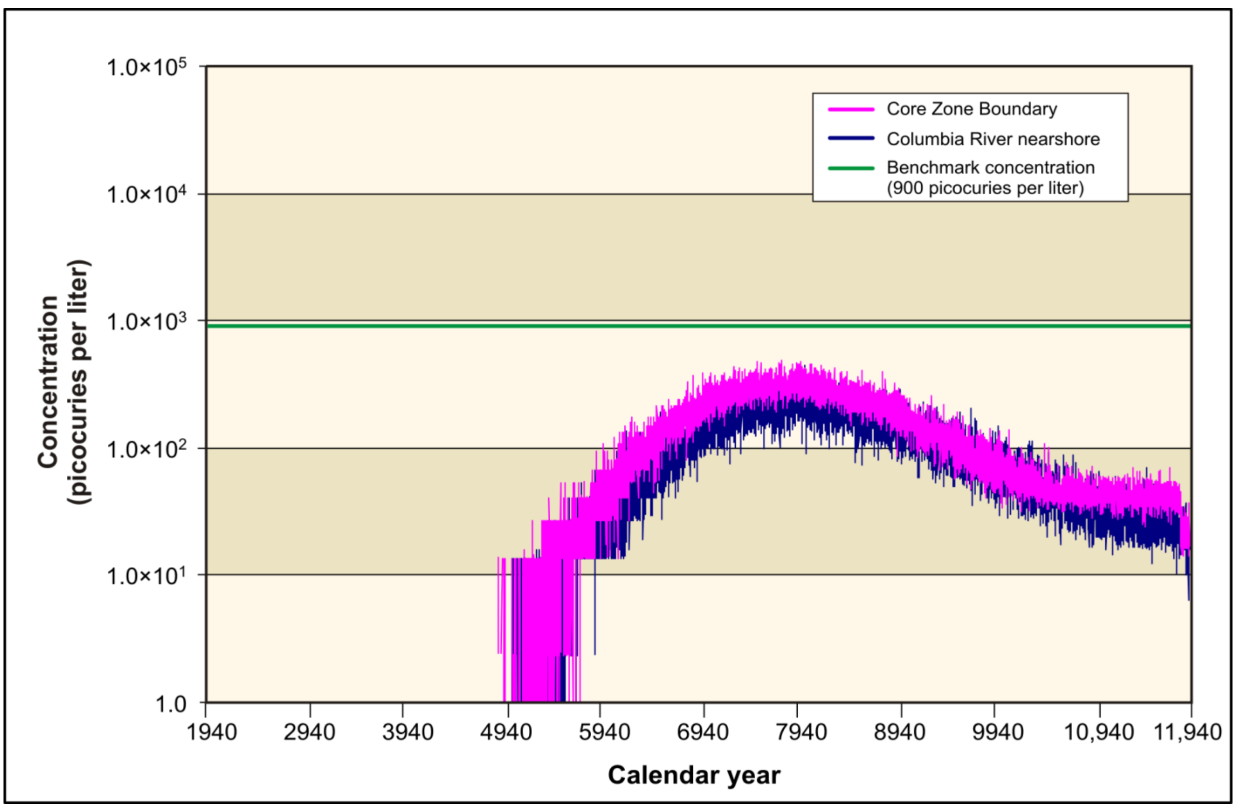


Figure 7–10. Tank Closure Alternative 2B Groundwater Technetium-99 Concentration with 1,500 Curies of Technetium-99 in Offsite Waste

Appendix M, Section M.5.7.6, presents similar concentration plots for intermediate concentrations of iodine-129 (e.g., 1 and 2 curies) and technetium-99 (e.g., 500 and 1,000 curies) in offsite waste. The data suggest a strong, proportional relationship between inventories of iodine-129 and technetium-99 in offsite waste disposed of in an IDF and long-term groundwater impacts at the Core Zone Boundary and the Columbia River.

In addition to mitigating measures such as restricting the acceptance of offsite waste or eliminating specific waste streams from consideration for disposal at Hanford, DOE could require pretreatment of offsite waste (e.g., grout, packaging) into better-performing waste forms prior to disposal in an IDF at Hanford. This might improve the release characteristics of offsite-waste forms, and thus downgrade the status of offsite waste as a dominating contributor to long-term groundwater impacts.

7.5.2.3 Sensitivity Analysis: Capture and Removal

The purpose of this sensitivity analysis was to evaluate the effect a planned pump-and-treat groundwater remediation system would have on a plume of carbon tetrachloride in the western portion of the Central Plateau. The plume is approximately 65,000 kilograms (143,000 pounds) of carbon tetrachloride that originated from the Plutonium Finishing Plant and was disposed of in three of the 216-Z cribs and trenches (ditches) (DOE 2010b). In addition to carbon tetrachloride, other COPCs such as chromium, nitrate, iodine-129, tritium, technetium-99, and uranium, also reside in this portion of the aquifer and would be affected by a pump-and-treat system. The Base Case for this *Final TC & WM EIS* does not take any credit for any planned remediation of this plume in the cumulative impacts analysis for long-term impacts on groundwater. This sensitivity analysis simulates two remedial end states for the plume at 95 and 99 percent removal and evaluates the predicted concentrations at the Core Zone Boundary and Columbia River for carbon tetrachloride, chromium, and technetium-99. The results for carbon tetrachloride are summarized in this section, and additional details and analysis for chromium and technetium-99 can be found in Appendix U, Section U.1.3.4.2. As a basis for the capture-and-removal sensitivity analysis, the following parameters were defined:

- Capture and removal of 0, 95, and 99 percent of COPC plume mass. For carbon tetrachloride, this corresponds to 0 percent removal (65,000 kilograms [143,000 pounds] released in CY 2005), 95 percent removal (3,250 kilograms [7,170 pounds] released in the year 2040), and 99 percent removal (650 kilograms [1,430 pounds] released in CY 2040).

- CY 2040 as an approximate date when remediation might be completed. This is based on a start date for full-scale remediation in approximately 2012 and an active pump-and-treat period of 25 years for the Operable Unit 200-ZP-1 groundwater system (EPA 2008).

A comparison of predicted concentrations of carbon tetrachloride at the Core Zone Boundary and Columbia River receptor locations for the 0, 95, and 99 percent mass removal scenarios is presented in Figures 7–11 and 7–12, respectively.

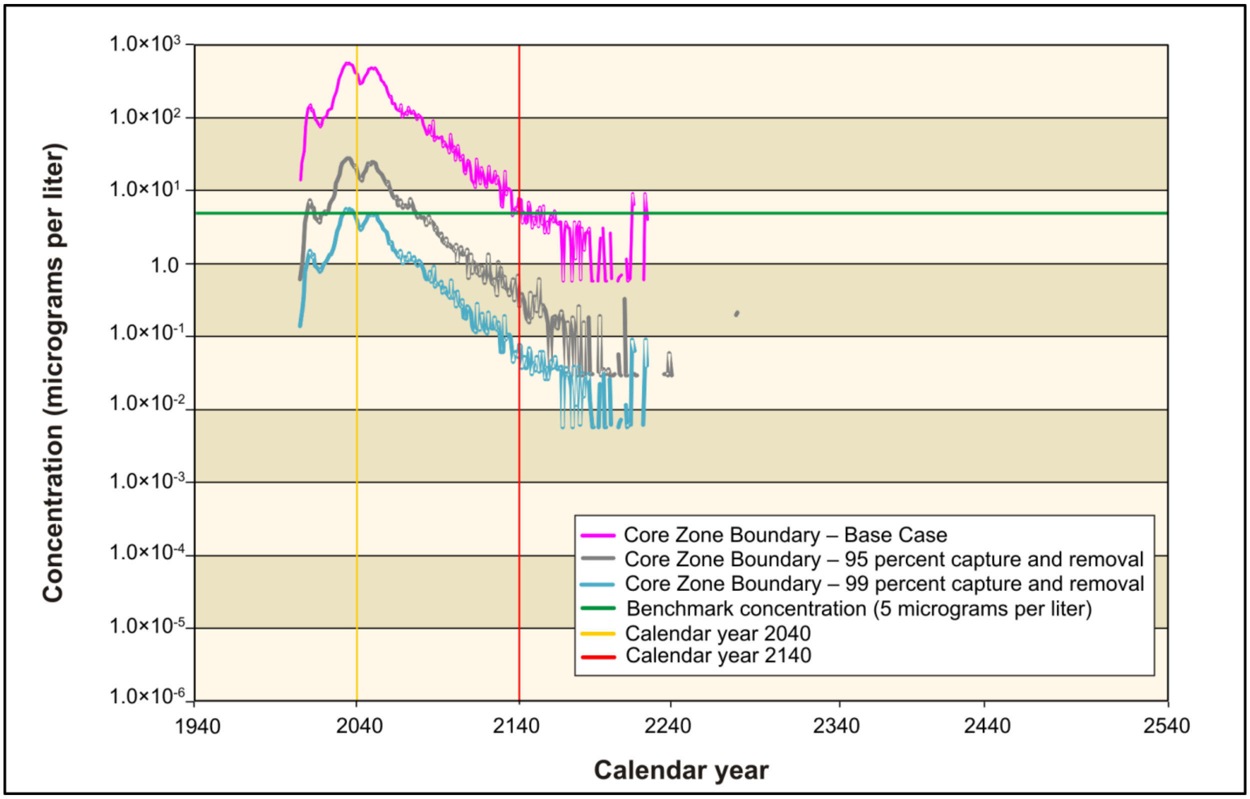


Figure 7–11. Carbon Tetrachloride Concentration Versus Time at the Core Zone Boundary, Capture-and-Removal Scenario Comparison

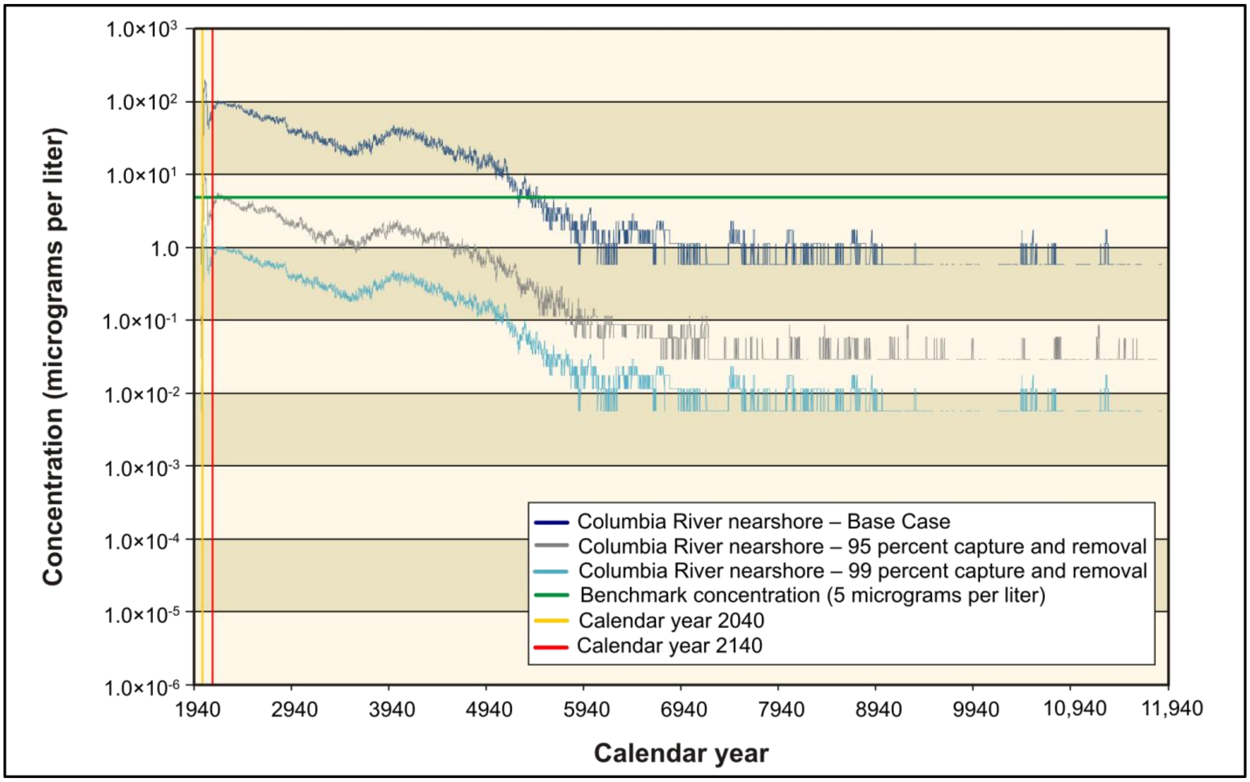


Figure 7–12. Carbon Tetrachloride Concentration Versus Time at the Columbia River, Capture-and-Removal Scenario Comparison

