AR TARGET SHEET

The following document was too large to scan as one unit, therefore, it has been divided into sections.

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TITLE:	Feasibility Study for Plutonium/Organic-Rich Process Condensate/Process Waste Group OU: Includes 200-PW-1, 200-PW-3, and 200-PW-6 OUs DOE/RL-2007-27 Draft A and Proposed Plan for 200-PW-1, 200-PW-3, and 200-PW-6 OUs DOE/RL-2007-40 Draft A

5.0 REMEDIAL-ACTION ALTERNATIVES

This chapter discusses the development of remedial alternatives for the 200-PW-1, 200-PW-3, and 200-PW-6 OU waste sites. Primary inputs for this process were (1) site characterization information (Chapter 2.0), (2) the identified risks and RAOs (Chapter 3.0), and (3) the remedial-technology screening results (Chapter 4.0). Special consideration was given to principal-threat contaminants and to the EPA preference for treatment of those contaminants to reduce toxicity, mobility, or volume.

The goal of the remedial-action development process was to identify suitable remedies for achieving the RAOs at the subject waste sites. The remedial-alternative development process attempts to generate a variety of remedies for each risk, giving decision makers as wide an array of options as possible. However, each alternative carried forward into the detailed analysis must be effective in meeting the RAOs.

For clarity, this discussion addresses one representative or unique waste site at a time. Site-specific risks are briefly summarized. Then, applicable retained treatment technologies are assembled into preliminary remedial alternatives including a limited-response action, containment, treatment, and removal with disposal elsewhere.

These alternatives were screened for effectiveness, implementability, and relative cost. Those warranting further consideration were identified and carried forward into the detailed analysis (Chapter 6.0). To the extent feasible, the alternatives carried forward for each site included one that minimized the need for long-term management, one that used treatment as a primary component, and one that emphasized containment. Only the six representative and unique waste sites were considered in the FS. As discussed in Section 2.1, the analogous waste sites will be addressed in the proposed plan.

In addition to remedial actions, remedial alternatives also may include activities intended to bring the site into a sustainable configuration. These activities are not required. They do not address actionable risks (risks requiring remedial action). They are not subject to evaluation with respect to CERCLA criteria. They are intended to help bring the site into a configuration that is suitable for long-term management under the Industrial Exclusive Land-Use Area (IELUA).

5.1 DEVELOPMENT OF ALTERNATIVES FOR THE 216-Z-1A TILE FIELD

5.1.1 Contaminant Distribution and Risk Summary

The RI Report (DOE/RL-2006-51) identifies elevated concentrations of radionuclides at the 216-Z-1A Tile Field, all found at depths of 2.9 m (9.5 ft) or more below the surface of the tile field, with most being very near the vertical projection of the waste-distribution line. Few samples were collected immediately beneath the central waste-distribution line, which is located roughly 1.5 to 1.8 m (5 to 6 ft) bgs (Hanford Site Drawing H-2-24923, *216-Z-1A Modifications*).

By design, the land surface above the tile field is approximately 2.4 m [8 ft] below the natural ground surface (see Figure 2-4). Section 2.5.2 provides more detailed information on the site and the contaminant distribution.

The risk-assessment process, discussed in Section 3.2, identified no unacceptable levels of risk to human health associated with nonradionuclides. Vadose-zone modeling using RESRAD identified no potential for the COCs at the 216-Z-1A Tile Field to exceed MCLs in groundwater within the next 1,000 years. Thus, there is no regulatory requirement to develop or implement related remedial actions for these COCs or pathways.

However, the risk assessment did determine that three radionuclides, Pu-239/240 and Am-241, present an unacceptable level of risk to the site construction worker. The risk is posed by the potential for the industrial-site construction worker to come into direct contact with contaminants that are within 4.6 m (15 ft) of the existing ground surface. Notably, they are more than 3.9 m (13 ft) below the surrounding land surface, which represents the original land surface at the site.

In addition, performance-evaluation data (SGW-33746) show that the SVE system operating at the 216-Z-1A Tile Field (and vicinity) continues to capture meaningful quantities of CCl_4 vapors from the vadose zone, accounting for 76 kg (168 lb) of CCl_4 in fiscal year 2006. However, recent soil samples collected at this site, down to 26 m (85 ft) depth, did not have VOC concentrations above risk-based screening levels (Section 3.2). Although no source area was identified, continued recovery of CCl_4 may suggest residual contamination at depths greater than 26 m (85 ft). Because of the continued effectiveness of the SVE system at the 216-Z-1A Tile Field, and the potential for residual contamination at depths greater than 26 m (85 ft), CCl_4 is considered to pose a potential threat to groundwater (see Section 3.4.3).

In summary, as presented in Table 5-1, formal assessment of the risks associated with the 216-Z-1A Tile Field identified the following actionable conditions. High concentrations of Pu-239/240 and Am-241, beginning at approximately 1.5 m (5 ft) below the current tile-field surface, exceed the 100 mrem/yr dose-based RBC, and at greater depths they exceed the 1×10^{-4} direct-contact RBC. Carbon tetrachloride still is being removed by the SVE system operated at the site and may be present at depths greater than 26 m (85 ft) in quantities that pose a threat to groundwater. The following sections discuss remedial actions targeting the associated RAOs, grouped by GRA.

5.1.2 Assembly of Alternatives for the 216-Z-1A Tile Field

A reasonable alternative must (1) eliminate or mitigate the identified direct-contact risk to the site construction worker, and (2) achieve protectiveness of groundwater. Retained technologies were reviewed to identify those capable of attaining the associated RAOs. Table 5-2 lists the remedial-action technologies identified and groups them into potential alternatives. A discussion of each follows.

5.1.2.1 Common Actions

Several actions are included in each of the activity-based remedial alternatives (i.e., all but the No-Action Alternative) developed for the 216-Z-1A Tile Field. To limit redundancy, they are listed here and then referenced under each alternative.

5.1.2.1.1 Institutional Controls and Monitoring

The 216-Z-1A Tile Field is within the IELUA. Each activity-based remedial alternative includes activities necessary to establish and maintain suitable institutional controls (Section 4.2.2.2) that would, at a minimum, (1) ensure industrial use only, (2) restrict drilling and use of groundwater, and (3) limit access to areas of residual contamination and to structures or features that are part of ongoing remedial actions. These controls would be implemented through the site-wide institutional controls plan, DOE/RL-2001-41.

In addition, each activity-based remedial alternative includes ongoing environmental monitoring and performance monitoring, as appropriate for the site. These monitoring activities will be site-specific to a large extent, because they will address the risks identified at the site and the remedy implemented. Specific monitoring plans will be developed in conjunction with the remedial design.

5.1.2.1.2 Expanded Soil-Vapor Extraction

Each activity-based alternative also includes expansion of the existing SVE system, consisting of (1) the installation of 10 new extraction wells, and (2) addition of a dedicated 28.3 m^3/min (1,000 ft^3/min). The FS assumes that the system will be operated three months per year (roughly the current annual operating time for the 216-Z-1A Tile Field well field), for a period of 10 years. The actual annual operating period will vary as a function of several performance metrics (e.g., mass removal rate) and operational considerations (e.g., effect of ambient temperature on the amount of contaminated condensate generated). Periodic evaluation of these metrics will be used to support optimal configuration and operation. Additionally, in conjunction with the remedial-design process, a specific set of performance metrics will be developed to help identify when SVE technology has reached the limits of its effectiveness at the site. Guidance provided in EPA/600/R-01/070, *Development of Recommendations and Methods to Support Assessment of Soil Venting Performance and Closure*, will be considered in developing this set of metrics and the associated performance monitoring plan and in deciding how to use those metrics to determine when SVE system operations should be terminated at the 216-Z-1A Tile Field.

5.1.2.1.3 Vadose-Zone Well Decommissioning

Each of the activity-based alternatives ultimately would fill in the depressed area above the tile field. Before that could occur, it would be necessary to decommission all wells that might be buried by that action. Decommissioning would be conducted in accordance with the substantive requirements of the applicable portions of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells." Decommissioning would not begin until SVE operations were completed at the site. Therefore, for each activity-based alternative, it will be necessary to

complete SVE operations and decommission all wells before beginning other remedial activities within the tile-field footprint.

5.1.2.1.4 Groundwater Monitoring

Each alternative, including the No-Action Alternative, would include groundwater monitoring to provide ongoing assessment for impacts from the waste site. Implementation of the site-wide groundwater monitoring requirements that are outlined in DOE/RL-89-12, *Hanford Site Groundwater Protection Management Plan*, and DOE/RL-91-50, *Environmental Monitoring Plan United States Department of Energy Richland Operations Office*, is described in PNNL-11989, *Integrated Monitoring Plan for the Hanford Groundwater Monitoring Project*. This plan includes a description of the monitoring-well networks, constituents, sampling frequencies, and criteria used to design the monitoring program; identifies Federal and state groundwater monitoring requirements and regulations; and provides a list of wells, constituents, and sampling frequencies for groundwater monitoring conducted on the Hanford Site. Federal and state regulations include RCRA, CERCLA, and the *Washington Administrative Code*. Groundwater monitoring for groundwater OUs associated with the 200-PW-1, 200-PW-3, and 200-PW-6 OUs is incorporated and described in PNNL-SA-32196; thus, no new groundwater-monitoring components are required. Any changes to the monitoring approach would be defined during the final-design phase of the selected remedy.

5.1.2.1.5 Nuclear Safety

The 216-Z-1A Tile Field is an inactive waste site. The current authorization basis does include remedial activities for this waste site. Therefore, any remedial action at the site would require a safety evaluation. Remedial actions that involve penetrating the ground surface (e.g., excavation or ISV) will require preparation of a new documented safety analysis (DSA) before the remedial actions are implemented. Nuclear-safety documentation is addressed in the discussion of common actions, but is not part of the remedy; therefore, it is not referenced in conjunction with those actions.

The nuclear-safety-analysis process includes hazard evaluations at conceptual, preliminary, and final design, accident analysis, preliminary documented safety analysis, and a DSA to support design, construction/fabrication, and operations of the selected remedial alternative for this trench. In addition, a criticality evaluation is required to ensure that modifications to the current configuration of the radionuclides located in soil beneath the trench will not cause a criticality (uncontrolled nuclear reaction).

Several different intrusive remedial alternatives to clean up the 216-Z-1A Tile Field are evaluated in this report. Any intrusive activity would require a revision to the current safety basis or a new safety basis. Remedial alternatives that are not considered intrusive would be evaluated through a nuclear-safety screening process to determine whether they were adequately addressed by the approved DSA. Thus, all but the No-Action Alternative would require some level of evaluation with respect to nuclear-safety concerns before they were implemented. The level of effort necessary, and the associated costs, were not quantified in the FS but likely would be much greater for the more intrusive remedies.

5.1.2.2 Alternative 0 – No-Action Alternative

The No-Action Alternative, as implemented at the 216-Z-1A Tile Field, would consist of groundwater monitoring to assess for changes in the identified conditions. Institutional controls would not be established; the site configuration would not be modified.

Evaluation of Alternative 0

This alternative is not effective, because it does not address the threat to groundwater. Because regulator approval of this alternative is unlikely (an administrative implementability criterion), this alternative is not considered implementable. Costs are low.

5.1.2.3 Alternative 1 – Soil Backfill Plus Expanded Soil-Vapor Extraction

Alternative 1 at the 216-Z-1A Tile Field would include institutional controls and monitoring (Section 5.2.2.1.1), expansion and continued operation of the SVE system (Section 5.2.2.1.2), decommissioning of the wells within the tile-field footprint (5.2.2.1.3), and groundwater monitoring (5.2.2.1.4). Following decommissioning of the wells, the depressed area above the tile field would be backfilled with clean fill, bringing that surface up to the level needed to provide 4.6 m (15 ft) of physical separation from the contaminants that exceed the RBCs. Backfilling to achieve the desired separation may require mounding above the ground surface in some areas at the northern end of the tile field. If required, these mounded areas are not expected to be more than 0.6 m (3 ft) above the ground surface, and would incorporate an engineered control to mitigate erosion. The identified risks to human health under the industrial-use scenario would be mitigated immediately and in a fairly sustainable manner.

Expansion and continued operation of the existing SVE system, a common action for all but the No-Action Alternative, effectively addresses the potential threat to groundwater by removing available (volatilized) contaminant mass.

Evaluation of Alternative 1

This alternative is judged effective in mitigating the direct-contact pathway for the site construction worker at the 216-Z-1A Tile Field and in mitigating the potential threat to groundwater. It is readily implemented with all required materials, services, and personnel being available and with no apparent technical challenges. Costs are low to moderate.

5.1.2.4 Alternative 2 – Intrusion-Prevention Feature Plus Expanded Soil-Vapor Extraction

Alternative 2 for the 216-Z-1A Tile Field would include institutional controls and monitoring (Section 5.2.2.1.1), expansion and continued operation of the SVE system (Section 5.2.2.1.2), decommissioning of the wells within the tile-field footprint (5.2.2.1.3), and groundwater monitoring (5.2.2.1.4). Following well decommissioning, an IPF would be constructed within the depressed area above the tile field. This aspect of the remedy is intended to impede direct contact with the contaminated soil.

Like Alternative 1, this approach also achieves 4.6 m (15 ft) of physical separation, but does so in a more robust manner. The actual design will be determined during remedial design. For the

purposes of the FS, the IPF is assumed to be a 2 m (6.6 ft) layer of coarse, fractured basalt with no fine-grained interstitial materials. The basalt would be overlain by materials intended to limit infiltration of finer grained material into the interstitial spaces of the basalt. The coarse, fractured basalt is an effective barrier to burrowing, digging, and well drilling. It also creates a dry rocky environment that is not conducive to root penetration.

Evaluation of Alternative 2

Alternative 2 for the 216-Z-1A Tile Field is judged effective, because it would address both the direct-contact risk to the site construction worker and the potential threat to groundwater. It would be readily implemented, with all equipment, services, and personnel readily available and no significant technical challenges. Costs are moderate.

5.1.2.5 Alternative 3 – In Situ Vitrification Plus Expanded Soil-Vapor Extraction

Based on the size and configuration of the tile field, and the desired depth of melt, GeoMelt SPV likely would be implemented at the 216-Z-1A Tile Field as 27 separate melts. Figure 5-1 depicts the general configuration proposed for the purposes of the FS. The actual configuration would be determined during remedial design.

The site would be prepared by adding approximately 1.5 m (5 ft) of compacted clean fill to accommodate melt-induced subsidence. Subsequent pre-melt operations include electrode emplacement, starter-path injection, hood placement, electrical installation, and others. The soils targeted are those from current ground surface to a depth of 6.1 m (20 ft), within the footprint of the base of the original tile-field excavation, which is 30.3 by 79.2 m (100 by 260 ft). This would entail approximately 27 melts, each targeting a volume of soils measuring roughly 10.4 by 8.8 m (34 by 29 ft) wide and 6.1 m (20 ft) thick. The starter path for each electrode pair would be remotely injected to a depth approximately 3.4 to 5.2 m (11 to 17 ft) below the top of the emplaced fill material. For the purposes of the FS, it is assumed that each melt would be advanced to a minimum of 7.6 m (25 ft) below the surface of the clean compacted fill. Previous GeoMelt SPV projects have achieved melt depths in excess of 7.6 m (25 ft).

After the melt operations are complete, the result would be a glass monolith, roughly 4.9 m (16 ft) thick (because of loss of pore space), with a lateral dimension of 30.3 by 79.2 m (100 by 260 ft). It would incorporate all waste-distribution lines and the coarse gravel emplaced beneath them, as well as well as approximately 3.7 m (12 ft) of native soil beneath the tile field. Note that the volume reduction resulting from the densification of soil to glass would result in a glass monolith of approximately 60 percent of the volume of the contaminated media and cover-soil treated.

- Convective mixing within the melt will result in a fairly even distribution of transuranics and other contaminants within the glass monolith.

- The vast majority of the alpha emitters would be encapsulated within the glass and pose no direct-contact risk. Those alpha emitters that remained on the exterior of the glass would pose only moderate risks, because dispersion and the inhalation-exposure pathways are greatly reduced. (AMEC has experience in the vitrification and subsequent removal of more than 4,600 metric tons of plutonium waste. During this glass-removal

operation, plutonium contamination immobilized in the glass was nonsmearable, and there was no detectable airborne plutonium.)

- The glass monolith would constitute a substantial physical barrier, impeding human and biological intrusion into residual contamination at greater depths.
- The process generates a relatively small volume of regulated waste, very little of that waste requiring off-site disposal.
- With the exception of those using vibratory drilling techniques (no soil cuttings) to install electrodes and inject the starter-path materials, remedial-action workers would not perform intrusive activities in highly contaminated soils.

Evaluation of Alternative 3

Alternative 3 is assessed to be effective in mitigating the direct-contact risk posed to the site construction worker, as well as mitigating the risk to groundwater. Although SPV conceptually is an ideal remedial technology in many respects, it is a more complex process than the others considered. That, in combination with fairly widespread knowledge of the problems encountered during earlier top-down melts (the old technology), may hinder acceptance and, thus, implementability. Substantial effort may be necessary to educate those unfamiliar with the current technology, SPV, to gain acceptance and limit the need for substantial precursor activities (e.g., treatability studies or proof-of-concept testing). Cost is assessed to be high relative to the other remedial actions considered. The ISV alternative is carried forward for detailed analysis.

5.1.2.6 Alternative 4 – Partial Removal, Treatment, and Disposal Plus Expanded Soil-Vapor Extraction

Alternative 4 at the 216-Z-1A Tile Field would include institutional controls and monitoring (Section 5.2.2.1.1), expansion and continued operation of the SVE system (Section 5.2.2.1.2), decommissioning of the wells within the tile-field footprint (5.2.2.1.3), and groundwater monitoring (5.2.2.1.4). Following well decommissioning, soils at the site would be excavated to a depth of about 6.1 m (20 ft) below the top of the tile field (the equivalent of 8.5 m [28 ft] below the surrounding ground surface). The excavation base would be about 79 m (260 ft) long and 30 m (100 ft) wide, centered on the main distribution pipeline. A significant portion of the soil excavated from the 216-Z-1A Tile Field would contain alpha-emitting transuranic isotopes with half-lives greater than 20 years, at concentrations exceeding 100 nCi/g, and may need to be disposed of at WIPP. Some portion of the remaining soil would be designated as low-level waste or mixed low-level waste and would be disposed of at ERDF. Available data do not support meaningful evaluation of quantities or proportions. Following removal of the contaminated soils, the excavation would be backfilled to the elevation of the surrounding land surface.

During excavation, alpha contamination on loose-soil particles will pose high short-term risks to the remedial-action workers and environment, but it can be mitigated effectively with existing program controls. Excavation costs will be relatively high because of the need for a high level of worker protection and environmental protection. Waste-disposal costs may be high, because of

the potential for a significant volume of the newly generated waste to contain alpha-emitting transuranic isotopes with half-lives greater than 20 years, at concentrations exceeding 100 nCi/g, which would require disposal at WIPP. The excavation would be backfilled to the original land-surface elevation, providing 8.5 m (28 ft) of separation from the shallowest residual contamination. Residual contamination above the RBCs will remain, primarily from 8.5 to 11.6 m (28 to 38 ft) below the top of the backfill, but will be present at depths up to 31.4 m (103 ft) in some locations.

Evaluation of Alternative 4

Alternative 4 for the 216-Z-1A Tile Field would be effective in mitigating the direct-contact pathway for the site construction worker, as well as in mitigating the potential threat to groundwater. All equipment, services, and personnel are readily available, and no significant technical challenges are identified. However, although RTD activities are, for the most part, routine activities, a significant level of effort will be necessary to implement worker- and environmental-protection programs necessary to mitigate the high risks posed by alpha contamination on the excavated soil particles. Relative costs are high to very high.

5.1.2.7 Summary of the Development of Remedial Alternatives for the 216-Z-1A Tile Field

In addition to the No-Action Alternative, four activity-based remedial alternatives were developed and evaluated for the 216-Z-1A Tile Field. Each of the four was assessed to be sufficiently effective and implementable to be carried forward for detailed analysis in Chapter 6.0. As summarized in Table 5-3, the alternatives carried forward for consideration were the following:

- Alternative 0 – No Action
- Alternative 1 – Soil Backfill plus Expanded SVE
- Alternative 2 – IPF plus Expanded SVE
- Alternative 3 – ISV plus Expanded SVE
- Alternative 4 – Partial RTD plus Expanded SVE.

Additional elements, common to all but the No-Action Alternative, include the following:

- Institutional controls
- Site-specific environmental monitoring and, where appropriate, performance monitoring
- Decommissioning of vadose-zone wells within the tile-field footprint
- Groundwater monitoring (as part of the site-wide program).

5.2 DEVELOPMENT OF ALTERNATIVES FOR THE 216-Z-9 TRENCH

5.2.1 Contaminant Distribution and Risk Summary

Risks to human health and the environment for the 216-Z-9 Trench were evaluated based on available site characterization information and the contaminant distribution, which is summarized in Section 2.5.1 and Figure 2-3. The risk assessment process and results are

presented in Sections 3.2, 3.3, and 3.4 and Appendices A, B, and E, and summarized below. The identified risks drive the development and evaluation of remedial alternatives for the 216-Z-9 Trench.

Risks to Human Health and the Environment – The risk assessment process and results, discussed in detail in Sections 3.2 and 3.3 and Appendices A and B, determined that under the industrial land-use scenario, the contaminants identified at the 216-Z-9 Trench pose no unacceptable direct-contact risks to human health, or to potential ecological receptors. Therefore, there is no regulatory requirement to implement remedial actions to mitigate the potential for direct contact with the contaminated soils. As a best management practice, institutional controls (Section 4.2.2.1) would be established and maintained to ensure continuation of the identified land use restrictions. (See *Consideration of Unrestricted Land Use* and *Summary of Risk Drivers* below.)

For informational purposes, risks to human health also were evaluated for unrestricted land uses. Sampling identified radionuclides throughout the soil column, with especially high activities at the base of the trench. However, in all instances, the contaminants were detected deeper than the regulatory point of compliance for direct-contact risks under unrestricted land use, which is 0 to 4.6 m (0 to 15 ft) bgs (WAC 173-340-740[6][d], "Unrestricted Land Use Soil Cleanup Standards," "Point of Compliance").

However, using Hanford Site risk assessment guidance (DOE-RL-91-45), a risk exceeding 1×10^{-4} was identified for the maximally exposed population, a residential farming population (adults and children) that lived at the waste site and obtained 25 percent of its fruits and vegetables from a garden that (1) contained drill cuttings (soil) from a well drilled through the waste site into the unconfined aquifer, and (2) was irrigated with water from that well, assumed to be contaminated at current levels. This potential risk was considered during the development and evaluation of remedial alternatives.

Radiological Threat to Groundwater – RESRAD was used to model radiological contaminant fate and transport in the vadose zone at the 216-Z-9 Trench. That evaluation, documented in Section 3.4 and Appendix E, assessed cumulative impacts from the identified radiological COCs over a period of 1,000 years from present. The maximum induced groundwater concentrations projected were all below the MCL. Thus, there is no regulatory requirement to develop or implement a related remedial action.

Nonradiological Threat to Groundwater – RESRAD-CHEM was used to model nonradiological contaminant fate and transport in the vadose zone at the 216-Z-9 Trench. As documented in Section 3.4 and Appendix E, modeling results indicate that the concentrations of CCl_4, PCE, and hexachloroethane found at the silt interval 19.8 m (65 ft) bgs could result in exceedance of their respective MCLs in groundwater. Therefore, it is necessary to develop and implement a remedial alternative to ensure the protection of groundwater. It should be noted that the model input used for this evaluation included very conservative assumptions regarding the contaminant mass, to provide a bounding case; these assumptions are documented in Appendix E.

Consideration of Unrestricted Land Use – For informational purposes, the risk assessment process also evaluated risks to human health that would exist under an unrestricted land-use scenario at the 216-Z-9 Trench. As documented in Sections 3.1 and 3.2 and Appendix A, if land use were not restricted, Pu-239/240 and Am-241 activity levels found in soils at the 216-Z-9 Trench could pose unacceptable levels of risk to maximally exposed populations. A significant portion of this risk is manifested by high concentrations of plutonium and americium in soils immediately below the base of the trench. Because the industrial-use-only scenario is accepted as the land use for the near future, risks identified under the unrestricted land-use scenarios do not require remedial action under CERCLA. However, as a best management practice, the risks posed by radionuclide contamination at the base of the 216-Z-9 Trench will be explicitly considered when evaluating the long-term protectiveness of the remedial alternatives.

Summary of Risk Drivers – Thus, as summarized in Table 5-4, formal assessment of the risks associated with the 216-Z-9 Trench under an industrial-use only scenario identified only one actionable condition, the potential for future impacts to groundwater posed by VOCs associated with the silt at 19.8 m (65 ft) bgs. The FS developed and evaluated remedial alternatives for the threat to groundwater. In addition, although not required by regulation, remedial activities also were developed and evaluated specifically to reduce the level of risk posed in an unrestricted land-use scenario by the radionuclide contamination immediately beneath the 216-Z-9 Trench.

The following sections discuss the development and preliminary screening of remedial alternatives. First, remedial actions (components of a comprehensive alternative) for the threat to groundwater are developed (Section 5.1.2). Then, remedies for the human-health risk that would exist under an unrestricted land-use scenario are developed and evaluated (Section 5.1.3). Finally, these are combined into comprehensive remedial alternatives (Section 5.1.4). The No-Action Alternative and actions common to all activity-based remedial alternatives (e.g., institutional controls) are discussed in Section 5.1.4.

5.2.2 Remedial Actions to Address the Threat to Groundwater at the 216-Z-9 Trench

This section discusses and evaluates remedial actions to address the threat to groundwater posed by VOCs associated with a silt layer roughly 19.8 m (65 ft) bgs at the 216-Z-9 Trench. The remedial actions carried forward from this evaluation will be paired with remedial actions identified to address the risk to the residential farmer population (Section 5.1.3) to form comprehensive remedial alternatives (Section 5.1.4) for the 216-Z-9 Trench.

A reasonable alternative must eliminate or mitigate the identified threat to groundwater. To do so, it must:

- Treat the contaminated media to reduce the toxicity, mobility, or volume of the contaminants
- Mitigate transport of the contaminants to groundwater, or
- Remove the contaminated media from the site for treatment, as necessary, and appropriate disposition.

Table 5-5 lists retained technologies, and groups those that are applicable into reasonable alternatives covering a range of GRAs for the identified threat to groundwater. The following sections discuss these alternatives.

Uncertainties – Available characterization data for the VOC contaminant source area (silt at 19.8 m [65 ft] bgs) leave some uncertainties with respect to its size and configuration, and with respect to contaminant mass and distribution. Further characterization would support a quantitative evaluation of the implementability and cost of remedial alternatives, and would support remedial design.

In addition, the RI/FS process did not identify existing information that would support a quantitative evaluation of the natural attenuation rates of CCl_4, PCE, and hexachloroethane in the vadose zone at the Hanford Site. This makes it difficult to assess the effectiveness of remedies that would rely on MNA to attain RAOs with respect to the targeted VOCs.

Additionally, the targeted VOCs are co-located with very high concentrations of TBP. It is not clear what impact this constituent might have on the mobility or volatilization rate of the VOCs. Treatability studies appear to be warranted, primarily to assess the effectiveness of SVE as a remedy for VOCs co-located with TBP, but also to assess VOC diffusion rates in the contaminated media.

5.2.2.1 Continued Soil-Vapor Extraction

This approach would involve continued operation of the existing SVE system, currently implemented at the site as an interim remedial action to remove CCl_4 mass and protect groundwater. As documented in SGW-33746, the system uses a 500-ft^3/min blower to extract soil vapor from vadose-zone wells near the 216-Z-9 Trench. The blower typically is operated several (three to four) months a year. During fiscal year 2006, it was operated for approximately 3 months and removed 97 kg (214 lb) of CCl_4. Removal rates have been diminishing for several years as the volume of CCl_4 vapor in the vadose zone becomes increasingly diffusion-rate limited. Under this alternative, the SVE system at the 216-Z-9 Trench would continue to be operated for several months each year. For the purposes of the FS, the system is assumed to operate 3 months per year for 10 years. In reality, the annual operating period would vary as a function of several performance metrics (e.g., mass removal rate) and operational considerations (e.g., effect of ambient temperature on the amount of contaminated condensate generated). Periodic evaluation of these metrics will be used to support optimal system configuration and operation.

Additionally, in conjunction with the remedial design process, a specific set of performance metrics will be developed to help identify when SVE technology has reached the limits of its effectiveness at the site. Guidance provided in EPA/600/R-01/070 will be considered in developing this set of metrics and the associated performance monitoring plan, and in determining how to use those metrics to determine when SVE system operations should be terminated at the 216-Z-9 Trench.

The SVE system includes several passive SVE wells (Section 4.2.2.6.2), equipped with one-way control valves that only allow airflow out of the subsurface, and an aboveground canister of granular activated carbon (GAC) to collect the venting CCl_4 and other VOCs. In fiscal

year 2006, eight passive SVE wells captured an estimated 10 kg (22 lb) of CCl_4. Operation of the passive SVE wells would continue for the duration of the remedial action.

This alternative would rely to some extent on natural attenuation processes to help achieve the PRGs for the three target VOCs. Quantitative information on natural attenuation rates for the identified COCs (CCl_4, PCE, and hexachloroethane at 19.8 m [65 ft] bgs) in the vadose zone at the Hanford Site was not identified during the FS. Treatability studies are needed to help quantify site-specific natural attenuation rates for these COCs, to support evaluation of this alternative.

Evaluation of Continued Soil-Vapor Extraction

Continued operation of the existing SVE system, although readily implemented, is determined to be ineffective because it does not sufficiently address recovery of vapors in the immediate vicinity of the recently identified VOC contaminant source area at 19.8 m (65 ft) bgs. This remedial action is not carried forward.

5.2.2.2 Targeted Soil-Vapor Extraction

This alternative would expand the existing SVE system (Section 5.2.2.2), which was implemented at the 216-Z-9 Trench in 1992 as an expedited response action to protect groundwater by removing CCl_4 vapors from the vadose zone. To ensure that the identified VOC source area is adequately targeted by the SVE system, new extraction wells would be installed into the contaminant source area soils. Also, the aging 500-ft^3/min blower would be replaced with a larger capacity blower to ensure sufficient, reliable extraction capacity. The following describes changes to the system, and discusses ongoing operation of the SVE system.

Based on current understanding of the size and configuration of the contaminant source area (Figure 2-3), and an extraction well radius of influence of roughly 7.6 m (25 ft) (SGW-33746), three new wells are believed sufficient to provide coverage of the VOC contaminant source area. Each well would penetrate the silt layer at 19.8 m (65 ft) bgs and be screened both above and below the silt. The aging 500-ft^3/min blower would be replaced with a new dedicated 1,000-ft^3/min blower to accommodate ventilation of the existing 216-Z-9 Trench well field and the new wells. The existing treatment train and emission controls are believed sufficient to accommodate the additional flow rate and contaminant mass. The actual number and configuration of new wells installed at the site, the capacity and configuration of the new blower, and the sufficiency of the existing treatment train and emission controls will all be established during remedial design.

The FS assumes that the system will be operated three months a year (roughly the current annual operating time for the 216-Z-9 Trench well field), for a period of 10 years. In reality, the annual operating period for the 216-Z-9 Trench SVE system will vary as a function of several performance metrics (e.g., mass removal rate) and operational considerations (e.g., effect of ambient temperature on the amount of contaminated condensate generated). Periodic evaluation of these metrics will be used to support optimal system configuration and operation, and may dictate operating periods substantially greater than 3 months per year.

Additionally, in conjunction with the remedial design process, a specific set of performance metrics will be developed to help identify when SVE technology has reached the limits of its effectiveness at the site. Guidance provided in EPA/600/R-01/070 will be considered in developing this set of metrics and the associated performance monitoring plan, and in determining how to use those metrics to determine when SVE system operations should be terminated at the 216-Z-9 Trench.

Evaluation of Targeted Soil-Vapor Extraction

Targeted SVE is assessed to be effective in removing additional quantities of the targeted VOCs from the vadose zone at the 216-Z-9 Trench. The addition of three new wells specifically ventilating the soils above and below the source area, and upgrading to a larger capacity blower will ensure improved removal rates and will help to reduce the contaminant mass in the source area. Although not independently sufficient to eliminate the threat to groundwater, it could be an effective component of a remedial alternative. This remedial action is easily implemented, with the necessary personnel, equipment, and services being readily available. Installation of new wells into the source area will incur short-term risk to the workers due to radiological contamination collocated with the VOCs. Costs are expected to be moderate. This alternative is carried forward for use in comprehensive remedial alternatives for the 216-Z-9 Trench.

5.2.2.3 Revegetation

This remedial action would be implemented by establishing and maintaining a population of suitable native plants above the VOC contaminant source area at the 216-Z-9 Trench. The intent would be to generate sufficient transpiration to limit infiltration, thereby mitigating the potential for transport of VOCs to groundwater.

Iterative evaluations using the RESRAD-CHEM model (Appendix E) indicated that reducing the precipitation infiltration rate to 13 mm/yr (0.5 in/yr) or less would mitigate transport of the identified COCs to groundwater during the next 1,000 years. Water-balance studies on the Hanford Site have shown that vegetation and soil type control the downward movement of precipitation. For fine-grained soils even without a healthy plant cover of shrubs and grasses, net recharge is close to zero (PNNL-14702). Site-specific evaluations may be appropriate to verify that an acceptable ET rate can be achieved with surface-planted vegetation.

Modeling runs to support this conclusion did not consider "worst case" scenarios, such as extreme weather conditions, or short periods of no vegetation due to fire or drought. These would be addressed as part of the remedial design process, ensuring that the remedy, as implemented, was sufficiently protective of groundwater.

This remedy does not suffice as a final remedy because the threat to groundwater will remain as long as the contaminants remain. Thus, revegetation must be used in conjunction with other remedial actions that ultimately would eliminate the threat to groundwater by reducing contaminant mass or permanently immobilizing it.

Evaluation of Revegetation

This remedial action is assessed to be effective in limiting infiltration enough to break the pathway for migration of contaminants to groundwater. Although not a standalone remedy, it can be an effective component when teamed with a remedial action that reduces contaminant mass. This action is easily implemented and relatively inexpensive. The revegetation remedial action is carried forward for use in comprehensive remedial alternatives for the 216-Z-9 Trench.

5.2.2.4 Monofill Evapotranspiration Barrier

Under this alternative, a monofill ET barrier (ET barrier) would be installed over the site to limit infiltration, thereby mitigating the potential for the residual VOCs to be transported to groundwater. The ET barrier would overlie the source area, and because the contaminants are relatively deep, it would extend some distance beyond the footprint of the contaminated soils, to protect against the lateral migration of infiltrating water. The ET barrier would have a footprint of approximately 40 by 46 m (130 by 150 ft), covering an area of approximately 1,850 m^2 (19,900 ft^2). This would cover the area currently occupied by the 216-Z-9 Trench, in addition to many existing SVE extraction and monitoring wells.