The results shown in both figures suggest that removal of the carbon tetrachloride in the upper 15 meters (49.2 feet) of the unconfined aquifer would result in a proportional decrease in concentrations predicted to occur at both the Columbia River nearshore and Core Zone Boundary receptor locations. There is some uncertainty associated with the technical limitations of the model. For instance, any plume remediation would take place over time; however, the model recognizes 95 and 99 percent mass removal in a single year, which was assumed to be CY 2040. Note that the timescale for Figure 7–11 is 600 years, whereas the timescale for Figure 7–12 is 10,000 years; this was done to provide a higher degree of resolution when evaluating impacts at the Core Zone Boundary. With the 0-percent-mass-removal case (i.e., the EIS case), concentrations are predicted to remain above benchmark standards at the Core Zone Boundary until approximately CY 2140 and at the Columbia River until approximately CY 5500. For the 95-percent-removal case, exceedances are predicted at both receptor locations from approximately CY 2050 to CY 2150, a much shorter duration than those predicted for the EIS case. For the 99-percent-removal case, concentrations are predicted to approach, but not exceed, benchmark standards at the Core Zone Boundary; concentrations at the Columbia River are predicted to remain at least one order of magnitude below benchmark standards during the period of analysis. The data suggest that remediation of the carbon tetrachloride plume in the western portion of the Central Plateau might be effective in significantly reducing groundwater concentrations that could occur at the Core Zone Boundary and Columbia River. On a larger scale, the data suggest that groundwater remediation systems may be an effective mitigation strategy at certain locations and for certain COPCs within the Central Plateau.

As discussed in Appendix U, Section U.1.3.4.2, concentrations of chromium and technetium-99 at the Columbia River nearshore and Core Zone Boundary receptor locations are not projected to exceed benchmark standards due to the mass of these COPCs residing within this portion of the aquifer, even for the 0-percent-removal case. However, similar to the carbon tetrachloride analysis, removal (both 95 percent and 99 percent) of the chromium or technetium-99 plume mass is also predicted to reduce predicted concentrations at the Columbia River nearshore and Core Zone Boundary receptor locations.

7.5.2.4 Sensitivity Analysis: Cribs and Trenches (Ditches) Partial Clean Closure

The purpose of this sensitivity analysis was to evaluate the predicted long-term groundwater impacts of proposed activities on concentration plots without the masking effect of the cribs and trenches (ditches). Past disposal practices in the cribs and trenches (ditches) impact groundwater early in the modeling timeframe, making it difficult to discern differences amongst the activities associated with Tank Closure alternatives (i.e., a masking effect). In other words, the analysis was conducted to determine the long-term groundwater impacts under Tank Closure Alternative 2B only if the contribution to groundwater impacts of the cribs and trenches (ditches) were removed. This analysis offered a higher degree of resolution in assessing the groundwater impacts. When conducting the analysis of crib and trench (ditch) partial clean closure, the following parameters were defined:

- The cribs and trenches (ditches) were removed from the sources of the COPCs analyzed under Tank Closure Alternative 2B long-term groundwater impacts.
- The radionuclides tritium, technetium-99, iodine-129, and uranium isotopes, as well as the chemicals chromium, nitrate, and total uranium, were evaluated.

In summary, the analysis indicates that groundwater impacts of past releases from cribs and trenches (ditches) occur early in the modeling timeframe (i.e., from approximately 1944 for 100 years) and that these impacts are significant when compared with impacts predicted to occur from activities associated with the Tank Closure alternatives. The contributions to groundwater impacts of past releases from cribs and trenches (ditches) are predicted to exceed benchmark standards under all Tank Closure alternatives, including the No Action Alternative.

Additional details and analysis can be found in Appendix O, Section O.6.6. From a mitigation perspective, this analysis does not directly lead to potential mitigation strategies; however, understanding the relative importance of tank closure activities when evaluating groundwater impacts may focus future mitigation planning.

7.5.2.5 Sensitivity Analysis: Iodine Recycle

The purpose of this sensitivity analysis was to evaluate the effect on predicted long-term groundwater impacts if treatment technologies were able to increase the amount of iodine-129 captured in ILAW glass waste forms instead of grouted secondary-waste forms. Under Tank Closure Alternative 2B, this *Final TC & WM EIS* assumes that iodine-129 would partition as 20 percent in ILAW glass and 80 percent in grouted secondary-waste forms. A portion of these results is summarized in this section, and additional details and analysis can be found in Appendix M, Section M.5.7.2. As a basis for the iodine-recycle analysis, the following parameters were defined:

- Partitioning of iodine-129 would increase to 70 percent in ILAW glass and decrease to 30 percent in grouted secondary waste, representing more capture of iodine-129 in primary-waste forms.
- Iodine-129 was modeled with a background IDF-East infiltration rate of 0.9 millimeters per year.

Figure 7–13 illustrates the predicted concentration for each contributing source of iodine-129 at the Core Zone Boundary, assuming that 20 percent of iodine-129 is captured in ILAW glass and 80 percent is captured in grouted secondary-waste forms (i.e., the EIS case). Offsite waste is the largest contributor to long-term groundwater impacts; ETF-generated secondary waste and solid secondary waste are the next-largest contributors, respectively. (Restriction of offsite waste as a potential mitigation measure is discussed in Section 7.5.2.2.) In this case, the grouted, ETF-generated secondary-waste contribution at the Core Zone Boundary is almost 1,000 times the secondary-waste contribution of WTP ILAW glass. Figure 7–14 illustrates the predicted concentrations for each contributing source at the Core Zone Boundary if less iodine-129 (30 percent) were captured in grouted ETF-generated and solid secondary-waste forms (i.e., the iodine recycle sensitivity case). In this second case, where more iodine-129 would be recycled and captured in the primary-waste form ILAW glass (70 percent), the predicted contribution from grouted ETF-generated and solid secondary waste decreases and the predicted contribution from ILAW glass increases accordingly. However, the grouted ETF-generated secondary-waste contribution at the Core Zone Boundary is still approximately 100 times that for WTP ILAW glass. Because grouted secondary-waste forms are the key drivers of long-term groundwater impacts, this reduction would have a significant beneficial effect on the overall predicted concentrations of iodine-129 at receptor locations.

The results indicate that iodine recycle, or an increase in the percentage capture of iodine-129 in the primary-waste form ILAW glass instead of grouted secondary-waste forms, would be an effective mitigation technique in reducing long-term groundwater impacts. However, iodine-129 is very volatile, and achieving greater partitioning of iodine-129 in ILAW glass, which involves a thermal treatment process, may be technologically challenging. Despite this challenge, the data suggest that even incremental increases in the capture of iodine-129 in ILAW glass could have an appreciable mitigating effect on long-term groundwater impacts.

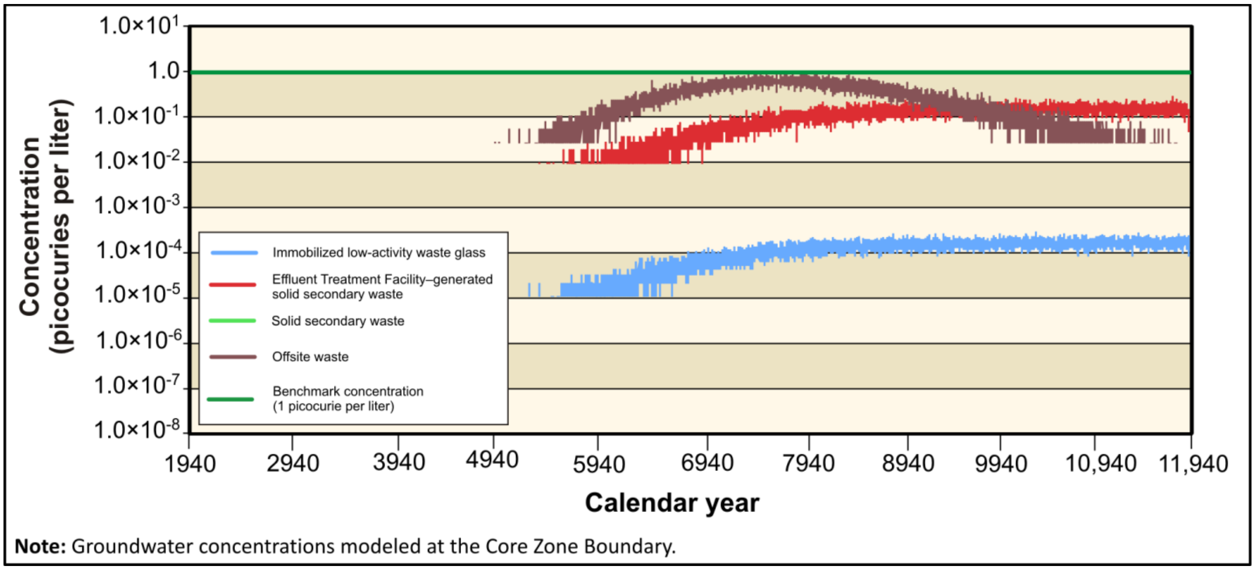


Figure 7–13. Waste Management Alternative 2, Tank Closure Alternative 2B, Groundwater Iodine-129 Concentrations at the Core Zone Boundary, *TC & WM EIS* Case

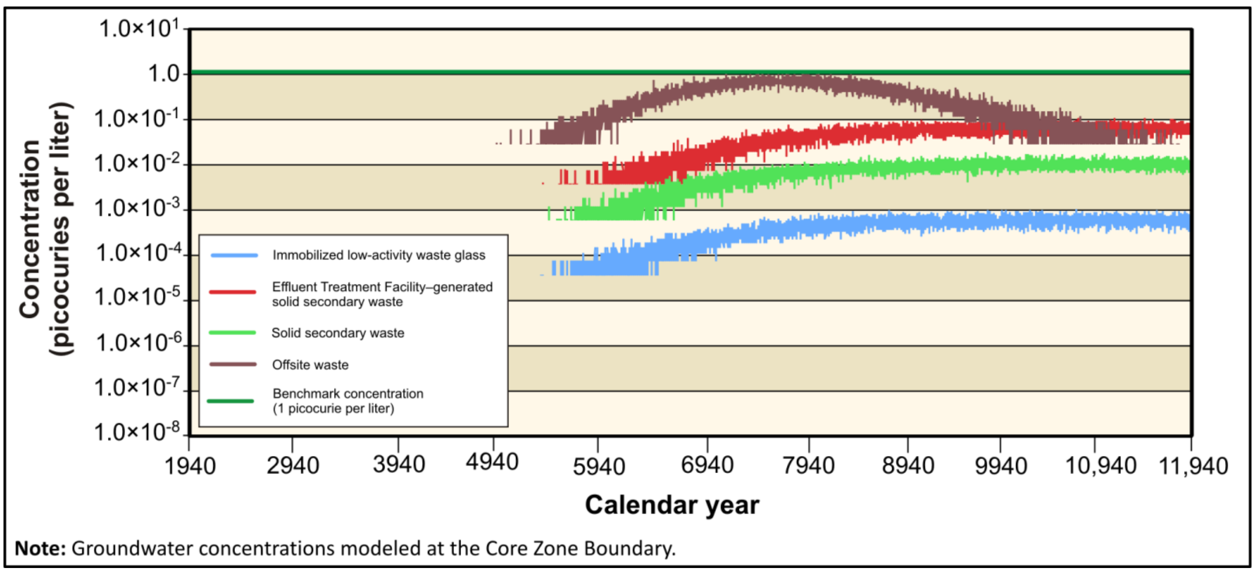


Figure 7–14. Waste Management Alternative 2, Tank Closure Alternative 2B, Groundwater Iodine-129 Concentrations at the Core Zone Boundary, Iodine Recycle Sensitivity Case