This remedy does not suffice as a final remedy because the threat to groundwater will remain as long as the contaminants remain. Thus, the Monofill ET Barrier Alternative must be used in conjunction with other remedial actions that ultimately would eliminate the threat to groundwater by reducing contaminant mass or permanently immobilizing it.

Evaluation of the Monofill Evapotranspiration Barrier

This remedial action is effective for mitigating the contaminant migration pathway. It is not a standalone remedy, and would need to be used in conjunction with an action that reduced contaminant mass. It is easily implemented, and moderately expensive. However, because the revegetation remedial action (Section 5.2.2.3) provides adequate mitigation of infiltration, the additional reduction in infiltration provided by the ET barrier, if any, appears unnecessary, and does not warrant the additional cost. This alternative is not carried forward for use in a comprehensive remedial alternative for the 216-Z-9 Trench. It is retained for consideration in contingent actions.

5.2.2.5 Removal, Treatment, and Disposal

To retrieve the contaminated media that pose a threat to groundwater, it would be necessary to excavate to a depth of 20.7 m (68 ft) over the full lateral extent of contamination, which is conservatively estimated to be 18.3 m (60 ft) wide (east-west) by 24.4 m (80 ft) long, centered on the southern border of the 216-Z-9 Trench. This excavation would consume the entire 216-Z-9 Trench. Laboratory analyses of the soils at the base of the 216-Z-9 Trench and those in the contaminant source area identified greater than 100 nCi/g of alpha-emitting transuranic isotopes. If excavated, waste designations may require some portion to be disposed at WIPP. See Appendix D for volume estimates.

Evaluation of Removal, Treatment, and Disposal

The RTD remedial action is assessed to be effective in eliminating the threat to groundwater. However, relative to the other alternatives, it would be extremely difficult to implement due to (1) the depth of excavation; (2) the level of effort necessary to mitigate the high level of radiological risk posed to workers, the public and the environment; and (3) the large volume of waste generated. This remedial action would be very expensive in comparison to the others. The RTD scenario is not carried forward.

5.2.2.6 Electrical-Resistance Heating and Targeted Soil-Vapor Extraction

ERH is effective in encouraging rapid volatilization of VOCs from fine-grained soils, such as those in the source area at the 216-Z-9 Trench. Based on available data and conservative assumptions regarding the size and configuration of the contaminant source area (silts at 19.8 m [65 ft] bgs), the FS assumes that ERH would be implemented by installing five new vadose-zone wells with electrodes into the CCl_4 contaminant source area at 19.8 m (65 ft) bgs. The FS assumes that these five wells would be installed around the perimeter of the 216-Z-9 Trench in a manner that avoided intersection with the highly contaminated trench base soils; the number and placement of wells would be determined in remedial design. For the purposes of the FS, the ERH system is assumed to operate continuously (year-round) to sustain the accelerated volatilization rate. The actual design, operating parameters, and annual operating schedules of the ERH system would be determined during remedial design, periodically evaluated, and revised as necessary.

This alternative also would incorporate the activities of the Targeted SVE alternative, using the enhanced SVE system to facilitate capture, extraction, and treatment of the ERH-volatilized VOCs. If the ERH system were operated continuously, the FS assumes that the SVE system also would operate continuously, ensuring capture of the ERH-generated contaminant vapors.

The size and configuration of the contaminant source area will need to be refined to allow assessment of the implementability of this alternative. If the source area is very thin or shows significant local discontinuity, it will be technically challenging to intercept the target soils with the electrodes. In addition, more information on the contaminant mass is needed to support estimation of the time to achieve PRGs using this technology.

Evaluation of the Electrical-Resistance Heating plus Targeted Soil-Vapor Extraction

Because of the uncertainties regarding implementability of the ERH technology, this alternative is not carried forward into the detailed analysis. However, ERH technology can be very effective, and is carried forward as a supplementary technology for consideration in contingent actions.

5.2.2.7 Monitored Natural Attenuation

MNA would entail ongoing monitoring of VOC contaminant levels in the contaminant source area, while natural attenuation processes (Section 4.2.2.6.6) reduced contaminant mass levels that posed no threat to groundwater. The RI/FS process did not identify any information that would suggest that MNA processes would produce any timely reduction in the amount of CCl_4,

PCE, or hexachloroethane in the source area. A study is underway (PNNL) that addresses the abiotic degradation of CCl_4 in Hanford Site soils, but results are not yet available.

Although it does not appear that MNA processes will provide substantial or rapid reductions in contaminant mass, it may have value in the long term, working in conjunction with the passive SVE wells to eliminate the vestiges of contamination, if any, that remain after the active SVE system is terminated.

Evaluation of Monitored Natural Attenuation

MNA is readily implemented and relatively inexpensive, but is not assessed to be effective for the targeted COCs. It is not carried forward as a remedial action, except for consideration in contingent actions.

5.2.2.8 Summary of Remedial Actions for the Threat to Groundwater at the 216-Z-9 Trench

Two of the five identified remedial actions were assessed to be effective and reasonably implementable. Although neither is independently viable as a final alternative, in conjunction they may have that capability. Based on the evaluation of remedial action to address the protectiveness of groundwater at the 216-Z-9 Trench, Revegetation and Targeted SVE are carried forward, to be implemented as common components of each remedial alternative developed for the 216-Z-9 Trench.

5.2.3 Remedial Actions to Address Contaminated Soils at the Base of the 216-Z-9 Trench

This discussion addresses the remedies for the potential risks to human health that would exist under unrestricted land-use scenarios, posed by radiologically contaminated soils below the 216-Z-9 Trench. Evaluation of each remedial alternative for the 216-Z-9 Trench will consider these potential risks when assessing the CERCLA balancing criteria (Section 6.1). The radiologically contaminated soils do not pose unacceptable direct-contact risks to human health under the industrial land use or unrestricted land-use scenarios, and they are not considered when evaluating 216-Z-9 Trench remedial alternatives with respect to the CERCLA threshold criteria (Section 6.1).

This evaluation will focus on reducing the potential for contact with the radiologically contaminated soils at the base of the trench. These soils are targeted because they are not at great depth, and they contain the highest radionuclide concentrations identified at the waste site, thereby presenting a significant portion of the potential risk. Characterization information for the soils at the base of the 216-Z-9 Trench is provided in Section 2.5.

The activities proposed for reducing these potential risks are discussed and evaluated here. Remedial actions carried forward from this section are combined with those carried forward from Section 5.2.2, which addressed the threat to groundwater, to form comprehensive remedial alternatives for the 216-Z-9 Trench (Section 5.2.4). Timing of the activities discussed here will

be coordinated with the other activities that comprise the full remedial alternative, and may vary depending on the remedy selected in the ROD.

Reasonable remedial actions will reduce the identified potential human-health risk by reducing the contaminant mass or by reducing the potential for intrusion into the contaminated media.

Uncertainties – Available analytical results for these soils only address Pu-239 and Am-241. Sampling occurred only within the perimeter of the trench base, and only extended 2.7 m (8.9 ft) below the trench base. Additional characterization would support a quantitative evaluation of the effectiveness, implementability and cost of these remedies.

5.2.3.1 Backfill with Controlled-Density Fill

This remedy is intended to inhibit direct contact with the contaminated soil. The remedy would be implemented by introducing CDF (a flowable cement product, Section 4.2.2.3.2) into the 216-Z-9 Trench through the existing concrete cover. The trench would be completely filled with CDF, eliminating all void space. The concrete cover and columns would remain in place. The concrete cover and CDF would act in concert to deter biological and human intrusion. Optimal formulation(s) and placement of the CDF would be determined during remedial design. Although this configuration will not physically preclude drilling or excavation, a reasonable person encountering a 30 cm (9-in.) concrete pad underlain by a CDF monolith could be expected to exercise caution.

A small soil cover would be placed over the site to provide additional separation from the contaminants, and to provide a base for vegetative cover. The soil cover would be integrated into the existing topographic rise that occurs to the west of the trench to enhance its durability. The actual size and configuration of this soil cover would be determined during remedial design. For the purposes of the FS, this soil cover is assumed to be 1.2 m (4 ft) thick over the concrete pad.

Evaluation of Backfill with Controlled-Density Fill

This action is assessed to be effective in reducing the potential for inadvertent intrusion into the contaminated soils. It is easily implemented and relatively inexpensive. The CDF remedial action is carried forward for inclusion in a comprehensive remedial alternative for the 216-Z-9 Trench.

5.2.3.2 Construct Subsurface Intrusion-Prevention Feature

This remedy is intended to impede direct contact with the contaminated soil. It would be implemented by removing the concrete cover and columns and constructing an IPF within the trench. The construction details will be determined during remedial design. For the purposes of the FS, the IPF (Section 4.2.2.3.2) is assumed to be a 3 m (10-ft) layer of coarse fractured basalt with no fine-grained interstitial materials. The basalt would be overlain by materials intended to limit infiltration of finer-grained material into the interstitial spaces of the basalt. The coarse fractured basalt is an effective barrier to burrowing, digging, and well drilling. It also creates a dry rocky environment that is not conducive to root penetration. The IPF would be covered with soil and indigenous vegetation to facilitate ET.

Evaluation of Intrusion-Prevention Feature

This action is assessed to be effective in reducing the potential for inadvertent intrusion into the contaminated soils. It is easily implemented and the cost is moderate, but will vary depending on the final design selected. The IPF remedial action is carried forward for inclusion in a comprehensive remedial alternative for the 216-Z-9 Trench.

5.2.3.3 In Situ Vitrification

Based on the size and configuration of the trench, and the desired depth of melt, GeoMelt SPV likely would be implemented at the 216-Z-9 Trench as three separate melts. Figure 5-1 depicts the general configuration proposed for the purposes of the FS. The general electrode separation, melt size, and treatment depth envisioned have all been achieved in the past during radioactive soil-remediation projects, notably at Los Alamos National Laboratory in 2000 (LA-UR-03-6494). As such, the process does not require scale-up for this application. The actual configuration would be determined during remedial design.

The concrete cover and six supporting columns would be removed to provide access to the trench, and disposed. Other ancillary items reported to be in the trench (e.g., aluminum sampling guide tubes, fallen acid-proof tiles) would be left in place. Next, the trench cavity would be partially filled by adding soil; for the purposes of the FS, the fill is assumed to be 1.5 m (5 ft) of compacted soil. Placement of the fill accomplishes the following:

- Covers the trench floor and part of the sloping walls to enhance radiological safety
- Provides overburden material to compensate for the volume reduction of the soil column due to vitrification (site soils have up to 30 percent void space; glass has none)
- Enhances radionuclide retention in the glass due to a sand filter effect (described below).

Sand filter effect: Under normal melting conditions, some radionuclides exhibit a degree of volatility. The fraction that volatilizes typically moves upward in the soil column and condenses in the overlying sand. The sand above the melt moves downward, because of melt-generated subsidence, and gradually incorporates into the melt during the process. Although the volatile species will continue to volatilize and then re-condense as the melt incorporates more and more of the overlying sand, a net decrease is seen over time as the cover soil eventually will all be incorporated into the melt. The same is true for organic constituents that may re-condense in the sand cover material. As the cover soil moves downward, these organic species are carried into the thermally hot region where reactions such as catalytic dechlorination or pyrolysis can occur.

Pre-melt operations including electrode emplacement, starter path injection, hood placement, and electrical installation would take place after the soil fill is added. The melt configuration is controlled by the electrode configuration; both are depicted in Figure 5-1. To cover the entire trench floor, a total of three melts would be required. These melts would be arranged to overlap, ensuring complete treatment of the trench floor area. Many GeoMelt projects have routinely involved overlapping melts. The starter path for each electrode pair would be remotely injected to a depth approximately 3.0 to 4.6 m (10 to 15 ft) below the surface of the trench floor. For the purposes of the FS, it is assumed that each melt would be advanced to a minimum of 4.6 m

(15 ft) below the surface of the trench floor. Previous GeoMelt SPV projects have achieved melt depths in excess of 7.6 m (25 ft), suggesting that a 4.6 m (15-ft) melt depth is readily achievable. After the melt operations are complete, the result would be a contiguous glass monolith, roughly 3.7 m (12 ft) thick (due to loss of pore space), which encompasses the entire trench floor area. Note that the volume reduction owing to the densification of soil to glass would result in a glass monolith of approximately 60 percent the volume of the contaminated media and cover soil treated.

The melting duration for each melt is estimated at 8 to 9 days, which equates to a processing rate of approximately 70 metric tons per day. This estimate is based on the melt rate achieved in 1987 at the 216-Z-12 Crib using the old top-down melting approach, and does not take into account the significant process improvements of the past 20 years.

Plutonium oxide has a fairly high solubility limit in most glasses, in the range of 2 to 5 wt%. Various programs under the DOE Office of Fissile Materials Disposition have achieved up to 10 wt% plutonium in certain glass formulations (PNNL-11346). Based on an estimate of 48 kg (106 lb) of plutonium remaining in the targeted soils at the base of the 216-Z-9 Trench (DOE/RL-2006-51), the GeoMelt SPV monolith would contain on the order of 0.003 wt% of plutonium.

The GeoMelt SPV process would convert the targeted trench base soils into a highly durable glass monolith, with a relatively uniform distribution of the retained contaminants. The advantages of this process are as follows.

- This may be an ideal final configuration with respect to nuclear safety concerns.
- The vast majority of the alpha emitters would be encapsulated within the glass, and pose no direct-contact risk. Those that remained on the exterior of the glass would pose only moderate risks because dispersion and the inhalation exposure pathways are greatly reduced. (AMEC has experience in the vitrification and subsequent removal of more than 4,600 metric tons of plutonium waste. During this glass removal operation, plutonium contamination immobilized in the glass was non-smearable and there was no detectable airborne plutonium.)
- The glass monolith would constitute a substantial physical barrier, inhibiting human and biological intrusion into much of the residual contamination at depth beneath the site.
- The process generates a relatively small volume of regulated waste, very little requiring off-site disposal.
- With the exception of those using vibratory drilling techniques (no soil cuttings) to install electrodes and inject the starter path materials, remedial action workers would not perform intrusive activities in highly contaminated soils.

Evaluation of In Situ Vitrification

SPV is assessed to be effective in greatly reducing the consequences of direct contact with the most highly contaminated soils (found immediately beneath the floor of the trench), and in

impeding intrusion into deeper residual contamination. Although SPV is conceptually an ideal remedial technology in many respects, it is a more complex process than the others considered. That, in combination with fairly widespread knowledge of the problems encountered during earlier top-down melts (the old technology), may hinder acceptance and thus, implementability. Substantial effort may be necessary to educate those unfamiliar with the current technology (SPV) to gain acceptance, and limit the need for substantial precursor activities (e.g., treatability studies or proof of concept testing). Relative costs are high.

Although SPV is not as fully mature and well-vetted as the other technologies considered here, it appears to be readily implementable. However, problems with early ISV configurations (top-down melting) resulted in a bias against the technology by some, and may necessitate precursor activities (e.g., treatability studies or proof-of-concept testing). Cost is assessed to be moderate to high, relative to the other remedial actions considered. The ISV remedial action is carried forward for inclusion in a comprehensive remedial alternative for the 216-Z-9 Trench.

5.2.3.4 Partial Removal, Treatment, and Disposal Plus Intrusion-Prevention Feature and Targeted Soil-Vapor Extraction

At the 216-Z-9 Trench, this alternative reduces potential risks by reducing contaminant mass and mitigating the potential for intrusion into the residual contamination. This alternative would be implemented by excavating the top 3 m (10 ft) of soil at the base of the trench and then constructing an IPF in the excavated area. The COCs are Pu-239/240 and Am-241, both significant alpha emitters. Sample analysis (ARH-2915) revealed an average Pu/Am activity in the first 1.5 m (5 ft) in excess of 6,000,000 pCi/g (average excludes the outlier, a single sample with Pu/Am activity of approximately 450,000,000 pCi/g).

All soil samples collected at the base of the trench exceeded the 100 nCi/g transuranic waste thresholds by at least one order of magnitude. The lateral spread of contamination near the base of the trench has not been fully delineated. For the purposes of the FS, contamination is not assumed to have spread laterally (see Figure 5-2). The current trench base is 9.1 by 18.3 m (30 by 60 ft). Based on sampling (ARH-2915), all contaminated soil excavated between the trench floor and the base of the excavation is expected to be designated as containing more than 100 nCi/g of alpha-emitting transuranic isotopes with half-lives greater than 20 years, and require storage at the CWC pending disposition to WIPP. Appendix D addresses anticipated excavation volumes and disposal volumes.

Engineered controls will be necessary for protection of human health and the environment. Excavation of soils that contain more than 100 nCi/g of alpha-emitting transuranic isotopes having half-lives of more than 20 years will be performed inside a greenhouse, to mitigate the release of airborne contamination to the environment. Active excavation will be conducted under respiratory controls. The respiratory control threshold for alpha contamination is 3,000 pCi/g with water misting deployed as an engineered control. Soils excavated beneath the trench floor will exceed this threshold by several orders of magnitude. Also, because the average activity of the primary contributor to dose, Am-241, exceeds 346,000 pCi/g, the whole-body dose rate at 30 cm (12 in.) from the soil surface will exceed 5 mrem/h and radiological controls will be required.

Evaluation of Partial RTD plus IPF

This action is assessed to be effective in reducing the potential for inadvertent intrusion into the contaminated soils. A significant level of effort will be required to ensure protectiveness of human health and the environment during implementation. This action will generate a very large volume of regulated waste compared to the other remedial actions considered, with most expected to require storage at the CWC pending disposal at WIPP. Cost is assessed to be very high relative to the other remedial actions considered. The Partial RTD plus IPF remedial action is carried forward for inclusion in a comprehensive remedial alternative for the 216-Z-9 Trench.

5.2.3.5 Summary of Remedial Actions for the Potential Direct-Contact Risk at the 216-Z-9 Trench

Four remedial actions were considered for their ability to mitigate or eliminate the potential for direct contact with the radiologically contaminated site soils. All four (backfilling with CDF, construction of an IPF, partial RTD, and ISV (SPV) were all assessed to be effective and implementable. None was eliminated because of cost. All four were carried forward for incorporation into comprehensive remedial alternatives for the 216-Z-9 Trench.

5.2.4 Comprehensive Remedial Alternatives for the 216-Z-9 Trench

This section combines the remedial actions carried forward from the evaluations in Section 5.2.2, which addressed the threat to groundwater, and Section 5.1.3 which addressed the potential risk posed to a maximally exposed population (residential farmer) by radionuclides in the soil. Table 5-6 summarizes the comprehensive remedial alternatives developed for the 216-Z-9 Trench.

5.2.4.1 Common Actions

Several actions are included in each of the activity-based remedial alternatives (i.e., all but the No-Action Alternative) developed for the 216-Z-9 Trench. To limit redundancy, they are listed here and then referenced under each alternative.

5.2.4.1.1 Institutional Controls and Monitoring

The 216-Z-9 Trench is within the IELUA. Each activity-based remedial alternative will include activities necessary to establish and maintain suitable institutional controls (Section 4.2.2.2) that would, at a minimum, (1) ensure industrial use only, (2) restrict drilling and use of groundwater, and (3) limit access to areas of residual contamination and to structures or features that are part of ongoing remedial actions. These controls would be implemented through the site-wide institutional controls plan, DOE/RL-2001-41.

In addition, each activity-based remedial alternative includes ongoing environmental monitoring and performance monitoring, as appropriate for the site. These monitoring activities will be site-specific to a large extent, because they will address the risks identified at the site and the

remedy implemented. Specific monitoring plans will be developed in conjunction with the remedial design.

5.2.4.1.2 Revegetation

Each remedial alternative considered for the 216-Z-9 Trench will include revegetation of the soils above the VOC contaminant source area. As discussed in Section 5.2.2.3, this remedial action would be implemented by establishing and maintaining a population of native plants, selected for their ability to capture and then transpire water infiltrating from the ground surface. Once established, the plant community would mitigate the potential for transport of VOCs to groundwater, providing protectiveness for as long as it was maintained.

5.2.4.1.3 Targeted Soil-Vapor Extraction

Each remedial alternative considered for the 216-Z-9 Trench will include expansion of the existing SVE system. As discussed in Section 5.2.2.2, three new vapor-extraction wells would be installed in the VOC contaminant source area, and the aging 500-ft^3/min blower would be replaced with a new 1,000-ft^3/min blower to ensure sufficient, reliable capacity. These improvements are expected to provide an increased capability to reduce the mass of the targeted contaminants within the VOC source area.

5.2.4.1.4 Groundwater Monitoring

Each alternative, including the No-Action Alternative, would include groundwater monitoring to provide ongoing assessment for impacts from the waste site. Implementation of the site-wide groundwater monitoring requirements that are outlined in DOE/RL-89-12 and DOE/RL-91-50 is described in PNNL-11989. This plan includes a description of the monitoring well networks, constituents, sampling frequencies, and criteria used to design the monitoring program; identifies Federal and state groundwater monitoring requirements and regulations; and provides a list of wells, constituents, and sampling frequencies for groundwater monitoring conducted on the Hanford Site. Federal and state regulations include RCRA, CERCLA, and the *Washington Administrative Code*. Groundwater monitoring for groundwater OUs associated with the 200-PW-1, 200-PW-3, and 200-PW-6 OUs is incorporated and described in PNNL-SA-32196; thus, no new groundwater monitoring components are required. Any changes to the monitoring approach would be defined during the final design phase of the selected remedy.

5.2.4.1.5 Nuclear Safety

The 216-Z-9 Trench is a Hazard Category 2 Facility with a DSA document. Approved DSA activities associated with this waste site do not cover any intrusive cleanup activities. Intrusive remedial activities will require revision to the DSA or preparation of a new DSA (Authorization Basis) before the start of remedial action. This activity is included in the discussion of common actions, but is not part of the remedy; therefore, it is not referenced in subsequent sections.

The nuclear safety analysis process includes hazard evaluations at conceptual, preliminary, and final design, accident analysis, preliminary documented safety analysis, and a DSA to support design, construction/fabrication, and operations of the selected remedial alternative for this trench. In addition, a criticality evaluation is required to ensure that modifications to the current

configuration of the radionuclides located in soil beneath the trench will not cause a criticality (uncontrolled nuclear reaction).

Several intrusive remedial alternatives are evaluated in this report to clean up the 216-Z-9 Trench. All but the No-Action Alternative involve accessing the trench, and would be expected to require revision to the DSA, as a minimum. Therefore, preparation of the nuclear safety basis documents should not be a significant discriminator (in terms of implementability or cost) in identifying the preferred remedial alternatives for the 216-Z-9 Trench.

5.2.4.2 Alternative 0 – No Action

At the 216-Z-9 Trench, the No-Action Alternative would consist of groundwater monitoring to assess for changes in the identified conditions (see definition in Section 4.2.2.1). Institutional controls would not be established. By definition, the No-Action Alternative would not include any remedial activities. Therefore, it would not mitigate the identified threat to groundwater. The No-Action Alternative does not include activities to address direct-contact risks that would exist if unrestricted land use was allowed.

Evaluation of Alternative 0

This alternative is not effective, because it does not address the threat to groundwater. Because regulator approval of this alternative is unlikely (an administrative implementability criterion), this alternative is not considered implementable. Costs are low.

5.2.4.3 Alternative 1 – Controlled-Density Fill Plus Targeted Soil-Vapor Extraction

In addition to implementing institutional controls and monitoring (Section 5.2.4.1.1), revegetation (Section 5.2.4.1.2), targeted SVE (Section 5.2.4.1.3), and groundwater monitoring (5.2.4.1.4), this alternative would backfill the entire trench with CDF, leaving the concrete cover and columns in place (Section 5.2.3.1). A small soil cover would be constructed over the concrete cover to provide a base for a selected plant community that would provide sufficient ET to control infiltration and mitigate transport of contaminants to groundwater. Three new vapor-extraction wells would be constructed through the VOC contaminant source area, and screened above and below the silt. A new 1,000-ft^3/min blower would replace the existing blower to provide additional extraction capacity.

Evaluation of Alternative 1

This alternative would be effective in mitigating the threat to groundwater, and in mitigating the direct-contact pathway. It would be readily implemented, with all equipment, services, and personnel readily available, and no apparent technical challenges. Relative costs are low to moderate.

5.2.4.4 Alternative 2 – Intrusion-Prevention Feature Plus Targeted Soil-Vapor Extraction

In addition to implementing institutional controls and monitoring (Section 5.2.4.1.1), revegetation (Section 5.2.4.1. 2), targeted SVE (Section 5.2.4.1.3), and groundwater monitoring (5.2.4.1.4), this alternative would construct an IPF within the trench as discussed in

Section 5.2.3.2). Initially, the concrete cover and columns would be removed and dispositioned to ERDF. Then an IPF would be constructed in the trench, to impede both intrusion by humans and biointrusion. Revegetation and Targeted SVE would be implemented as in Alternative 1, to address the threat to groundwater.

Evaluation of Alternative 2

This alternative would be effective in mitigating the threat to groundwater at the 216-Z-9 Trench, and in mitigating the potential for direct-contact risks. It would be readily implemented, with all equipment, services, and personnel readily available, and no significant technical challenges. Relative costs are moderate.

5.2.4.5 Alternative 3 – In Situ Vitrification Plus Targeted Soil-Vapor Extraction

In addition to implementing institutional controls and monitoring (Section 5.2.4.1.1), revegetation (Section 5.2.4.1. 2), targeted SVE (Section 5.2.4.1.3), and groundwater monitoring (5.2.4.1.4), this alternative would employ ISV to melt and then solidify soils at the base of the trench to a depth of approximately 4.6 m (15 ft), as discussed in Section 5.2.3.4. This would significantly decrease the risks associated with directly contacting these radionuclides, and would form a barrier impeding intrusion into the residual contaminants below the melted areas. Revegetation and Targeted SVE would be implemented as in Alternative 1.

Evaluation of Alternative 3

This alternative would be effective in mitigating the threat to groundwater at the 216-Z-9 Trench, and in mitigating the potential for direct-contact risks. All equipment, services, and personnel are readily available. Although SPV is conceptually an ideal remedial technology in many respects, it is a more complex process than the others considered. That, in combination with fairly widespread knowledge of the problems encountered during earlier top-down melts (the old technology), may hinder acceptance and thus, implementability. Substantial effort may be necessary to educate those unfamiliar with the current technology (SPV) to gain acceptance and limit the need for substantial precursor activities (e.g., treatability studies or proof-of-concept testing). Relative costs are high.

5.2.4.6 Alternative 4 – Partial Removal, Treatment, and Disposal Plus Targeted Soil-Vapor Extraction

In addition to implementing institutional controls and monitoring (Section 5.2.4.1.1), revegetation (Section 5.2.4.1. 2), targeted SVE (Section 5.2.4.1.3), and groundwater monitoring (5.2.4.1.4), this alternative would excavate approximately 3 m (10 ft) of soil from the base of the trench (Section 5.2.3.3), removing the most highly contaminated soils at the site, and increasing the physical separation from the residual contaminants. Then an IPF would be constructed within the trench and backfill would be added to bring the site to grade. The upper 1.2 m (4 ft) of the backfill would be fine-grained material suitable for sustaining the planned revegetation (to control infiltration). Then revegetation and targeted SVE would be implemented.

Evaluation of Alternative 4

Alternative 4 at the 216-Z-9 Trench would be effective in mitigating the threat to groundwater, and in mitigating the direct-contact pathway. All equipment, services, and personnel are readily available, and no significant technical challenges are identified. However, although RTD activities are, for the most part, routine activities, a significant level of effort will be necessary to implement worker and environmental protection programs necessary to mitigate the high risks posed by alpha contamination on the excavated soil particles. Relative costs are high to very high.

5.2.5 Summary of the Development of Remedial Alternatives for the 216-Z-9 Trench

In addition to the No-Action Alternative, four activity-based remedial alternatives were developed and evaluated for the 216-Z-9 Trench. Each of the four was assessed to be sufficiently effective and implementable to be carried forward for detailed analysis in Section 6.0. The alternatives carried forward for consideration at the 216-Z-9 Trench are as follows:

- Alternative 0 – No Action
- Alternative 1 – CDF plus Targeted SVE
- Alternative 2 – IPF plus Targeted SVE
- Alternative 3 – ISV plus Targeted SVE
- Alternative 4 – Partial RTD plus Targeted SVE.

Additional elements, common to all but the No-Action Alternative, include the following:

- Institutional controls
- Site-specific environmental monitoring and, where appropriate, performance monitoring
- Groundwater monitoring (as part of the site-wide program).

5.3 DEVELOPMENT OF ALTERNATIVES FOR THE 216-A-8 CRIB

5.3.1 Contaminant Distribution and Risk Summary

The RI Report (DOE/RL-2006-51) notes significant Cs-137 contamination at the 216-A-8 Crib. Geophysical logging in Borehole C4545 during 2005 showed high Cs-137 activities between 3.4 and 22.3 m (11 and 73 ft) bgs, with a maximum of 1.5 x 10^6 pCi/g identified at 6.1 m (20 ft) bgs. Soil sampling from Borehole C4545 in 2005 showed a maximum concentration of 877,000 pCi/g, found in a sample collected from the interval between 5.8 and 6.6 m (19 and 21.5 ft) bgs. In addition, soil sampling at Borehole C4545 identified 79.6 pCi/g of Tc-99, also collected from the interval between 5.8 and 6.6 m (19 and 21.5 ft) bgs. Depths given are depths below the top of a 0.6 m (2-ft) thick stabilization cover emplaced in 1990. Section 2.5 discusses

the site characterization in more detail. The contaminant distribution model is presented in Figure 2-6.

The risk assessment process, discussed in Section 3.2, determined that Cs-137 posed an unacceptable level of risk to human health, based on the industrial site construction worker scenario. The risk assessment process derived a Cs-137 RBC of 1,228 pCi/g for a target dose of 100 mrem/yr dose, and an RBC of 1,600 pCi/g for a risk-based dose of 1×10^{-4}. Based on comparison of soil sample analyses and geophysical logs, both associated with Borehole C4545, soils with Cs-137 activities exceeding the RBCs are located from approximately 3.3 to 6.6 m (11 to 21.5 ft) bgs at Borehole C4545.

Conservative modeling indicates that Tc-99 in soil beneath the 216-A-8 Crib may migrate to groundwater in concentrations above MCLs (Appendix E). This is based on laboratory analysis of a single soil sample from Borehole C4545. Additional soil sampling is needed to estimate the mass of Tc-99 present in the vadose zone so that the potential impact of this COC can be better defined. In addition, as part of the remedy for this crib, groundwater monitoring will be used to assess if the Tc-99 will migrate through the vadose zone after implementation of the preferred remedy at this crib. The results of future groundwater monitoring will be evaluated in a risk assessment to determine the need to take action for this COPC at this crib. Action will be taken to mitigate this potential risk while the additional evaluation is performed.

The assessment of human-health risks under the industrial-use-only scenario identified no unacceptable levels of risk to human health associated with nonradionuclides.

Thus, as summarized in Table 5-7, formal assessment of the risks associated with the 216-A-8 Crib identified two COCs. Cesium-137 is present at less than 4.6 m (15 ft) bgs in concentrations that would pose an unacceptable direct-contact risk to the industrial site worker, and in concentrations that would pose unacceptable levels of risk to a hypothetical residential farmer population. Technetium-99 is a potential threat to groundwater. The following sections discuss remedial actions targeting that risk, grouped by GRA.

5.3.2 Assembly of Alternatives for the 216-A-8 Crib

A reasonable alternative must eliminate or mitigate the identified direct-contact risk to the industrial site construction worker, and mitigate or eliminate the potential threat to groundwater. Retained technologies (Chapter 4.0) were reviewed to identify those capable of providing in situ treatment of the Cs-137, or controlling inadvertent intrusion. Because Cs-137 has a half-life of approximately 30 years, natural attenuation (radiological decay) will reduce concentrations in the 0 to 4.6 m (0 to 15 ft) depth interval to below the dose-based RBC of 1,228 pCi/g within 136 years, and throughout the soil column (based on available data) within 249 years (see Figure 6-2). Therefore, containment options would need to maintain protectiveness for 136 years to mitigate risk to the industrial site construction worker. No suitable in situ treatment technology was identified to mitigate the risk posed by proximity to the contaminant.

The potential threat to groundwater is mitigated by immobilizing the Tc-99 in the subsurface, impeding infiltration of water from the land surface, or by removing the contaminant from the subsurface.

Table 5-8 lists the remedial technologies considered viable for the risks identified at the 216-A-8 Crib, and groups them into potential alternatives.

5.3.2.1 Common Actions

Several actions are included in each of the activity-based remedial alternatives (i.e., all but the No-Action Alternative) developed for the 216-A-8 Crib. To limit redundancy, they are listed here and then referenced under each alternative.

5.3.2.1.1 Institutional Controls and Monitoring

The 216-A-8 Crib is within the IELUA. Each activity-based remedial alternative includes activities necessary to establish and maintain suitable institutional controls (Section 4.2.2.2) that would, at a minimum, (1) ensure industrial use only, (2) restrict drilling and use of groundwater, and (3) limit access to areas of residual contamination and to structures or features that are part of ongoing remedial actions. These controls would be implemented through the site-wide institutional controls plan, DOE/RL-2001-41.

In addition, each activity-based remedial alternative includes ongoing environmental monitoring and performance monitoring, as appropriate for the site. These monitoring activities will be site-specific to a large extent, because they will address the risks identified at the site and the remedy implemented. Specific monitoring plans will be developed in conjunction with the remedial design.

5.3.2.1.2 Vadose Zone Well Decommissioning

For each of the activity-based alternatives, it would be necessary to decommission all wells that might be impacted by the action. Decommissioning would be conducted in accordance with the substantive requirements of the applicable portions of WAC 173-160.

5.3.2.1.3 Groundwater Monitoring

Each alternative, including the No-Action Alternative, would include groundwater monitoring to provide ongoing assessment for impacts from the waste site. Implementation of the site-wide groundwater monitoring requirements that are outlined in DOE/RL-89-12 and DOE/RL-91-50 is described in PNNL-11989. This plan includes a description of the monitoring well networks, constituents, sampling frequencies, and criteria used to design the monitoring program; identifies Federal and state groundwater-monitoring requirements and regulations; and provides a list of wells, constituents, and sampling frequencies for groundwater monitoring conducted on the Hanford Site. Federal and state regulations include RCRA, CERCLA, and the *Washington Administrative Code*. Groundwater monitoring for groundwater OUs associated with the 200-PW-1, 200-PW-3, and 200-PW-6 OUs is incorporated and described in PNNL-SA-32196; thus, no new groundwater-monitoring components are required. Any changes to the monitoring approach would be defined during the final design phase of the selected remedy.

5.3.2.2 Alternative 0 – No Action

At the 216-A-8 Crib, the No-Action Alternative would consist of groundwater monitoring (Section 5.3.2.1.3) to assess for changes in the identified conditions. Institutional controls would not be established; the site configuration would not be modified.

Evaluation of Alternative 0 – No Action

This alternative is not effective, because it does not address the direct-contact risks to human health or the potential threat to groundwater. Because regulator approval of this alternative is unlikely (an administrative implementability criterion), this alternative is not considered implementable. Costs are low.

5.3.2.3 Alternative 1 – Monofill Evapotranspiration Barrier

This alternative would mitigate risk to human health by providing increased physical separation from soil with Cs-137 activities that exceeded the RBC, relying on natural radioactive decay to reduce the Cs-137 to levels below the RBCs. It also would impede transport of Tc-99 to groundwater by controlling the infiltration of water from the ground surface.

Alternative 1 for the 216-A-8 Crib would include institutional controls and monitoring (Section 5.3.2.1.1), decommissioning of the wells within the remedial action footprint (Section 5.3.2.1.2), and groundwater monitoring (Section 5.3.2.1.3). Following well decommissioning, an ET barrier would be constructed to cover the portion of the crib with contaminant concentrations that exceed the RBCs. The FS assumes a similar distribution for Tc-99 concentrations that pose a threat to groundwater. Thus, an ET barrier that covers the Tc-99 concentrations that pose a risk to groundwater also would cover the portion of the crib where Cs-137 poses an unacceptable risk to human health. For the purposes of the FS, this area of contamination is assumed to be 6.1 m (20 ft) wide and 259 m (850 ft) long. With functional overhangs and engineered perimeters, the ET barrier footprint would be 52 by 305 m (170 by 1,000 ft). A more detailed discussion is provided in Chapter 6.0.

The ET barrier would need to be maintained approximately 140 years, based on the half-life of Cs-137, to facilitate natural radioactive decay of the Cs-137 to levels that pose no unacceptable risk under the industrial-use-only scenario. However, Tc-99 has a very long half-life. If the additional evaluation determines that Tc-99 does threaten groundwater, it would be necessary to continue to maintain the barrier to maintain protection of groundwater.

Evaluation of Alternative 1 – Monofill Evapotranspiration Barrier

This action is assessed to be effective in mitigating the direct-contact risk until radiological decay reduces the risk to acceptable levels. It also would be effective in limiting infiltration sufficiently to mitigate the potential threat to groundwater, but would require operation and maintenance beyond those necessary for the direct-contact risk. This alternative is readily implemented, with all equipment, services, and skilled personnel easily obtained. Cost is assessed to be moderate. Alternative 1 – Monofill ET Barrier is carried forward for detailed analysis (Chapter 6.0).

5.3.2.4 Alternative 2 – Partial Removal, Treatment, and Disposal

This alternative would remove soils that pose an unacceptable level of risk to human health, or pose a potential threat to groundwater. To facilitate comparison of the alternatives, Alternative 2 assumes the same lateral dimensions for the area of contamination as those used in Alternative 1. Thus, the base of the RTD excavation would be 6.1 m (20 ft) wide and 259 m (850 ft) long. Based on extrapolation of existing data, the excavation would extend to a depth of 9.1 m (30 ft). The excavation would be backfilled to grade with appropriate fill material. Waste would be packaged as appropriate to meet container dose rate requirements and transported to ERDF for disposal. No treatment would be required to meet the ERDF waste acceptance criteria. Additional discussion is provided in Chapter 6.0.

Based on the high Cs-137 activities identified (up to 877,000 pCi/g), water misting or respiratory controls will be needed to facilitate active excavation. In addition, because the excavation will encounter soils with a Cs-137 concentration exceeding 5,300 pCi/g, which will result in a whole body dose rate at 30 cm (12 in.) from the soil surface that exceeds 5 mrem/h, radiological controls will be required during excavation.

Evaluation of Alternative 2 – Removal, Treatment, and Disposal

This remedial alternative is assessed to be effective in addressing the identified risks, because it removes enough contaminant mass to reduce identified risks to acceptable levels. A significant level of effort would be required to ensure protectiveness of human health and the environment during implementation. This alternative would generate a very large volume of regulated waste, compared to Alternative 1, that would require disposal at ERDF. Cost is assessed to be very high relative to the other alternative. Alternative 2 – RTD is carried forward for detailed analysis (Chapter 6.0).

5.3.3 Summary of the Development of Alternatives for the 216-A-8 Crib

In addition to the No-Action Alternative, two activity-based remedial alternatives were developed and evaluated for the 216-A-8 Crib. Both were assessed to be sufficiently effective and implementable to be carried forward for detailed analysis in Section 6.0. As summarized in Table 5-9, the alternatives carried forward for consideration are as follows:

- Alternative 0 – No Action
- Alternative 1 – Monofill ET Barrier
- Alternative 2 – Partial RTD.

Additional elements, common to all but the No-Action Alternative, include the following:

- Institutional controls
- Site-specific environmental monitoring and, where appropriate, performance monitoring
- Decommissioning of vadose zone wells within the tile field footprint
- Groundwater monitoring (as part of the site-wide program).

5.4 DEVELOPMENT OF ALTERNATIVES FOR THE 241-Z-361 SETTLING TANK

The FS addresses two issues at the 241-Z-361 Settling Tank. The first is mitigation of the potential risks to human health and the environment posed by the sludge that remains in the tank. The second is tank closure, intended to achieve compliance with substantive requirements of WAC 173-303-640(8)(a), "Tank Systems," "Closure and Post-Closure Care," which is an ARAR for this site. (Note that related administrative requirements, such as preparation and submittal of a tank closure plan, do not need to be addressed under CERCLA.) The contaminant distribution model is presented in Figure 2-5.

5.4.1 Residual Sludge

As discussed in Section 2.5, the 241-Z-361 Settling Tank contains approximately 75 m^3 (98 yd^3) of sludge with RCRA-regulated constituents (metals) as well as approximately 29 kg (64 lb) of plutonium, making it a mixed transuranic waste upon retrieval. Polychlorinated biphenyl concentrations identified in the tank average approximately 28 ppm; therefore, the waste would not have to be managed under the *Toxic Substances Control Act of 1976* requirements. Available information indicates that the sludge is effectively contained by the tank. However, because of the magnitude of the future risk posed by the sludge should the tank leak, best management practice is to minimize the future risk from an accidental release or inadvertent intrusion.

5.4.2 Remedial Alternative

An earlier report, DOE/RL-2003-52, identified potential remedial technologies, developed and evaluated the reasonable alternatives (based on effectiveness, implementability, and cost), and recommended a specific alternative. Because no new information has been developed since 2003 for this tank, the alternative recommended in that study is carried forward in this FS.

The recommended alternative for the 241-Z-361 Settling Tank would employ a Power Fluidics system to loosen and homogenize the sludge, and transfer it to SWBs. WaterWorks SP-400 Superabsorbent Crystals, a polymer absorbent, would be added to the SWBs to absorb residual liquids and stabilize the sludge. The SWBs then would be transported to the CWC for storage pending proper disposition. Based on available data, the SWBs likely will designate as mixed transuranic waste. The only path forward for mixed transuranic wastes at this time is disposal at WIPP.

5.4.3 Tank Closure

Once the sludge has been removed from the tank and transported to the CWC, there would be no identified unacceptable level of risk associated with the 241-Z-361 Settling Tank. However, WAC 173-303-640(8)(a), a potential ARAR, will require closure of the tank. The 241-Z-361 Settling Tank is, at a minimum, "ancillary equipment" for a mixed waste "tank system" (see WAC-173-303-040, "Definitions.") The tank closure requirement is not applicable

under CERCLA because the tank was taken out of service in 1976, before implementation of RCRA. However, in its current configuration, the 241-Z-361 Settling Tank is functionally a mixed-waste storage tank, and the substantive portion of the tank closure requirement (WAC 173-303-640[8][a]) is relevant and appropriate. The associated closure requirements have the following two goals.

- Document conclusively that the tank system has not caused any unacceptable impacts to the subsurface environment (typically involves environmental sampling).
- Eliminate the potential for future impacts by emptying the tank system and then ensuring that it cannot be reused.

Because there is no evidence of subsurface contamination at this time, there would be no identified risk once the tank was emptied. Therefore, many of the CERCLA evaluation criteria (e.g., protectiveness and use of treatment to reduce toxicity, mobility, or volume) do not apply. Tank-closure options are evaluated based on compliance with the identified potential ARAR, implementability, and cost.

Two tank closure options are considered. The first is closure in place, which leaves the tank in the ground, backfilling it with CDF to make it unusable and to provide the stability needed to avoid structural failure. Piping and other ancillary equipment are removed and disposed of or plugged and blanked. The second option is tank removal, where the tank and ancillary equipment are removed and disposed of, and the site is backfilled.

Under the identified conditions, both are effective and readily implementable. Tank closure is not a remedial action and does not require detailed or comparative analysis. For the purposes of the FS, tank closure is assumed to be in-place closure by backfilling with CDF. Site-specific sampling is necessary to support selection of an appropriate closure option, and ensure clean closure.

5.5 DEVELOPMENT OF ALTERNATIVES FOR THE 216-Z-8 FRENCH DRAIN

COPCs at the 216-Z-8 French Drain are Pu-238, Pu-239/240, and Am-241. The contaminant distribution model is presented in Figure 2-7. Historical sampling results, documented in the RI, indicate that these contaminants primarily are 5 to 11 m (16 to 35 ft) bgs. The risk assessment process determined that human-health risks incurred under the industrial-use scenario were less than 1.0×10^{-4}, primarily because there were no significant concentrations identified within the upper 4.6 m (15 ft) of the soil column. The RESRAD modeling of plutonium at the 216-Z-9 Trench showed no risk to groundwater, so even though there are differences in the depth of the plutonium contamination between these sites, the limited amount of plutonium at the 216-Z-8 French Drain is not likely to pose a threat to groundwater. Therefore, there is no regulatory requirement to develop or implement remedial alternatives at the 216-Z-8 French Drain.

5.6 DEVELOPMENT OF ALTERNATIVES FOR THE 216-Z-10 INJECTION/REVERSE WELL

As discussed in the RI Report (DOE/RL-2006-51), historical soil sampling and geophysical logging in three adjacent boreholes identified no significant soil contamination at the 216-Z-10 Injection/Reverse Well. Because no contamination has been identified in the upper 4.6 m (15 ft) of the soil column, there is no identified direct-contact risk to potential human and ecological receptors. The plutonium disposed of in this well is expected to be bound to the sediments in near proximity to the well. The RESRAD modeling of plutonium at the 216-Z-9 Trench showed no risk to groundwater, so even though there are differences in the depth of the plutonium contamination between these sites, the limited amount of plutonium at the 216-Z-10 Injection/Reverse Well is not likely to pose a threat to groundwater. Therefore, there is no regulatory requirement to develop or implement remedial alternatives for this waste site. The contaminant distribution model is presented in Figure 2-8.

This waste site will be closed by decommissioning the well in accordance with WAC 173-160-381, "Minimum Standards for Construction and Maintenance of Wells," "What are the Standards for Decommissioning a Well?" As a precaution, decommissioning activities will be modified to the extent possible to minimize the volume of liquid introduced into the well during the decommissioning process. Grouting will seal the well and annular space, precluding infiltration of water from the surface.

Figure 5-1. Conceptual Schematic: Alternative 3 – In Situ Vitrification at the 216-Z-9 Trench.

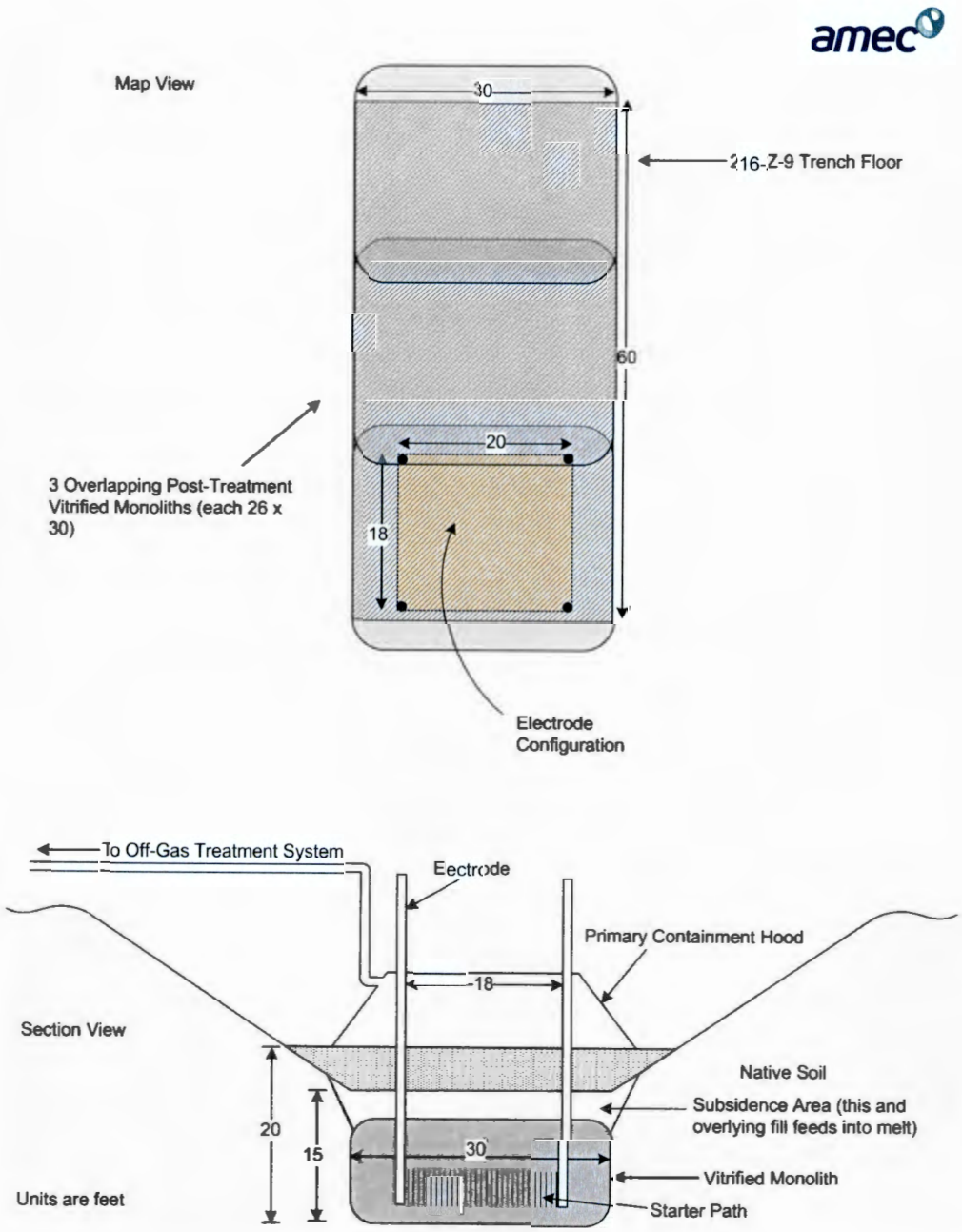

Figure 5-2. Conceptual Schematic: Cross Section of Alternative 4 – Partial Removal, Treatment, and Disposal at the 216-Z-9 Trench.

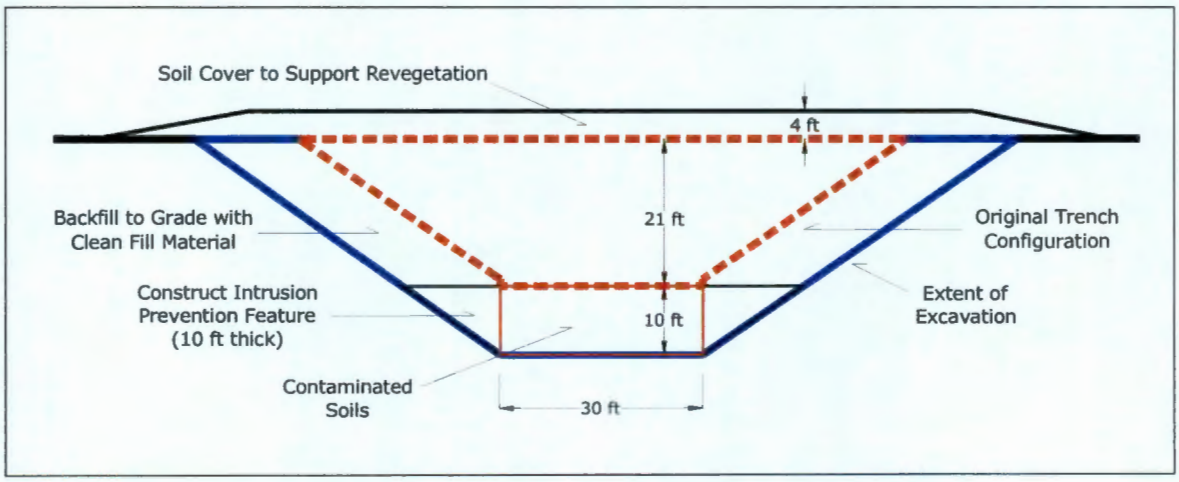

Table 5-1. Risks Posed by Contaminants of Concern at the 216-Z-1A Tile Field.

Location and Depth	Contaminant of Concern	Risk to Human Health [a]	Risk to Groundwater [b]
Beneath central waste-distribution piping, from 1.5 to 30.5 m (5 to 100 ft) bgs	Pu-239/240	Yes	No
	Am-241	Yes	No
Potentially present at depths greater than 26 m (85 ft)	CCl_4	No	Yes [c]

[a] Baseline risk-assessment result using the industrial-use scenario; contaminants more than 4.6 m (15 ft) below grade are specifically excluded from risk-assessment requirements and presumed to pose no unacceptable direct-contact risks.

[b] Determination of no unacceptable risk indicates that calculated impacts to groundwater do not exceed maximum contaminant levels within the next 1,000 years.

[c] Although not detected in recent soil sampling, CCl_4 still is being removed by the soil-vapor extraction system currently operated at the site and may be present at depths greater than 26 m (85 ft), the vertical extent of recent soil sampling, in quantities that pose a threat to groundwater.

bgs = below ground surface.

Table 5-2. Preliminary Alternatives for the 216-Z-1A Tile Field.

General-Response Action	Technology Type	Remediation Technology	No Action	Soil Backfill + Expanded Soil-Vapor Extraction	Intrusion-Prevention Feature + Expanded Soil-Vapor Extraction	In Situ Vitrification + Expanded Soil-Vapor Extraction	Partial Removal, Treatment, and Disposal + Expanded Soil-Vapor Extraction
No Action	No Action	No Action	X				
Institutional Controls	Land-Use Restrictions	Deed Restrictions		X	X	X	X
	Access Controls	Signs/Fences		X	X	X	X
		Entry Control					
	Monitoring	Monitoring	X	X	X	X	X
Containment	Intruder Barriers	Physical Barrier		X*	X		
Removal	Excavation	Conventional Excavation					X
		Remote Excavation					X
		Soil Vacuum Excavation					X
Disposal	Landfill Disposal	Onsite Landfill					X
		Offsite Repository					X
Ex Situ Treatment (Assumes Excavation)	Physical/ Chemical Treatment	Automated Segregation Based on Radioactivity					X
In Situ Treatment	Chemical/ Physical Treatment	Soil-Vapor Extraction		X	X	X	X
	Thermal Treatment	Vitrification				X	

*Area overlying the tile field would be backfilled with nonengineered fill material having no specific feature intended to limit intrusion. Its purpose is to provide physical separation from the contaminants.

Table 5-3. Remedial Alternatives Developed for the 216-Z-1A Tile Field.

Alternative		Effectiveness	Implementability	Cost
0	No Action	Not effective	Not readily implemented	Very low
1	Soil Backfill + Expanded SVE	Effective	Readily implemented	Low
2	IPF + Expanded SVE	Effective	Readily implemented	Low
3	ISV + Expanded SVE	Effective	Implementable (significant power demands; multiple mobilizations to cover the site)	High
4	Partial RTD + Expanded SVE	Effective	Readily implemented (high short-term risk to workers; generates significant waste streams)	High

IPF = intrusion-prevention feature.
RTD = removal, treatment, and disposal.
SVE = soil-vapor extraction.

Table 5-4. Risks Posed by Contaminants of Concern at the 216-Z-9 Trench.

Location and Depth	COC/COPC	Risk to Human Health [a]	Threat to Groundwater [b]
From the trench base to the Cold Creek unit (6.4 to 36.6 m [21 to 120 ft])	Pu-239/240	No [c]	No
	Am-241	No [c]	No
Associated with thin silt lens beneath the southern portion of the trench (19.8 m [65 ft] bgs).	CCl_4, tetrachloroethylene, and hexachloroethane	No	Yes – migration-to-groundwater evaluations predict impacts to groundwater

[a] Baseline risk-assessment result using the industrial-use scenario; contaminants more than 4.6 m (15 ft) below grade are specifically excluded from risk-assessment requirements and are presumed to pose no unacceptable direct-contact risks.
[b] Determination of no risk indicates that calculated impacts to groundwater do not exceed maximum contaminant levels within the next 1,000 years.
[c] Using less restrictive land-use assumptions, the risk assessment determined that these COCs could pose an unacceptable level of risk to human health. These conditions might be encountered if institutional controls were circumvented.

COC = contaminant of concern.
COPC = contaminant of potential concern.

Table 5-5. Preliminary Remedial Actions Addressing the Threat to Groundwater at the 216-Z-9 Trench.

General-Response Action	Technology Type	Remediation Technology	No Action	Revegetate	Evapotranspiration Barrier	Removal, Treatment, and Disposal	Soil-Vapor Extraction	Soil-Vapor Extraction +Electrical-Resistance Heating
No Action	No Action	No Action	X					
Institutional Controls	Land-Use Management	Land-use and real property controls. Excavation permits		X	X	X	X	X
	Entry Restrictions	Fencing		X	X	X	X	X
		Procedural controls for entry. Warning signs		X	X	X	X	X
	Monitoring	Monitoring	X	X	X	X	X	X
Containment	Surface Barriers	Arid-Climate Engineered Cap		X*	X			
	Intruder Barriers	Physical Barrier						
Removal	Excavation	Conventional				X		
		Remote				X		
Disposal	Landfill Disposal	Onsite Landfill				X		
		Offsite Repository				X		
Ex Situ Treatment (Assumes Excavation)	Physical/ Chemical Treatment	Vapor Extraction						
		Automated Segregation Based on Radioactivity				X		
In Situ Treatment	Chemical/ Physical Treatment	Soil-Vapor Extraction					X	X
		Passive Soil-Vapor Extraction		X	X		X	X
	Thermal Treatment	In Situ Vitrification						
		Soil-Vapor Extraction + Electrical-Resistance Heating						X
		Dry-air barrier						
Natural Attenuation (not a technology or treatment process)		Monitored Natural Attenuation		X	X			

*In this instance, there is no specific engineered-barrier structure (e.g., coarse fractured basalt). Evapotranspiration is provided by native soils revegetated with a selected plant community that will be established and maintained at ground level.

Table 5-6. Remedial Alternatives Developed for the 216-Z-9 Trench.

Alternative		Effectiveness	Implementability	Cost
0	No Action	Not effective	Not readily implemented	Very Low
1	Controlled-density fill plus targeted soil-vapor extraction	Effective (uncertainty: effectiveness of soil-vapor extraction in reducing contaminant mass)	Readily implemented (long-term management of selected vegetation), low short-term risks	Low
2	Intrusion-prevention feature plus targeted soil-vapor extraction	Effective (uncertainty: effectiveness of soil-vapor extraction in reducing contaminant mass)	Readily implemented (high short-term risk to workers drilling new soil-vapor extraction wells; generates waste streams; must meet substantive portion of air permitting requirements)	Low
3	In situ vitrification plus targeted soil-vapor extraction	Effective	Implementable, in situ vitrification may be technically challenging, requiring treatability studies. Soil-vapor extraction issues as above	High
4	Partial removal, treatment, and disposal plus targeted soil-vapor extraction	Effective	Implementable (high short-term risks to remedial action workers; generates very large quantity of waste, much with high levels of transuranics; soil-vapor extraction issues as above)	High

Table 5-7. Risks Posed by Contaminants of Concern at the 216-A-8 Crib.

Location and Depth	Contaminant of Concern	Risk to Human Health [a]	Risk to Groundwater [b]
From 4 to 9 m (13 to 30 ft) bgs	Cs-137	Yes	No
From 5.8 to 6.6 m (19 to 21.5 ft) bgs	Tc-99	No	Yes [c]

[a] Baseline risk-assessment result using the industrial-use scenario; contaminants more than 4.6 m (15 ft) below grade are specifically excluded from risk-assessment requirements and are presumed to pose no unacceptable direct-contact risks.

[b] Determination of no risk indicates that calculated impacts to groundwater do not exceed maximum contaminant levels within the next 1,000 years.

[c] Technetium-99 was identified at significant concentrations in only one soil sample (79.6 pCi/g at 5.8 to 6.6 m [19 to 21.5 ft] bgs). Pending confirmatory soil sampling, the preferred alternative will include activities to mitigate the potential future impacts that this contaminant may have on groundwater beneath the waste site.

bgs = below ground surface.

Table 5-8. Preliminary Alternatives for the 216-A-8 Crib.

General-Response Action	Technology Type	Remediation Technology	No Action	Monofill Evapotranspiration Barrier	Partial Removal, Treatment, and Disposal
No Action	No Action	No Action	X		
Institutional Controls	Land-Use Restrictions	Deed Restrictions		X	X
	Access Controls	Signs/Fences		X	X
		Entry Control		X	
	Monitoring	Monitoring	X	X	X
Containment	Surface Barriers	Arid-Climate Engineered Cap		X	
Removal	Excavation	Conventional Excavation			X
		Remote Excavation			X
		Soil-Vapor Excavation			X
Disposal	Landfill Disposal	Onsite Landfill			X
		Offsite Repository			
Ex Situ Treatment (assumes Excavation)	Physical/ Chemical Treatment	Vapor Extraction			
		Automated Segregation Based on Radioactivity			X
In Situ Treatment	Chemical/ Physical Treatment	Soil-Vapor Extraction			
		Passive Soil-Vapor Extraction			
Natural Attenuation (not a Technology or Treatment Process)		Monitored Natural Attenuation		X	X

Table 5-9. Remedial Alternatives Developed for the 216-A-8 Crib.

Alternative		Effectiveness	Implementability	Cost
0	No Action	Not effective	Not readily implemented	Very Low
1	Monofill Evapotranspiration Barrier	Effective	Readily implemented (long-term maintenance)	Low
2	Removal, Treatment, and Disposal	Effective	Implementable (high short-term risks; generates large quantity of waste, with significant quantities being remote handled)	High

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6.0 DETAILED ANALYSIS OF ALTERNATIVES

Each of the alternatives described in Chapter 5.0 was evaluated with respect to specific CERCLA evaluation criteria, as required by 40 CFR 300.430[e][9], "Detailed Analysis of Alternatives." The CERCLA criteria are identified and discussed in Section 6.1 of this chapter. Subsequent sections describe the detailed analysis of specific alternatives.

Analysis of the alternatives takes into account the nature of the contaminants at each site and the anticipated future land use. Current land use for the 200 Areas is industrial, associated with the waste-management activities. This land-use status is reasonably predicted to remain the same until the year 2150, in light of the current DOE commitment to waste-management activities. Industrial use is presumed for the foreseeable future.

6.1 DESCRIPTION OF EVALUATION CRITERIA

The EPA has developed nine CERCLA evaluation criteria, defined in EPA/540/G-89/004, to address the statutory requirements and the technical and policy considerations important for selecting remedial alternatives. These criteria serve as the basis for conducting detailed and comparative analyses and, subsequently, for selection of appropriate remedial actions.

The nine CERCLA evaluation criteria fall into three categories.

- Threshold Criteria
  - Overall protection of human health and the environment
  - Compliance with ARARs
- Balancing Criteria
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, or volume through treatment
  - Short-term effectiveness
  - Implementability
  - Cost
- Modifying Criteria
  - State acceptance
  - Community acceptance.

Threshold criteria constitute the statutory requirements for the remedial action. All alternatives must (1) achieve and maintain protection of human health and the environment, and (2) achieve compliance with the ARARs. Only alternatives that meet both threshold criteria are carried forward in the detailed analysis.

Each alternative then is evaluated to determine its efficacy with respect to the five balancing criteria. The evaluation process is consistent for each alternative, and is quantitative to the extent necessary to allow meaningful comparison of the alternatives during the comparative analysis (discussed in Chapter 7.0).

The modifying criteria are not formally addressed during the FS process. Although there is interaction with the stakeholders during the RI/FS process, the modifying criteria are formally addressed through the preparation of two post-FS documents. State acceptance is achieved through the process that generates the proposed plan. The proposed plan will identify the preferred remedy (or remedies). Community acceptance is formally addressed by issuing the proposed plan, and facilitating public review and comment.

In addition to the CERCLA criteria, NEPA values (e.g., analysis of cumulative off-site ecological and socioeconomic impacts) also are considered. Specific consideration of NEPA values is driven by Section 5(a)(13) of DOE O 451.1, *National Environmental Policy Act Compliance Program*, and *DOE Policies on the Application of NEPA to CERCLA and RCRA Cleanup Actions* (DOE, 2002).

6.1.1 Overall Protection of Human Health and the Environment

Overall protection, the first threshold criterion, is the primary objective of the remedial-action program. As noted in EPA/540/G-89/004, the assessment of protectiveness draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

To address this criterion, each alternative is evaluated with regard to its ability to achieve and maintain adequate protection of human health and the environment, including preservation of natural systems and biological diversity. Protection includes (1) reducing existing risks to acceptable levels, either by reducing contaminant concentrations or by eliminating potential routes of exposure, and (2) minimizing risks, typically short-term risks, manifested by the remedial activities, including impacts to natural, cultural, and historical resources. The potential for cross-media impacts (i.e., soil cleanup actions that negatively impact air quality or groundwater quality) also is addressed. This criterion considers whether a net environmental benefit will result from implementing the remedial alternative.

Action-based alternatives that do not pass this threshold criterion are not carried forward in the detailed analysis.

6.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

The second threshold criterion is compliance with all ARARs. Exceptions occur only when suitable justification exists for waiving an ARAR, as described in 40 CFR 300.430(f)(1)(ii)(C), "Modifying Criteria."

Appendix C discusses ARARs identified for the 200-PW-1, 200-PW-3, and 200-PW-6 OUs. Detailed analysis identifies ARARs that apply to each alternative, and considers whether compliance can be achieved. If a requirement waiver appears warranted (e.g., technical impracticability), the basis for seeking that waiver will be presented.

6.1.3 Long-Term Effectiveness and Permanence

Efficacy with respect to this balancing criterion is based on (1) post-remedy risk to human and ecological receptors and (2) the adequacy and reliability (durability) of controls implemented to mitigate post-remedy risks. This criterion is addressed through a formal assessment of anticipated post-remedy risks.

6.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This balancing criterion addresses the degree to which a remedial alternative reduces the toxicity, mobility, or volume of a hazardous substance through treatment. This criterion focuses on the following factors:

- The treatment processes used and the materials treated
- Whether recycling, reuse, and/or waste minimization are used in the treatment process
- The type and quantity of residuals that remain following treatment, and whether any special treatment actions will be needed
- Whether the alternative satisfies the statutory preference for treatment as a primary element in addressing principal threat contaminants.

6.1.5 Short-Term Effectiveness

This balancing criterion evaluates the potential effects on human health and the environment during the construction and implementation phases of a remedial action. This criterion also considers the speed with which an alternative achieves protection. The following factors are considered for each alternative.

- Health and safety of remediation workers and reliability of protective measures taken. Specifically, this involves identification and evaluation of risks resulting from implementation, such as fugitive dust, transportation of hazardous materials, or air-quality impacts from off-gas emissions.

- Physical, biological, and cultural impacts that might result from the construction and implementation of the remedial action, and whether the impacts can be controlled or mitigated.

- The amount of time required to meet RAOs (i.e., duration of the short-term risks).

Short-term human-health impacts are closely related to the duration of exposure to hazardous materials and the other risks associated with remedial activities. Greater exposure time equates to greater risk. Remedial actions will be implemented in compliance with all applicable work-protection requirements.

Short-term environmental impacts typically are proportional to the extent of physical disturbance of a site and its associated habitat. Risks also can be associated with the potential disturbance of sensitive species because of increased human activity in the area.

6.1.6 Implementability

This balancing criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of the required services and materials.

The following factors are considered for each alternative:

- Technical feasibility
  - The likelihood of technical difficulties in constructing and operating the alternative
  - The likelihood of delays because of technical problems
  - Uncertainties related to innovative technologies (e.g., failures)
- Administrative feasibility
  - Ability to coordinate activities with other offices and agencies
  - Ability to coordinate activities with adjacent and nearby facilities
  - Ability to coordinate activities with those of other OUs
  - Potential for regulatory constraints to develop (e.g., as a result of uncovering buried cultural resources or encountering endangered species)
- Availability of services, materials, and infrastructure
  - Availability of adequate onsite or offsite treatment storage capacity, and disposal services, if necessary
  - Availability of necessary equipment, specialists, and provisions to ensure obtaining any additional resources, if necessary.

6.1.7 Cost

This balancing criterion considers the cost of implementing a remedial alternative, including capital costs, operation and maintenance costs, and monitoring costs. The cost evaluation also addresses monitoring of any restoration or mitigation measures for natural, cultural, and historical resources.

Cost estimates for the purposes of this study are presented in present-worth terms. Cost estimates were prepared in accordance with EPA/540/G-89/004 using the information available at the time of this study. The actual cost of the project will depend on additional information gained during the remedial design phase, the final scope and design of the selected remedial action, the schedule of implementation, competitive market conditions, and other variables. However, most of these factors are not expected to significantly affect the relative cost differences of alternatives.

6.1.8 State Acceptance

This modifying criterion evaluates the technical issues and concerns that the EPA and Ecology could have regarding a remedial alternative. The regulatory acceptance process would involve a review and concurrence by the EPA and Ecology. This criterion will be addressed at the time that the proposed plan is published.

6.1.9 Community Acceptance

This modifying criterion evaluates the issues and concerns that the public may have regarding a remedial alternative. This criterion will be addressed following public review of the proposed plan.