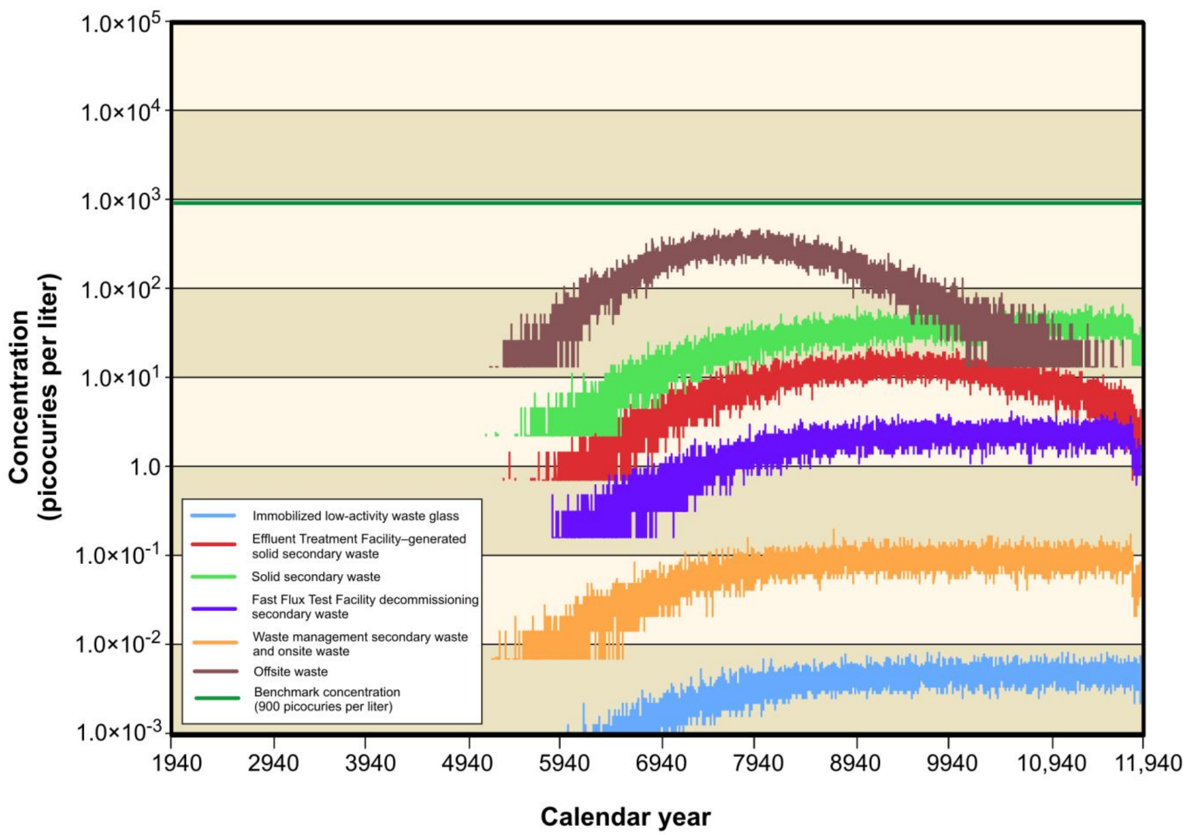
7.5.2.6 Sensitivity Analysis: No Technetium-99 Removal

The purpose of this sensitivity analysis was to evaluate the effect on predicted long-term groundwater impacts if technetium-99 were not selectively removed and partitioned in IHLW glass, which would be disposed of off site. This *Final TC & WM EIS* assumes that, under Tank Closure Alternative 2B, technetium-99 would be selectively removed from the LAW stream as a pretreatment step to WTP treatment and captured in IHLW glass. In this case, approximately 29,000 curies would be partitioned in IHLW glass; approximately 288 curies, in ILAW glass; and approximately 578 curies, in grouted secondary-waste forms. A portion of the results are summarized in this section, and additional details and analysis can be found in Appendix M, Section M.5.7.3. As a basis for the no-technetium-removal analysis, the following parameters were defined:

- Partitioning of technetium-99 would decrease to 247 curies in IHLW glass, increase to 28,800 curies in ILAW glass, and decrease to 517 curies in grouted secondary-waste forms. Sites analyzed included waste sources associated with Tank Closure Alternative 2B.

- Technetium-99 was modeled with a background IDF-East infiltration rate of 0.9 millimeters per year.

Figure 7–15 illustrates the predicted concentration of technetium-99 for each contributing source at the Core Zone Boundary assuming its selective removal and partitioning in IHLW glass. After offsite waste, grouted secondary-waste forms are the next-largest contributors to long-term groundwater impacts, as was predicted for iodine-129; however, the two types are reversed. This is due to the inventory of technetium-99 associated with solid secondary waste from WTP melter operations and spent resins. Figure 7–16 illustrates the predicted concentrations at the Core Zone Boundary without selective technetium-99 removal. In this second case, where more technetium-99 would be partitioned in ILAW glass and disposed of in an IDF, the predicted contribution from grouted ETF-generated and solid secondary waste slightly decreases and the predicted contribution from ILAW glass increases significantly. The slight reduction in technetium-99 in grouted secondary-waste forms appears to have a very small impact on overall predicted concentrations of technetium-99 at receptor locations and is somewhat offset by the significant increase in technetium-99 inventory that would be disposed of in an IDF as ILAW glass.



Note: Groundwater concentrations modeled at the Core Zone Boundary.

Figure 7–15. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, Groundwater Technetium-99 Concentrations at the Core Zone Boundary

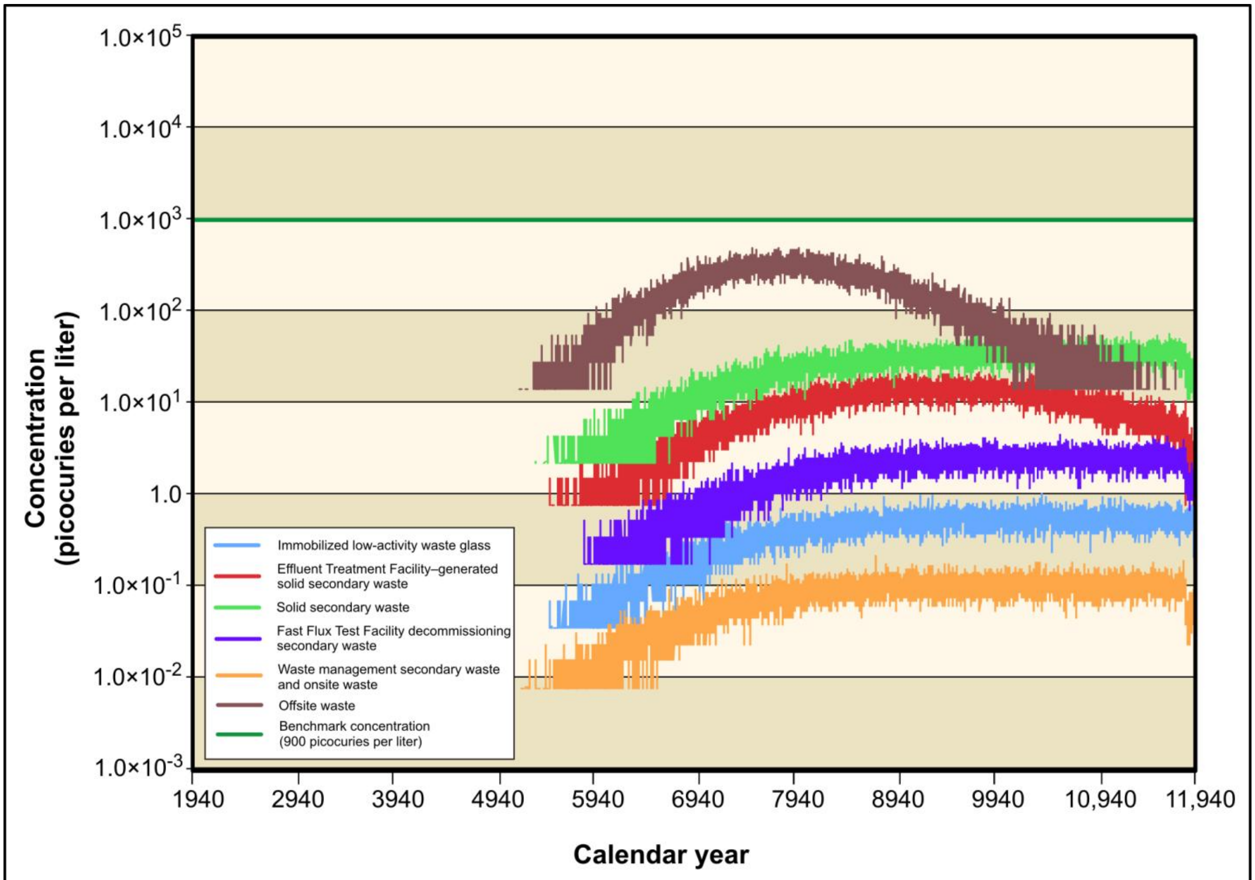


Figure 7–16. Groundwater Technetium-99 Concentration at the Core Zone Boundary, No-Technetium-99-Removal Case

The results suggest that selectively removing technetium-99 from the ILAW stream and partitioning it in IHLW glass has a limited overall effect on long-term groundwater impacts. This can be attributed to the determination that grouted secondary-waste forms (i.e., ETF-generated secondary waste and solid secondary waste) are still major contributors to long-term groundwater impacts. Selective removal of technetium-99 would not significantly alter the combined inventory that is partitioned in these waste forms. Therefore, data suggest that selectively removing technetium-99 from the ILAW stream and partitioning it into IHLW glass is not an effective strategy for mitigating long-term groundwater impacts. However, the data also suggest that a strategy to reduce the amount of technetium-99 found in all types of grouted secondary-waste forms could be effective in reducing long-term groundwater impacts, similar to the discussion for the iodine-129 recycle sensitivity analysis. Since ILAW glass is assumed to be a much better performing waste form than those generated from supplemental treatment technologies, it could be anticipated that, if supplemental treatment under Tank Closure Alternatives 3A, 3B, or 3C were pursued, selectively removing technetium-99 from supplemental treatment waste streams and incorporating it into IHLW or ILAW glass might yield more-positive results.

7.5.2.7 Sensitivity Analysis: Tank Waste Retrieval Losses

The purpose of this sensitivity analysis was to evaluate the relative predicted contributions of tank waste retrieval losses on long-term groundwater impacts compared with those from other sources after in situ tank closure (e.g., grouted ancillary equipment and tank residuals). This *Final TC & WM EIS* assumes retrieval losses of 15,142 liters (4,000 gallons) would occur from each SST, and the amount lost during retrieval operations would be approximately 25 percent of the original tank waste concentration. Both of these assumptions are perceived as conservative. Additional details and analysis can be found in Appendix M, Section M.5.6. As a basis for the tank waste retrieval loss sensitivity analysis, the following parameters were defined:

- Tank Closure Alternative 2B tank farm sources were evaluated, including retrieval losses, ancillary equipment, and tank residuals.
- Retrieval losses were assumed to be 15,142 liters (4,000 gallons), equal to 25 percent of original tank waste concentrations.
- Ancillary equipment and tank residuals would be grouted. The grouted waste forms would fail in 500 years, releasing their inventories of COPCs.
- Technetium-99 was modeled.

Tank waste retrieval losses are those leaks that could occur during tank waste retrieval operations; some tank waste retrieval technologies could result in more or less losses than other technologies, depending on the nature and aggressiveness of the technology during deployment (e.g., the amount of tank waste disturbance). Ancillary equipment includes subsurface piping to and from the tank farms systems, miscellaneous underground storage tanks, pump pits, diversion boxes, valve pits, and other miscellaneous facilities (see Appendix E, Section E.1.2.5.2) that would be grouted in place. Tank residuals are the 0.1, 1, or 10 percent residual tank waste that would remain in the tanks, depending on whether 99.9, 99, or 90 percent tank waste removal was selected by DOE. The peak release of COPCs from tank waste retrieval losses (i.e., 15,142 liters [4,000 gallons]) to the vadose zone is predicted to be at least one order of magnitude higher than those for other tank farm sources, although the releases from other tank farm sources would occur for a short period of time. Tank waste retrieval losses would occur during tank closure operations. Grouted waste forms for ancillary equipment and tank residuals would fail after 500 years, releasing their inventories of COPCs.

Figures 7–17 and 7–18 illustrate the predicted concentration of technetium-99 at the Core Zone Boundary and the Columbia River with and without the contribution of retrieval losses, respectively. Comparison of these concentration plots suggests that retrieval losses are not a major contributor to long-term groundwater impacts. The analysis also suggests that the amount of waste retrieved for treatment is important, regardless of whether retrieval losses occur. Mitigation strategies would include those that have the potential for reducing tank waste retrieval losses and could include using less-aggressive retrieval methods or developing and selecting more-effective retrieval technologies. As discussed previously, there is uncertainty associated with the assumption that 15,142 liters (4,000 gallons) of tank waste would leak during retrieval operations or that the concentration of COPCs that would be contained in these losses would have long-term groundwater impacts. It is possible that, during retrieval operations, less than 15,142 liters (4,000 gallons) of liquid would be released to the vadose zone.