6.2 DETAILED ANALYSIS OF ALTERNATIVES FOR THE 216-Z-1A TILE FIELD

Using the industrial-use risk scenario, assessment of risks to human health at the 216-Z-1A Tile Field identified an unacceptable level of risk to the future site construction worker. The risk is posed by the potential for direct contact with soils containing high concentrations of Pu-239/240 and Am-241; these three radionuclides are the principal threat contaminants at this site. Existing data indicate that, in some locations, contaminant concentrations generating the actionable risk levels (i.e., concentrations exceeding the RBCs) are located approximately 1.5 m (5 ft) bgs. Ground surface above the tile field is approximately 2.4 m (8 ft) below the natural ground surface (Figure 2-4). Thus, action-level contamination is at least 3.9 m (13 ft) below the natural ground surface. Vadose-zone calculations using fate and transport models identified no risk of potentially exceeding MCLs in the groundwater within 1,000 years for the COPCs (see Appendix E). No ARAR-driven cleanup levels were identified.

However, the SVE system operating at the 216-Z-1A Tile Field continues to remove kilogram quantities of CCl_4 annually. Although recent soil analyses did not identify CCl_4 at concentrations that would pose a threat to groundwater, sampling did not extend more than 26 m (85 ft) bgs. Based on the continued recovery of CCl_4, the FS notes a potential for residual contamination more than 26 m (85 ft) bgs that may pose a threat to groundwater, and therefore identifies CCl_4 as a COPC warranting remedial action to ensure protection of groundwater.

The risk assessment process included evaluation of scenarios that assumed loss of institutional control, for consideration during evaluation of remedial alternatives. The assessment concluded that contamination identified at the site posed no unacceptable risk to the future driller population, but would pose unacceptable risks to the hypothetical residential farmer population, under the scenario discussed in Section 3.2. and Appendix A.

Simply backfilling the depression above the tile field with soil to 0.6 m (2 ft) above the current ground surface would achieve sufficient protectiveness for the site construction worker, providing more than 4.6 m (15 ft) of physical separation between the contaminants and ground surface. However, more robust alternatives also are considered here to provide an increased level of protectiveness, should institutional controls be circumvented in the future.

The following five alternatives were carried forward for detailed analysis.

- Alternative 0 – No Action
- Alternative 1 – Soil Backfill plus Expanded SVE
- Alternative 2 – IPF plus Expanded SVE
- Alternative 3 – ISV plus Expanded SVE
- Alternative 4 – Partial RTD plus Expanded SVE.

6.2.1 Common Activities

Several actions are included in each of the activity-based remedial alternatives (i.e., all but the No-Action Alternative) developed for the 216-Z-1A Tile Field. The actions include institutional controls and monitoring (Section 5.1.2.1.1), expansion and continued operation of the SVE system (Section 5.1.2.1.2), decommissioning of the wells within the tile field footprint (Section 5.1.2.1.3), and groundwater monitoring (Section 5.1.2.1.4). Nuclear safety considerations (Section 5.1.2.1.5) also would need to be addressed before implementation of any alternative. To limit redundancy, these activities are incorporated by referencing the earlier sections.

6.2.2 Alternative 0 – No Action

As required by CERCLA (40 CFR 300.430[e][6], "The No Action Alternative"), the No-Action Alternative is carried forward as the baseline response. This alternative implements no institutional controls or remedies.

6.2.2.1 Contingency Plan

The No-Action Alternative has no contingent actions.

6.2.2.2 Environmental Monitoring

Environmental monitoring would consist of groundwater monitoring to provide ongoing assessment for impacts from the waste site, implemented through a site-wide program (Section 6.2.1).

6.2.2.3 Evaluation by Criteria

The following discussion considers the 216-Z-1A Tile Field No-Action Alternative (Alternative 0) with respect to the seven CERCLA criteria.

Overall Protection of Human Health and the Environment: This alternative does not eliminate or mitigate the identified risk, and thus fails to meet this threshold criterion.

Compliance with ARARs: There are no chemical-specific, or location-specific ARARs for this site, and the No-Action Alternative has no action-specific ARARs.

Long-Term Effectiveness and Permanence: This alternative does not eliminate or mitigate the identified risk to the industrial site construction worker. The No-Action Alternative does not meet this criterion.

Reduction of Toxicity, Mobility, or Volume through Treatment: The No-Action Alternative does not employ treatment technology.

Short-Term Effectiveness: Because there are no actions associated with this alternative, it poses no additional short-term risks to human health or the environment. However, because it is not protective of the site construction worker, it does not meet this criterion.

Implementability: The only difficultly encountered in implementing this alternative would be difficulty in obtaining the necessary regulatory approval. Probability of obtaining this approval is very low; therefore, this alternative is most likely not implementable.

Cost: Costs associated with this alternative are estimated at $0.

6.2.3 Alternative 1 – Soil Backfill Plus Expanded Soil-Vapor Extraction

In addition to institutional controls and monitoring, expansion and continued operation of the SVE system, decommissioning of the wells within the tile field footprint, and groundwater monitoring (Section 6.2.1), Alternative 1 would include backfilling the area above the existing surface of the tile field with clean fill, bringing that surface up to the level needed to provide 4.6 m (15 ft) of physical separation between contaminants that exceed the RBCs and the potential human and ecological receptors. Backfilling would not begin until SVE operations were completed and the wells had been decommissioned.

Backfilling to achieve the desired separation is expected to require mounding above the ground surface in some areas at the northern end of the tile field. The mounded areas would not be more than 0.9 m (3 ft) above the ground surface, and would incorporate a feature to mitigate erosion. The identified risks to the industrial site construction worker would be mitigated immediately and in a fairly sustainable manner.

6.2.3.1 Contingency Plan

Reasonable deviations from the anticipated outcome might be (1) discovery of radiological contamination exceeding the RBCs at depths that would be less than 4.6 m (15 ft) from the top of the backfill, or (2) discovery of a CCl_4 source area. Contingent actions that would address these conditions would include the following:

- For the more shallow radionuclides,
  - Excavate the hot spot, treat the soils as necessary to meet waste acceptance criteria, and dispose,
  - ISV of the hot spot, or
  - Modify the backfilling operations to incorporate an IPF over the hot spot

- For a newly discovered CCl_4 source area,
  - RTD, or
  - More aggressive application of SVE, augmented with ERH as appropriate.

6.2.3.2 Environmental Monitoring

Environmental monitoring would consist of periodic groundwater monitoring conducted as part of the site-wide program, and soil vapor monitoring (Section 6.2.1).

6.2.3.3 Evaluation by Criteria

The following discussion considers the Alternative 1 – Soil Backfill plus Expanded SVE for the 216-Z-1A Tile Field with respect to the seven CERCLA criteria.

Overall Protection of Human Health and the Environment: The identified direct-contact risk to the industrial site construction worker is controlled by the existing soil overburden and institutional controls until the trench is backfilled to grade. Once backfilled, risk to the site construction worker is mitigated, because there would be at least 4.6 m (15 ft) of separation from the high-activity contaminants. The expanded SVE system reduces the potential threat to groundwater effectively. Short-term risks of significance are related to potential for radiological exposures during installation of the ten new SVE wells; these are readily mitigated under existing safety programs.

Compliance with ARARs: The 216-Z-1A Tile Field has no ARAR-derived (chemical-specific) remedial goals. Alternative 1 will incur ARARs associated with air emissions, waste management, and state waste discharge permit requirements when expanding and operating the existing SVE system; air emissions, waste management, state waste discharge permit, and well construction and decommissioning requirements associated with installation and decommissioning of SVE wells; fugitive dust control and protection of ecological receptors while backfilling the tile field; and sample analysis and waste management (including disposition of residual sample material) during sampling events. Work would be conducted under the existing environmental protection program, which is engaged substantively during the remedial design process, and integrated fully into work planning and execution. Based on current knowledge, no difficulty is anticipated in complying with these ARARs. ARAR are listed in Appendix C.

Long-Term Effectiveness and Permanence: Risk to the site construction worker is reduced to acceptable levels by achieving more than 4.6 m (15 ft) of separation. The risk assessment determined that no unacceptable risk is posed to the future driller population, but did identify unacceptable levels of risk to the hypothetical residential farmer population. Alternative 1 does not substantively change risks posed to the residential farmer population.

Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative 1 at the 216-Z-1A Tile Field uses no treatment technologies to address principal threat contaminants. It does employ an expanded SVE system to remove CCl_4 vapors from the vadose zone, which is considered protective of groundwater.

Short-Term Effectiveness: The risk to human health posed by the subsurface radionuclides is effectively mitigated by the existing soil overburden and institutional controls. Installation of ten new SVE wells presents radiological exposure risks. Operation of the expanded SVE system, and the associated waste management activities, also poses risks to human health and the environment. Well decommissioning and backfilling operations pose relatively minor risks. All identified risks are believed to be readily mitigated by current worker protection and environmental protection programs.

Implementability: All services, equipment, and personnel are readily available. No technical challenges are perceived.

Cost: Total costs for Alternative 1 are estimated at $5,619,236; see Appendix D for further details.

6.2.4 Alternative 2 – Intrusion-Prevention Feature Plus Expanded Soil-Vapor Extraction

In addition to institutional controls and monitoring, expansion and continued operation of the SVE system, decommissioning of the wells within the tile field footprint, and groundwater monitoring (Section 6.2.1), Alternative 2 at the 216-Z-1A Tile Field would include construction of an IPF in the depression above the tile field, mounding the top of the feature as necessary to achieve 4.6 m (15 ft) of physical separation. The type and configuration of the IPF will be determined during remedial design. For the purposes of the FS, the IPF is assumed to be a 2 m (6.6-ft) layer of coarse fractured basalt with no fine-grained interstitial materials. The basalt would be overlain by materials intended to limit infiltration of finer-grained material into the interstitial spaces of the basalt. The coarse fractured basalt is an effective barrier to burrowing, digging, and well drilling. It also creates a dry rocky environment that is not conducive to root penetration. The upper surface would incorporate engineered features to minimize erosion. Construction activities would not begin until SVE operations were completed.

6.2.4.1 Contingency Plan

Reasonable deviations from the anticipated outcome might be (1) discovery of radiological contamination exceeding the RBCs at depths that would be less than 4.6 m (15 ft) from the top of the backfill, or (2) discovery of a CCl_4 source area. Contingent actions that would address these conditions include the following:

- for the more shallow radionuclides,
  - Excavate the hot spot, treat the soils as necessary to meet waste acceptance criteria, and dispose,
  - ISV of the hot spot,
- and, for an unanticipated CCl_4 source area,
  - RTD, or
  - More aggressive application of SVE, augmented with ERH as appropriate.

6.2.4.2 Environmental Monitoring

Environmental monitoring would consist of periodic groundwater monitoring conducted as part of the site-wide program, and soil vapor monitoring (Section 6.2.1).

6.2.4.3 Evaluation by Criteria

The following discussion considers the 216-Z-1A Tile Field Alternative 2 – IPF plus Expanded SVE with respect to the seven CERCLA criteria.

Overall Protection of Human Health and the Environment: The identified risk to the industrial site construction worker is controlled by existing institutional controls until the IPF is constructed. Once installed, risk to the site construction worker is mitigated, because there would be approximately 4.6 m (15 ft) of separation from the soils exceeding the RBCs. The expanded SVE system reduces the potential threat to groundwater effectively. Short-term risks of significance are related to the potential for radiological exposures during installation of the ten new SVE wells; these are readily mitigated under existing safety programs.

Compliance with ARARs: The 216-Z-1A Tile Field has no ARAR-derived (chemical-specific) remedial goals. Alternative 2 will incur activity related activity-, chemical-, and location-specific ARARs for air emissions, waste management, and state waste discharge permit requirements when operating the existing SVE system; air emissions, waste management, state waste discharge permit, and well construction and decommissioning requirements associated with installation and decommissioning of SVE wells; fugitive dust control and protection of ecological receptors while constructing the IPF; and sample analysis and waste management (including disposition of residual sample material) during sampling events. Work would be conducted under the existing environmental protection programs, which are engaged substantively during the remedial design process, and integrated fully into work planning and execution. Based on current knowledge, no difficulty is anticipated in complying with these ARARs. ARARs are listed in Appendix C.

Long-Term Effectiveness and Permanence: Risk to the site construction worker is reduced to acceptable levels by achieving more than 4.6 m (15 ft) of separation. The risk assessment determined that no unacceptable risk is posed to the future driller population, but did identify unacceptable levels of risk to the hypothetical residential farmer population. This risk would be substantially mitigated by the IPF, which is expected to be very durable and will have design criteria specifying minimal long-term maintenance requirements, but the level of risk is not reduced. The expanded SVE system enhances long-term protectiveness of groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative 2 uses SVE to reduce the mass and concentration of CCl_4 in soils beneath the 216-Z-1A Tile Field. Carbon tetrachloride was carried forward as a COPC warranting action; it is not a COC.

Short-Term Effectiveness: The current risk to human health posed by the subsurface radionuclides is effectively mitigated by the existing soil overburden and institutional controls. Short-term risks of significance are related to potential for remedial-action worker radiological exposures during installation of the ten new SVE wells. Operation of the SVE system poses moderate risks to human health and the environment. Decommissioning of the numerous wells

currently located within the footprint of the 216-Z-1A Tile Field will pose relatively minor risk to the workers and the environment. Construction activities within the depression above the 216-Z-1A Tile Field will pose relatively minor risks to human health. All identified short-term risks are readily mitigated by current worker protection and environmental protection programs.

Implementability: Expansion and continued operation of the SVE system, and ultimately, decommissioning of the vapor extraction wells within the site footprint, are readily implementable activities. Construction of the IPF also is readily implemented. All required materials and services are expected to be readily available, and existing environmental and worker protection programs will readily address all the identified implementation risks.

Cost: Total costs for Alternative 2 are estimated at $5,814,907; see Appendix D for further details.

6.2.5 Alternative 3 – In Situ Vitrification Plus Expanded Soil-Vapor Extraction

In addition to institutional controls and monitoring, expansion and continued operation of the SVE system, decommissioning of the wells within the tile field footprint, and groundwater monitoring (Section 6.2.1), Alternative 3 at the 216-Z-1A Tile Field would implement ISV using GeoMelt SPV technology. It would target soils from the current ground surface to a depth of 6.1 m (20 ft), over an area equivalent to the footprint of the base of the original tile field excavation, which is 30.3 by 79.2 m (100 by 260 ft). This would entail approximately 27 melts, and would generate a glass monolith roughly 4.9 m (16 ft) thick (due to loss of pore space), with lateral dimension of 30.3 by 79.2 m (100 by 260 ft). Additional discussion is provided in Section 5.2.2.6.

The glass monolith essentially would encapsulate COCs that had been present in the upper 6.1 m (20 ft) of the soil column, and would impede inadvertent intrusion into the deeper residual contamination.

6.2.5.1 Contingency Plan

Assuming that sufficient characterization is conducted before implementation, no reasonable deviations were identified for the ISV portion of Alternative 3 at the 216-Z-1A Tile Field. A reasonable deviation from the SVE portion of Alternative 3 would be discovery of a CCl_4 source area. Contingent action that would address this discovery would include the following:

- Removal of the contaminated soils, treatment as necessary, and disposal, or
- More aggressive application of SVE, augmented with ERH as appropriate.

6.2.5.2 Environmental Monitoring

Environmental monitoring would consist of periodic groundwater monitoring conducted as part of the site-wide program, and soil vapor monitoring (Section 6.2.1).

6.2.5.3 Evaluation by Criteria

The following discussion considers Alternative 3 – ISV plus Expanded SVE at the 216-Z-1A Tile Field with respect to the seven CERCLA criteria.

Overall Protection of Human Health and the Environment: Alternative 3 vitrifies all media within 8.5 m (28 ft) of the finished ground surface (level with the surrounding land surface) that has COC concentrations exceeding the RBCs. This eliminates all unacceptable direct-contact risks to the industrial site construction worker. It also would enhance protectiveness of groundwater by removing CCl_4 vapors from the vadose zone to the effective limits of SVE technology. Remedial-action workers incur moderate risks associated with installation of the ten new SVE wells, operation and maintenance of the SVE system, and management of the wastes that system generates. Vitrification poses risks to the remedial-action worker, the public, and the environment, the most significant being associated with the capture and treatment of off-gases, and the associated waste-management activities. All identified risks are readily mitigated under existing Hanford Site worker and environmental protection programs.

Compliance with ARARs: Alternative 3 will incur ARARs for air emissions, waste management, and state waste discharge permit requirements when expanding and operating the SVE system; air emissions and waste management when implementing the ISV process; air emissions, waste management, and well construction and decommissioning requirements during the expansion, operation, and decommissioning of the existing SVE system; and sample analysis and waste management (including disposition of residual sample material) during sampling events. All work would be conducted under the existing environmental protection program, which is engaged substantively during the remedial design process, and integrated fully into work planning and execution. No difficulty is anticipated in complying with these action- and location-specific ARARs. ARARs are listed in Appendix C.

Long-Term Effectiveness and Permanence: Alternative 3 vitrifies all media within 8.5 m (28 ft) of the finished ground surface that has COC concentrations exceeding the RBCs. This eliminates all unacceptable levels of risk to the industrial site construction worker. The risk assessment determined that no unacceptable risk is posed to the future driller population, but did identify unacceptable levels of risk to the hypothetical residential farmer population. That risk would be reduced, and the exposure pathway mitigated to an extent, but the level of risk still would exceed acceptable levels. The expanded SVE system enhances long-term protectiveness of groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative 3 uses treatment (ISV) to reduce the consequences of direct contact with radionuclides. Convection that occurs within the melt will result in a fairly consistent activity level for the three COCs through each melt, so the highest concentrations are reduced. Also, the mobility (e.g., leachability into garden soils, or transport to groundwater) of the radionuclides is greatly reduced by vitrification. The glass form is very stable and is expected to retain its properties for the duration of the potential risk posed by the radiologically contaminated soils.

Alternative 3 at the 216-Z-1A Tiled Field also employs SVE to reduce the mass of CCl_4 in site soils. However, CCl_4 it is not a COC; it was carried forward as a COPC warranting action.

Short-Term Effectiveness: The current risk to human health posed by the subsurface radionuclides is effectively mitigated by the existing soil overburden and institutional controls. Any potential threat to groundwater posed by CCl_4 (CCl_4 is not a COC at this site) is addressed through ongoing operation of the SVE system. Short-term risks of significance are related to potential for remedial-action worker radiological exposures during installation of the ten new SVE wells. More moderate risks are posed to workers and the environment by implementation of the ISV activities and operation of the SVE system. Decommissioning of the numerous wells currently located within the footprint of the 216-Z-1A Tile Field will pose relatively minor risk to the workers and the environment. All identified short-term risks would be mitigated by current worker protection and environmental protection programs.

Implementability: Expansion of the SVE system is readily implemented. For ISV, all equipment, services, and skilled personnel are readily available. However, although the GeoMelt SPV process is conceptually an ideal remedial technology in many respects, it is a more complex process than the others considered. That, in combination with fairly widespread knowledge of the problems encountered during earlier top-down melts (the old technology), may hinder acceptance and thus, implementability. Substantial effort may be necessary to educate those unfamiliar with the current technology (GeoMelt SPV) to gain acceptance, and limit the need for substantial precursor activities (e.g., treatability studies or proof-of-concept testing). Because ISV is an intrusive activity, this alternative would require a relatively significant level of effort to address nuclear safety issues (Section 5.1.2.1.5) before implementation.

Cost: Total costs for Alternative 3 are estimated at $356,819,181; see Appendix D for further details.

6.2.6 Alternative 4 – Partial Removal, Treatment, and Disposal Plus Expanded Soil-Vapor Extraction

In addition to institutional controls and monitoring, expansion and continued operation of the SVE system, decommissioning of the wells within the tile field footprint, and groundwater monitoring (Section 6.2.1), Alternative 4 at the 216-Z-1A Tile Field would include excavation, removal, and treatment of a portion of the radiologically contaminated soils. The excavation would target soils directly below the base of the original tile field excavation to a depth of about 6.1 m (20 ft) below the top of the tile field (the equivalent of 8.5 m [28 ft] below the surrounding land surface). The base of the RTD excavation would be about 79 m (260 ft) long (north-south) and 30 m (100 ft) wide, centered on the central waste distribution pipeline.

A significant portion of the targeted soils would contain alpha-emitting transuranic isotopes with half-lives greater than 20 years at concentration exceeding 100 nCi/g, and may require storage at the CWC pending final designation and subsequent disposition to WIPP. Available analytical data indicate that treatment of the excavated soils would not be required to meet the waste-acceptance criteria at WIPP. Some potion of the excavated soils will designate as low-level waste or mixed low-level waste, and would be disposed at ERDF. Available data do not support meaningful calculation of the volume of waste destined for WIPP or ERDF. The remainder of the excavated soil, which did not designate as regulated waste, would be used for backfilling. The excavation would be backfilled to the elevation of the surrounding land surface,

providing 8.5 m (28 ft) of separation for soils containing COCs at concentrations exceeding the RBCs.

During implementation, engineered controls will be necessary for protection of human health and the environment. Excavation of soils that contain more than 100 nCi/g of transuranic materials having half-lives of more than 20 years will be performed inside a greenhouse, to mitigate the release of airborne contamination to the environment. Active excavation will be conducted under respiratory controls. The respiratory control threshold for alpha contamination is 3,000 pCi/g with water misting deployed as an engineered control. Additional evaluation will be necessary to determine if radiological controls will be required.

6.2.6.1 Contingency Plan

Assuming that sufficient characterization is conducted before implementation, and the activities are coordinated through the Hanford transuranic Waste Certification Program, no reasonable deviations were identified for the RTD portion of Alternative 4 at the 216-Z-1A Tile Field. A reasonable deviation from the SVE portion of Alternative 4 would be discovery of a CCl_4 source area. Contingent action that would address this discovery would include the following:

- Removal of the contaminated soils, treatment as necessary, and disposal, or
- More aggressive application of SVE, augmented with ERH as appropriate.

6.2.6.2 Environmental Monitoring

Environmental monitoring would consist of periodic groundwater monitoring conducted as part of the site-wide program, and soil vapor monitoring (Section 6.2.1).

6.2.6.3 Evaluation by Criteria

The following discussion considers Alternative 4 – Partial RTD plus Expanded SVE at the 216-Z-1A Tile Field with respect to the seven CERCLA criteria.

Overall Protection of Human Health and the Environment: This alternative would eliminate the direct-contact risk to the site construction worker by removing radiological contamination to a depth of 8.5 m (28 ft) below the finished ground surface. It also would enhance protectiveness of groundwater by removing CCl_4 vapors from the vadose zone to the effective limits of SVE technology. Remedial-action workers would incur high radiological exposure risks during installation of the ten new SVE wells, and while performing the RTD activities. All risks are manageable and can be addressed under existing Hanford Site worker and environmental protection programs.

Compliance with ARARs: Alternative 4 will incur ARARs for air emissions, waste management, and state waste discharge permit requirements when expanding and operating the SVE system; air emissions and waste management when excavating and managing soils; air emissions, waste management, and well construction and decommissioning requirements when installing and decommissioning SVE wells; fugitive dust control and protection of ecological receptors while backfilling the tile field; and sample analysis and waste management (including disposition of residual sample material) during sampling events. All work would be conducted

under the existing environmental protection program, which is engaged substantively during the remedial design process, and integrated fully into work planning and execution. No difficulty is anticipated in complying with these ARARs. ARARs are listed in Appendix C.

Long-Term Effectiveness and Permanence: The RTD alternative achieves long-term protectiveness by removing all contaminants that exceed the RBCs, down to a depth of 8.5 m (28 ft) below the final site surface. This eliminates the direct-contact risk to the site construction worker. The risk assessment determined that no unacceptable risk is posed to the future driller population, but did identify unacceptable levels of risk to the hypothetical residential farmer population. That risk would be reduced, but would still exceed acceptable levels. The expanded SVE system enhances long-term protectiveness of groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative 4 does not use treatment to address the identified COCs. It does employ SVE to reduce the mass of CCl_4 in soils at the 216-Z-1A Tile Field. However, CCl_4 was carried forward as a COPC warranting action; it is not a COC.

Short-Term Effectiveness: The current risk to human health posed by the subsurface radionuclides is effectively mitigated by the existing soil overburden and institutional controls. Any potential threat to groundwater posed by CCl_4 is addressed through ongoing operation of the SVE system. Short-term risks of significance are related to potential for remedial-action worker radiological exposures during installation of the ten new SVE wells and, most significantly, during active excavation and management of contaminated soils. Excavation and management of contaminated soils also would pose risks to the public and the environment, due to the potential for spread of contamination. Operation of the SVE system poses moderate risks to human health and the environment. Decommissioning of the numerous wells currently located within the footprint of the 216-Z-1A Tile Field will pose relatively minor risk to the workers and the environment. All identified short-term risks would be mitigated by current worker protection and environmental protection programs.

Implementability: Implementation of this alternative will require a significant level of effort. The work is not extremely challenging in the technical sense, with most of the activities being routine activities. However, at this scale, and with the large volumes of excavated soil that are expected to contain more than 100 nCi/g of transuranic isotopes will half-lives exceeding 20 years, and the relatively high radiological activities expected, integration and coordination of the various organizations and programs involved, as well as regulatory interface, will be challenging. Because RTD is an intrusive activity, this alternative would require a relatively significant level of effort to address nuclear safety issues (Section 5.1.2.1.5) before implementation.

Cost: Total costs for Alternative 4 are estimated at $418,806,585; see Appendix D for further details.

6.3 DETAILED ANALYSIS OF ALTERNATIVES FOR THE 216-Z-9 TRENCH

The only actionable risk (a risk requiring remedial action) identified at the 216-Z-9 Trench is a threat of future groundwater impacts posed by VOCs located at 19.8 m (65 ft) bgs beneath the southern end of the trench. This identified threat to groundwater currently is mitigated to some extent by (1) operation of the existing SVE system, which targets residual VOC vapors, and (2) reductions in the infiltration rate provided by the 216-Z-9 Trench cover and transpiration by indigenous plants. A final remedy is needed to specifically address the threat to groundwater. This section provides detailed analyses of the alternatives carried forward to address the threat to groundwater at the 216-Z-9 Trench.

The risk assessment (summarized in Sections 3.2 and 3.3) identified no unacceptable levels of risk to human health or potential ecological receptors under the industrial-site-use scenario. However, evaluation of unrestricted land-use scenarios showed unacceptable levels of risk to human health due to the potential for direct contact with radiologically contaminated soils at the site. Radiological contamination is identified in soils from the base of the trench to the CCU, with the highest concentrations being at the base of the trench. This potential risk does not drive remedial action, but it is considered during evaluation of the long-term protectiveness of each remedial alternative.

6.3.1 Detailed Analysis of Alternatives for the 216-Z-9 Trench

Six alternatives are considered for final remediation of the 216-Z-9 Trench. This section presents the detailed analysis of the following:

- Alternative 0 – No Action
- Alternative 1 – CDF plus Targeted SVE
- Alternative 2 – IPF plus Targeted SVE
- Alternative 3 – ISV plus Targeted SVE
- Alternative 4 – Partial RTD plus Targeted SVE.

6.3.1.1 Common Activities

Several activities are common to the activity-based alternatives listed here (excludes the No-Action Alternative). These activities are substantially the same for each alternative and are not expected to influence the selection of a preferred alternative. Therefore, implementation of these activities is not relevant to the comparison of these alternatives. Any notable variations will be addressed in the alternative description.

6.3.1.2 Institutional Controls and Monitoring

The 216-Z-9 Trench is within the IELUA. Each activity-based remedial alternative will include activities necessary to establish and maintain suitable institutional controls (Section 4.2.2.2) that would, at a minimum (1) ensure industrial use only, (2) restrict drilling and use of groundwater, and (3) limit access to areas of residual contamination and to structures or features that are part

of ongoing remedial actions. These controls would be implemented through the site-wide institutional controls plan, DOE/RL-2001-41.

In addition, each activity-based remedial alternative includes ongoing environmental monitoring and performance monitoring, as appropriate for the site. These monitoring activities will be site-specific to a large extent, because they will address the risks identified at the site and the remedy implemented. Specific monitoring plans will be developed in conjunction with the remedial design.

6.3.1.3 Revegetation

As discussed in Section 5.2.2.3, each activity-based alternative considered for the 216-Z-9 Trench would establish a sustainable population of suitable native plants at the site, intended to provide a sufficient level of transpiration to limit infiltration, thereby reducing the potential for transport of the VOCs to groundwater. Iterative evaluations using fate and transport modeling (Appendix E) showed that an infiltration rate of 13 mm/yr (0.5 in/yr) or less would mitigate transport to groundwater during the next 1,000 years. Water-balance studies on the Hanford Site have shown that vegetation and soil type control the downward movement of precipitation, and for finer-grained soils with a healthy plant cover of shrubs and grasses, net recharge is close to zero (PNNL-14702). Site-specific studies are warranted to support effective implementation of this action.

The FS assumes that the planted area would extend beyond the perimeter of the VOC source area by at least 16 m (50 ft), making it approximately 49 by 55 m (160 by 180 ft). The extension beyond would help protect against the lateral migration of infiltrating water. Once established, the plant population would require maintenance to ensure that it remained viable for the duration of the risk. As long as a suitable plant population is maintained, it is expected to mitigate the potential for infiltrating water to transport the VOCs to groundwater during the next 1,000 years.

6.3.1.4 Targeted Soil-Vapor Extraction

In addition, each activity-based alternative considered for the 216-Z-9 Trench would include expansion of the existing SVE system as discussed in Section 5.2.2.2. To ensure that the identified VOC source area is adequately targeted by the SVE system, three new extraction wells would be advanced into the VOC contaminant source area, each screened both above and below the silt layer at 19.8 m (65 ft) bgs. Also, the aging 500-ft^3/min blower would be replaced with a new dedicated 1,000-ft^3/min blower to ensure sufficient, reliable extraction capacity for the expanded well field. The actual number and configuration of new wells installed at the site, the capacity and configuration of the new blower, and the sufficiency of the existing treatment train and emission controls will be established during remedial design.

The FS assumes that the system will be operated 3 months a year (roughly the current annual operating time for the 216-Z-9 Trench well field), for a period of 10 years. In reality, the annual operating period for the 216-Z-9 Trench SVE system will vary as a function of several performance metrics (e.g., mass removal rate) and operational considerations (e.g., effect of ambient temperature on the amount of contaminated condensate generated). Periodic evaluation of these metrics will be used to support optimal system configuration and operation, and may dictate operating periods substantially greater than 3 months a year.

Additionally, in conjunction with the remedial design process, a specific set of performance metrics will be developed to help identify when SVE technology has reached the limits of its effectiveness at the site. Guidance provided in EPA/600/R-01/070 will be considered in developing this set of metrics and the associated performance monitoring plan, and in determining how to use those metrics to determine when SVE system operations should be terminated at the 216-Z-9 Trench.

6.3.1.5 Groundwater Monitoring

Each alternative, including the No-Action Alternative, would include groundwater monitoring to provide ongoing assessment for impacts from the waste site. Implementation of the site-wide groundwater monitoring requirements that are outlined in DOE/RL-89-12 and DOE/RL-91-50 is described in PNNL-11989. This plan includes a description of the monitoring well networks, constituents, sampling frequencies, and criteria used to design the monitoring program; identifies Federal and state groundwater monitoring requirements and regulations; and provides a list of wells, constituents, and sampling frequencies for groundwater monitoring conducted on the Hanford Site. Federal and state regulations include RCRA, CERCLA, and the *Washington Administrative Code*. Groundwater monitoring for groundwater OUs associated with the 200-PW-1, 200-PW-3, and 200-PW-6 OUs is incorporated and described in PNNL-SA-32196; thus, no new groundwater monitoring components are required. Any changes to the monitoring approach would be defined during the final design phase of the selected remedy.

6.3.2 Alternative 0 – No Action

As required by CERCLA (40 CFR 300.430[e][6]), the No-Action Alternative is carried forward as the baseline response. This alternative implements no institutional controls or remedies. It would include groundwater monitoring (Section 6.3.1.5) and administrative closeout of the current site controls.

6.3.2.1 Contingency Plan

The No-Action Alternative has no contingent actions.

6.3.2.2 Environmental Monitoring

Environmental monitoring under the No-Action Alternative would consist of periodic groundwater monitoring, conducted as part of the site-wide program, to assess for indications of VOC impacts from the source area (Section 6.3.1.5).

6.3.2.3 Evaluation by Criteria

The following discussion considers this alternative with respect to the seven CERCLA criteria.

<u>Evaluation Overall Protection of Human Health and the Environment</u>: This alternative does not eliminate or mitigate the identified risk, and thus fails to meet this criterion.

Compliance with ARARs: There are chemical-specific ARARs associated with CCl_4 concentrations in groundwater, and methodologies for deriving soil cleanup levels based on those ARARs. The derived soil cleanup level is considered an ARAR. The No-Action Alternative is not compliant with a soil cleanup levels calculated using the methodologies for deriving soil cleanup levels. Therefore, the No-Action Alternative is not compliant with ARARs. There are no location-specific ARARs for this site, and the No-Action Alternative has no action-specific ARARs.

Long-Term Effectiveness and Permanence: This alternative does not eliminate or mitigate the threat to groundwater. It does not employ treatment to reduce contaminant toxicity, mobility, or volume, and although natural attenuation processes that will slowly reduce the contaminant mass, it will not do so in time to eliminate the projected impact to groundwater. The No-Action Alternative does not meet this criterion.

Reduction of Toxicity, Mobility, or Volume through Treatment: The No-Action Alternative does not employ treatment technology.

Short-Term Effectiveness: Because there are no actions associated with this alternative, it poses no additional short-term risks to human health or the environment. However, because it does not achieve protectiveness in a reasonable period of time, it does not meet this criterion.

Implementability: The only difficultly encountered in implementing this alternative would be difficulty in obtaining the necessary regulatory approval. Probability of obtaining this approval is very low; therefore, this alternative is most likely not implementable.

Cost: Costs associated with this alternative are nominal, covering the activities necessary to complete administrative closeout of the existing controls. Costs for implementing no action are very small. Therefore, for the purposes of the FS, costs for the No-Action Alternative are assigned a value of $0. The value of costs assigned to the No-Action Alternative will not affect balancing criteria because the relative cost for the No-Action Alternative is the same for all of the representative waste sites.

6.3.3 Alternative 1 – Controlled-Density Fill Plus Targeted Soil-Vapor Extraction

In addition to implementing institutional controls and monitoring (Section 6.3.1.2), revegetation to control infiltration (Section 6.3.1.3), targeted SVE to capture and treat VOCs from the vadose zone (Section 6.3.1.4), and groundwater monitoring (Section 6.3.1.5), Alternative 1 would backfill the trench with CDF to impede inadvertent intrusion.

As discussed in Section 5.2.3.1, the 216-Z-9 Trench cover and columns would be left in place, and the trench void space would be filled with CDF, a flowable, self-leveling, self-compacting cement product (Section 4.2.2.3.2). The CDF would stabilize the cover. It also would help to control human intrusion. A reasonable person who excavated or drilled through the concrete cover and several feet of CDF could be expected to notice that they had encountered abnormal conditions that may warrant care. CDF formulation can be varied to enhance its ability to

impede human and biological intrusion. Appropriate formulation of the CDF, and considerations regarding compatibility with the contaminated soil, would be addressed during remedial design.

6.3.3.1 Contingency Plan

Two reasonable deviations from the anticipated outcome were identified. The first would be that the existing SVE system would not be able to make sufficient reductions in the VOC contaminant mass in the source zone. The second would be a determination, through soil moisture measurements, that the established plant community was not adequately controlling infiltration.

Contingent actions could include the following:

- A more aggressive SVE approach (more wells, expanded operating periods) to increase the VOC mass removed
- Application of ERH technology (Section 4.2.2.6.4) to enhance volatilization of VOCs in the source area, and increase the effectiveness of the SVE system
- Application of dry air barrier technology (Section 4.2.2.4.4) to further impede infiltration, and potentially augment SVE operations by increasing airflow adjacent to the source area (the injection of heated air, which may accelerate volatilization and abiotic degradation, also would be considered)
- Installation of a monofill ET barrier (Section 4.2.2.3.1) to further limit infiltration.

6.3.3.2 Environmental Monitoring

In addition to groundwater monitoring (Section 6.3.1.5), SVE wells and soil vapor monitoring wells in the vicinity of the source area would be sampled to quantify VOC mass removal, vapor concentrations, and moisture levels. The frequency of vapor sampling will vary, depending on conditions and project needs, but will support reporting for the CERCLA 5-year review process. Vapor monitoring would document progress toward the remedial goal, triggering contingent actions if appropriate, and triggering confirmatory sampling when it appears that the remedial goal has been achieved.

6.3.3.3 Evaluation by Criteria

The following discussion considers Alternative 1 – CDF Plus Targeted SVE with respect to the seven CERCLA criteria.

Overall Protection of Human Health and the Environment: At the 216-Z-9 Trench, Alternative 1 uses treatment (specifically the SVE system) to reduce the volume and mobility of the three VOCs identified as COCs due to the threat they pose to groundwater. Infiltration is controlled in a fairly sustainable manner (native plants), mitigating contaminant transport. Short-term risks, most significant for workers installing the three new SVE wells, are readily mitigated. Potential long-term risks (under the hypothetical unrestricted land-use scenarios) are reduced by leaving the concrete trench cover in place and filling the trench void space with CDF, both of which have

some ability to physically impede intrusion, and to serve as visual cues to abnormal subsurface conditions. Time to attainment of the RAO (protection of groundwater) is not readily calculated, due to uncertainties regarding the effectiveness of the SVE system.

Compliance with ARARs: There are chemical-specific ARARs associated with the three targeted VOCs in groundwater (drinking water MCLs). Alternative 1 mitigates the risk to groundwater by controlling infiltration with a suitable plant population, and uses the existing SVE system, and potentially MNA, to reduce contaminant mass. The active SVE system will be operated until it is no longer effective. Passive SVE wells will continue to remove contaminant mass after the active system is decommissioned. The impact of MNA processes on the three VOCs is not yet quantified sufficiently to determine whether it will be an effective mechanism for contaminant mass reduction.

The FS assumes readily achievable compliance with the operations-related ARARs pertaining to operation of the SVE system, based on the compliant operation of the current SVE system. In addition to these, Alternative 1 will incur ARARs for air emissions and waste management when stabilizing the 216-Z-9 Trench with CDF; protection of cultural resources and ecological receptors when preparing and revegetating the surface soils; air emissions, waste management, and well-decommissioning requirements during the future decommissioning of the existing SVE system; and sample analysis and waste management (including disposition of residual sample material) during sampling events. Work would be conducted under the existing environmental protection program, which is engaged substantively during the remedial design process, and integrated fully into work planning and execution. No difficulty is anticipated in complying with these action- and location-specific ARARs. ARARs are listed in Appendix C.

Long-Term Effectiveness and Permanence: On completion of SVE operations, residual VOCs will be tightly held in the fine-grained soils, and due to the reduced infiltration rate achieved by vegetating the site surface, will have limited opportunity for transport to groundwater over the next 1,000 years. This alternative provides long-term protectiveness of groundwater.

In addition, by retaining the concrete cover and backfilling the trench with CDF, this alternative reduces the probability of direct contact with radionuclide contaminated soils, especially those immediately beneath the trench. This alternative includes no process to reduce the impact of direct contact with the contaminated media if the CDF is breached. CDF formulation will be determined during remedial design; formulation will focus on containing the contaminants at depth, physically impeding human intrusion and biointrusion, and providing visual cues to alert inadvertent intruders.

Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative 1 uses SVE and an existing surface-based treatment system to reduce the volume and mobility of the three VOCs that pose a threat to groundwater.

It includes no treatment process to address the toxicity, mobility, or volume of the radionuclide contaminants that would pose an unacceptable risk to the hypothetical maximally exposed population under unrestricted land-use scenarios.

Short-Term Effectiveness: Alternative 1 presents relatively minor short-term risks. Radiological exposure risks are incurred by the workers pouring CDF into the 216-Z-9 Trench. Operation of the SVE system poses moderate risks to workers, the public, and the environment associated with system operation and waste-management activities. All are readily addressed by existing worker protection and environmental protection programs.

Implementability: The remedial actions under this alternative are readily implemented, presenting no significant technical challenges. With the exception of establishing a new plant population, all activities targeting the VOCs already are in progress. Backfilling the 216-Z-9 Trench, conducted to reduce the likelihood of potential risks to human health in the future, presents direct-contact risks to workers and poses a risk of spreading contamination. These concerns are readily addressed by existing worker protection and environmental protection programs. No significant administrative challenges are apparent.

Cost: The total estimated cost for filling in the 216-Z-9 Trench with CDF and annual monitoring is $4,706,371; see Appendix D for further details.

6.3.4 Alternative 2 – Intrusion-Prevention Feature Plus Targeted Soil-Vapor Extraction

In addition to implementing institutional controls and monitoring (Section 6.3.1.2), revegetation to control infiltration (Section 6.3.1.3), targeted SVE to capture and treat VOCs from the vadose zone (Section 6.3.1.4), and groundwater monitoring (Section 6.3.1.5), Alternative 2 for the 216-Z-9 Trench would include construction of an IPF to limit the potential for inadvertent intrusion into the radionuclide-contaminated soils at the base of the trench.

As discussed in Section 5.2.3.2, the concrete cover and concrete columns would be removed and the disposed of at ERDF, and then the IPF would be constructed within the trench. The actual design would be determined during remedial design. For the purposes of the FS, the IPF is assumed to be a 3 m (10-ft) layer of coarse fractured basalt with no fine-grained interstitial materials. The basalt would be overlain by materials intended to limit infiltration of finer-grained material into the interstitial spaces of the basalt. The coarse fractured basalt is an effective barrier to burrowing, digging, and well drilling. It also creates a dry rocky environment that is not conducive to root penetration. The IPF would be covered with soil to support revegetation to facilitate ET.

6.3.4.1 Contingency Plan

For Alternative 2, reasonable deviations from the anticipated outcome, and the associated contingent actions, are the same as those identified for Alternative 1. The reader is referred to Section 6.3.3.1 for that discussion.

6.3.4.2 Environmental Monitoring

In addition to groundwater monitoring (Section 6.3.1.5), SVE wells and soil vapor monitoring wells in the vicinity of the source area would be sampled to quantify VOC mass removal, vapor concentrations, and moisture levels. The frequency of vapor sampling will vary, depending on

conditions and project needs, but will support reporting for the CERCLA 5-year review process. Vapor monitoring would document progress toward the remedial goal, triggering contingent actions if appropriate, and triggering confirmatory sampling when it appears that the remedial goal has been achieved.

6.3.4.3 Evaluation by Criteria

The following discussion considers Alternative 2 – IPF plus Targeted SVE with respect to the seven CERCLA criteria.

Overall Protection of Human Health and the Environment: Alternative 2 uses plants to control infiltration and mitigate the threat to groundwater (the only condition identified that requires remediation). It also uses treatment (SVE plus GAC) to reduce the volume and mobility of the VOCs of concern. Short-term risks to the worker, public, and environment are readily controlled. Time to attainment of RAOs is not easily determined due to uncertainties regarding the capability of the SVE system to sufficiently reduce VOC contaminant mass under current site conditions. The pathway to groundwater remains controlled until the RAO is achieved. Potential human-health risks that would exist under a unrestricted land-use scenario are mitigated by impeding access to highly contaminated soils at the base of the trench. Remedial-action workers incur moderate to high short-term risks while installing new SVE wells and working within the 216-Z-9 Trench due to the potential for direct contact with high concentrations of alpha-emitting radionuclides in the soils.

Compliance with ARARs: There are chemical-specific ARARs (the drinking-water MCLs) associated with the concentration of the three targeted VOCs in groundwater. Alternative 2 achieves protectiveness through the following actions. The threat to groundwater is mitigated by controlling infiltration with a suitable plant population, and implementing targeted SVE actions to reduce VOC concentrations to levels that pose no threat.

The FS assumes effective compliance with the ARARs pertaining to operation of the SVE system. In addition to these, Alternative 2 will incur ARARs for air emissions and waste management when removing the 216-Z-9 Trench cover and columns and constructing the IPF; protection of cultural resources and ecological receptors when preparing and revegetating the surface soils; air emissions, waste management, and well-decommissioning requirements during the future decommissioning of the existing SVE system; and sample analysis and waste management (including disposition of residual sample material) during sampling events. All work would be conducted under the existing environmental protection program, which would employ the remedial design process, and integrated fully into work planning and execution. No difficulty is anticipated in complying with these action- and location-specific ARARs. ARARs are listed in Appendix C.

Long-Term Effectiveness and Permanence: On completion of SVE operations, residual VOCs will be tightly held in the fine-grained soils, and due to the reduced infiltration rate achieved by vegetating the site surface, will have limited opportunity for transport to groundwater over the next 1,000 years. Until ARARs are attained, continued maintenance of the plant population will ensure long-term protectiveness of groundwater.

In addition, the IPF will significantly impede, although not preclude, physical access to the most highly contaminated soils, found immediately beneath the trench floor. This alternative includes no process to reduce the impact of direct contact with the contaminated media if the IPF is breached or circumvented. The type and configuration of the IPF will be determined in remedial design.

Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative 2 uses SVE and an existing surface-based treatment system to reduce the volume and mobility of the three VOCs that pose a threat to groundwater. It includes no treatment process to address the toxicity, mobility, or volume of the radionuclide contaminants that would pose an unacceptable risk to the hypothetical maximally exposed population (the residential farmer population) under unrestricted land-use scenarios.

Short-Term Effectiveness: Mitigation of the threat to groundwater is achieved fairly rapidly once the plant population is established. Alternative 2 presents moderate to high radiological exposure risks to the workers that install the new SVE wells, and those that remove the trench cover and columns and install the IPF in the trench, due to the potential for direct contact with soils containing high concentrations of alpha-emitting radionuclides. Operation of the SVE system poses moderate risks to workers, the public, and the environment associated with system operation and waste-management activities. All identified risks are readily addressed by existing worker protection and environmental protection programs.

Implementability: The remedial actions under this alternative are readily implemented, presenting no significant technical or health and safety challenges. No significant administrative challenges are apparent.

Cost: Total costs for Alternative 2 at the 216-Z-9 Trench are estimated at $4,740,027; see Appendix D for further details.

6.3.5 Alternative 3 – In Situ Vitrification Plus Targeted Soil-Vapor Extraction

In addition to implementing institutional controls and monitoring (Section 6.3.1.2), revegetation to control infiltration (Section 6.3.1.3), targeted SVE to capture and treat VOCs from the vadose zone (Section 6.3.1.4), and groundwater monitoring (Section 6.3.1.5), Alternative 3 would vitrify the soils beneath the floor of the 216-Z-9 Trench.

As discussed in Section 5.2.3.4, three contiguous melts would target the uppermost 4.6 m (15 ft) of soil beneath the trench floor. The result would be a contiguous glass monolith that had the lateral dimensions of the trench floor, and was approximately 3.7 m (12 ft) thick. The top of the glass monolith would be about 7.3 m (24 ft) bgs, and it would be overlain with clean backfill, added to bring the trench back to grade.

6.3.5.1 Contingency Plan

For the SVE components of Alternative 3, reasonable deviations from the anticipated outcome, and the associated contingent actions, are the same as those identified for Alternative 1. The

reader is referred to Section 6.3.3.1 for that discussion. In addition, deviations from the anticipated results of the ISV activity might be addressed by constructing an IPF in the trench, to further impede intrusion.

6.3.5.2 Environmental Monitoring

In addition to groundwater monitoring (Section 6.3.1.5), SVE wells and soil vapor monitoring wells in the vicinity of the source area would be sampled to quantify VOC mass removal, vapor concentrations, and moisture levels. The frequency of vapor sampling will vary, depending on conditions and project needs, but will support reporting for the CERCLA 5-year review process. Vapor monitoring would document progress toward the remedial goal, triggering contingent actions if appropriate, and triggering confirmatory sampling when it appears that the remedial goal has been achieved.

6.3.5.3 Evaluation by Criteria

The following discussion considers this alternative with respect to the seven CERCLA criteria.

Overall Protection of Human Health and the Environment: Alternative 3 uses plants to control infiltration and mitigate the threat to groundwater (the only condition identified that requires remediation). It also uses treatment (SVE plus GAC) to reduce the volume and mobility of the VOCs of concern. Short-term risks to the worker, public, and environment are readily controlled. Time to attainment of RAOs is not easily determined due to uncertainties regarding the capability of the SVE system to sufficiently reduce VOC contaminant mass under current site conditions. The pathway to groundwater remains controlled until the RAO is achieved. Vitrification of the soils at the base of the trench provides substantial mitigation of the potential human-health risks that would exist under a unrestricted land-use scenario, reducing the consequences of direct contact with uppermost soils (alpha and beta emitters encapsulated in glass) and impeding access to the deeper, untreated soils. Remedial-action workers incur moderate to high short-term radiological exposure risks while installing new SVE wells and moderate radiological exposure risks when performing vitrification-related activities within the trench (due to the potential for direct contact with high concentrations of alpha-emitting transuranic isotopes in the soils), and lesser risks performing waste-management activities. All risks are readily mitigated under existing Hanford Site worker and environmental protection programs.

Compliance with ARARs: There are chemical-specific ARARs (drinking water MCLs) associated with the concentration of the three targeted VOCs in groundwater. Alternative 3 achieves protectiveness through the following actions. The threat to groundwater is mitigated by controlling infiltration with a suitable plant population, and implementing targeted SVE actions to reduce VOC concentrations to levels that pose no threat.

The FS assumes effective compliance with the ARARs pertaining to operation of the existing SVE system. In addition to these, Alternative 3 will incur ARARs for air emissions and waste management when removing the 216-Z-9 Trench cover and columns and implementing the ISV process; protection of cultural resources and ecological receptors when preparing and revegetating the surface soils; air emissions, waste management, and well construction and decommissioning requirements during the expansion, operation, and decommissioning of the

existing SVE system; and sample analysis and waste management (including disposition of residual sample material) during sampling events. All work would be conducted under the existing environmental protection program, which would be employed during the remedial design process, and integrated fully into work planning and execution. No difficulty is anticipated in complying with these action- and location-specific ARARs. ARARs are listed in Appendix C.

Long-Term Effectiveness and Permanence: On completion of SVE operations, residual VOCs will be tightly held in the fine-grained soils, and due to the reduced infiltration rate achieved by vegetating the site surface, will have limited opportunity for transport to groundwater over the next 1,000 years. Until ARARs are attained, continued maintenance of the plant population will ensure long-term protectiveness of groundwater.

In addition, vitrification of the soils at the trench base provides a significant reduction in the potential human-health risks that would exist under an unrestricted land-use scenario. Vitrification encapsulates the alpha and beta emitters in glass, which greatly reduces the likelihood and consequences of exposure. The thick glass monolith extending the entire length and width of the trench floor also will impede intrusion into the residual contamination at depth.

Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative 3 uses SVE and an existing surface-based treatment system to reduce the volume and mobility of the three VOCs that pose a threat to groundwater.

The dose consequences of direct contact with radionuclides are reduced by vitrification. Also, the mobility (i.e., leachability into garden soils) of the radionuclides essentially is eliminated by vitrification. The glass form is very stable and is expected to retain its properties for the duration of the potential risk posed by the radiologically contaminated soils.

Short-Term Effectiveness: Mitigation of the threat to groundwater is achieved fairly rapidly once the plant population is established. Alternative 3 presents moderate to high radiological exposure risks to the workers that install the new SVE wells, and moderate risks to those that implement the ISV process, due to the potential for direct contact with soils having high concentrations of alpha emitters. Operation of the SVE system poses ongoing risks to workers, the public, and the environment associated with system operation and waste-management activities. All identified risks are readily addressed by existing worker protection and environmental protection programs.

Implementability: SVE is readily implemented, presenting no significant technical or health and safety challenges. For ISV, all equipment, services, and skilled personnel are readily available. However, although the SPV is conceptually an ideal remedial technology in many respects, it is a more complex process than the others considered. That, in combination with fairly widespread knowledge of the problems encountered during earlier top-down melts (the old technology), may hinder acceptance and thus, implementability. Substantial effort may be necessary to educate those unfamiliar with the current technology (GeoMelt SPV) to gain acceptance, and limit the need for substantial precursor activities (e.g., treatability studies or proof-of-concept testing). The level of effort necessary to address nuclear safety concerns (Section 5.2.4.1.5), and the

associated costs, is not expected to differ significantly among the identified remedial alternatives for the 216-Z-9 Trench.

Cost: Total costs for Alternative 3 are estimated at $26,951,350; see Appendix D for further details.

6.3.6 Alternative 4 – Partial Removal, Treatment, and Disposal Plus Targeted Soil-Vapor Extraction

In addition to implementing institutional controls and monitoring (Section 6.3.1.2), revegetation to control infiltration (Section 6.3.1.3), targeted SVE to capture and treat VOCs from the vadose zone (Section 6.3.1.4), and groundwater monitoring (Section 6.3.1.5), Alternative 4 would remove, treat as necessary, and dispose of highly contaminated soils located immediately below the floor of the 216-Z-9 Trench.

To specifically address the potential risks to the hypothetical maximally exposed population (the residential farmer population), Alternative 4 would remove, treat, and dispose of the upper 3 m (10 ft) of contaminated soil at the base of the trench, and then construct an IPF in the excavation to impede intrusion into the residual contaminants. This activity would include removal and disposal of the concrete pad that covers the trench as well as the six concrete support columns; these would be disposed to ERDF. Then, the top 3 m (10 ft) of soil beneath the trench floor would be excavated, treated as necessary to facilitate disposal, and disposed. Once RTD activities were completed, an IPF (see Alternative 2, Section 6.3.4) would be constructed within the trench, and then the trench would be backfilled to grade.

Contaminants that would pose the primary risk to the residential farmer population are Pu-239/240 and Am-241, both alpha emitters. Sample analysis (ARH-2915) revealed that Pu-239 and Am-241 have an average combined activity in the first 1.5 m (5 ft) in excess of 6,000,000 pCi/g (average excludes the outlier, a single sample with combined activity of approximately 450,000,000 pCi/g). All soil samples collected at the base of the trench (ARH-2915, samples collected to 2.7 m [9 ft] below the trench base) had concentrations of transuranic isotopes that exceeded 100 nCi/g by at least one order of magnitude.

The lateral spread of contamination near the base of the trench has not been fully delineated. For the purposes of the FS, contamination is assumed to have moved vertically with no lateral spreading in the soils targeted for excavation (Figure 5-2). Thus, the contaminated soils excavated would have in situ dimensions of 19.1 by 18.3 by 3.0 m (30 by 60 by 10 ft). If it was necessary to layback the excavation sidewalls, the excavation may encroach on two wells adjacent to the trench, 299-W15-46 and 299-W15-48, making it necessary to decommission both.

Based on the sampling from the 216-Z-9 Trench (ARH-2915), all soil excavated between the trench floor and the base of the excavation is expected to contain alpha-emitting transuranic isotopes with half-lives greater than 20 years at concentrations exceeding 100 nCi/g. Appendix D addresses anticipated excavation volumes and waste volumes. Activities that may generate transuranic waste must be planned and implemented in coordination with the Hanford Transuranic Waste Certification Program, to ensure that such wastes are minimized and, once

generated, are properly packaged, managed, and dispositioned. All transuranic waste generated will be disposed of off site at WIPP near Carlsbad, New Mexico. Substantive and administrative requirements will apply. The transuranic waste generated during this remedial action will meet the WIPP waste acceptance criteria if packaging requirements are met.

Engineered controls will be necessary for protection of human health and the environment. Excavation of soils that contain more than 100 nCi/g of transuranic materials having half-lives of more than 20 years will be performed inside a greenhouse, to mitigate the release of airborne contamination to the environment. Active excavation will be conducted under respiratory controls. The respiratory control threshold for alpha contamination is 3,000 pCi/g with water misting deployed as an engineered control. Soils excavated beneath the trench floor will exceed this threshold by orders of magnitude. Also, because the average activity of the primary contributor to dose, Am-241, exceeds 346,000 pCi/g, the whole-body dose rate at 30 cm (12 in.) from the soil surface will exceed 5 mrem/h, so radiological controls will be required.

6.3.6.1 Contingency Plan

Two reasonable deviations were identified with respect to activities performed to protect groundwater. The first would be that the SVE system would not be able to make significant reductions in the contaminant mass in the VOC contaminant source zone. The second deviation would be a determination, through soil moisture measurements, that the plant community was not adequately controlling infiltration. These deviations and the associated contingent actions are the same as those identified under Alternative 1. The reader is referred to Section 6.3.3.1 for that discussion.

Reasonable deviations from the anticipated results of the partial RTD activity might be discovery of significant lateral spread of high levels of radiological contamination immediately beneath the trench. The contingent action would be to expand the boundaries of the excavation to allow removal of the additional contaminated media. The decision to extend the excavation and the revised planning would be done in conjunction with the Hanford Transuranic Waste Certification Program.

6.3.6.2 Environmental Monitoring

In addition to groundwater monitoring (Section 6.3.1.5), SVE wells and soil vapor monitoring wells in the vicinity of the source area would be sampled to quantify VOC mass removal, vapor concentrations, and moisture levels. The frequency of vapor sampling will vary, depending on conditions and project needs, but will support reporting for the CERCLA 5-year review process. Vapor monitoring would document progress toward the remedial goal, triggering contingent actions if appropriate, and triggering confirmatory sampling when it appears that the remedial goal has been achieved.

6.3.6.3 Evaluation by Criteria

The following discussion considers this alternative with respect to the seven CERCLA criteria.

Overall Protection of Human Health and the Environment: Alternative 4 uses plants to control infiltration and mitigate the threat to groundwater (the only condition identified that requires remediation). It also uses treatment (SVE plus GAC) to reduce the volume and mobility of the VOCs of concern. Short-term risks to the worker, public, and environment are readily controlled. Time to attainment of RAOs is not easily determined due to uncertainties regarding the capability of the SVE system to sufficiently reduce VOC contaminant mass under current site conditions. The pathway to groundwater remains controlled until the RAO is achieved.

Partial RTD reduces, but does not eliminate, the magnitude of potential human-health risks that would exist under a unrestricted land-use scenario, by removing the most highly contaminated soils at the site and by providing an additional 3 m (10 ft) of separation between the contaminants and potential human receptors. Installation of an IPF within the trench after the RTD was completed would further reduce the potential for inadvertent intrusion. However, if the IPF were breached, the human-health risk to the hypothetical maximally exposed population still would exceed the CERCLA threshold of 1×10^{-4}.

Remedial-action workers would incur moderate to high short-term risks while installing new SVE wells, and high to very high levels of risk while performing the RTD activities, due to the potential for exposure to alpha-emitting radioisotopes. The risks are manageable and can be addressed under existing Hanford Site worker and environmental protection programs.

Compliance with ARARs: There are chemical-specific ARARs (drinking water MCLs) associated with the concentration of the three targeted VOCs in groundwater. Alternative 4 achieves protectiveness through the following actions. The threat to groundwater is mitigated by controlling infiltration with a suitable plant population, and implementing targeted SVE actions to reduce VOC concentrations to levels that pose no threat.

The FS assumes effective compliance with the ARARs pertaining to operation of the existing SVE system. In addition to these, Alternative 4 will incur ARARs for air emissions and waste management when removing the 216-Z-9 Trench cover and columns and soil, and when constructing the IPF; protection of cultural resources and ecological receptors when preparing and revegetating the surface soils; air emissions, waste management, well construction, and well-decommissioning requirements when expanding, operating, and decommissioning the SVE system; and sample analysis and waste management (including disposition of residual sample material) during sampling events. Work would be conducted under the existing environmental protection program, which would be employed during the remedial design process, and integrated fully into work planning and execution. No difficulty is anticipated in complying with these action- and location-specific ARARs. ARARs are listed in Appendix C.

Long-Term Effectiveness and Permanence: On completion of the SVE phase, residual VOCs will be tightly held in the fine-grained soils, and due to the reduced infiltration rate achieved by vegetating the site surface, will have limited opportunity for transport to groundwater over the next 1,000 years. Until ARARs are attained, continued maintenance of the plant population will ensure long-term protectiveness of groundwater.

In addition, RTD of 1.5 m (5 ft) of highly contaminated soil from the trench base, and construction of an IPF within the trench, will provide a significant reduction in the potential

human-health risks that would exist under an unrestricted land-use scenario. However, the human-health risk to the hypothetical maximally exposed population still would exceed the CERCLA threshold of 1×10^{-4}.

Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative 4 uses SVE and an existing surface-based treatment system to reduce the volume and mobility of the three VOCs that pose a threat to groundwater.

RTD and the IPF do not constitute treatment processes.

Short-Term Effectiveness: Mitigation of the threat to groundwater is achieved fairly rapidly once the plant population is established. Alternative 4 presents moderate to high radiological exposure risks to the workers that install the new SVE wells, and high risk to those that implement the RTD process. Operation of the SVE system poses minimal risks to workers, the public, and the environment associated with system operation and waste management activities. Identified risks are readily addressed by existing worker protection and environmental protection programs.

Implementability: SVE is readily implemented, presenting no significant technical or health and safety challenges. RTD activities and installation of the IPF will have significant worker safety and environmental protection controls, so implementation will be more challenging than previous alternatives, but can be managed. No significant administrative challenges are apparent.

Cost: Total costs for Alternative 4 are estimated at $28,258,025; see Appendix D for further details.

6.4 DETAILED ANALYSIS OF ALTERNATIVES FOR THE 216-A-8 CRIB

The RI Report (DOE/RL-2006-51) identified significant Cs-137 contamination at the 216-A-8 Crib. Geophysical logging in Borehole C4545 during 2005 showed high Cs-137 activities between 3.4 and 22.3 m (11 and 73 ft) bgs, with a maximum of 1.5×10^6 pCi/g identified at 6.1 m (20 ft) bgs. Soil sampling at Borehole C4545 in 2005 showed a maximum concentration of 877,000 pCi/g in a sample collected from the interval between 5.8 and 6.6 m (19 and 21.5 ft) bgs. It also identified a maximum of 79.6 pCi/g of Tc-99, also collected from the interval between 5.8 and 6.6 m (19 and 21.5 ft) bgs. Sample depths reflect the depth below the top of a 0.6 m (2-ft) thick soil stabilization cover emplaced in 1990. Section 2.5 discusses the site characterization in more detail. The contaminant distribution model is presented in Figure 2-6.

The risk assessment process, discussed in Section 3.2, determined that Cs-137 posed an unacceptable level of risk to human health, based on the industrial site construction worker scenario. The risk assessment process derived a Cs-137 RBC of 1,228 pCi/g; contaminant concentrations exceeding this RBC were detected in Borehole C4545 from approximately 3.3 to 6.6 m (11 to 21.5 ft) bgs (based on soil analyses and geophysical logging). Using the relationship between analytical data and gamma logs from Borehole C4545 (RI Report, DOE/RL-2006-51) as a guide, the FS conservatively assumes that the minimum depth to

actionable levels of Cs-137 is 3 m (10 ft) bgs, and that the highest level of activity in the upper 4.6 m (15 ft) is 50,000 pCi/g. Cesium-137 has a half-life of approximately 30 years. By the year 2150, the Cs-137 will have decayed through approximately five half-lives, only 3 percent of the contaminant mass will remain, and Cs-137 concentrations in the upper 4.6 m (15 ft) of the site will have dropped below the RBC (see Figure 6-1). Risk levels posed by the highest levels of Cs-137 at the site, currently shown to be roughly 6.1 m (20 ft) bgs, will have been reduced to approximately 1×10^{-3}, and would be reduced to acceptable levels by radioactive decay processes during the subsequent 100 years (by the year 2250).

Fate and transport modeling indicates that Tc-99 in soil beneath the 216-A-8 Crib may migrate to groundwater in concentrations above MCLs (Appendix E). Additional soil sampling is needed to estimate the mass of Tc-99 present in the vadose zone so that the potential impact of this tentatively identified COC can be better defined. In addition, as part of the remedy for this crib, groundwater monitoring will be used to assess if the Tc-99 will migrate through the vadose zone after implementation of the preferred remedy at this crib. The results of future groundwater monitoring will be evaluated in a risk assessment to determine the need to take action for this COC at this crib. Action will be taken to mitigate this potential risk while the additional evaluation is performed.

The assessment of human-health risks under the industrial-use only scenario identified no unacceptable levels of risk to human health associated with nonradionuclides.

Thus, as summarized in Table 5-8, formal assessment of the risks associated with the 216-A-8 Crib identified a direct-contact risk associated with Cs-137, and a potential threat to groundwater posed by Tc-99. In addition, an evaluation of risks posed to hypothetical future populations under unrestricted land-use scenarios determined that Cs-137 risks to the future driller population would be acceptable, but that risks to the residential farmer population would exceed 1×10^{-4}. The following sections discuss remedial actions targeting the risk to the industrial site construction worker, grouped by GRA.

In comparing the alternatives, the FS does not consider the overflow area located at the northeast end of the crib. The overflow area has not been characterized, but its omission is not expected to affect the outcome of the FS process. Evaluation of the geophysical logs for the 216-A-8 Crib show that residual contaminant activity levels are the highest (by orders of magnitude) in the western portion of the crib. This is interpreted to indicate that the majority of discharges to the 216-A-8 Crib were at flow rates and volumes that were readily accommodated by the main portion of the crib, and that discharges would seldom if ever reach the overflow area.

The following alternatives were carried forward from Chapter 5.0 for detailed analysis.

- Alternative 0 – No Action
- Alternative 1 – Monofill ET Barrier
- Alternative 2 – Partial RTD.

6.4.1 Common Activities

Several actions are included in each of the activity-based remedial alternatives (i.e., all but the No-Action Alternative) developed for the 216-A-8 Crib. To limit redundancy, they are listed here and then referenced under each alternative.

6.4.1.1 Institutional Controls and Monitoring

The 216-A-8 Crib is within the IELUA. Each activity-based remedial alternative includes activities necessary to establish and maintain suitable institutional controls (Section 4.2.2.2) that would, at a minimum (1) ensure industrial use only, (2) restrict drilling and use of groundwater, and (3) limit access to areas of residual contamination and to structures or features that are part of ongoing remedial actions. These controls would be implemented through the site-wide institutional controls plan, DOE/RL-2001-41.

In addition, each activity-based remedial alternative includes ongoing environmental monitoring and performance monitoring, as appropriate for the site. These monitoring activities will be site-specific to a large extent, because they will address the risks identified at the site and the remedy implemented. Specific monitoring plans will be developed in conjunction with the remedial design.

6.4.1.2 Vadose Zone Well Decommissioning

For each of the activity-based alternatives, it would be necessary to decommission all wells that might be impacted by the action. Decommissioning would be conducted in accordance with the substantive requirements of the applicable portions of WAC 173-160.

6.4.1.3 Groundwater Monitoring

Each alternative, including the No-Action Alternative, would include groundwater monitoring to provide ongoing assessment for impacts from the waste site. Implementation of the site-wide groundwater monitoring requirements that are outlined in DOE/RL-89-12 and DOE/RL-91-50 is described in PNNL-11989. This plan includes a description of the monitoring well networks, constituents, sampling frequencies, and criteria used to design the monitoring program; identifies Federal and state groundwater monitoring requirements and regulations; and provides a list of wells, constituents, and sampling frequencies for groundwater monitoring conducted on the Hanford Site. Federal and state regulations include RCRA, CERCLA, and the *Washington Administrative Code*. Groundwater monitoring for groundwater OUs associated with the 200-PW-1, 200-PW-3, and 200-PW-6 OUs is incorporated and described in PNNL-SA-32196; thus, no new groundwater monitoring components are required. Any changes to the monitoring approach would be defined during the final design phase of the selected remedy.

Several activities are common to the activity-based alternatives for the 216-A-8 Crib. These activities are substantially the same for each alternative and are not expected to influence the selection of a preferred alternative. These activities include institutional controls, site-specific environmental and performance monitoring, decommissioning of vadose-zone wells within the footprint of the remedy, and groundwater monitoring. To limit redundancy, the reader is referred to the discussion of these common activities in Section 5.3.2.1.

6.4.2 Alternative 0 – No Action

As required by CERCLA (40 CFR 300.430[e][6], the No-Action Alternative is carried forward as the baseline response. This alternative implements no institutional controls or remedies. It would include groundwater monitoring (Section 6.4.1.2) and administrative closeout of the current site controls.

6.4.2.1 Contingency Plan

The No-Action Alternative has no contingent actions.

6.4.2.2 Environmental Monitoring

Environmental monitoring would consist of periodic groundwater monitoring conducted as part of the site-wide program (Section 6.4.1.3).

6.4.2.3 Evaluation by Criteria

The following discussion considers the 216-A-8 Crib No-Action Alternative with respect to the seven CERCLA criteria.

Overall Protection of Human Health and the Environment: This alternative does not eliminate or mitigate the identified risk, and thus fails to meet this criterion.

Compliance with ARARs: There are no chemical- or location-specific ARARs for this site, and the No-Action Alternative has no action-specific ARARs. However, because this alternative does not eliminate or mitigate the identified risk, it fails to comply with ARARs.

Long-Term Effectiveness and Permanence: The principal threat contaminant will decay, ultimately presenting no significant risk. The No-Action Alternative does not employ treatment to reduce contaminant toxicity, mobility, or volume, but does, in the end, achieve protectiveness and permanence. However, because the No-Action Alternative provides no post-remedy protectiveness in the interim, it does not meet this criterion.

Reduction of Toxicity, Mobility, or Volume through Treatment: The No-Action Alternative does not employ treatment technology.

Short-Term Effectiveness: Because there are no actions associated with this alternative, it poses no additional short-term risks to human health or the environment. However, the existing risk to site construction workers would not be mitigated. Therefore, the No-Action Alternative does not meet this criterion.

Implementability: The only difficultly encountered in implementing this alternative would be difficulty in obtaining the necessary regulatory approval. Probability of obtaining this approval is very low; therefore, this alternative is most likely not implementable.