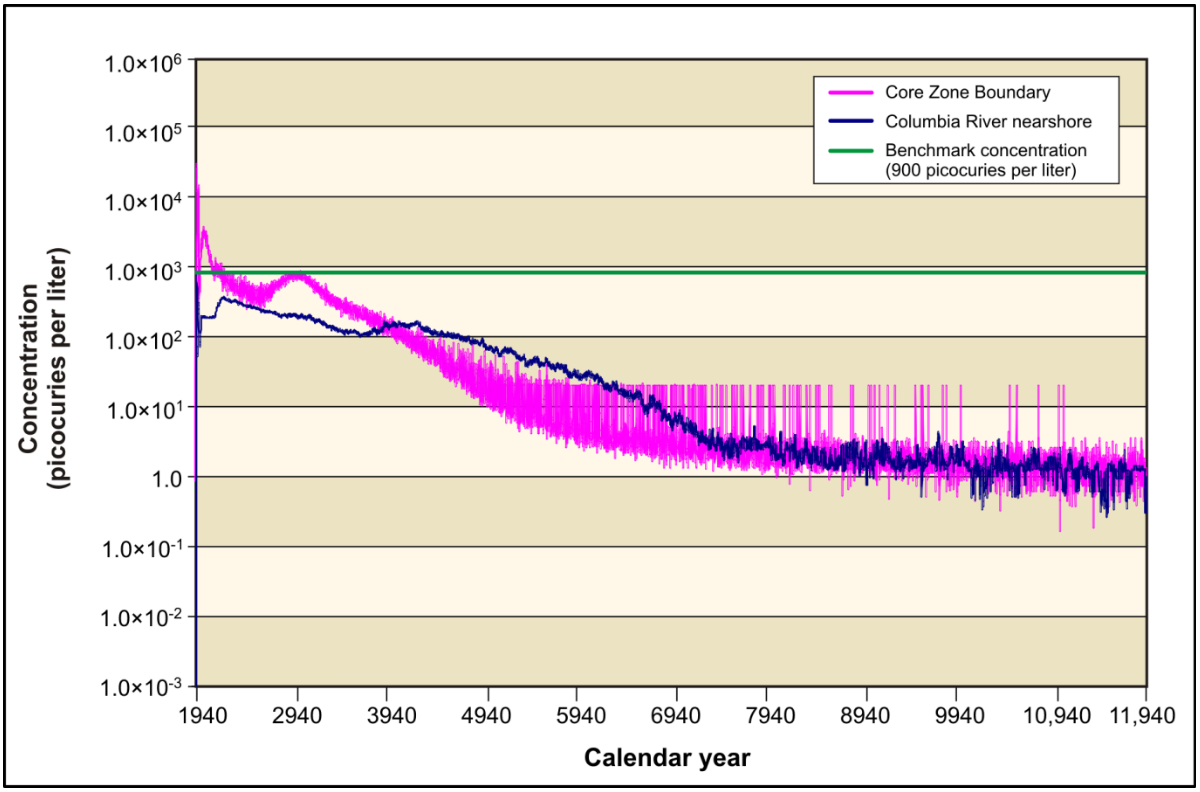


Figure 7–17. Tank Closure Alternative 2B Groundwater Technetium-99 Concentration at the Core Zone Boundary and the Columbia River, Retrieval Loss Sensitivity Case

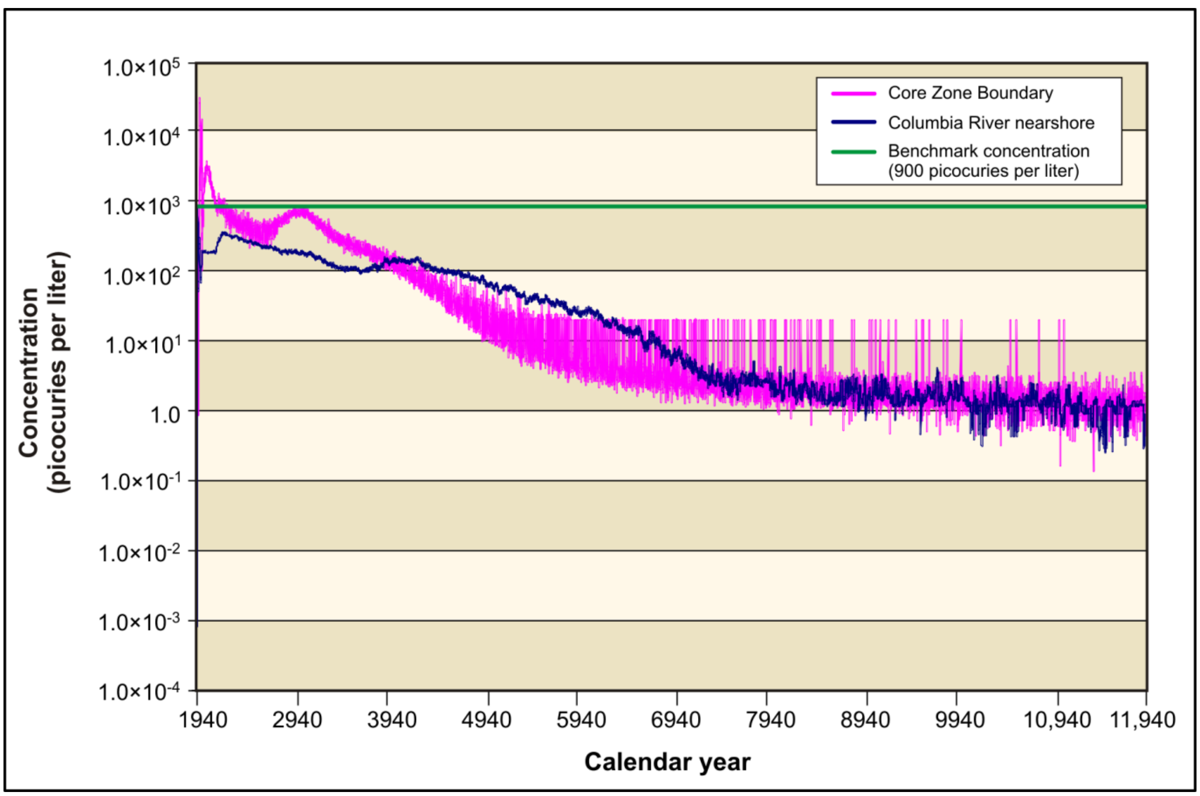


Figure 7–18. Tank Closure Alternative 2B Groundwater Technetium-99 Concentration at the Core Zone Boundary and the Columbia River, No-Retrieval-Losses Sensitivity Case

7.5.2.8 Sensitivity Analysis: Waste Form Performance

Under the Waste Management action alternatives, where an IDF would be constructed and operated in the 200-East and/or 200-West Areas, COPCs that would leach from the IDF(s) would result in the majority of long-term groundwater impacts when compared with other *TC & WM EIS* sources (i.e., the Tank Closure and FFTF Decommissioning action alternatives). As such, the performance of waste forms that would be disposed of in an IDF becomes very important when predicting long-term groundwater impacts. WTP ILAW glass, onsite non-CERCLA waste, offsite waste, FFTF closure waste, secondary waste, and, potentially, supplemental treatment waste would be disposed of in an IDF. As discussed in Section 7.5.2.5 and shown in Figures 7–13 and 7–14, offsite waste is predicted to be the largest contributor to long-term groundwater impacts for sources disposed of in an IDF, followed by grouted waste forms. As previously discussed in Section 7.5.2.2, this *Final TC & WM EIS* analysis assumes that offsite waste would be disposed of in an IDF as it is received, with no pretreatment or additional stabilization steps taken. In the evaluation of long-term groundwater impacts of an IDF, the remaining waste forms that can be considered are from onsite sources. As has been discussed, there is a level of uncertainty regarding waste form performance in an IDF. There are very limited data to support long-term performance assessments for some of the waste forms analyzed in this EIS, particularly those associated with the supplemental treatment technologies, bulk vitrification, and steam reforming, as analyzed under Tank Closure Alternatives 3B and 3C. Bulk vitrification waste forms are discussed in more detail in Appendix M, Section M.5.7.4. Steam reforming waste forms are discussed in more detail in Appendix M, Section M.5.5. The sensitivity analyses discussed below address four specific areas of waste form performance: ILAW glass from WTP treatment, bulk vitrification glass from supplemental treatment under Tank Closure Alternative 3A, steam reforming waste from supplemental treatment under Tank Closure Alternative 3C, and grouted waste.

ILAW Glass Waste Form Performance

The purpose of this sensitivity analysis was to determine the effect if the ILAW glass primary-waste form from the WTP performed better or worse than expected in an IDF. The performance of ILAW glass assumes a fractional release model for COPCs. A portion of the results are summarized in this section, and additional details and analysis can be found in Appendix M, Section M.5.7.1. As a basis for the ILAW glass waste form performance sensitivity analysis, the following parameters were defined:

- The IDF-East configuration was assumed to be consistent with Tank Closure Alternative 2B, Waste Management Alternative 2.
- The performance of ILAW glass was evaluated and compared, assuming three different fractional release rates: (1) 2.80×10^{-8} grams per gram per year (i.e., the EIS case); (2) 2.80×10^{-7} grams per gram per year, representing a decrease in waste form performance; and (3) 2.80×10^{-9} grams per gram per year, representing an improvement in waste form performance.
- Technetium-99 was modeled with a background IDF-East infiltration rate of 0.9 millimeters per year.

Figure 7–19 illustrates the predicted concentration of technetium-99 at the Core Zone Boundary for individual waste forms that might be disposed of in an IDF under Tank Closure Alternative 2B for the EIS case (e.g., fractional release equivalent to 2.80×10^{-8} grams per gram per year). Of several contributors, ILAW glass contributes the least to long-term groundwater impacts. For the sensitivity cases, where the fractional release of COPCs increases or decreases by an order of magnitude, the contribution from ILAW glass likewise increases or decreases one order of magnitude accordingly. However, even for the sensitivity case where ILAW glass performance decreases by an order of magnitude, it is predicted that ILAW glass would still contribute the least to groundwater impacts. Since the contribution from ILAW glass represents only a small fraction of the cumulative long-term groundwater impacts, improvements in the performance of this primary-waste form would not likely yield any observable reductions in concentrations of COPCs at the Core Zone Boundary or the Columbia River.

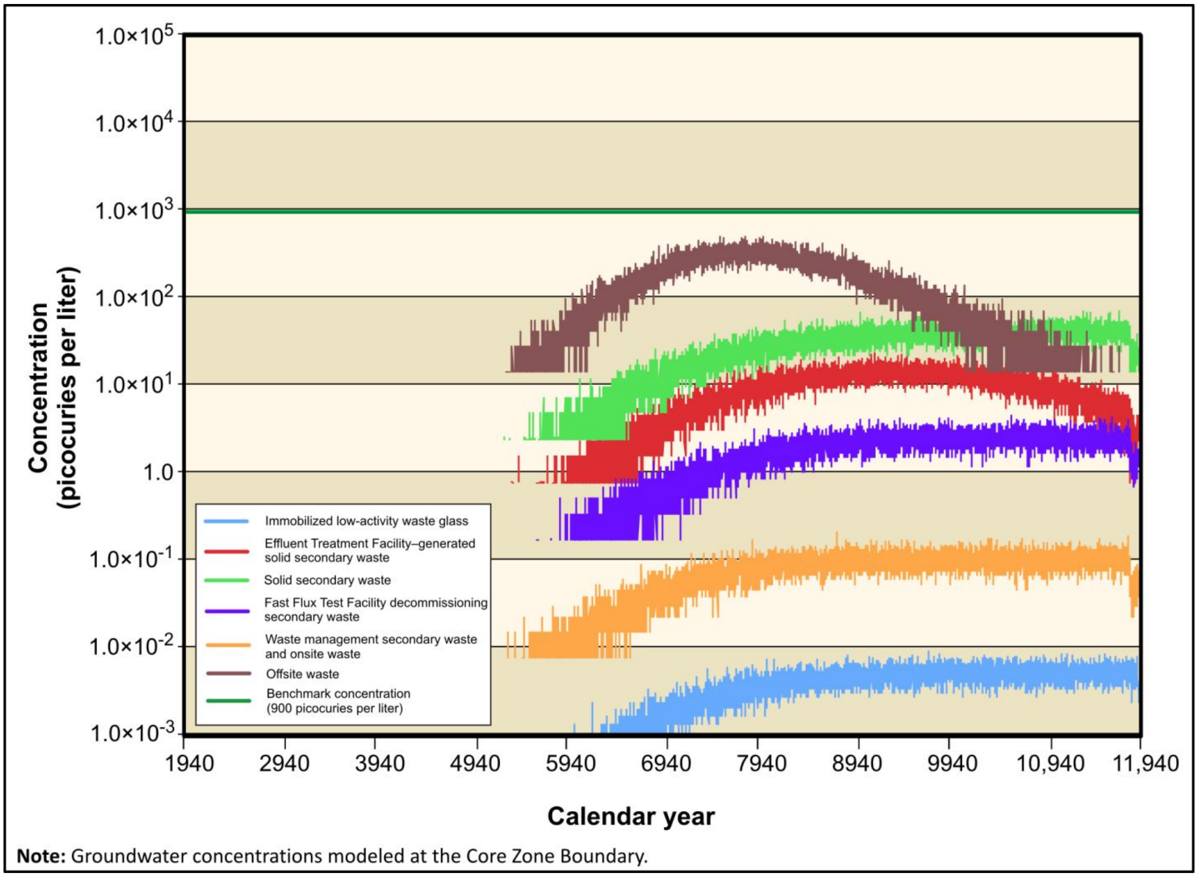


Figure 7–19. Tank Closure Alternative 2B Groundwater Technetium-99 Concentration at the Core Zone Boundary

Bulk Vitrification Waste Glass Performance

The purpose of this sensitivity analysis was to determine the effect if the bulk vitrification supplemental treatment process could be improved. The performance of bulk vitrification glass assumes a fractional release model for COPCs in the primary-waste form and a convection-limited release for the castable refractory block. Furthermore, the EIS analysis assumes that COPCs will partition between the primary-waste form and the castable refractory block. The castable refractory block is a thermal insulating layer that envelops the primary-waste form along the edges of the bulk vitrification container. As discussed in Appendix E, Section E.1.2.3.6.5, there is uncertainty regarding the amount of COPCs that will partition between the primary-waste form and the castable refractory block. This sensitivity analysis evaluates improvement in the fractional release of the primary-waste form and improvement in the partitioning of COPCs. A portion of the results are summarized in this section, and additional details and analysis can be found in Appendix M, Section M.5.7.4. As a basis for this sensitivity analysis, the following parameters were defined:

- The IDF-East configuration was assumed to be consistent with Tank Closure Alternative 3A, Waste Management Alternative 2.

- The performance of bulk vitrification glass was evaluated and compared, assuming a higher percentage of COPCs is captured in the primary-waste form: (1) 93.5 percent in bulk vitrification glass and 6.5 percent in the castable refractory block (i.e., the EIS case), and (2) 99.7 percent in bulk vitrification glass and 0.3 percent in the castable refractory block (i.e., the sensitivity case).
- The performance of bulk vitrification glass was evaluated and compared, assuming a lower fractional release rate from the primary-waste form: (1) 1.00×10^{-8} grams per gram per year (i.e., the EIS case), and (2) 1.00×10^{-9} grams per gram per year (i.e., the sensitivity case, which assumes better-performing waste forms).
- Technetium-99 was modeled with a background IDF-East infiltration rate of 0.9 millimeters per year.

Figure 7–20 illustrates the predicted concentration of technetium-99 at the Core Zone Boundary for individual waste forms that might be disposed of in an IDF under Tank Closure Alternative 3A for the EIS case (i.e., 93.5 percent partitioned in bulk vitrification glass and a fractional release equivalent to 1.00×10^{-8} grams per gram per year). The two largest contributors are offsite waste and bulk vitrification glass. (Note: "Bulk vitrification glass," as shown in the figures, includes the contribution to impacts from both the bulk vitrification primary-waste form and the castable refractory block added together.) Figure 7–21 illustrates the predicted concentration if more technetium-99 is partitioned in the primary waste (e.g., increase to 99.7 percent from 93.5 percent) and less in the castable refractory block (e.g., decrease to 0.3 percent from 6.5 percent). The results suggest that an increase in the amount of technetium-99 partitioned in the primary-waste form yields a corresponding reduction in the contribution to impacts from bulk vitrification glass. The sensitivity case predicts that the contribution to impacts from bulk vitrification glass would decrease to the level of other grouted secondary-waste forms and would no longer contribute as much as offsite waste.

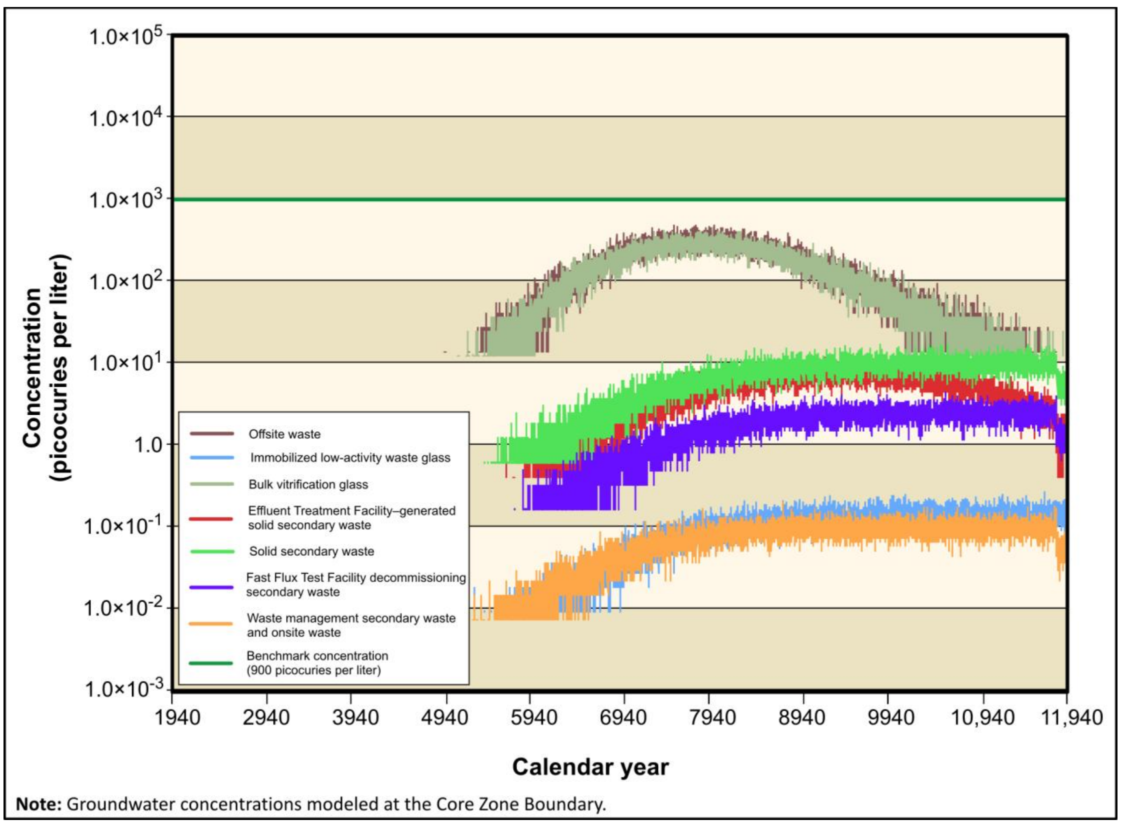


Figure 7–20. Groundwater Technetium-99 Concentrations at the Core Zone Boundary, Bulk Vitrification EIS Case

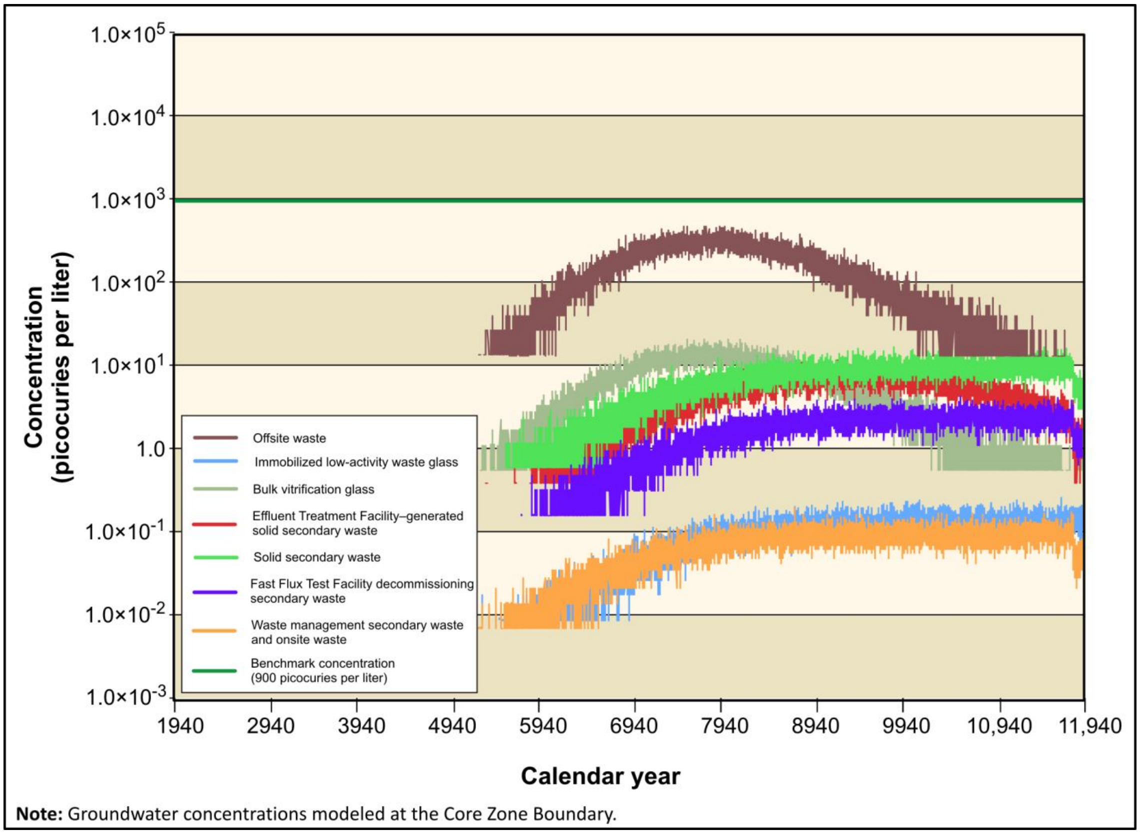
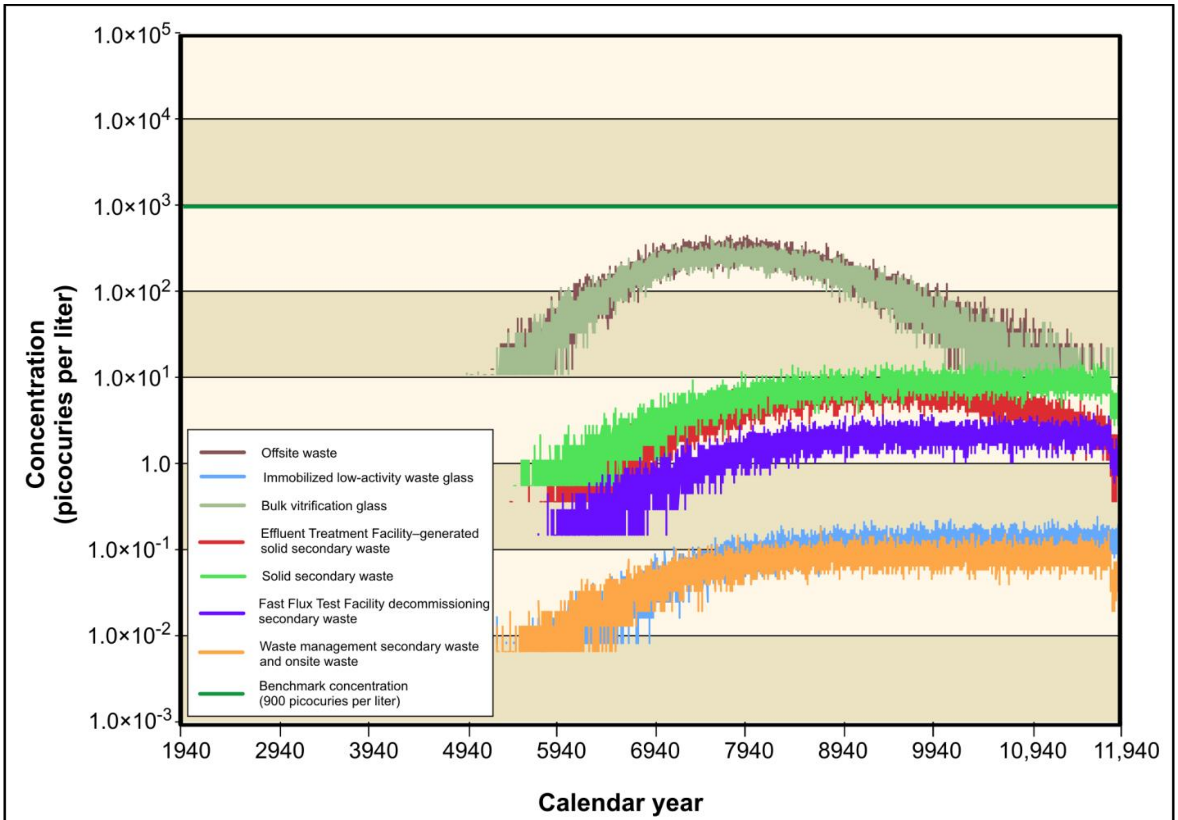