Cost: Costs associated with this alternative are nominal, covering the activities necessary to complete administrative closeout of the existing controls. For the purposes of the FS, costs for the No-Action Alternative are set at $0.

6.4.3 Alternative 1 – Monofill Evapotranspiration Barrier

In addition to implementing institutional controls and monitoring (Section 6.4.1.1), decommissioning area wells (Section 6.4.1.2), and groundwater monitoring (Section 6.4.1.3), Alternative 1 for the 216-A-8 Crib would mitigate risk to human health by providing increased physical separation from soil with Cs-137 activities that exceeded the RBC, relying on MNA, which in this instance is radioactive decay, to reduce the Cs-137 to levels below the RBC. It also would impede transport of Tc-99 to groundwater by controlling the infiltration of water from the ground surface.

The ET barrier would overlie the area of the crib with contaminant concentrations of concern. Based on geophysical logs from several locations within the crib, it appears that actionable levels of Cs-137 may be limited to the western half of the crib. However, lacking soil analyses for the eastern half of the crib, the FS conservatively assumed that RBCs were exceeded in all soils beneath the crib base footprint, which is 6.1 m (20 ft) wide and 259 m (850 ft) long, to a depth of 9 m (30 ft). The FS assumes a similar distribution for the Tc-99 that poses a threat to groundwater. Thus, an ET barrier that covers the Tc-99 where its concentration poses a risk to groundwater also would cover the portion of the crib where Cs-137 poses an unacceptable risk to human health. Additional characterization may be necessary to delineate contamination sufficiently to allow design of the barrier and determination of the appropriate barrier overhang (distance the barrier extends beyond the contaminants to ensure that infiltration moving laterally does not intersect and transport contaminants).

With functional overhangs of 15.2 m (50 ft) on each side, and engineered perimeter features (for stability and durability) extending laterally another 7.6 m (25 ft) on each side, the ET barrier footprint would be 52 by 305 m (170 by 1,000 ft) as shown in Figure 6-2. The FS assumes a minimum functional thickness of 1.5 m (5 ft) and a 2 percent surface slope. The 1.5 m (5-ft) thickness will provide 4.6 m (15 ft) of separation between the top of the cap and the soils that exceed the Cs-137 RBC. Before construction of the ET barrier, all wells within the planned operational footprint of the barrier would need to be decommissioned.

The actual size and configuration of the monofill ET barrier would be determined in remedial design. The FS assumes a structure with three layers, each a minimum of 50 cm (20 in.) thick. The upper-most layer would be composed of pea gravel and silt loam. It would overlie a layer of silt loam, which would sit atop an engineered fill base. The perimeter of the cover would have side slopes with a 3:1 slope constructed from soil-filled basalt (8 to 20 cm [3 to 8 in.] of basalt) that was 30 cm (12 in.) thick. The surface would be planted with a mixture of warm- and cool-season plant species (native species to the extent feasible) selected for their ability to capture and transpire water.

Before construction of the ET barrier, all wells within the planned operational footprint of the barrier would need to be decommissioned. New borings/dry wells would be installed either

during or after construction of the monofill ET barrier to support monitoring for effectiveness of the remedy with geophysical logging techniques. For comparison purposes, the FS assumes four new 10 cm (4-in.) dry wells drilled at the perimeter of the cover to a depth of 21 m (70 ft). The actual number, location, and depth of the wells are determined based on pre-design sampling and analysis results. Logging would be conducted periodically, as necessary, to support the CERCLA 5-year review process.

6.4.3.1 Contingency Plan

Three reasonable deviations from the anticipated outcome were considered. One would be the discovery of organics at levels that posed a threat to groundwater. The second would be determination that Tc-99 is present in quantities that pose a significant threat to groundwater. The third would be discovery of localized areas with much higher levels of Cs-137 contamination than anticipated within 4.6 m (15 ft) of the surface.

Discovery of Organics: The monofill ET barrier provides protectiveness of groundwater, so no additional remedial activity likely would be needed, although additional monitoring would be necessary. If warranted or desirable, an SVE system could be implemented to accelerate cleanup. If shallow and not co-located with radionuclides, a partial RTD option also might be viable.

Discovery of significant quantities of Tc-99: If Tc-99 is determined to be present in quantities that pose a clear threat to groundwater, the monofill ET cover would not serve as a final remedial action, due to its long half-life. Viable contingent actions in this instance could be partial RTD, or ISV (to immobilize the contaminant).

Discovery of local areas of more shallow or much higher concentration of Cs-137: Contingent actions in this instance could include increasing the thickness of the monofill ET barrier, partial RTD, or ISV of the hot spots.

6.4.3.2 Environmental Monitoring

Environmental monitoring would consist of periodic groundwater monitoring conducted as part of the site-wide program (Section 6.4.1.3), and performance monitoring. New borings/dry wells would be installed either during or after construction of the monofill ET barrier to support monitoring for effectiveness of the remedy with geophysical logging techniques. For comparison purposes, the FS assumes four new 10 cm (4-in.) dry wells drilled at the perimeter of the cover to a depth of 21 m (70 ft). The actual number, location, and depth of the wells are determined based on pre-design sampling and analysis results. Logging would be conducted periodically, as necessary, to support the CERCLA 5-year review process.

6.4.3.3 Evaluation by Criteria

The following discussion considers the 216-A-8 Crib physical barrier alternative with respect to the seven CERCLA criteria.

Overall Protection of Human Health and the Environment: The barrier mitigates risk by providing sufficient physical separation from the Cs-137 and by limiting infiltration to mitigate

transport of Tc-99 to groundwater. This alternative does not employ treatment technology, relying instead on radioactive decay to reduce the Cs-137 contaminant mass to levels that impart no unacceptable risk. Short-term risks are greatest to those that construct new dry wells used to monitor remedy performance. No significant short-term risk is presented to the public.

Compliance with ARARs: Action-specific ARARs address well decommissioning, fugitive dust control, well design and construction during drilling, emission of chemical pollutants and radionuclides, and generation and management of waste. These ARARs are all addressed by existing environmental protection programs (includes waste management), which are engaged during the project design phase and again during the work planning and implementation process. Existing administrative controls drive this interaction as part of an integrated safety and environmental management system. At present, there is no identified need to seek the waiver of any ARAR.

Long-Term Effectiveness and Permanence: The ET barrier controls infiltration to mitigate the risk to groundwater and achieves sufficient physical separation from the Cs-137. The armoring materials should make it relatively durable with respect to the duration of the direct-contact risk posed by the Cs-137. In conjunction with the planned institutional controls, it will provide reliable mitigation of the identified risks to human health. Additional evaluation is necessary to determine if the Tc-99 does pose a threat to groundwater. If it does, then protectiveness of groundwater requires continued maintenance of the barrier. Uncertainty regarding the durability of institutional controls increases with time. Fortunately, at this site, risk due to Cs-137 is decreasing with time. Taking into consideration both the anticipated durability of the barrier and the decreasing risk, the long-term effectiveness of this alternative appears to be good.

Reduction of Toxicity, Mobility, or Volume through Treatment: This alternative does not employ treatment to address the COCs.

Short-Term Effectiveness: Short-term risks are greatest to the individuals constructing the monitoring points at the site. These risks would be readily addressed by existing environmental and worker protection programs. Based on current understanding of the site, no significant short-term risk is presented to the public. Protectiveness is achieved with construction of the barrier. The remedial goal for Cs-137 is achieved through natural radioactive decay, which reduces Cs-137 activity levels in the 0 to 4.6 m (0 to 15 ft) depth interval to the RBC (1,228 pCi/g) in approximately 136 years.

Implementability: This alternative can be implemented relatively easily. It will require acquisition, transport, and staging of monofill ET barrier construction materials. Design and construction of the barrier are expected to be relatively easily implemented. Well installation (for performance monitoring) may generate small quantities of high-dose-rate wastes, which require proper management and packaging to facilitate disposal at ERDF. Personnel conducting the monitoring point installation work will incur radiological exposure risks, which can be effectively addressed by existing worker protection programs. These activities also will require controls to mitigate the potential for release of contaminants to the environment, which will be addressed by existing environmental protection programs.

Cost: Total costs for Alternative 1 at the 216-A-8 Crib are estimated at $3,965,968; see Appendix D for further details.

6.4.4 Alternative 2 – Partial Removal, Treatment, and Disposal

In addition to implementing institutional controls and monitoring (Section 6.4.1.1), decommissioning area wells (Section 6.4.1.2), and groundwater monitoring (Section 6.4.1.3), Alternative 2 for the 216-A-8 Crib would excavate the COCs and transport them to a permitted on-site disposal facility, ERDF. The alternative would be implemented as follows:

- Decommission existing wells
- Excavate to remove "clean" overburden
- Excavate to remove contaminated soils, including those containing the very high concentrations of Cs-137
- Sample to verify attainment of remedial goals
- Backfill to grade with suitable material.

The following assumptions are documented to support calculation of the size of the excavation and the volume of material that will be designated as mixed waste.

- Soils currently located less than 1.8 m (6 ft) bgs will be suitable for reuse as backfill material.
- The highest Cs-137 activities are located between 5.8 and 7.3 m (19 and 25 ft) bgs. Excavation depth includes 5 ft below contamination bringing the total excavation depth to 30 ft.

Additional information regarding waste volumes is provided in Appendix D.

6.4.4.1 Contingency Plan

Reasonable deviations from the anticipated outcome might be discovery of organics, or discovery of significant Tc-99 at greater depth. Contingent actions for these conditions would be as follows:

- RTD to a greater depth to remove sufficient mass to eliminate the threat to groundwater
- SVE to reduce the mass of the organics
- ISV, implemented at the base of the RTD excavation, to immobilize the residual contaminants or to form a durable barrier to infiltration.

6.4.4.2 Environmental Monitoring

Environmental monitoring would consist of periodic groundwater monitoring conducted as part of the site-wide program (Section 6.4.1.3).

6.4.4.3 Evaluation by Criteria

The following discussion considers the 216-A-8 Crib RTD alternative with respect to the seven CERCLA criteria.

Overall Protection of Human Health and the Environment: RTD removes sufficient contaminant mass to eliminate unacceptable levels of risk to human health and the groundwater, and is therefore very effective at achieving long-term protectiveness and permanence. However, in implementing the RTD alternative, remedial-action workers incur high levels of risk from exposure to the gamma radiation emitted by the Cs-137. The potential for spread of contamination during excavation also poses a risk to ecological receptors and, to a lesser extent, the public. These risks can be mitigated under the existing worker protection and environmental protection programs.

Compliance with ARARs: Excavation of the Tc-99 contaminated soils would achieve protectiveness by removing sufficient contaminant mass to eliminate the threat to groundwater. Activity- and location-specific ARARs include air emissions, waste management, and well decommissioning requirements associated with decommissioning of the existing wells; fugitive dust control and protection of ecological receptors while excavating and backfilling; and sample analysis and waste management (including disposition of residual sample material) during sampling events. Work would be conducted under the existing environmental protection program, which is engaged substantively during the remedial design process and integrated fully into work planning and execution. Based on current knowledge, no difficulty is anticipated in complying with these action- and location-specific ARARs. ARARs are listed in Appendix C.

Long-Term Effectiveness and Permanence: RTD removes all soils contaminated in excess of the Cs-137 RBC, thereby achieving protectiveness of human health for the industrial site construction worker, and greatly reducing risks to human health that would exist under unrestricted land-use scenarios. It also removes the Tc-99 that poses a potential threat to groundwater. The RTD alternative achieves long-term protectiveness and permanence.

Reduction of Toxicity, Mobility, or Volume through Treatment: The RTD alternative does not apply treatment technology to reduce the toxicity, mobility, or volume of the principal threat contaminant.

Short-Term Effectiveness: The RTD alternative mitigates the identified risk fairly quickly. However, during implementation the remedial-action workers incur high levels of risk from exposure to the gamma radiation emitted by the Cs-137. The potential for airborne spread of contamination during excavation also poses a risk to ecological receptors and, to a lesser extent, the public. These risks can be mitigated under the existing worker protection and environmental protection programs.

Implementability: This alternative is implementable, although it faces several challenges. Primary among these is mitigation of the radiological risk posed to remedial-action workers. It will require development and implementation of a radiation control program that addresses excavation activities and waste-management activities. Other notable challenges include staging, packaging, transport, and disposition of a large volume of contaminated soil, some of which is expected to require remote handling.

Costs: Capital costs would include decommissioning the existing wells; implementation of worker safety and environmental protection programs; design and construction of a containment structure; conventional excavation; remote excavation; waste management, transport, and disposition; and acquisition, transport, and emplacement of fill. There would be no operation and maintenance costs. Total costs to implement this alternative are estimated to be approximately $51,396,466; see Appendix D for details.

6.5 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 VALUES EVALUATION

The NEPA process is intended to help Federal agencies make decisions that are based on understanding environmental consequences and then to take actions that protect, restore, and enhance the environment. The NEPA values will be evaluated as part of DOE's responsibility. NEPA and its implementing regulations, DOE Order 451.1B, *National Environmental Policy Act Compliance Program*; *DOE Policies on the Application of NEPA to CERCLA and RCRA Cleanup Actions* (July 11, 2002), and DOE guidance for decommissioning (DOE G 430.1-4, *Decommissioning Implementation Guide*) require that NEPA values be incorporated into decisions and documents as part of the CERCLA process. These values include, but are not limited to, cumulative, ecological, cultural, historical, and socioeconomic impacts, and Irreversible and Irretrievable Statements in lieu of preparing separate NEPA documentation. The impacts of these aspects of the human environment usually are not otherwise addressed within the CERCLA process. This integration provides a more comprehensive analysis of potential impacts resulting from the proposed 200-PW-1, 200-PW-3, and 200-PW-6 OU cleanup activities. To support the CERCLA decision-making process, the NEPA value analysis is provided in the following sections.

6.5.1 Description of National Environmental Policy Act of 1969 Values

Several of the CERCLA evaluation criteria involve consideration of environmental resources, but the emphasis frequently is directed at the potential effects of chemical contaminants on living organisms. The NEPA regulations (40 CFR 1502.16, "Environmental Impact Statement," "Environmental Consequences") specify evaluation of the environmental consequences of proposed alternatives. These include potential effects on transportation resources, air quality, and cultural and historical resources; noise; visual, and aesthetic effects; environmental justice; and the socioeconomic aspects of implementation. The NEPA process also involves consideration of several issues such as cumulative impacts (direct and indirect), mitigation of adversely impacted resources, and the irreversible and irretrievable commitment of resources. The NEPA-related resources and values that DOE has considered in this evaluation include the following.

- Transportation Impacts. This value considers impacts of the proposed remedial action on local traffic (i.e., traffic at the Hanford Site) and traffic in the surrounding region. Transportation impacts are considered in part under the CERCLA criteria of short-term effectiveness or implementability.

- Air Quality. This value considers potential air quality concerns associated with emissions generated during the proposed remedial actions.

- Natural, Cultural, and Historical Resources. This value considers impacts of the proposed remedial actions on wildlife, wildlife habitat, archeological sites and artifacts, and historically significant properties in the Central Plateau.

- Noise, Visual, and Aesthetic Effects. This value considers increases in noise levels or impaired visual or aesthetic values in the Central Plateau during or following the proposed remedial actions.

- Socioeconomic Impacts. This value considers impacts pertaining to employment, income, other services (e.g., water and power utilities), and the effect of implementation of the proposed remedial actions on the availability of services and materials.

- Environmental Justice. Environmental justice, as mandated by Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, refers to fair treatment of humans of all races, cultures, and income levels with respect to laws, policies, and government actions. This value considers whether the proposed remedial actions would have inappropriately or disproportionately high and adverse human health or environmental effects on minority or low-income populations.

- Cumulative Impacts (Direct and Indirect). This value considers whether the proposed remedial actions could have cumulative impacts on human health or the environment when considered together with other activities in the Central Plateau, at the Hanford Site, or in the region.

- Mitigation. If adverse impacts cannot be avoided, remedial-action planning should minimize them to the extent practicable. This value identifies required mitigation activities.

- Irreversible and Irretrievable Commitment of Resources. This value evaluates the use of nonrenewable resources for the proposed remedial actions and the effects that resource consumption would have on future generations. When a resource (e.g., energy, minerals, water, wetland) is used or destroyed and cannot be replaced within a reasonable amount of time, its use is considered irreversible.

6.5.2 Detailed Evaluation of the National Environmental Policy Act of 1969

6.5.2.1 Transportation Impacts

216-Z-1A Tile Field

No transportation impacts are associated with Alternative 0. Implementation of all other remedial alternatives at the 216-Z-1A Tile Field likely would have some nominal short-term

impacts on local traffic and traffic in the surrounding region. Specifically, Alternative 3 would incorporate minimal transportation impacts for the backfill material, and Alternative 4 would require transportation of waste and backfill material. The SVE system would have minimal short-term impacts on local traffic and traffic in the surrounding region during planning and maintenance; however, using the existing SVE system will not cause additional transportation impacts. The Targeted SVE system would have minimal transportation impacts from the installation of new wells and ancillary equipment. RTD transportation impacts would result from hauling waste to ERDF and CWC/WIPP, and hauling clean fill to the waste site. Increases in the workforce traffic related to waste treatment would be expected to be minor. Transportation activities in the 200-PW-1, 200-PW-3, and 200-PW-6 OUs would nominally increase as a result of bringing construction equipment to the site, transporting contaminated soils to ERDF and CWC/WIPP, and bringing clean fill to any excavated sites. Because ERDF is located onsite, minimal uncertainties are associated with the transport of waste. Transport to WIPP is more involved. Given the relatively small volumes of material compared with the rest of the Central Plateau and River Corridor, transportation activities associated with the 216-Z-1A Tile Field remedial alternatives are not expected to have a significant environmental impact.

216-Z-9 Trench

No transportation impacts are associated with Alternative 0. Implementation of all other remedial alternatives at the 216-Z-9 Trench likely would have some nominal short-term impacts on local traffic and traffic in the surrounding region. Specifically, Alternative 3 would incorporate minimal transportation impacts for the backfill material and Alternative 4 would require transportation of waste and backfill material. The SVE system would have minimal short-term impacts on local traffic and traffic in the surrounding region during planning and maintenance; however, using the existing SVE system will not cause additional transportation impacts. The Targeted SVE system would have minimal transportation impacts from the installation of new wells and ancillary equipment. RTD transportation impacts would result from hauling waste to ERDF and CWC/WIPP, and hauling clean fill to the waste site. Increases in the workforce traffic related to waste treatment would be expected to be minor. Transportation activities in the 200-PW-1, 200-PW-3, and 200-PW-6 OUs would nominally increase as a result of bringing construction equipment to the site, transporting contaminated soils to ERDF and CWC/WIPP, and bringing clean fill to any excavated sites. Because ERDF is located onsite, minimal uncertainties are associated with the transport of waste. Transporting waste to WIPP is more involved. Given the relatively small volumes of material compared with the rest of the Central Plateau and River Corridor, transportation activities associated with the 216-Z-9 Trench remedial alternatives are not expected to have a significant environmental impact.

216-A-8 Crib

No transportation impacts are associated with Alternative 0. Implementation of the other two remedial alternatives at the 216-A-8 Crib likely would have some nominal short-term impacts on local traffic and traffic in the surrounding region. Alternative 1 would require transportation of barrier materials and Alternative 2 would require transportation of waste. RTD transportation impacts would result from hauling waste to ERDF and hauling clean fill to the waste site.

Increases in the workforce traffic related to waste treatment would be expected to be minor. Transportation activities in the 200-PW-1, 200-PW-3, and 200-PW-6 OUs would nominally increase as a result of bringing construction equipment to the site, transporting contaminated soils to ERDF, and bringing clean fill to the excavated sites. Because ERDF is located onsite, minimal uncertainties are associated with the transport of waste. Given the relatively large volumes of material, there is likely to be an environmental impact from transportation of RTD waste to ERDF and clean backfill to the waste site.

6.5.2.2 Air Quality

No current air quality impacts are associated with Alternative 0 for any waste site; however, potential impacts to air quality could be associated with plant or animal uptake of contaminants and wind dispersion. Potential near-term impacts to air quality associated with all other alternatives are expected to be minor and could be mitigated through appropriate engineering controls. Potential air quality impacts primarily would be associated with fugitive dust during site preparation, excavation, placement of backfill or barriers, and revegetation activities. Dust suppression (both water and water treated with soil fixatives) would be used to control visible fugitive dust, so neither local nor regional air quality is expected to be affected. Routine emissions from vehicles would occur.

216-Z-1A Tile Field

Minimal air quality impacts resulting from Alternative 1 and 2 are a result of the SVE system and fugitive dust generated during placement of fill or barrier materials. Impacts from Alternative 3 would result from ISV, SVE, and dust. Impacts from Alternative 4 would result from SVE and RTD activities. Alternative 4 presents the most significant air quality risks, due to the potential for airborne particulate alpha contamination during excavation.

216-Z-9 Trench

Minimal air quality impacts resulting from Alternative 1 and 2 are a result of the SVE system and fugitive dust generated during placement of fill or barrier materials. Potential impacts from Alternative 3 would result from ISV off-gas, SVE emissions, and fugitive dust during placement of fill material. Impacts from Alternative 4 would result from SVE and RTD activities. Alternative 4 presents the most significant air quality risks, due to the potential for airborne particulate alpha contamination during excavation.

216-A-8 Crib

Alternative 1 air quality impacts would result from dust. Alternative 2 air quality impacts would result from RTD activities and dust when backfilling.

6.5.2.3 Natural, Cultural, and Historical Resources

The No-Action Alternative would not disturb or destroy natural, cultural, or historical resources; however, in some sites, biologic resources could be exposed to contaminants with potential impacts. In all cases, remediation will be performed at sites that are highly disturbed by industrial activities as discussed in Chapter 2.0. Adverse impacts to cultural resources could

occur, if such resources were encountered and appropriate mitigating actions were not taken. Adverse impacts would be minimized by avoiding known cultural resources and traditional-use areas whenever possible. Although cultural resources could be encountered during the excavation and construction of staging areas, the probability is low. A cultural resource mitigation plan would be established before remediation begins. If cultural resources were encountered during excavation, the State Historic Preservation Office and Native American Tribes would be consulted about minimizing impacts and taking appropriate actions for resource documentation or recovery. Some short-term adverse impacts to natural resources (e.g., local wildlife) could occur during the construction and implementation phases of remedial action. Ecological surveys would be performed to identify the species present and the special precautions that should be taken to minimize adverse impacts. The potential for exposure to contaminants would be minimized.

216-Z-1A Tile Field

No natural, cultural, or historical resource impacts are associated with Alternatives 1–4.

216-Z-9 Trench

No natural, cultural, or historical resource impacts are associated with Alternatives 1–4.

216-A-8 Crib

No natural, cultural, or historical resource impacts are associated with Alternative 0 or Alternative 1. Alternative 2 has the potential to have a natural, cultural, or historical resource impact.

6.5.2.4 Noise, Visual, and Aesthetic Effects

No noise, visual, or aesthetic impacts are associated with Alternative 0. Aesthetically, given the past disturbance in the 200 Areas and on the Central Plateau, no impacts would be expected from the remedial alternatives.

216-Z-1A Tile Field

Minimal impacts would result from Alternatives 1, 2, and 3 as a result of the noise of the SVE system and construction. Some noise, visual, and aesthetic effects also would result from Alternative 4. Targeted SVE would temporarily increase noise and impair visual values, especially during the placement of wells and ancillary equipment. The physical barriers would cause temporarily increased noise and decreased visibility possibly due to dust during construction. RTD would increase noise levels and impair visual values, but the impacts would be short-term during remedial actions and ultimately would improve the aesthetics.

216-Z-9 Trench

Minimal impacts would result from Alternatives 1, 2, and 3 as a result of the noise of the SVE system and construction. Some noise, visual, and aesthetic effects would result from Alternative 4. Targeted SVE would temporarily increase noise and impair visual values,

especially during the placement of wells and ancillary equipment. The physical barriers would cause temporarily increased noise and decreased visibility possibly due to dust during construction. RTD would increase noise levels and impair visual values, but the impacts would be short-term during remedial actions and ultimately would improve the aesthetics.

216-A-8 Crib

Alternative 1 would increase noise levels and impair visual values in the short-term during construction of the barrier. Negative impacts may be associated with the visibility and aesthetics of the cap over large distances if they were not contoured to blend in with the surrounding area. Alternative 2 would increase noise levels and impair visual values, but the impacts would be short-term during remedial actions and ultimately would improve the aesthetics.

6.5.2.5 Socioeconomic Impacts

The No-Action Alternative would have no socioeconomic impacts. The other remedial alternatives would have some positive socioeconomic impacts related to the employment opportunities that would occur during the life of the remedial action project. The labor force required to implement remedial action would be drawn from current Hanford Site contractors and the local labor force, so the socioeconomic impacts would be expected to be minimal.

6.5.2.6 Environmental Justice

Under all alternatives, except Alternative 0, environmental justice impacts would be minimal because future use restrictions would pertain to only a small percentage of the Central Plateau, and the Central Plateau still would be under active waste management industrial land use.

6.5.2.7 Irreversible and Irretrievable Commitment of Resources

All of the alternatives, with the exception of no action, would result in some temporary land- use loss and would require some irreversible or irretrievable commitment of natural resources. The various alternatives do not result in any further loss of use. However, some of the alternatives may be able to return land to beneficial industrial use. The amount of land-use loss would vary among alternatives.

In addition, the RTD alternative and the Physical Barrier alternative may require the use of a fine silty loam during construction. This use of fine silty loam would be an irreversible and irretrievable commitment of a natural resource. An evaluation of available NEPA documentation concerning this resource will be conducted before implementation. The necessary NEPA documentation for the use of silty loam will be described in the remedial design report/remedial action work plan.

216-Z-1A Tile Field

Physical Barriers and RTD would result in some land-use loss as a result of requiring additional soils and would require some irreversible or irretrievable commitment of natural resources. Targeted SVE would require some irreversible or irretrievable commitment of natural resources in the form of equipment (wells, blowers, etc.) and petroleum products (e.g., diesel fuel,

gasoline). RTD generally would allow land use from the ground surface to a depth of 4.6 m (15 ft) bgs or greater following the completion and regulatory acceptance of remedial activities. Physical Barriers and RTD would require an irretrievable and irreversible commitment of resources in the form of geologic materials and petroleum products (e.g., diesel fuel, gasoline). With RTD, excavated material would be replaced with a stockpile of clean soil cover removed from the site, as well as clean soil fill from onsite or offsite borrow pits requiring an irretrievable and irreversible commitment of resources in the form of petroleum products (e.g., diesel fuel, gasoline).

216-Z-9 Trench

Physical Barriers and RTD would result in some land-use loss as a result of requiring additional soils and would require some irreversible or irretrievable commitment of natural resources. Targeted SVE would require some irreversible or irretrievable commitment of natural resources in the form of equipment (wells, blowers, etc.) and petroleum products (e.g., diesel fuel, gasoline). RTD generally would allow land use from the ground surface to a depth of 4.6 m (15 ft) bgs or greater following the completion and regulatory acceptance of remedial activities. Physical Barriers and RTD would require an irretrievable and irreversible commitment of resources in the form of geologic materials and petroleum products (e.g., diesel fuel, gasoline). With RTD, excavated material would be replaced with a stockpile of clean soil cover removed from the site, as well as clean soil fill from onsite or offsite borrow pits requiring an irretrievable and irreversible commitment of resources in the form of petroleum products (e.g., diesel fuel, gasoline).

216-A-8 Crib

Alternative 1 and 2 would result in some land-use loss as a result of requiring additional soils and would require some irreversible or irretrievable commitment of natural resources. Alternative 2 generally would allow land use from the ground surface to a depth of 4.6 m (15 ft) bgs or greater following the completion and regulatory acceptance of remedial activities. Alternative 1 would preclude surface use of the land so barrier integrity could be ensured. Alternative 2 would require a considerable commitment of available disposal volume at ERDF, possibly including expansion to accommodate the additional waste. Alternatives 1 and 2 would require an irretrievable and irreversible commitment of resources in the form of geologic materials and petroleum products (e.g., diesel fuel, gasoline). Alternative 2 excavated materials would be replaced with a stockpile of clean soil cover removed from the site, as well as clean soil fill from onsite or offsite borrow pits requiring an irretrievable and irreversible commitment of resources in the form of petroleum products (e.g., diesel fuel, gasoline).

6.5.2.8 Cumulative Impacts

The proposed remedial-action alternatives could have impacts when considered together with impacts from past and foreseeable future actions at and near the Hanford Site. Authorized current and future activities include soil and groundwater remediation; waste management and treatment (e.g., tank farms, the Waste Treatment Plant); and surveillance, maintenance, decontamination, and decommissioning of facilities. Other Hanford Site activities that might be ongoing during remedial action at the Central Plateau waste sites include deactivation and

decontamination of reprocessing facilities and operation of the Energy Northwest reactor. Activities near the Hanford Site include a privately owned radioactive and mixed-waste treatment facility, a commercial fuel manufacturer, a commercial low-level radioactive waste disposal facility, and a titanium reprocessing plant.

The proposed remediation alternatives would have minimal impacts on transportation; air quality; and natural, cultural, and historical resources. Noise, visual and aesthetic effects, and socioeconomic impacts also would be minimal. Therefore, cumulative impacts with respect to these values are expected to be insignificant. The most notable area for cumulative impacts is with respect to the irretrievable and irreversible commitment of resources. All of the proposed alternatives except for the No-Action Alternative would require long-term land-use restrictions, but the cumulative impacts with respect to loss of land use are not expected to be significant.

The RTD alternative also would require a commitment of land use at ERDF, and possibly expansion in the Central Plateau. This would be in addition to numerous other Hanford Site projects that would commit land use in the Central Plateau. The 200-PW-1, 200-PW-3, and 200-PW-6 OU waste sites constitute only a portion of the total actions requiring material for barriers and backfill at the Hanford Site. The total quantity of geologic materials required for other Hanford Site actions currently is being identified and has been addressed adequately in DOE/EA-1403, *Environmental Assessment, Use of Existing Borrow Areas, Hanford Site, Richland, Washington.*

6.5.2.9 Mitigation

Alternative 0 at all sites would not include mitigation. Mitigation measures for all other alternatives at all sites would include engineered controls for suppression of fugitive dust, containment of airborne particulate contamination, control of process (i.e., SVE, ISV) emissions, and planning activities to avoid nesting and breeding cycles of birds and mammals.

6.5.2.10 Summary of National Environmental Policy Act of 1969 Evaluation

The 200-PW-1, 200-PW-3, and 200-PW-6 OU waste sites cover 0.07 km^2 (0.03 mi^2). Remedial actions at the 200-PW-1, 200-PW-3, and 200-PW-6 OU waste sites would result in some impacts to public health and the environment. The short-term impacts are relatively more significant than the long-term impacts. However, the overall environmental impacts under normal operating conditions would not be very large, nor would they vary greatly among the remedial alternatives.

Figure 6-1. Decay of Cesium-137 in Soils at the 216-A-8 Crib.

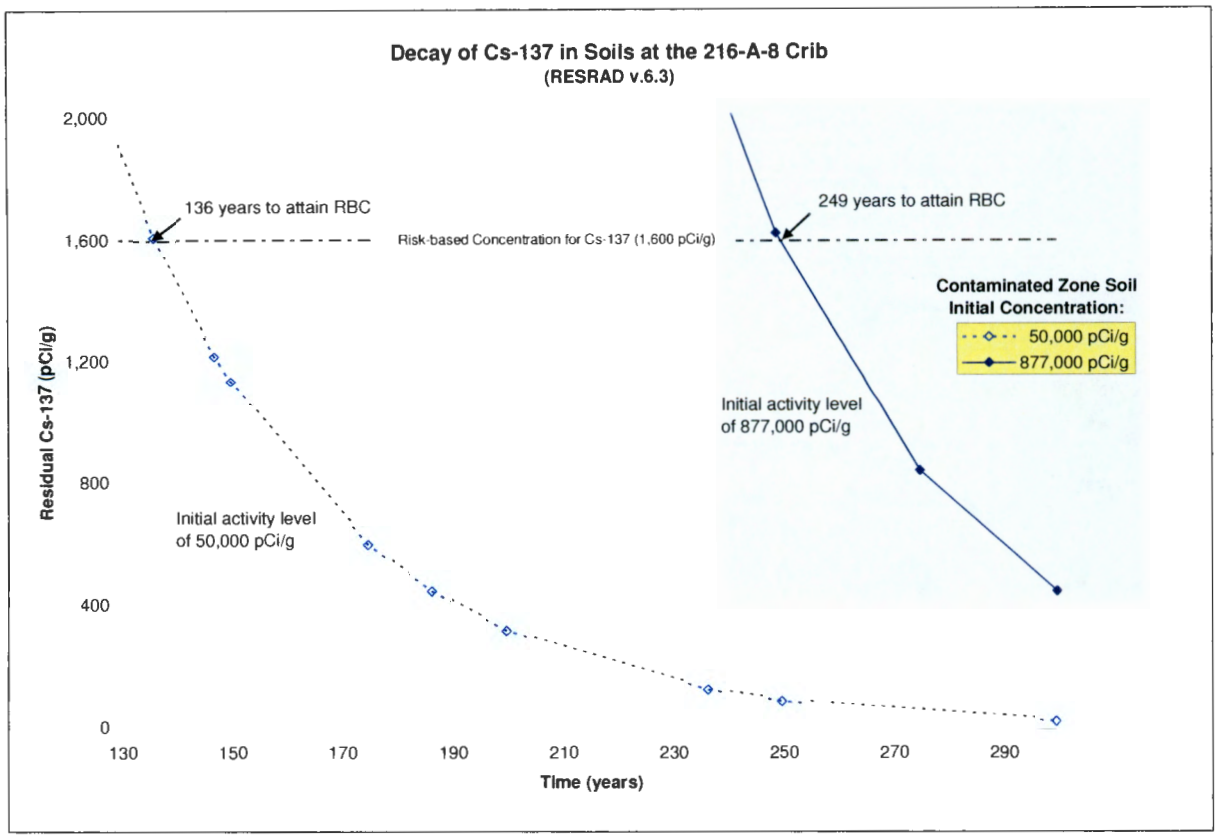
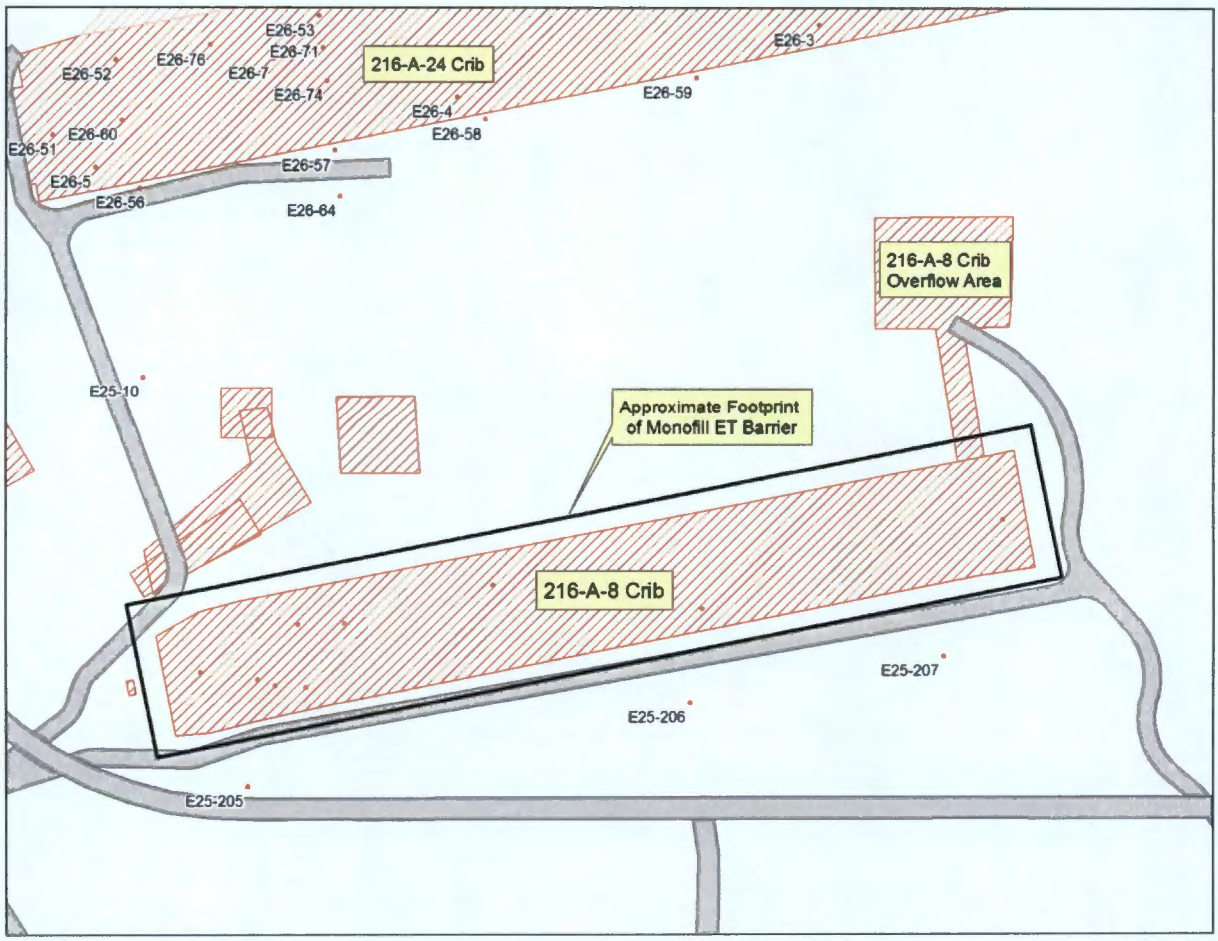


Figure 6-2. Conceptual Footprint of Alternative 1 – Monofill Evapotranspiration Barrier at the 216-A-8 Crib.