Figure 7–21. Groundwater Technetium-99 Concentrations at the Core Zone Boundary, Bulk Vitrification Sensitivity Case 1

Figure 7–22 illustrates the predicted concentration of technetium-99 at the Core Zone Boundary for the sensitivity case where the release rate of the primary-waste form for bulk vitrification is reduced by an order of magnitude. Unlike the ILAW glass sensitivity case analyzed and discussed above, there does not appear to be a corresponding reduction in the predicted contribution to impacts when comparing these results with the EIS case shown in Figure 7–20. The reason for an apparent lack of response to the groundwater system is that bulk vitrification glass consists of two components: the primary-waste form and the castable refractory block. The castable refractory block, which is modeled assuming a convective release of COPCs, contributes more than the primary-waste form to long-term groundwater impacts for bulk vitrification glass; therefore, changes to the fractional release of the primary-waste form have an imperceptible effect on the predicted concentrations for bulk vitrification glass as a whole.

The sensitivity analysis of bulk vitrification waste glass performance suggests that mitigation measures designed either to increase the partitioning of COPCs in the primary-waste form or to improve the release mechanisms in the castable refractory block could reduce the predicted concentrations in groundwater. However, there is a high degree of uncertainty associated with how COPCs partition between bulk vitrification components or which release mechanisms prevail for the castable refractory block. The data also suggest that, because the castable refractory block is the largest contributor to impacts from bulk vitrification glass, a reduction in the fractional release rate of the primary-waste form would not likely result in noticeable improvements in groundwater concentrations.



Note: Groundwater concentrations modeled at the Core Zone Boundary.

Figure 7–22. Groundwater Technetium-99 Concentrations at the Core Zone Boundary, Bulk Vitrification Sensitivity Case 2

Steam Reforming Waste Performance

The purpose of this sensitivity analysis was to determine the effect of variation in the release model concept on the estimates of rate of release from steam reforming waste. A fluidized-bed steam reformer contacts a waste stream containing organics, nitrates, and dissolved solids with a carbonaceous or clay co-reactant in a reducing steam environment to produce a mineralized waste form product (i.e., steam reforming waste). Depending on the fluidized-bed steam reforming operating conditions and the nature of the co-reactant, the solid product may adopt amorphous, glassy, or crystalline structures exhibiting a range of matrix solubility and constituent retention properties. Release models considered in this *TC & WM EIS* include a reactant (water)-limited release model supported by surface-reaction-rate data and a chemical reaction equilibrium–limited release model (i.e., solubility-limited release model) based on certain assumptions. Preliminary test data suggest that the primary matrix of the fluidized-bed steam reforming product is nepheline, an aluminosilicate mineral. A summary of results is provided in this section, and additional details and analysis can be found in Appendix M, Section M.5.5. As a basis for the steam reforming waste sensitivity analysis, the following conditions were defined:

- The IDF-East configuration was assumed to be consistent with Tank Closure Alternative 3C and Waste Management Alternative 2.

- The rate of release of steam reforming waste was evaluated and compared for three solubility cases for nepheline: (1) 2.01×10^6 grams per cubic meter based on the reactant-limited release model; (2) 1.75×10^5 grams per cubic meter (i.e., the EIS case), representing an upper limit based on the chemical reaction equilibrium–limited release model; and (3) 220 grams per cubic meter, representing a lower limit based on the chemical reaction equilibrium–limited release model.

- Technetium-99 was modeled.

Consistent with the values of solubility, the peak release rate to the vadose zone for the reactant-limited release model is a factor of approximately 10 higher than that for the EIS case, the upper-limit chemical reaction equilibrium–limited release model. The peak release rate to the vadose zone for the lower-limit solubility case is a factor of approximately 1,000 lower than that for the EIS case. Model evaluation in this final EIS requires knowledge of product particle and alteration-product structure, as well as parameters such as mass transfer coefficients and effective diffusivities, which have not been investigated for the current fluidized-bed steam reforming waste forms; therefore, some uncertainty exists regarding waste form performance for steam reforming waste under disposal conditions.

Grouted Waste Performance

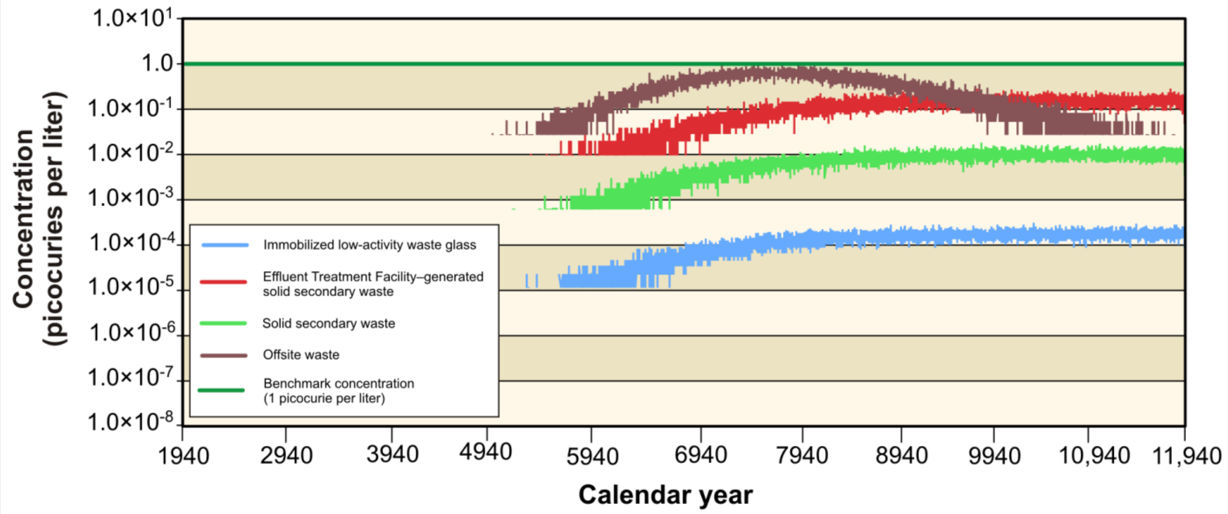
The purpose of this sensitivity analysis was to determine the effect if grouted waste forms performed better. Grouted waste forms may include ETF-generated secondary waste, solid secondary waste, FFTF decommissioning or waste management secondary waste, onsite non-CERCLA waste, and cast stone from supplemental treatment under Tank Closure Alternative 3B. A portion of the results are summarized in this section, and additional details and analysis can be found in Appendix M, Section M.5.7.5. As a basis for this analysis, the following parameters were defined:

- The IDF-East configuration was assumed to be consistent with Tank Closure Alternatives 2B, 3A, 3B, and 3C and Waste Management Alternative 2.

- The performance of grouted waste forms was evaluated and compared under two environmental conditions: (1) when the grouted waste form is saturated (i.e., the EIS case), and (2) when the moisture content is 7 percent (i.e., the grout sensitivity case). Effective diffusion coefficients depend on the soil moisture content in contact with the grouted waste forms.

- Iodine-129 was modeled with a background IDF-East infiltration rate of 0.9 millimeters per year.

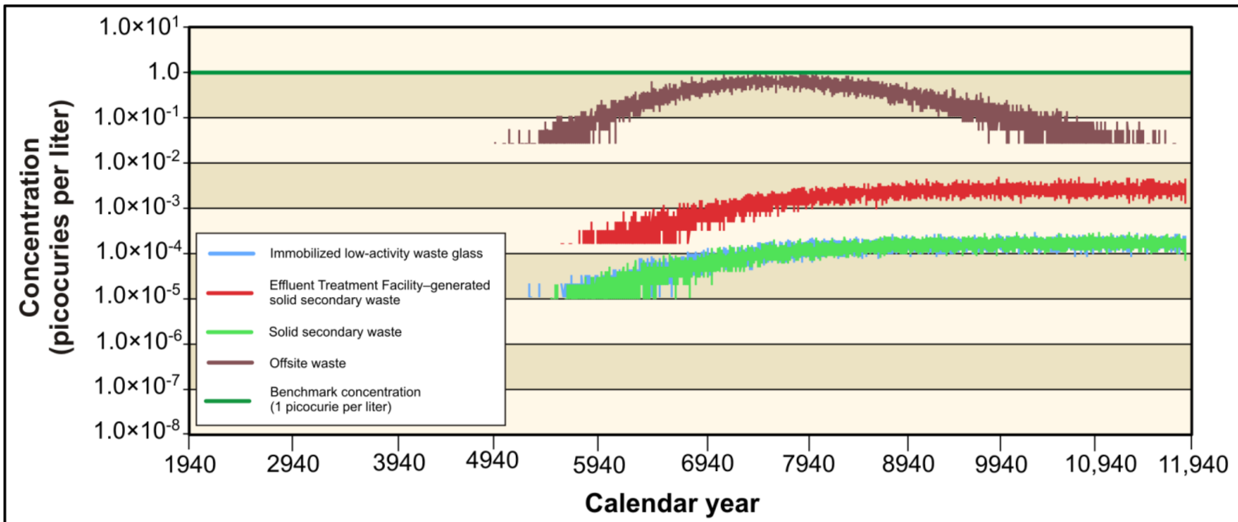
Figure 7–23 illustrates the predicted concentration of iodine-129 at the Core Zone Boundary for individual waste forms that might be disposed of in IDF-East under Tank Closure Alternative 2B for the EIS case (i.e., saturated waste form). Offsite waste is the largest contributor to long-term groundwater impacts, followed by ETF-generated secondary waste, solid secondary waste, and ILAW glass. In this case, the grouted ETF-generated secondary-waste contribution at the Core Zone Boundary is almost 1,000 times that of ILAW glass, and the secondary-waste contribution of grouted solid secondary waste at the Core Zone Boundary is almost 100 times that of ILAW glass. Excluding offsite waste, this suggests that an increase or decrease in the performance of grouted secondary-waste forms would have a corresponding proportional effect on long-term groundwater impacts from onsite sources of waste disposed of in an IDF.



Note: Groundwater concentrations modeled at the Core Zone Boundary.

Figure 7–23. Waste Management Alternative 2, Tank Closure Alternative 2B, Groundwater Iodine-129 Concentrations at the Core Zone Boundary, EIS Performance Case

Data suggest that grout surrounded by soil with a lower moisture content would lead to a corresponding decrease in the diffusivity of concrete for grouted waste forms, and thus a better-performing waste form with slower release rates (Mattigod et al. 2001). Figure 7–24 reanalyzes the data for the grout sensitivity case (i.e., 7 percent moisture content). The results suggest that the sensitivity grout would perform substantially better—almost two orders of magnitude better for all grouted waste forms—and thus would likely lead to much lower concentrations in groundwater at the Core Zone Boundary for onsite sources of waste disposed of in an IDF. At an infiltration rate of 3.5 millimeters per year, lowering the diffusivity for grout by two orders of magnitude (i.e., from 1.00×10^{-10} to 1.00×10^{-12} square centimeters per second) would decrease the contribution of ETF-generated secondary waste by a factor of 100, thus deleting this waste from the list of dominant contributors to risk. Similar results were predicted for simulations under Tank Closure Alternatives 3A, 3B, and 3C, as discussed in Appendix M, Section M.5.7.5.



Note: Groundwater concentrations modeled at the Core Zone Boundary.

Figure 7–24. Waste Management Alternative 2, Tank Closure Alternative 2B, Groundwater Iodine-129 Concentrations at the Core Zone Boundary, Sensitivity Grout Case

Sensitivity Analysis: Waste Form Performance Conclusions

Mitigation strategies could involve the development of test methods for assessing the long-term performance of primary- and secondary-waste forms, thereby reducing the associated uncertainty. However, the data also suggest that a very promising mitigation measure would be to develop better-performing grout for the disposal of secondary waste in an IDF, which could lead to significant improvements in the overall performance of an IDF. As discussed above, when offsite waste is considered for disposal in an IDF, this waste stream becomes the largest contributor, even more so if the performance of grouted ETF-generated secondary waste is improved. However, the assumption for offsite waste is that it would be accepted for disposal because it would be received with no additional stabilization steps taken. Waste form performance for offsite waste would likewise be improved if it is grouted prior to disposal, therefore improving its long-term performance

Operation of an IDF would be permitted and regulated by the Washington State Department of Ecology. The permit is likely to contain specific performance-based stipulations (e.g., groundwater concentrations at a receptor location may not exceed a certain value). These permit conditions can be used to determine which waste form performance standards would be required to meet these conditions before accepting a supplemental-treatment-, secondary-, or offsite-waste form for disposal in an IDF.

DOE recognizes the importance of improving secondary-waste-form performance and has already taken steps to address this need. On July 21 through July 23, 2008, DOE held a workshop to identify the risks and uncertainties associated with treatment and disposal of secondary waste and to develop a roadmap for addressing those risks and uncertainties. Attending the workshop were representatives from DOE, the U.S. Environmental Protection Agency, the Washington State Department of Ecology, the Oregon State Department of Energy, and the U.S. Nuclear Regulatory Commission, as well as technical experts from DOE national laboratories, academia, and private industry. As a result of the individual contributions to the workshop, DOE published the *Hanford Site Secondary Waste Roadmap* in January 2009 (PNNL 2009). This secondary-waste roadmap includes elements addressing regulatory and performance requirements, waste composition, preliminary waste form screening, waste form development, process design and support, and validation. The regulatory and performance requirements activity will provide the secondary-waste-form performance requirements. The waste-composition activity will provide workable ranges of secondary-waste compositions and formulations for stimulants and surrogates. Preliminary waste form screening will identify candidate waste forms for immobilizing the secondary waste. The waste form development activity will mature the waste forms, leading to one or more selected waste forms and providing a defensible understanding of the long-term release rate and input into the critical decision process for a secondary-waste treatment process/facility. The process and design support activity will provide a reliable process flowsheet and input to support a robust facility design. The validation effort will confirm that the selected waste form meets regulatory requirements. Implementation of the secondary-waste roadmap will ensure compliant, effective, timely, and cost-effective disposal of the secondary waste (PNNL 2009).

Improvement in the performance of primary-waste forms may also reduce long-term groundwater impacts, although it is expected these improvements would be small and incremental compared with improvements in the performance of secondary-waste forms. The results of the sensitivity analysis for grouted secondary-waste forms where environmental conditions are drier (i.e., the grouted waste form is not saturated) indicate that significant improvements in grouted-waste-form performance might be achievable if these conditions could be controlled in some manner. However, improvements in primary-waste forms that would increase partitioning of COPCs in primary- rather than secondary-waste forms would lead to more-significant and proportional reductions in long-term groundwater impacts.

7.5.2.9 Sensitivity Analysis: Infiltration Rates

Another parameter that can significantly affect the fate and transport of COPCs is infiltration rates. The infiltration rate is the rate in which moisture moves vertically through the vadose zone. Background (i.e., natural) infiltration rates at Hanford have been a subject of debate. This *Final TC & WM EIS* relies on the *Technical Guidance Document for Tank Closure Environmental Impact Statement Vadose Zone and Groundwater Revised Analyses* (*Technical Guidance Document*) (DOE 2005) when defining infiltration rates in long-term groundwater modeling. The *Technical Guidance Document* specifies background infiltration rates of 0.9 millimeters per year for IDF-East and 3.5 millimeters per year for other Hanford sites. The *Technical Guidance Document* also specifies a range of 0.9 to 5.0 millimeters per year for analyzing sensitivity cases. Infiltration rates can be temporarily influenced by constructing barriers over waste sites. This *Final TC & WM EIS* assumes that an engineered barrier would temporarily depress the infiltration rate to 0.5 millimeters per year for its design life. An RCRA barrier has an assumed design life of 500 years before failure, whereas the Hanford barrier analyzed under Tank Closure Alternative 5 has an assumed design life of 1,000 years before failure. Because decisions must be made to support WTP operations and to close tank farms prior to knowing for certain what the long-term postclosure infiltration rate is, a sensitivity analysis was performed to show how this uncertainty should be viewed when establishing permit conditions associated with an IDF. The results are summarized in this section, and additional details and analysis can be found in Appendix N, Section N.5.9. As a basis for this sensitivity analysis, the following parameters were defined:

- Background infiltration rates for IDF-East were assumed to be 0.9, 1.75, 2.5, 3.5, 4.25, and 5.0 millimeters per year, representing the full range of sensitivity analysis. These infiltration rates apply to pre-Hanford (i.e., background) and post–barrier failure periods at IDF-East. Background infiltration rates were assumed to remain at 3.5 millimeters per year for all other sites at Hanford, including IDF-West under Waste Management Alternative 3. The EIS case assumes a background infiltration rate of 0.9 millimeters per year.
- The configuration of IDF-East was assumed to be consistent with Waste Management Alternative 2 under Tank Closure Alternatives 2B, 3A, 3B, and 3C.
- Technetium-99 was modeled.

Figures 7–25, 7–26, and 7–27 illustrate the predicted concentration of technetium-99 at the Core Zone Boundary for background infiltration rates at IDF-East of 0.9 millimeters per year, 3.5 millimeters per year, and 5.0 millimeters per year, respectively, under Tank Closure Alternative 2B. Each of these plots assumes infiltration of 0.5 millimeters per year until the RCRA barrier fails in approximately CY 2500. For a background infiltration rate of 0.9 millimeters per year (i.e., the EIS case), the concentrations of technetium-99 at the Core Zone Boundary and Columbia River approach, but do not exceed, benchmark standards. The peak occurs in approximately CY 7800. Increasing the background infiltration rate to 3.5 millimeters per year causes the predicted concentrations of technetium-99 to exceed benchmark standards at the Core Zone Boundary and to very nearly exceed technical standards at the Columbia River. The peak concentration occurs in approximately CY 4000, then decreases rapidly thereafter. Increasing the background infiltration rate to 5.0 millimeters per year causes the predicted concentrations of technetium-99 to exceed benchmark standards at both the Core Zone Boundary and the Columbia River. The peak concentration occurs in approximately CY 3800, then decreases rapidly thereafter. Additional figures illustrating the full range of sensitivity cases for background infiltration rates under Tank Closure Alternative 2B, as well as under Tank Closure Alternatives 3A, 3B, and 3C, are provided in Appendix N, Section N.5.9. Generally, similar observations could be made with regard to the results found for all Tank Closure alternatives analyzed. As infiltration rates increase, the peak occurs sooner and with greater magnitude. The tradeoff is that the concentrations at receptor locations would decrease more quickly beyond the peak year. A closer examination of other infiltration rates, as presented in Appendix N, Section N.5.9, suggests that concentrations of COPCs are most sensitive to changes in infiltration from 0.9 to approximately 2.0 millimeters per year, after which sensitivity to changes in infiltration rates are not as noticeable.

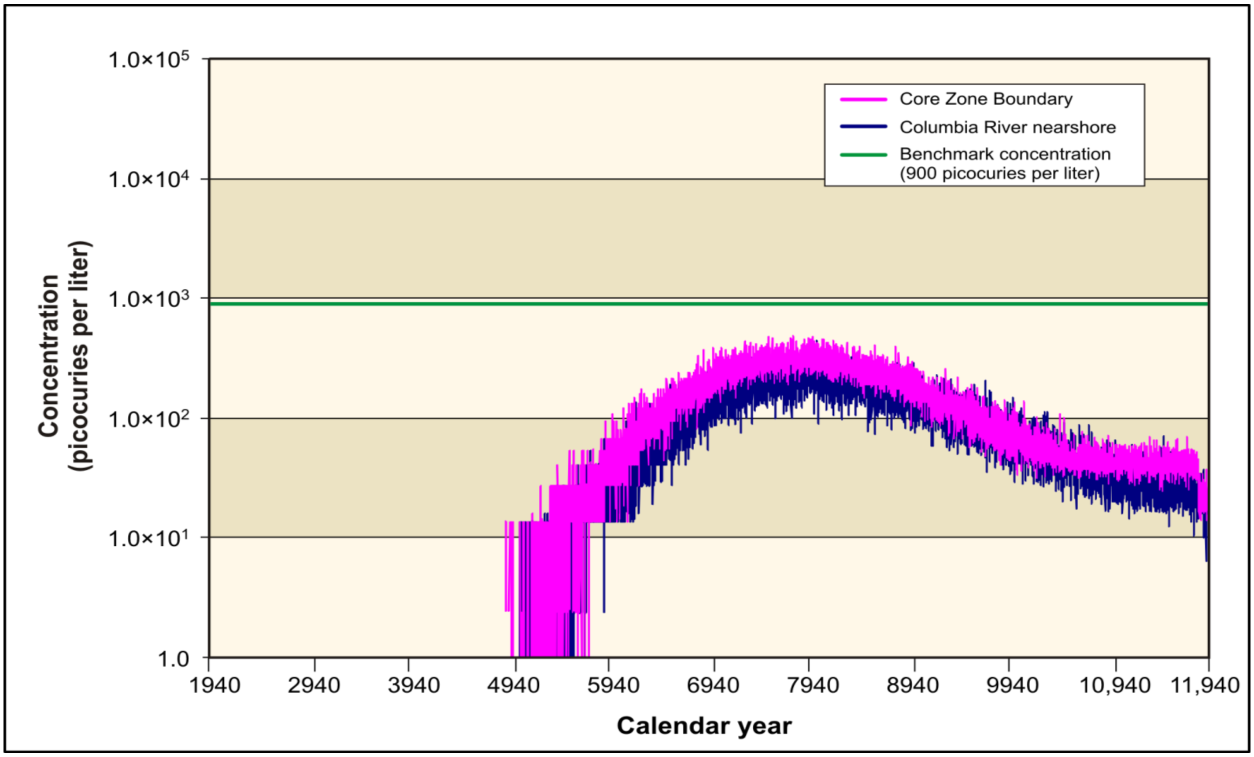


Figure 7–25. Waste Management Alternative 2, Tank Closure Alternative 2B, Groundwater Technetium-99 Concentrations at a Background Infiltration Rate of 0.9 Millimeters per Year