7.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

The remedial-action alternatives for the 200-PW-1, 200-PW-3, and 200-PW-6 OUs representative waste sites (which were developed in Chapter 5.0 and analyzed in detail in Chapter 6.0) are compared in this chapter. The comparative analysis identifies the relative advantages and disadvantages of each alternative in the context of the CERCLA evaluation criteria so that key trade-offs may be identified and balanced. The comparative analysis provides a measure of the relative performance of the alternatives against each evaluation criterion.

Alternatives are compared based on two of the three CERCLA categories, including threshold criteria and primary balancing criteria. The third category, modifying criteria, including state and community acceptance, will not be addressed until the proposed plan has been issued for public review. These modifying criteria will be addressed in the responsiveness summary and the ROD, which will be prepared following a public comment period.

Based on the risk assessment (Section 3.2) only three representative waste sites will require remedial action. In the 200-PW-1 OU, both the 216-Z-9 Trench and the 216-Z-1A Tile Field will require remedial action. The third representative waste site in the 200-PW-1 OU is the 241-Z-361 Settling Tank. Because this site was previously evaluated (DOE/RL-2003-52) and a remedy was recommended, it was not carried through the alternative development and analysis process in this FS. The representative waste site for the 200-PW-3 OU, the 216-A-8 Crib, also will require remedial action. Evaluation of the two unique waste sites in the 200-PW-6 OU, the 216-Z-10 Injection/Reverse Well and the 216-Z-8 French Drain, identified no need for remedial action.

For each waste site, there were remedial activities that would be common to all of the activity-based alternatives. For example, at the 216-Z-1A Tile Field, all activity-based remedial alternatives would include expansion of the existing SVE system. The benefits and detriments of the common activities are essentially the same under each alternative. Therefore, comparison of the alternatives focuses primarily on activities that are unique to each alternative.

Comparative analysis results are summarized in Table 7-1 (216-Z-1A Tile Field), Table 7-2 (216-Z-9 Trench), and Table 7-3 (216-A-8 Crib).

7.1 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR THE 216-Z-1A TILE FIELD

The identified actionable risk at the 216-Z-1A Tile Field is a direct-contact risk to the industrial site construction worker, posed by Pu-239/240 and Am-241 located in soils within 4.6 m (15 ft) of the ground surface above the tile field. Remedial alternatives carried forward specifically target this risk. Threshold criteria are considered with respect to this risk. In addition, a potential threat to groundwater was identified, not through the risk assessment process, but empirically based on continued capture of CCl_4 vapors with the site's SVE system. All alternatives employ the same remedy for this condition, so it is not considered in this comparison of alternatives.

The comparison of alternatives also considers risks incurred if institutional controls were substantially circumvented, allowing unrestricted use of the site. The risk assessment concluded that contamination identified at the site posed no unacceptable risk to the future driller population, but would pose unacceptable levels of risk to the hypothetical residential farmer population, as described in Section 3.2. These risks to the residential farmer population are excluded when addressing the threshold criteria, but are specifically considered under the balancing criteria.

This section documents comparative analysis of the five alternatives considered for final remediation of the identified risk to human health at the 216-Z-1A Tile Field:

- Alternative 0 – No Action
- Alternative 1 – Soil Backfill plus Expanded SVE
- Alternative 2 – IPF plus Expanded SVE
- Alternative 3 – ISV plus Expanded SVE
- Alternative 4 – Partial RTD plus Expanded SVE.

7.1.1 Threshold Criteria

Threshold criteria are of greatest importance in the comparative analysis because they reflect the key statutory mandates of CERCLA. The threshold criteria that any viable alternative must meet are as follows:

- Overall protection of human health and the environment
- Compliance with the ARARs.

7.1.1.1 Overall Protection of Human Health and the Environment

The primary measure of this criterion at the 216-Z-1A Tile Field is the ability of an alternative to meet RAO 1, which is to prevent unacceptable risk to human health due to exposure to radiological COCs. Again, each alternative includes the same actions to mitigate the potential threat to groundwater, making that aspect of the alternatives irrelevant for comparative purposes.

Alternative 0 is not protective, failing to address the identified direct-contact risk, and is not carried forward in the comparative analysis of remedial alternatives for the 216-Z-1A Tile Field.

Alternatives 1 through 4 meet RAO 1. Each relies on existing institutional controls to mitigate the current direct-contact risk until the remedy is implemented. Each ultimately achieves at least 4.6 m (15 ft) of separation between the contaminated soils and potential human receptors.

At the 216-Z-1A Tile Field, Alternative 2 (with IPF) is ranked first. It establishes 4.6 m (15 ft) of physical separation from the COCs that exceed RBCs, and uses a durable engineered feature to impede intrusion into the contaminated subsurface. The activities conducted to mitigate direct-contact risks present minimal short-term risks and generate no significant waste stream.

Alternative 3 (with ISV) is ranked second. It vitrifies contaminated soils down to 8.5 m (28 ft) below the final finished grade, and leaves a glass monolith to impede intrusion into contaminated

soils that lie deeper in the vadose zone. Short-term risks are moderate, associated primarily with the off-gas treatment system and associated waste streams, and are readily mitigated.

Alternative 4 (with partial RTD) is ranked third. It eliminates risk to the site construction worker by removing all contaminated soils to a depth of 8.5 m (28 ft) below the final finished grade. However, it poses significant short-term risk to the worker, public, and the environment associated with the potential for radiological exposures and spread of contamination during excavation activities and subsequent management of the wastes. Existing site safety programs are believed capable of mitigating all identified risks. Alternative 4 is expected to generate significant quantities of waste that contain greater than 100 nCi/g of transuranic isotopes with half-lives exceeding 20 years.

Alternative 1 (with soil backfill) is ranked fourth. It mitigates risk to the industrial site worker by establishing 4.6 m (15 ft) of separation from the COCs that exceed the RBCs. The activities conducted to mitigate direct-contact risks present minimal short-term risks and generate no significant waste stream.

Alternatives 1 through 4 are equally protective of groundwater, implementing identical remedial actions (Expanded SVE) to enhance capture of CCl_4 vapors present in the subsurface. Therefore, consideration of this aspect of each remedial action is not relevant to comparison of the alternatives. Expanded SVE is not considered in comparison of alternatives with respect to the seven CERCLA criteria.

7.1.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

The ARARs are identified in Appendix C. ARARs do not drive remedial actions at the 216-Z-1A Tile Field. However, all incur ARARs associated with the remedial activities that they implement.

Although the complexity of the ARARs incurred by each alternative varies, sometimes substantially, no compliance difficulties are anticipated for Alternatives 1–4. All meet this threshold criterion.

Alternatives 1 and 2 incur ARARS associated with filling in the depression above the tile field, such as fugitive dust control and protection of cultural and ecological resources. Both can readily achieve compliance.

Alternative 3 (with ISV) incurs ARARs for air emissions and waste management associated primarily with the off-gas system and the associated waste streams. Compliance is believed to be readily achievable.

Alternative 4 will incur ARARs associated with air quality, air emissions, and waste management associated with excavation. Compliance is believed to be readily achievable.

7.1.2 Balancing Criteria

The alternatives are compared with respect to the balancing criteria in the following discussion. The primary balancing criteria to which relative advantages and disadvantages of the alternatives are compared include the following:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost.

The first balancing criterion assesses the ability of the alternative to remain effective for the duration of elevated risk. The second balancing criterion addresses the statutory preference for treatment as a principal element of the remedy and the bias against offsite land disposal of untreated material. Together with the third and fourth criteria, they form the basis for determining the general feasibility of each potential remedy. The final criterion addresses whether the costs associated with a potential remedy are proportional to its overall effectiveness, considering both the cleanup period and operation and maintenance requirements during and following cleanup. Therefore, it can be determined whether a potential remedy is cost-effective relative to others. Key trade-offs among alternatives most frequently will relate to one or more of the balancing criteria.

Where appropriate, these criteria will be addressed with respect to risks incurred under both industrial land use and unrestricted land use. As noted in Section 3.2, the risk assessment determined that none of the sites evaluated would pose an unacceptable level of risk to the future driller population, but that the residential farmer population would incur unacceptable levels of risk at the 216-Z-1A Tile Field, the 216-Z-9 Trench, and the 216-A-8 Crib.

7.1.2.1 Long-Term Effectiveness and Permanence

Efficacy with respect to this alternative is based on (1) post-remedy risk to human and ecological receptors and (2) the adequacy and reliability (durability) of controls implemented to mitigate post-remedy risks.

Alternative 3 (with ISV) ranks first, using vitrification to essentially encapsulate COCs down to 8.5 m (28 ft) below the finished grade, and leaving a durable glass monolith to impede intrusion into contaminated soils that lie deeper in the soil column. Unacceptable levels of risk will be eliminated for the industrial site worker. The level of risk to the hypothetical residential farmer population is reduced, although it remains at unacceptable levels, but the exposure pathway is mitigated to a significant degree by the glass monolith, which not only physically impedes intrusion, but also be would expected to alert a reasonable person to off-normal subsurface conditions.

Alternative 4 (with partial RTD) ranks second because it removes all contamination down to a depth of 8.5 m (28 ft) below the finished grade. Unacceptable levels of risk will be eliminated for the industrial site worker and reduced (although not to acceptable levels) for the hypothetical residential farmer population.

Alternatives 2 and 1 rank third and fourth, respectively. Both provide effective post-remedy reduction of risk to the industrial site worker by providing a minimum of 4.6 m (15 ft) of separation for COCs that exceed the RBCs. Neither reduces the level of risk to the residential farmer population. Alternative 2 provides a deterrent to intrusion, which to some extent mitigates the exposure pathway associated with the risk to the residential farmer population.

7.1.2.2 Reduction in Toxicity, Mobility, or Volume through Treatment

Alternative 3 (with ISV) ranks first because it uses treatment to reduce the risk associated with the radionuclide COCs. Alternatives 1, 2, and 4 do not use treatment to address the radionuclide COCs and therefore do meet this criterion.

7.1.2.3 Short-Term Effectiveness

At the 216-Z-1A Tile Field, Alternatives 1 and 2 are ranked equally as first. They pose minor, essentially identical, short-term risks to workers, the public, and the environment. Both achieve RAOs relatively quickly in comparison to Alternatives 3 and 4, because planning and logistics will be less complicated.

Alternative 3 (with ISV) ranks third because its short-term risks to workers, the public, and environment are substantially lower than those of Alternative 3, and will not require the same level of effort to mitigate.

Alternative 4 is ranked fourth due to the high levels of risk posed to workers, and the significant potential for spread of contamination that will exist when site soils are excavated. Although these risks can be mitigated, it will require considerable effort, and the consequences of a failure in risk mitigation could be significant.

7.1.2.4 Implementability

Alternative 1 ranks first. It is the most readily implementable alternative. Materials and services needed are all readily available and technical difficulties are unlikely. (Again, implementation of the expanded SVE remedial action is common to all alternatives, except No-Action, and is not relevant in a comparison of alternatives.)

Alternative 2 (with IPF) is ranked a close second, requiring some design activities. Depending on the design chosen, there may be an increased chance of technical difficulties, and complications in obtaining the needed materials and services.

Alternative 4 (with partial RTD) consists of routine activities, but the excavation work is conducted at a larger scale than usual, and with substantial radiological exposure risks. This will increase the potential for technical problems; problems in integrating between the various organizations and programs that support the effort; and temporary shortages of needed personnel, services, and equipment. A notable concern would be availability of sufficient storage, assaying, and disposal capacity for the wastes generated by the RTD effort, depending on the volume of newly generated waste (excavated soil) containing more than 100 nCi/g of transuranic isotopes with half-lives exceeding 20 years.

Alternative 3 (with ISV) is ranked fourth. The equipment, services, and trained personnel are readily available. The technology is appropriate and effective. However, ISV is a more complex process that the others considered. Some effort, possibly a significant effort, would be needed to educate those unfamiliar with the current version of the technology, and it may be necessary to conduct treatability and/or proof-of-concept testing to gain acceptance by the Tri-Parties and stakeholders.

7.1.2.5 Cost

The present-worth cost for each alternative, developed in Appendix D, is as follows:

- Alternative 0 = $0
- Alternative 1 = $5,619,236
- Alternative 2 = $5,814,907
- Alternative 3 = $356,819,181
- Alternative 4 = $418,806,585.

7.1.3 Preferred Remedy for the 216-Z-1A Tile Field

Based on comparative analysis of the alternatives carried forward for the 216-Z-1A Tile Field, **Alternative 2 – IPF plus Expanded SVE** was selected as the most feasible alternative. It achieves protectiveness for the site construction worker by establishing 4.6 m (15 ft) of separation between the contaminants that exceed the RBCs, and provides a relatively durable physical barrier to intrusion that mitigates risk to the hypothetical residential farmer population. Short-term risks during implementation are minor, associated with activities that are routine at the Hanford Site and readily and effectively controlled by existing site worker protection and environmental protection programs. The only significant regulated waste stream generated is from expansion and continued operation of the SVE system, currently implemented at the site as an interim remedial action to remove CCl_4 mass and protect groundwater. The cost for this alternative is $5,814,907; see Appendix D for details.

7.2 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR THE 216-Z-9 TRENCH

The identified actionable risk at the 216-Z-9 Trench is a threat to groundwater posed by CCl_4, PCE, and hexachloroethane contamination in soils located approximately 19.8 m (65 ft) bgs beneath the southern portion of the trench. Remedial alternatives carried forward specifically target this risk. The CERCLA threshold criteria are considered with respect to this risk.

Remedy selection also considers the human-health risks that would exist under unrestricted land-use scenarios, using the residential farmer population as the hypothetical maximally exposed population. The risk assessment process determined that if land use was not restricted, this population would incur risks in excess of 1×10^{-4}, due to Pu-239/240 and Am-241 concentrations identified in the site soils between the trench floor and the CCU (see Section 3.2). The comparative analysis process considers the ability of each alternative to address this potential risk when evaluating with respect to the CERCLA balancing criteria.

This section documents comparative analysis of the five alternatives considered for final remediation of the identified threat to groundwater at the 216-Z-9 Trench. Note that each alternative includes revegetation and targeted SVE. These remedial actions are essentially identical under each alternative and therefore are not relevant to a comparison of alternatives. Discussion of these activities is very limited.

- Alternative 0 – No Action
- Alternative 1 – CDF plus Targeted SVE
- Alternative 2 – IPF plus Targeted SVE
- Alternative 3 – ISV plus Targeted SVE
- Alternative 4 – Partial RTD plus Targeted SVE.

7.2.1 Threshold Criteria

Threshold criteria are of greatest importance in the comparative analysis because they reflect the key statutory mandates of CERCLA. The threshold criteria that any viable alternative must meet are as follows:

- Overall protection of human health and the environment
- Compliance with the ARARs.

7.2.1.1 Overall Protection of Human Health and the Environment

At the 216-Z-9 Trench, this criterion addresses the ability of an alternative to achieve RAO 2, protectiveness of groundwater, and to minimize risk to human health and the environment during implementation. To support comparison, the discussion here typically will focus on activities that are unique to each alternative, and avoid mention of activities that are included in all remedial alternatives, such as targeted SVE. Alternatives 1 through 4 all meet this threshold criterion.

Alternative 1 (with CDF) is ranked first. It provides viable protection of groundwater, equal to that of the other alternatives. Alternative 1 ensures continued mitigation of direct-contact risks to the site construction worker by leaving the trench cover in place and filling the trench void with appropriately formulated CDF, providing durable physical separation from the contaminated soils beneath the trench floor. Implementation risks are significantly lower for this alternative than for the others.

Alternative 2 (with IPF) is ranked second. It provides viable protection of groundwater, equal to that of the other alternatives. Alternative 1 ensures continued mitigation of direct-contact risks to the site construction worker by removing the cover and columns and constructing a substantive physical barrier, providing durable physical separation from the contaminated soils beneath the trench floor. Activities to gain entry to the trench and prepare it for construction of the IPF pose radiological exposure risks to the workers. These activities involve very limited intrusion into soils at the trench base. All identified short-term risks are readily mitigated by existing safety programs.

Alternative 3 (with ISV) is ranked third. This alternative achieves protectiveness of groundwater. It also ensures continued mitigation of direct-contact risks to the site construction worker by essentially encapsulating the contaminated soils beneath the trench floor in a glass matrix, and then backfilling the trench with soil. Activities to gain entry to the trench and prepare it for ISV operations pose radiological exposure risks to the workers. These activities involve limited intrusion into soils at the trench base. There also are risks to human health and the environmental associated with the generation, capture, and treatment of off-gases, and management of the associated waste streams. All risks are believed to be readily mitigated by existing safety programs.

Alternative 4 (with Partial RTD) is ranked fourth. It is protective of groundwater. Alternative 4 ensures continued mitigation of direct-contact risk to the site construction worker by removing contamination to a depth of 9.4 m (31 ft) below the finished ground surface, and uses an IPF constructed in the trench to impede intrusion into the deeper residual contamination. However, it poses significant short-term risks to the worker, public, and environment.

The No-Action Alternative, Alternative 0, does not address the identified threat to groundwater, and so does not meet this threshold criterion. This alternative is not considered further in the comparative analysis of the 216-Z-9 Trench remedial alternatives.

7.2.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

The ARARs are identified in Appendix C. No location-specific ARARs were identified for any of the described alternatives at the 216-Z-9 Trench.

Alternatives 1 through 4 are all expected to achieve compliance with the ARARs driving protection of groundwater. Each also is expected to achieve compliance with activity-specific ARARs. Therefore, Alternatives 1 through 4 all meet this criterion.

7.2.2 Balancing Criteria

The alternatives are compared with respect to the balancing criteria in the following discussion. The primary balancing criteria to which relative advantages and disadvantages of the alternatives are compared include the following:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost.

The first balancing criterion assesses the ability of the alternative to eliminate the risk or remain effective for the duration of elevated risk. The second balancing criterion addresses the statutory preference for treatment as a principal element of the remedy and the bias against offsite land disposal of untreated material. Together with the third and fourth criteria, they form the basis for determining the general feasibility of each potential remedy. The final criterion addresses whether the costs associated with a potential remedy are proportional to its overall effectiveness, considering both the cleanup period and operation and maintenance requirements during and

following cleanup. Therefore, it can be determined whether a potential remedy is cost-effective relative to others. Key trade-offs among alternatives will most frequently relate to one or more of the balancing criteria.

7.2.2.1 Long-Term Effectiveness and Permanence

Rankings address protection of groundwater first and then protection of the hypothetical residential farmer population. Alternatives 1 through 4 rank equally for long-term protectiveness and permanence with respect to the threat to groundwater. Each also ensures continued mitigation of the direct-contact risk to the site construction worker by maintaining 6.4 m (21 ft) of physical separation between ground surface and the contaminants beneath the trench floor. However, the alternatives do vary under this criterion with respect to their ability to address the risk posed to the hypothetical residential farmer population. This risk is incurred through use of contaminated drill cuttings (soil brought to the surface during drilling) and contaminated groundwater. The ranking below is based primarily on this latter risk, incurred under hypothetical future unrestricted land use.

Alternatives 3 (includes ISV) is ranked first because it essentially encapsulates the most highly contaminated soils (those immediately beneath the trench floor) in a very durable glass, which greatly reduces the risks associated with direct contact, and it also impedes intrusion into deeper residual contamination.

Alternative 4 is ranked second because it eliminates direct-contact risks for a smaller portion of the soil column (3.0 m [10 ft] versus 4.5 m [15 ft] for ISV). Its ability to physically limit intrusion, and its durability, may vary from those of the ISV glass monolith, but are difficult to compare before final design.

Alternatives 2 and 1 are ranked third and fourth, respectively, with respect to their ability to preclude intrusion. Both are containment remedies. Neither reduces the level of risk that would be incurred by the residential farmer population.

7.2.2.2 Reduction in Toxicity, Mobility, or Volume through Treatment

At the 216-Z-9 Trench, Alternatives 1 through 4 use SVE plus GAC to treat the COCs that pose a threat to groundwater, thus meeting this criterion.

Alternative 3 is ranked first because it also uses ISV to treat the radionuclide-contaminated soils that would pose a risk to human health under unrestricted land-use scenarios. (Note that these contaminants are not identified as COCs.)

Alternatives 1, 2, and 4 rank equally at second because they use targeted SVE, but do not use other treatment technologies.

7.2.2.3 Short-Term Effectiveness

The actionable condition at the 216-Z-9 Trench is a threat to groundwater. It is not an imminent threat. Alternatives 1 through 4 all achieve sufficient protectiveness in a timely manner. All also incur identical short-term risks when implementing the revegetation and targeted SVE actions.

Ranking under this criterion is a reflection of the potential impacts on workers, the environment, and the public when addressing risks to the hypothetical residential farmer population, and is related directly to how intrusive the remedy is and how much waste it generates.

All implementation risks for the identified alternatives are believed to be readily manageable under existing Hanford Site worker protection and environmental protection programs. Ranking is based on the level of risk posed by the activity if no controls were implemented, which allows consideration of the consequences if controls fail. Clearly, all else being equal, a remedy that would impart little or no risk if controls failed would be preferred over one where the consequences could result in significant worker health effects or uncontrolled airborne spread of contamination.

Alternative 1 (includes CDF) ranks first because the trench cover remains in place, and there is almost no potential for direct contact with, or significant disturbance of, soils containing high concentrations of alpha-emitting transuranic radioisotopes. No significant waste stream is generated.

Alternative 2 (includes IPF) ranks second, because although it involves entering the trench, highly contaminated soils at the base of the trench are not significantly disturbed. Wastes generated are essentially limited to the concrete cover and columns.

Alternative 3 (includes ISV) ranks third because the trench cover and columns are removed, and holes are drilled (vibratory drilling, no soil cuttings) into the trench base soils to install electrodes and to inject conductive materials between the electrodes to establish a starter plane for the electrical current. There also are risks to human health and the environmental associated with the generation, capture, and treatment of off-gases, and management of the associated waste streams.

Alternative 4 (includes Partial RTD) ranks fourth because it includes excavation of the highly contaminated soils beneath the floor of the trench, and management of those soils as a regulated waste, posing significant risk to the workers, public, and the environment. Although these risks can be mitigated by existing site safety programs, it will require a considerable level of effort, and the consequences of failed controls could be significant.

7.2.2.4 Implementability

All considered alternatives (except No-Action) include revegetation of the site and expansion of the SVE system. Related implementability issues are identical for each alternative, and therefore are not relevant to the comparison. These activities are not mentioned.

Alternative 1 ranks first, because it is the most easily implemented. It involves backfilling the trench void space with CDF. There are no significant technical challenges or anticipated difficulties associated with this alternative. The necessary services and materials are all readily available.

Alternative 2 ranks second. It is slightly more challenging from a technical perspective, involving removal of the concrete trench cover and support columns and their disposal at ERDF, acquisition and transport of IPF materials, and construction of an IPF within the trench.

Alternative 4 (with partial RTD) ranks third. Although it involves, for the most part, routine work activities, it will entail a substantial level of effort due to the level of contamination and the types of contaminants. Some portion of the newly generated waste (excavated soil) will require disposal at WIPP, which presents administrative challenges. Work planning and implementation will need to be coordinated with the Hanford Transuranic Waste Certification Program. Because of the very high levels of contamination at the trench base, increased levels of oversight and regulator involvement are anticipated.

Alternative 3 ranks fourth. ISV technology is much improved since its application at the 216-Z-12 Trench in the 1980s, and conceptually shows great promise for application at the liquid waste disposal sites. However, this technology is still not considered fully mature and well-vetted. Significant precursor activities may be necessary to overcome unfamiliarity with the current technology, and to overcome negative preconceptions (associated with earlier versions of the technology) on the part of regulators and the public.

7.2.2.5 Cost

The present-worth cost for each alternative, developed in Appendix D, is as follows:

- Alternative 0 = $0
- Alternative 1 = $4,706,371
- Alternative 2 = $4,740,027
- Alternative 3 = $26,951,350
- Alternative 4 = $28,258,025.

7.2.3 Preferred Remedy for the 216-Z-9 Trench

Based on comparative analysis of the remedial alternatives carried forward for the 216-Z-9 Trench, **Alternative 1 – CDF plus Targeted SVE** was identified as the most feasible alternative. It achieves protectiveness upon implementation, upgrading the SVE system to enhance its ability to reduce contaminant mass in the source area, and controlling infiltration by establishing a selected plant community at the site. It also backfills the trench void space with CDF, leaving the cover and columns in place, which ensures acceptable levels of risk for the site construction worker and effectively mitigates the exposure pathway for the hypothetical future residential farmer population. All short-term risks unique to this alternative (i.e., associated with placement of the CDF) are very minor and readily mitigated. Total costs for this alternative are estimated at $4,706,371; see Appendix D for further details.

7.3 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR THE 216-A-8 CRIB

The identified actionable risk at the 216-A-8 Crib is a direct-contact risk to the industrial site construction worker, posed by Cs-137 located in soils within 4.6 m (15 ft) of the surface of the crib. Remedial alternatives carried forward specifically target this risk. Threshold criteria are considered with respect to this risk. In addition, a potential threat to groundwater from Tc-99

was identified using fate and transport modeling (details provided in Appendix E). Action will be taken to mitigate this potential risk while additional evaluation is performed.

Remedy selection also considers the human-health risks that would exist under unrestricted land-use scenarios. The risk assessment process determined that if land use was not restricted, radiologically contaminated soils at the site would pose unacceptable levels of risk under the well driller and residential farmer scenarios (see Section 3.2). The comparative analysis process considers each alternative's ability to address the "unrestricted land use" risks as part of the balancing criteria, primarily under long-term effectiveness and permanence.

The principal threat contaminant at the 216-A-8 Crib is Cs-137, which has a half-life of approximately 30 years. Cesium-137 activity levels within 4.6 m (15 ft) of the surface are expected to decay to below 1,600 pCi/g within 136 years. The maximum Cs-137 activities identified to date at the site, 877,000 pCi/g, are expected to decay to below 1,600 pCi/g within 249 years.

This section documents comparative analysis of the three alternatives considered for final remediation of the identified risk to human health at the 216-A-8 Crib:

- Alternative 0 – No Action
- Alternative 1 – Monofill ET Barrier
- Alternative 2 – Partial RTD.

7.3.1 Threshold Criteria

Threshold criteria are of greatest importance in the comparative analysis because they reflect the key statutory mandates of CERCLA. The threshold criteria that any viable alternative must meet are as follows:

- Overall protection of human health and the environment
- Compliance with the ARARs.

7.3.1.1 Overall Protection of Human Health and the Environment

This criterion addresses the ability of a remedial alternative to reduce or control direct-contact risks (Cs-137) to the industrial site construction worker; reduce or control the potential threat to groundwater (Tc-99); and minimize risk to remedial action workers, the public, and the environment before and during implementation of the remedy.

Alternative 0 does not meet this criterion because it does not address risks associated with the COCs. Because it fails this threshold criterion, it is not addressed under the other criteria.

Alternative 1 is ranked first because it (1) mitigates risk to the site construction worker while MNA processes reduce Cs-137 concentrations to levels below the RBC, (2) mitigates the potential threat to groundwater by limiting infiltration, and (3) poses relatively minor risks during implementation.

Alternative 2 ranks second. Although it achieves long-term protectiveness quickly, this benefit is offset by very high short-term risks to remedial-action workers. Although excavation of radiologically contaminated soils is a routine activity, the risks incurred are substantial. These risks can be mitigated through the implementation of existing safety programs, but the consequences of failed mitigations could be substantial.

7.3.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 0 incurs no action-specific ARARs. Alternatives 1 and 2 are both expected to achieve compliance with the ARARs driving protection of human health and ecological receptors.

7.3.2 Balancing Criteria

The alternatives are compared with respect to the balancing criteria in the following discussion. The primary balancing criteria to which relative advantages and disadvantages of the alternatives are compared include the following:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost.

The first balancing criterion assesses the ability of the alternative to remain effective for the duration of elevated risk. The second balancing criterion addresses the statutory preference for treatment as a principal element of the remedy and the bias against offsite land disposal of untreated material. Together with the third and fourth criteria, they form the basis for determining the general feasibility of each potential remedy. The final criterion addresses whether the costs associated with a potential remedy are proportional to its overall effectiveness, considering both the cleanup period and operation and maintenance requirements during and following cleanup. Therefore, it can be determined whether a potential remedy is cost-effective relative to others. Key trade-offs among alternatives will most frequently relate to one or more of the balancing criteria.

7.3.2.1 Long-Term Effectiveness and Permanence

Both Alternatives 1 and 2 achieve long-term protectiveness and permanence with respect to the Cs-137-related risks to the site construction worker and the hypothetical residential farmer population. (Again, no unacceptable risks are posed to the future driller population.)

Alternative 2 is ranked first because it achieves this protectiveness more quickly and eliminates the potential threat to groundwater posed by long-lived Tc-99.

Alternative 1 is ranked second because the monofill ET barrier would need to be maintained to sustain protectiveness.

7.3.2.2 Reduction in Toxicity, Mobility, or Volume through Treatment

None of the alternatives uses treatment to address the principal threat contaminant. Alternative 2 ranks higher than Alternative 1 because RTD reduces contaminant volume.

7.3.2.3 Short-Term Effectiveness

Alternatives 1 and 2 both ensure protectiveness in the near term.

Alternative 1 is ranked first because it poses much lower short-term risks to human health and the environment during implementation.

Alternative 2 (Partial RTD) is ranked second because it involves excavation and management of highly contaminated soils, which will pose significant risks to human health and the environment. Although existing safety programs are capable of addressing these risks, the consequences of an error could be significant.

7.3.2.4 Implementability

Alternative 0 is not considered implementable due to anticipated difficulties in obtaining required approvals.

Alternatives 1 and 2 are both implementable.

Alternative 1 is ranked first because it is the most easily implemented with the least amount of technical and administrative challenges.

Alternative 2 is ranked second because it is much more logistically complex, requiring significant efforts for protection of human health and the environment during excavation and management of the contaminated soils.

7.3.2.5 Cost

The present-worth cost for each alternative, developed in Appendix D, is as follows:

- Alternative 0 = $0
- Alternative 1 = $3,965,968
- Alternative 2 = $51,396,466.

7.3.3 Preferred Remedy for the 216-A-8 Crib

Based on comparative analysis of the alternatives carried forward for the 216-A-8 Crib, **Alternative 1 – Monofill ET Barrier** was selected as the most feasible alternative. It achieves protectiveness by controlling access to the principal threat contaminants and limiting infiltration and thus migration of the more mobile contaminants. The principal threat contaminant, Cs-137, is expected to decay to levels that pose no unacceptable risk to the industrial site construction worker within 136 years, and to levels that pose no unacceptable risk to the well driller or residential farmer within 249 years. Institutional controls will ensure that the barrier is protected and maintained during that time period. Short-term risks incurred are associated

with activities that are routine at the Hanford Site and readily and effectively controlled by existing Site worker protection and environmental protection programs. The cost for this alternative is $3,965,968; see Appendix D for details.

Table 7-1. Comparative Analysis Summary for the 216-Z-1A Tile Field Remedial Alternatives.