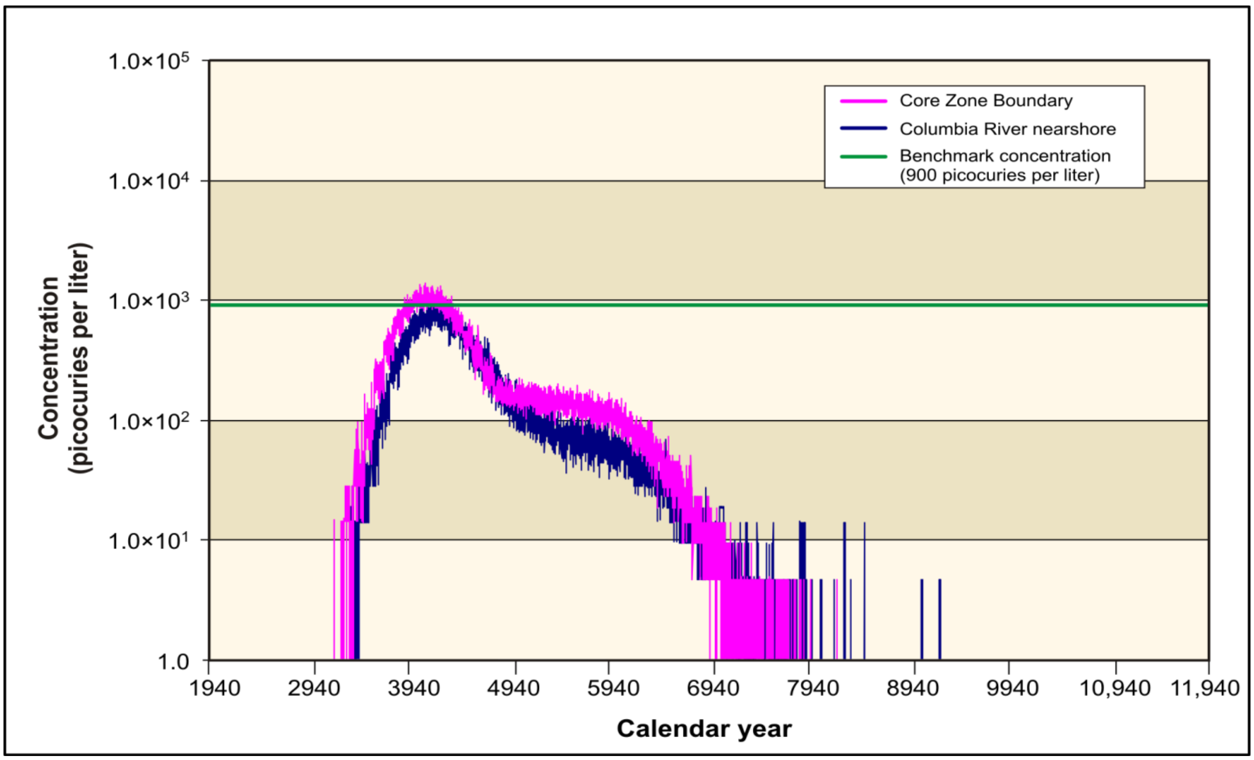


Figure 7–26. Waste Management Alternative 2, Tank Closure Alternative 2B, Groundwater Technetium-99 Concentrations at a Background Infiltration Rate of 3.5 Millimeters per Year

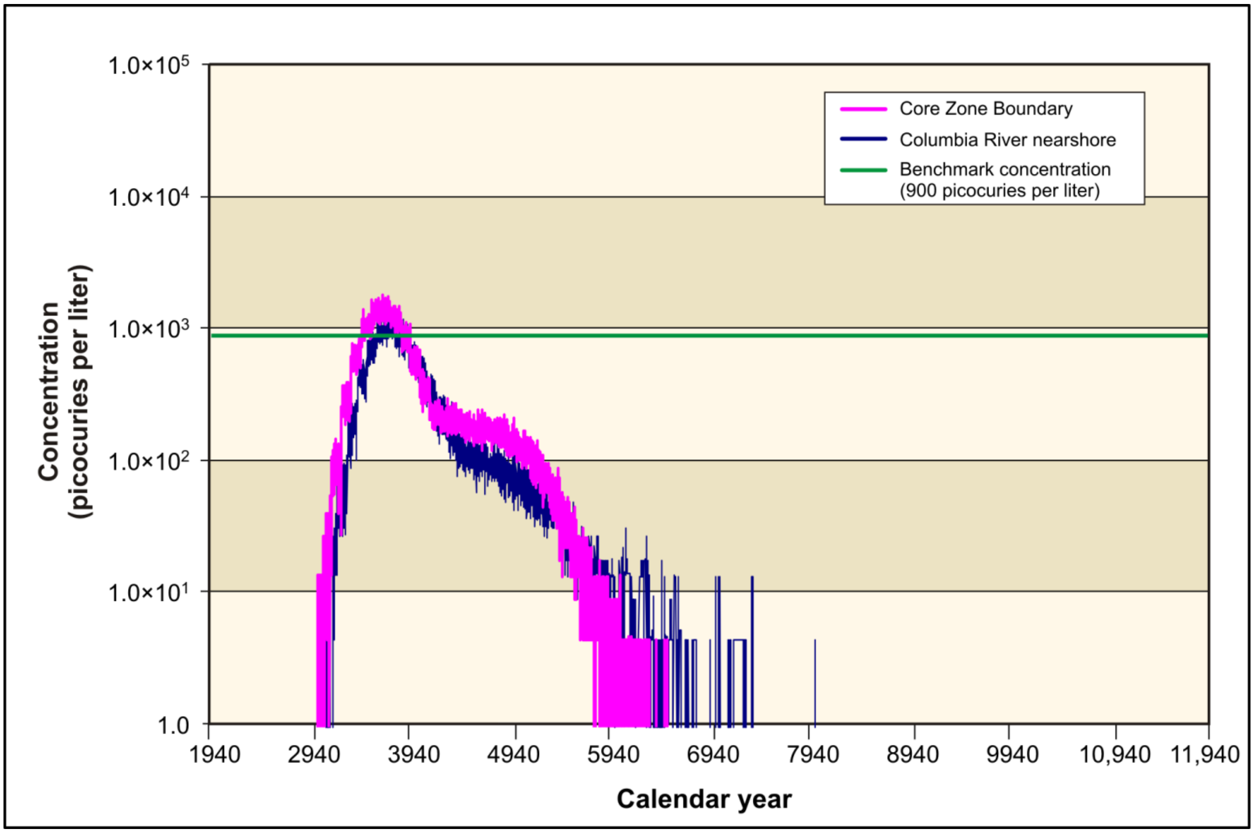


Figure 7–27. Waste Management Alternative 2, Tank Closure Alternative 2B, Groundwater Technetium-99 Concentrations at a Background Infiltration Rate of 5.0 Millimeters per Year

From a mitigation perspective, background infiltration is not a parameter that can be controlled. However, the range of infiltration rates associated with Hanford that is used in modeling might be narrowed with continued research and analysis. Additionally, as mentioned above, infiltration rates can be artificially influenced by the construction of engineered barriers that might last between 500 and 1,000 years before failure.

7.5.2.10 Sensitivity Analysis: Climate Change

The purpose of this sensitivity analysis is to evaluate the effect if the climate or natural environment were to change in a significant manner over time. This is worth considering given that long-term impacts on groundwater are considered over a 10,000-year period, where even small changes in the climate or natural environment could influence the groundwater system. As a basis for this analysis, the following parameters were defined:

- A 10-fold increase in regional rainfall was assumed, from 3.5 millimeters per year to 35 millimeters per year (i.e., background recharge sensitivity case).
- An increase of 10 meters (32.8 feet) head in surface-water flow from the west was assumed to simulate a sustained increase in mountain water runoff (i.e., Generalized Head Boundary sensitivity case).
- An increase of 5 meters (16.4 feet) head in the Columbia River was assumed (i.e., Columbia River recharge sensitivity case).

- Technetium-99 was modeled under Tank Closure Alternative 2B and Waste Management Alternative 2.

In summary, all three sensitivity cases are predicted to cause a shift in the bifurcating groundwater divide within the Central Plateau, resulting in a change in the predicted flow of particles either toward the north through the Gable Mountain–Gable Butte Gap and onward to the Columbia River or to the east directly toward the Columbia River. However, although there may be a shift in the location of the bifurcating groundwater divide due to climate change, none of the sensitivity cases were determined to result in a significant change to the predicted peak technetium-99 concentrations at the Core Zone Boundary or Columbia River receptor locations within the context of the selected *TC & WM EIS* alternatives.

A detailed discussion and the results of this analysis can be found in Appendix V. From a mitigation perspective, this analysis does not directly lead to potential mitigation strategies; however, understanding how climate change might influence the behavior of the groundwater system in the future may lead to a change in the timing and aggressiveness of future mitigation planning.

7.5.3 Sensitivity Analyses Summary and Mitigation Strategies

The sensitivity analyses conducted for this *Final TC & WM EIS* are a few examples of the parameters that could be modeled to better understand the uncertainties associated with certain assumptions and what changes those assumptions might have on the predicted long-term impacts on groundwater. Table 7–28 provides the location in this *Final TC & WM EIS* where additional details can be found regarding each area of the sensitivity analyses summarized in this chapter. Such analyses may assist DOE in determining where to focus mitigation efforts that might yield the most benefit in reducing impacts. The overall purpose of conducting these sensitivity analyses is to understand the major impact drivers and the magnitude and timing of impacts.

Table 7–28. Locations of Details Regarding Sensitivity Analyses in This *Final TC & WM EIS*

Area of Sensitivity Analysis	Location
Flux reduction	Appendix U, Section U.1.3.4.1
Offsite-waste acceptance	Appendix M, Section M.5.7.6
Capture-and-removal scenario (200-West Area carbon tetrachloride plume)	Appendix U, Section U.1.3.4.2
Cribs and trenches (ditches) partial clean closure	Appendix O, Section O.6.6
Iodine recycle	Appendix M, Section M.5.7.2
Technetium removal	Appendix M, Section M.5.7.3
Tank waste retrieval losses	Appendix M, Section M.5.6
Waste form performance ILAW glass Bulk vitrification waste glass Steam reforming waste Grouted waste	 Appendix M, Section M.5.7.1 Appendix M, Section M.5.7.4 Appendix M, Section M.5.5 Appendix M, Section M.5.7.5
Infiltration rates	Appendix N, Section N.5.9
Climate change	Appendix V

Key: ILAW=immobilized low-activity waste; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*.

Table 7–29 lists potential mitigation strategies that have been identified and could be implemented, as previously discussed in this section under each area of sensitivity analysis.

Table 7–29. Other Potential Long-Term Mitigation Strategies

Flux reduction	Perform additional sensitivity analyses in the area of flux reduction and integrate the results into cleanup programs for the Central Plateau by using the data to prioritize the remediation of sites.
	Target remediation on more-mobile COPCs (e.g., iodine-129, technetium-99) at low-discharge and some moderate-discharge sites.
	Target remediation on less-mobile COPCs (e.g., uranium-238, chromium) at moderate-discharge sites.
	Deploy groundwater remediation technologies such as pump-and-treat, reactive barrier, or other groundwater extraction methods for heavy-discharge sites where COPCs are predicted to have been released to the underlying aquifer.
Offsite-waste acceptance	Restrict, through waste acceptance criteria, certain waste streams or waste streams with high concentrations of certain COPCs from disposal at Hanford.
	Require pretreatment (i.e., stabilization) of offsite waste prior to disposal in an IDF.
Iodine recycle	Reduce the mass percentage of iodine-129 partitioned in grouted secondary-waste forms.
Technetium removal	Reduce the mass percentage of technetium-99 partitioned in grouted secondary waste.
Tank waste retrieval losses	Develop and implement retrieval technologies that would reduce the amount of potential tank waste leaked during retrieval operations.
Waste form performance	Develop improvements in secondary-waste-form performance by either improving grouted formulations or developing other stabilization methods (e.g., ceramics).
	Implemented the *Hanford Site Secondary Waste Roadmap* in January 2009, which addressed regulatory and performance requirements, waste composition, preliminary waste form screening, waste form development, process design and support, and validation (PNNL 2009).
	Improve grouted-waste-form performance by investigating methods to maintain drier conditions within and surrounding the grouted waste form.
	Continue research and development on supplemental-waste forms (e.g., bulk vitrification glass, steam reforming waste) and their associated release characteristics to reduce uncertainties about how these waste forms might impact groundwater in the long term.
	Develop primary-waste forms that would allow an increase in waste loading and, thus, a reduction in the mass percentage of COPCs that would partition in secondary-waste forms.
	Develop pretreatment and waste acceptance criteria for offsite waste prior to disposal in an IDF.
	Develop a set of performance criteria (release rates, etc.) for primary- and secondary-waste forms that would be emplaced in an IDF as part of the permit conditions for an IDF.
Infiltration rates	Perform research and data collection to better understand prevailing background infiltration rates at Hanford.
	Artificially reduce infiltration rates through the use of engineered barriers or replace barriers at the onset of original barrier failure.

Key: COPC=constituent of potential concern; Hanford=Hanford Site; IDF=Integrated Disposal Facility.

Following completion of this *TC & WM EIS* and its associated ROD, DOE would be required to prepare a mitigation action plan that explains the mitigation commitments expressed in the ROD (10 CFR 1021.331). This mitigation action plan would be prepared before DOE would implement any *TC & WM EIS* alternative actions that are the subject of a mitigation commitment expressed in the ROD. The mitigation action plan will address both short-term and long-term actions designed to mitigate adverse environmental impacts that are appropriate for the tank closure, FFTF decommissioning, and waste management actions selected for implementation. After implementation, DOE will periodically evaluate the efficacy of mitigation actions, and if necessary, will change or revise these mitigation actions to maintain the ability to achieve desired environmental outcomes.

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