Alternative	Overall Protectiveness (Threshold)	ARARs (Threshold)	Long-Term Effectiveness and Permanence	Treatment	Short-Term Effectiveness	Implementability	Cost
Alternative 0 No Action	Fail	Fail	N/A	N/A	N/A	N/A	N/A
Alternative 1 Soil Backfill + Expanded SVE	Ranks FOURTH. Meets RAOs, but not robust. Short-term risk very low.	Pass	Ranks FOURTH. Achieves RAOs, no risk reduction or barrier for direct-contact pathway.	Ranks FOURTH. No treatment of COC radioisotopes in soils. Uses SVE to treat CCl_4.	Ranks **FIRST** (tie). Attains RAOs relatively quickly. Very low short-term risks.	Ranks **FIRST**. Readily implemented. No notable challenges.	Ranks FIRST. $5,619,236
Alternative 2 IPF + Expanded SVE	Ranks **FIRST**. Meets RAOs, includes barrier. Very minor short-term risks.	Pass	Ranks THIRD. Meets RAOs. Durable barrier to intrusion.	Ranks FOURTH. No treatment of COC radioisotopes in soils. Uses SVE to treat CCl_4.	Ranks **FIRST** (tie). Attains RAOs relatively quickly. Very low short-term risks.	Ranks SECOND. Readily implemented. Design work adds challenges.	Ranks SECOND. $5,814,907
Alternative 3 ISV + Expanded SVE	Ranks SECOND. Meets RAOs, includes barrier. Moderate short-term risks.	Pass	Ranks **FIRST**. Achieves RAOs, encapsulates top 20 ft of high activity radioisotopes, establishes durable barrier to intrusion.	Ranks **FIRST**. SVE to treat COCs. ISV to treat highest concentrations of non-COC radioisotopes in soils.	Ranks THIRD. Attains RAOs relatively quickly. Some intrusive work presenting direct-contact risks. Waste stream.	Ranks FOURTH. Technology not fully vetted. Not recently implemented at Hanford. Precursor activities needed to gain acceptance.	Ranks THIRD. $356,819,181
Alternative 4 Partial RTD + Expanded SVE	Ranks THIRD. Meets RAOs, reduces risk, but high short-term risks.	Pass	Ranks SECOND. Achieves RAOs, removes top 20 ft of high concentration radioisotopes, establishes durable barrier to intrusion.	Ranks FOURTH. No treatment of COC radioisotopes in soils. Uses SVE to treat CCl_4.	Ranks FOURTH. Attains RAOs relatively quickly. Much intrusive work (high-rad) and large waste stream.	Ranks THIRD. Routine activities, but significant level of effort. Substantial waste management activities and off-site disposal.	Ranks FOURTH. $418,806,585

ARAR = applicable or relevant and appropriate requirement.
COC = contaminant of concern.
IPF = intrusion-prevention feature.
ISV = in situ vitrification.
RAO = remedial-action objective.
RTD = removal, treatment, and disposal.
SVE = soil-vapor extraction.

Table 7-2. Comparative Analysis Summary for the 216-Z-9 Trench Remedial Alternatives.

Alternative	Overall Protectiveness (Threshold)	ARARs (Threshold)	Long-Term Effectiveness and Permanence	Treatment	Short-Term Effectiveness	Implementability	Cost
Alternative 0 No Action	Fail	Fail	N/A	N/A	N/A	N/A	N/A
Alternative 1 CDF + Targeted SVE	Ranks **FIRST**. Achieves RAOs, robust, lowest short-term risks.	Pass	Ranks FOURTH. Achieves RAOs, mitigates direct-contact pathway.	Ranks SECOND (tie). SVE to treat COCs. No treatment of non-COC radioisotopes in soils.	Ranks **FIRST**. Attains RAOs relatively quickly. Lowest short-term risks.	Ranks **FIRST**. Readily implemented. No notable challenges.	Ranks **FIRST**. $4,706,371
Alternative 2 IPF + Targeted SVE	Ranks SECOND. Achieves RAOs, robust, second lowest short-term risk.	Pass	Ranks THIRD. Achieve RAOs, mitigates direct-contact risk more robustly than Alternative 1.	Ranks SECOND (tie). SVE to treat COCs. No treatment of non-COC radioisotopes in soils.	Ranks SECOND. Attains RAOs relatively quickly. Second lowest implementation risks.	Ranks SECOND. Readily implemented. Slightly more challenging that CDF.	Ranks SECOND. $4,740,027
Alternative 3 ISV + Targeted SVE	Ranks THIRD. Achieves RAOs, very robust, moderate short-term risks.	Pass	Ranks **FIRST**. Achieves RAOs, encapsulates top 15 ft of high concentration radioisotopes, establishes durable barrier to intrusion.	Ranks **FIRST**. SVE to treat COCs. ISV to treat highest concentrations of non-COC radioisotopes in soils.	Ranks THIRD. Attains RAOs relatively quickly. Some intrusive work presenting direct-contact risks.	Ranks FOURTH. Technology not fully vetted. Not recently implemented at Hanford. Precursor activities needed to gain acceptance.	Ranks THIRD. $26,951,350
Alternative 4 Partial RTD + Targeted SVE	Ranks FOURTH. Achieves RAOs, very robust, highest short-term risk.	Pass	Ranks SECOND. Achieves RAOs, removes top 10 ft of high concentration radioisotopes, establishes barrier to intrusion.	Ranks SECOND (tie). SVE to treat COCs. No treatment of non-COC radioisotopes in soils.	Ranks FOURTH. Attains RAOs relatively quickly. Much intrusive work presenting direct-contact risks, and risks to public and environment.	Ranks THIRD. Routine activities, but significant level of effort. Substantial waste management activities and off-site disposal.	Ranks FOURTH. $28,258,025

ARAR = applicable or relevant and appropriate requirement.
CDF = controlled-density fill.
COC = contaminant of concern.
IPF = intrusion-prevention feature.
ISV = in situ vitrification.
RAO = remedial-action objective.
RTD = removal, treatment, and disposal.
SVE = soil-vapor extraction.

Table 7-3. Comparative Analysis Summary for the 216-A-8 Crib Remedial Alternatives.

Alternative	Overall Protectiveness (Threshold)	ARARs (Threshold)	Long-Term Effectiveness and Permanence	Treatment	Short-Term Effectiveness	Implementability	Cost
Alternative 0 No Action	Fail	Fail	N/A	N/A	N/A	N/A	N/A
Alternative 1 Monofill ET Barrier	Ranks **FIRST**.[1] Achieves RAOs, lowest short-term risks.	Pass	Ranks SECOND. Achieves RAOs, mitigates direct-contact pathway.	Does not meet this criterion.	Ranks **FIRST**. Mitigation for 150 years while MNA reduces risk to acceptable levels. Relatively low short-term risks.	Ranks **FIRST**. Readily implemented. No notable challenges.	Ranks **FIRST**. $3,965,968
Alternative 2 Partial RTD	Ranks SECOND.[1] Achieves RAOs, high short-term risk.	Pass	Ranks **FIRST**. Achieves RAOs, mitigates direct-contact risk more robustly than Alternative 1.	Does not meet this criterion.	Ranks SECOND. Attains RAOs relatively quickly. Short-term risks are high.	Ranks SECOND. Routine activities high level of effort to mitigate risks.	Ranks SECOND. $51,396,466

[1] Assumes that sampling will show that Tc-99 does not pose an unacceptable threat to groundwater. If not true, then ranking would switch in this column.
ARAR = applicable or relevant and appropriate requirement.
RAO = remedial-action objective.
RTD = removal, treatment, and disposal.

8.0 UNCERTAINTIES RELATED TO DECISION MAKING

The purpose of this section is to describe the uncertainties inherent to the analyses performed as part of the FS. Uncertainties are propagated throughout any evaluation of technical processes that have a scope as complex as environmental restoration. The uncertainty is a reflection of limited knowledge, engineering, and technical assumptions made during the evaluation. Examples of the uncertainties that propagate through the FS evaluations are in the areas of technology, cost, performance, policy, future land use, and human health and ecological risk. Other associated uncertainties include the following:

- Uncertainties in estimating and evaluating health risk posed by contamination
- Uncertainty of estimating the extent of contamination and the resulting efficiency of the selected remedial alternative
- Uncertainty associated with the cost of implementing remedial technologies.

A summary of these uncertainties and their associated potential impacts is presented below.

8.1 UNCERTAINTIES IN ESTIMATING AND EVALUATING HEALTH RISK POSED BY CONTAMINATION

Estimating and evaluating health risk from exposure to environmental contaminants is a complex process with inherent uncertainties. Uncertainty reflects limitations in knowledge, and simplifying assumptions that must be made to quantify health risks. Some key areas of uncertainty evaluated in the human-health risk assessment are listed below. A more detailed discussion regarding uncertainties in the risk assessment process is presented in Section A6 of Appendix A.

- No data for Pu-241. The measured concentrations of Am-241 are the result of in-growth from decay of Pu-241 released to the Z Plant sites from the plutonium production. Because laboratory analysis for Pu-241 is difficult, Pu-241 has not been analyzed at any of the Z Plant sites; therefore, the Am-241 concentrations measured at the sites may not be at their maximum concentration, depending on how much Pu-241 is present and how much has decayed. The half-life of Pu-241 is 14.5 years. Therefore, the percent of maximum Am-241 concentration currently present in soil was estimated using disposal information from the waste sites and the information on the half-life of Pu-241. The "0" year for the RESRAD modeling of Am-241 in-growth was estimated to be 1967 for the 216-Z-1A Tile Field and 1960 for the 216-Z-9 Trench. The final wastes disposal to the major 200-PW-1, 200-PW-3, and 200-PW-6 OU waste sites varied in time and therefore some sites are further along the Am-241 in-growth curve than others. Furthermore, there is an uncertainty at the Z Plant sites as to whether the maximum concentrations of Am-241 have been adequately captured; however, analysis indicates that 97 percent of the Am-241 maximum concentrations have likely been reached.

- Produce ingestion: Risks are significantly above target health goals due largely to ingesting homegrown produce grown in impacted soils (Table 3-2). Risks and hazards also are significantly above target health goals if produce is watered with impacted groundwater (see Tables A5-10 and A5-11 in Appendix A). Calculated risks and hazards from ingestion of homegrown produce are dependent on the concentration in the plant tissue and the produce ingestion rate. Plant tissue concentrations were estimated using health-protective modeling that likely over-estimates the amount of COPC that could be in the plant. The modeling equations used were from the RESRAD computer model (soil-to-plants) and those developed by the Oak Ridge National Laboratory for calculation of PRGs (water-to-plants and water-to-cattle). The transfer factors for water-to-plants and water-to-cattle were obtained from HNF-SD-WM-TI-707, which preferentially used Hanford Site-specific data where they were available. Modeling details and transfer factors are described in detail in Section A3.2.3 of Appendix A.

  In addition to uncertainties surrounding actual concentrations of COPCs in plants, there also is uncertainty surrounding how much homegrown produce a person would eat. The risk calculations used average homegrown fruit and vegetable ingestion rates for households who farm in the Western United States from EPA/600/R-97/006, *The Lognormal Distribution in Environmental Applications* (see also Section A3.3.2.1 in Appendix A). These values were selected to best represent a rural farming population that would be expected to receive a significant portion of their produce from their own garden; however, actual ingestion rates could vary. A more detailed discussion regarding produce ingestion rates can be found in Section A6.2.4 of Appendix A.

- Native American population: A Native American population was qualitatively evaluated because cancer risks and non-cancer hazards already are well above target health goals for the residential farmer. A residential farming population was selected to represent the RME "bounding" scenario because this population has widely accepted exposure factors that have been used over many years at many CERCLA sites. However, based on on-going work evaluating the differences between a tribal scenario and a residential farmer, Native Americans likely have higher exposure to many environmental media, although, with few exceptions, Native American exposure pathways are the same as the residential farmer's (e.g., both groups could be exposed via direct contact with contaminated materials and the food chain). Table 3-3 compares the exposure factors and possible risks for a residential farmer and Native Americans using exposure factors established for the Confederated Tribes of the Umatilla Indian Reservation by Harris and Harper (2004) for the exposure pathways that are the same (i.e., direct soil and water contact pathways).

  Another area where tribal subsistence scenarios and residential scenarios can differ in addition to increased exposures for pathways that are the same (e.g., soil ingestion) is in the amount of food gathered or grown locally. Under the assumptions in this risk assessment, groundwater is used to irrigate a garden area, sufficient to produce a significant portion of a residential farmer's diet, but not sufficient in size to supply all a family's dietary needs. Therefore, in this case, the homegrown produce ingestion rates (produce ingestion was a risk-driving pathway) would be similar between the two populations.

Similar to produce irrigated with groundwater, if a Native American produced more of their own protein than a residential farmer, they might ingest more of their own beef. Beef ingestion had the lowest risks and hazards for the residential farmer exposure pathways with risks of 3×10^{-5} or less and no non-cancer hazards above one (see Section A5 of Appendix A for risks from groundwater-to-cattle food chain pathways). Ingestion rates of dairy products from home-raised dairy cattle also are potentially different for Native Americans than the ingestion rates established by EPA for families who farm.

There are several exposure pathways applicable to a Native American population that are not evaluated for the residential farmer: ingestion of wild plants and wild game, and exposures to water and water vapor in a sweat lodge. Under the assumptions in this assessment, wild plants and game would not be significantly affected by contaminants because contaminants are confined to a residential garden and water from groundwater. While contaminants in soil might be spread by wind-blown dust, and, if an irrigation ditch system is used, there could be minimal exposure to groundwater, in general a developed farm would not be conducive to wild plant and animal growth and habitat. Therefore, these exposure pathways are not applicable to the Hanford Site Central Plateau waste sites. However, a sweat lodge using groundwater would be possible and, using the sweat lodge exposure parameters developed by Harris and Harper (2004), a sweat lodge could be a significant source of contaminants in groundwater, with risks and hazards potentially exceeding the drinking water pathway. The estimates of sweat lodge risks are approximately an order of magnitude larger than those for drinking water shown in the example on Table 3-3 and are based on a comparison of risks from vapor inhalation in a sweat lodge to risks from drinking water for the Native American sweat lodge scenario evaluated for Midnite Mine (EPA 2006), a uranium mine in northeastern Washington State.

- Construction worker: Characterization of the top 4.6 m (15 ft) at several waste sites was limited with few soil samples representing that depth horizon because the shallower soil has not been impacted. Therefore, use of exposure concentrations from the deepest soil depth construction workers likely would encounter has potentially resulted in risks that are biased high because the majority of a construction workers' exposure would be to the shallower, uncontaminated soil.

- Residential farmer soil concentrations: Concentrations are dependent on the size of garden over which drill cuttings would be spread. The risk calculations assumed a 100 m^2 garden, based on an area that likely could supply 25 percent of vegetables and fruit for a family of four. Larger size gardens or other types of spreading areas would result in a decrease in concentrations.

8.1.1 Potential Impacts

Potential impacts associated with the uncertainty in the human-health risks described above most likely would not have an impact on protecting human health because the construction worker pathway was the primary pathway evaluated for remedy selection. The risk assessment most likely over-estimates the amount of COPCs found in plant tissue, which could increase the

effects that contaminant exposure might have on the future residential farmer. Potential impacts associated with the second uncertainty described above are not expected to alter the proposed remedies, because cancer risks and non-cancer hazards for the residential farmer already are above target health goals under CERCLA (i.e., have a hazard index >1 and cancer risks >1 x 10^{-4}) and the primary exposure considered for remedy development was for the construction worker. Increased exposures for a Native American population would not result in a change in action, because the risks already exceed the action threshold and require action to the taken. Potential impacts related to constructions workers are biased high because the majority of a construction workers' exposure would be to the shallower, uncontaminated soil. Potential impact associated with the residential farmer soil concentrations are calculated assuming a 100 m^2 (1,076 ft^2) garden; thus, larger sized gardens would result in a decrease of concentrations and risk.

8.2 UNCERTAINTY OF ESTIMATING THE EXTENT OF CONTAMINATION AND POTENTIAL IMPACTS TO GROUNDWATER

The Implementation Plan (DOE/RL-98-28) established the use of the analogous waste site concept. This strategy was selected to organize waste sites in the 200 Areas into waste groups based on similar processes, waste-disposal histories, and type of site (Implementation Plan; DOE/RL-98-28). Recognition was given in the Implementation Plan regarding the capacity of this concept to introduce uncertainty with respect to the selected remedy. Individual waste-site data were reviewed for the following:

- Location
- Waste source and associated chemical process
- Volume of liquids received
- Type of contaminant(s) received and associated cumulative inventory
- Waste site type/structure.

Uncertainty in selecting the appropriate remedy is dependent on the characterization and relationship of the representative waste sites to the analogous waste sites.

RESRAD, Version 6.3, and RESRAD-CHEM were used to evaluate the potential impact to groundwater within 1,000 years from radionuclide, organic, and inorganic COPCs left in the vadose zone in the 200 West Area and the 200 East Area under current and future conditions. Selecting the appropriate remedy to mitigate and/or prevent risk associated with the analysis of the modeling results poses a degree of uncertainty. Uncertainties lie in the execution of RESRAD and RESRAD-CHEM modeling scenarios.

To execute these models, the following assumptions were made.

- RESRAD and RESRAD-CHEM models are simplified representations of natural systems that reliably represent the subsurface environment at the waste sites evaluated.
- The soil characteristics and contamination properties for the model adequately represent the contamination within the modeled areas.

- Soil properties within each model layer are homogenous.
- Contamination is homogenously distributed in the contamination zone.
- RESRAD assumes that the groundwater well is located at the downgradient edge of the contaminated zone.
- Contamination transport is one-dimensional.
- Future site conditions are consistent with current conditions.
- Radionuclides with half-lives less than 180 days are in equilibrium with principal radionuclides (those in the decay chain with half-lives greater then 180 days).

8.2.1 Potential Impacts

Selected remedies are based on representative waste sites, which can present potential impacts to the remedies of the analogous waste sites if characterization of an analogous waste site reveals conditions significantly different from the representative waste site. However, acknowledgement of this uncertainty was taken into consideration during the Implementation Plan and as a result, confirmation sampling of the analogous waste sites after remedy selection may be conducted (see Section 2.5). In addition, contingent remedial actions are described that would mitigate this uncertainty.

Potential impacts regarding the risks evaluated in RESRAD and RESRAD-CHEM may alter the design of the selected remedy. However, remedies may be modified during the proposed plan and ROD. The assumptions made in the modeling are considered conservative and therefore, the selected remedies are expected to address a conservative worst-case scenario.

8.3 UNCERTAINTY WITH THE COST OF REMEDIAL TECHNOLOGIES

The purpose of a cost estimate is to provide adequate information so alternatives can be compared. Uncertainties regarding both capital and annual costs are associated with the assumptions of the remedial alternatives and current economics. See Appendix D for assumptions used and considered in the cost estimating.

The extent of contamination used in the analysis of alternatives was based on the best data available at the time of analysis. Inherent uncertainty in the depths and lateral extents of contamination are expected to have only minor impact on the cost of the evaluated alternatives. Changes in the extent of contamination will not be known until additional characterization during confirmatory sampling and remedial design sampling or remedial implementation is undertaken. The impact from these uncertainties is expected to be minimal and likely will have a similar impact on each of the evaluated alternatives at a site.

The effectiveness of MNA processes has not been quantified sufficiently to determine whether it will be an effective mechanism for organic contaminant mass reduction in the vadose zone. The uncertainties related to MNA include the magnitude, rate, and extent to which MNA processes will degrade organic contaminants.

8.3.1 Potential Impacts

The uncertainty with respect to MNA processes is not expected to affect the evaluation of remedies and selection of the preferred remedy. Potential impacts from the uncertainty in MNA processes and cost estimate assumptions would result in under- or over-estimating the remedial-alternative cost. Costs will be refined during the remedial design to better reflect the selected remedy and extent of remediation to be implemented at each waste site.

9.0 CONCLUSIONS AND PATH FORWARD

The 200-PW-1, 200-PW-3, and 200-PW-6 OUs FS resulted in identification of a preferred alternative for the representative and unique waste sites by considering seven of the nine CERCLA evaluation criteria. A summary of the FS evaluation process and the path forward for the 200-PW-1, 200-PW-3, and 200-PW-6 OUs are described in this chapter.

9.1 FEASIBILITY STUDY SUMMARY

This FS report focused on the evaluation of remedial alternatives for the six representative and unique waste sites within the 200-PW-1, 200-PW-3, and 200-PW-6 OUs: 216-Z-1A Tile Field, 216-Z-8 French Drain, 216-Z-9 Trench, 216-Z-10 Injection/Reverse Well, 241-Z-361 Settling Tank, and 216-A-8 Crib. The evaluation of the appropriateness of the identified preferred remedial alternative for the representative waste sites to the remaining 11 analogous waste sites will be presented in the proposed plan for the 200-PW-1, 200-PW-3, and 200-PW-6 OUs.

The human-health risk assessment evaluated organic, inorganic, and radionuclide COPCs for the representative and unique waste sites. The screening-level ecological risk assessment ruled out all 17 waste sites in these OUs from further consideration of potential ecological risk. An evaluation of future migration to groundwater from the 200-PW-1, 200-PW-3, and 200-PW-6 OU COPCs was performed. The human-health risk assessment and groundwater migration evaluation identified COCs for the representative and unique waste sites, as shown in Table 9-1.

Table 9-1. Contaminants of Concern for Representative and Unique Waste Sites. (2 Pages)

Waste Site	Risk Receptor				
	Industrial Site Construction Worker	Ecological Risk	Future Well Driller	Future Residential Farmer	Groundwater Protection
216-Z-1A Tile Field	Am-241 Pu-239/240	None Identified	None Identified	Am-241 Pu-239/240	CCl_4 [a]
216-Z-8 French Drain	None Identified	None Identified	None Identified	None Identified	None Identified
216-Z-9 Trench	Am-241 Pu-239/240[b]	None Identified	None Identified	Am-241 Pu-239/240	CCl_4 Hexachloroethane Tetrachloroethylene
216-Z-10 Injection/Reverse Well	None Identified	None Identified	None Identified	None Identified	None Identified
241-Z-361 Settling Tank [c]	None Identified	None Identified	None Identified	None Identified	None Identified

Table 9-1. Contaminants of Concern for Representative and Unique Waste Sites. (2 Pages)

Waste Site	Risk Receptor				
	Industrial Site Construction Worker	Ecological Risk	Future Well Driller	Future Residential Farmer	Groundwater Protection
216-A-8 Crib	Cs-137	None Identified	None Identified	Cs-137	Tc-99 [d]

"None identified" – The CERCLA risk assessment process did not identify any condition that would result in unacceptable levels of risk to human health or the environment.

[a] Although not identified in remedial investigation soil samples, soil vapor recovery efforts continue to remove kilogram quantities of CCl_4 from the vadose zone annually, suggesting that migration to groundwater is possible.
[b] Not identified as contaminants of concern for the site construction worker, but best management practice warrants a more substantial form of physical separation from the contaminated soil.
[c] Contaminants of concern were not identified for this site because there has been no identified release to the environment.
[d] Technetium-99 was only identified at significant concentrations in one soil sample (79.6 pCi/g at 5.8-6.5 m [19-21.5 ft] below ground surface). Pending confirmatory soil sampling, the preferred alternative will mitigate the potential future impacts this contaminant may have on groundwater beneath the waste site.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*

Based on the current and anticipated future land use of the site as industrial, the risks to construction workers and potential impacts to groundwater were identified as the key risk pathways to be addressed by the remedial alternatives evaluated in this FS report.

The RAOs developed in Chapter 3.0 provide a basis for evaluating the capability of a specific remediation alternative to achieve compliance with potential ARARs and/or an intended level of risk reduction in order to protect human health and the environment. Specific RAOs for this FS were defined based on the fate and transport of contaminants, projected land uses for the 200 Areas, and the human-health risk assessment exposure pathways. The RAOs for this FS are as follows:

- **RAO 1.** Prevent unacceptable risk to human health due to direct contact with COCs in the soil within 4.6 m (15 ft) of the ground surface. Unacceptable risks are (1) an excess lifetime cancer risk greater than 1 in 10,000 (1×10^{-4}) or (2) a dose exceeding 100 mrem/yr, consistent with an industrial land-use scenario. With respect to this RAO, COCs include Am-241 and Pu-239/240 at the 200-PW-1 OU and 200-PW-6 OU waste sites, and Cs-137 at the 200-PW-3 OU waste sites.
- **RAO 2.** Prevent migration of COCs to groundwater in concentrations that exceed MCLs. With respect to this RAO, COCs include CCl_4, hexachloroethane, and PCE at the 200-PW-1 OU waste sites, and Tc-99 at 200-PW-3 OU waste sites.

Development and Evaluation of Remedial Alternatives

For each waste site where remedial action was required, the FS identified and evaluated technologies capable of addressing the identified risks, selected those judged to be most effective and implementable, and combined them into remedial alternatives. Then, each of these remedial alternatives was evaluated with respect to the CERCLA threshold and balancing criteria, as

documented in Chapter 6.0. This detailed analysis assessed each site-specific remedial alternative with respect to the following criteria.

- Threshold criteria:
  - Overall protection of human health and the environment
  - Compliance with ARARs
- Balancing criteria
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, or volume through treatment
  - Short-term effectiveness
  - Implementability
  - Cost.

For each representative waste site, alternatives that met the threshold criteria were carried forward into the comparative analysis, documented in Chapter 7.0. Here, the information developed in the detailed analysis was used to compare the remedial alternatives, and to identify a preferred alternative for each representative waste site. The outcome of the detailed analysis and the subsequent comparative analysis was as follows.

Detailed analysis of alternatives for the 216-Z-1A Tile Field brought forward the following five remedial alternatives:

- Alternative 0 – No Action (consideration required by CERCLA)
- Alternative 1 – Soil Backfill plus Expanded SVE
- Alternative 2 – IPF plus Expanded SVE
- Alternative 3 – ISV plus Expanded SVE
- Alternative 4 – Partial RTD plus Expanded SVE.

Based on the comparative analysis of these alternatives, **Alternative 2 – Intrusion-Prevention Feature plus Expanded Soil-Vapor Extraction** was identified as the preferred alternative for the 216-Z-1A Tile Field. It achieves protectiveness by establishing 4.6 m (15 ft) of separation between the contaminants that exceed RBCs, and provides a durable physical barrier to intrusion that is effective under both industrial use and a potential future unrestricted land-use scenario, should institutional controls fail in the future. Short-term risks are minor, associated with activities that are routine at the Hanford Site and readily and effectively controlled by existing Hanford Site worker protection and environmental protection programs. The only waste stream generated is from the SVE system, currently implemented at the site as an expedited response action to remove CCl_4 mass and protect groundwater. The present-worth cost for this alternative is estimated at $5,814,907; see Appendix D for further details.

Detailed analysis of alternatives for the 216-Z-9 Trench brought forward the following five remedial alternatives:

- Alternative 0 – No Action (consideration required by CERCLA)
- Alternative 1 – CDF plus Targeted SVE
- Alternative 2 – IPF plus Targeted SVE

- Alternative 3 – ISV plus Targeted SVE
- Alternative 4 – Partial RTD and IPF plus Targeted SVE.

Based on the comparative analysis of these remedial alternatives, **Alternative 1 – Controlled-Density Fill plus Targeted Soil-Vapor Extraction** was identified as the preferred remedial alternative for the 216-Z-9 Trench. It mitigates the threat to groundwater by controlling infiltration, and uses an expanded SVE system (including new wells that target the contaminant source area) to reduce contaminant mass. This alternative also uses CDF (Section 4.2.2.3.2) to fill the trench void space, which stabilizes the concrete trench cover and establishes substantive physical separation from the contaminants below the trench floor. The present-worth cost for this alternative is estimated at $4,706,371; see Appendix D for further details.

Detailed analysis of alternatives for the 216-A-8 Crib brought forward the following three remedial alternatives:

- Alternative 0 – No Action (consideration required by CERCLA)
- Alternative 1 – Monofill ET Barrier
- Alternative 2 – Partial RTD.

Based on comparative analysis of these alternatives, **Alternative 1 – Monofill Evapotranspiration Barrier** was identified as the preferred remedial alternative for the 216-A-8 Crib. It achieves protectiveness with respect to the principal threat contaminant, Cs-137, by increasing physical separation and maintaining that separation while natural radioactive decay reduces the contaminant concentrations to levels that pose no unacceptable risk. Cesium-137 has a half-life of approximately 30 years and is expected to decay to levels protective of the site construction worker in approximately 136 years, and to levels that pose no unacceptable risk to the future well driller or future residential farmer in 249 years. Institutional controls will ensure that the barrier is protected and maintained during that time period. Short-term risks incurred are associated with activities that are routine at the Hanford Site and readily and effectively controlled by existing Hanford Site worker protection and environmental protection programs. The present-worth cost for this alternative is estimated at $3,965,968; see Appendix D for further details.

Other Representative and Unique Waste Sites

241-Z-361 Settling Tank: The remaining sludge in this tank poses a potential risk to human health and the environment. An earlier evaluation (DOE/RL-2003-52) determined that this potential risk would best be remediated by (1) using a Power Fluidics system to loosen and homogenize the sludge and transfer it to SWBs, and (2) adding WaterWorks SP-400 Superabsorbent Crystals, a polymer absorbent, to the containers to absorb residual liquids, thereby stabilizing the waste. The SWBs then would be transported to the CWC for storage pending proper disposition. Based on available data, the SWBs likely will contain more than 100 nCi/g of alpha-emitting transuranic radioisotopes with half-lives greater than 20 years, and would require disposal at WIPP. Once the sludge has been removed from the tank and transported to the CWC, there would be no identified unacceptable level of risk associated with the 241-Z-361 Settling Tank. The tank would be left in place and backfilled with CDF. The

present-worth cost for this alternative is estimated at $12,918,889; see Appendix D for further details.

216-Z-8 French Drain: Results from the risk assessment indicated that contaminants identified at the 216-Z-8 French Drain (Am-241 and Pu-239/240) pose no unacceptable risks to human health or ecological receptors; therefore, no remedial actions are required for this site.

216-Z-10 Injection/Reverse Well: Historical soil sampling and analysis specifically targeting the potential for contamination at the 216-Z-10 Injection/Reverse Well identified no significant plutonium contamination. Because there are no direct-contact risks to human health or to potential ecological receptors, no remedial action is required at the 216-Z-10 Reverse/Injection Well. This waste site will be closed by decommissioning the well in accordance with the substantive requirements of WAC 173-160-381. As a precaution, decommissioning activities will be modified to the extent practicable to minimize the volume of liquid introduced into the well during the decommissioning process. Grouting will seal the well and annular space, precluding infiltration of water from the surface.

9.2 PATH FORWARD

The CERCLA activities that have been completed for the 200-PW-1, 200-PW-3, and 200-PW-6 OU representative and unique waste sites have quantified risks to human health and the environment, identified waste sites where those risks are unacceptable, and identified a preferred remedial alternative for each of those waste sites. The final selection of a preferred remedy for each of the waste sites in the 200-PW-1, 200-PW-3, and 200-PW-6 OUs will be made by EPA based on the information presented in the RI Report (DOE/RL-2006-51), the baseline risk assessment, this FS report, and the proposed plan, as well as comments submitted to EPA on the proposed plan by the state, the public, and other interested parties. The path forward for the 200-PW-1, 200-PW-3, and 200-PW-6 OUs is described in the following subsections.

9.2.1 Proposed Plan

The proposed plan is the document issued to the public by EPA that identifies the EPA's preferred remedial alternative for each waste site in the 200-PW-1, 200-PW-3, and 200-PW-6 OUs. The document outlines pertinent information from the RI and FS and provides a summary of the remedial alternatives that were evaluated. Evaluation of the appropriateness of the identified preferred remedial alternative for the representative waste sites in the FS report to the 11 analogous waste sites will be presented in the proposed plan for the 200-PW-1, 200-PW-3, and 200-PW-6 OUs. The analogous waste sites will be described, the anticipated risks identified, and a preferred remedial alternative will be identified for each waste site. A key principle of the analogous waste sites approach is to recognize that contingencies are considered whereby alternative remedial action may be required should data collected during the remedial design or implementation demonstrate that the preferred remedy identified in the FS report or proposed plan is not appropriate. Contingent remedial alternatives that may need to be applied to the analogous waste site preferred remedial alternatives also will be presented in the proposed plan.

When the proposed plan for the 200-PW-1, 200-PW-3, and 200-PW-6 OUs is issued, EPA will hold public meetings at which the proposed plan will be formally presented. The EPA also will open a public comment period during which oral and written comments from the public on the proposed plan will be considered. After the public comments have been reviewed, EPA will sign a ROD that documents the final decision and the remedial alternatives selected for each waste site. Along with the ROD, EPA will issue a summary that provides the response to all significant comments submitted during the public comment period.

9.2.2 Record of Decision

The ROD is a public document that explains which cleanup alternatives will be used to clean up the 200-PW-1, 200-PW-3, and 200-PW-6 OUs. Generally, the lead agency performs the following steps during the ROD development process:

- Prepares the draft ROD
- Submits the draft ROD to other lead agency program offices and to the support agency for review and comment
- Reviews and responds to comments and revising the ROD, if necessary
- Briefs the Regional Administrator or delegated decision-maker (and, if necessary, the appropriate Headquarters manager or the Assistant Administrator of the Office of Solid Waste and Emergency Response), as well as designated personnel in the support agency
- Submits the ROD to the Regional Administrator or the Assistant Administrator of OSWER, if necessary, for signature.
- Publishes the notice of ROD availability.

9.2.3 Post-Record of Decision

After the ROD is signed, new information may be received or generated that could affect the implementation of the remedy selected in the ROD or that could prompt the reassessment of that remedy. The information could be identified at any time during, immediately before, or after the implementation of the remedy. Where information is submitted by a potentially responsible party, the public, or the supporting agency after a ROD is signed, the lead agency must consider and respond to this information and place such comments and responses in the Administrative Record file when all of the following criteria are met (40 CFR 300.825[c], "National Oil and Hazardous Substances Pollution Contingency Plan," "Record Requirements"):

- Comments contain significant information
- The new information is not contained elsewhere in the Administrative Record file
- The new information could not have been submitted during the public comment period
- The new information substantially supports the need to significantly alter the remedial action that is not considered by the FS report or the proposed plan remedial alternatives or contingency remedial alternatives.

The lead agency also may evaluate whether a remedy change is warranted on its own merits, even where the requirements of the NCP (40 CFR 300.825[c]) are not triggered.

9.2.4 Remedial Design

The technical specifications for cleanup remedies and technologies are detailed in the remedial design after development of the remedial design/remedial action work plan. The remedial design for the 200-PW-1, 200-PW-3, and 200-PW-6 OUs and the 200-ZP-1 Groundwater OU will need to be integrated to address remediation of CCl_4 in the vadose zone and groundwater. The EPA oversees development of the design and specifications for the selected remedy based on the specifications described in the ROD.

9.2.5 Remedial Action

Remedial action follows the remedial design phase and involves the actual construction or implementation phase of site cleanup. EPA oversees construction and operation of the remedy based on the specifications described in the ROD and the remedial design.

9.2.6 Five-year Review

CERCLA 5-year reviews provide an opportunity to evaluate the implementation and performance of a remedy to determine whether it remains protective of human health and the environment. Data summaries will be reviewed for performance monitoring of the remedy implementation in the 5-year review. Generally, reviews are performed 5 years following the initiation of a CERCLA response action, and are repeated every succeeding 5 years as long as future uses remain restricted. EPA will perform 5-year reviews, and EPA retains responsibility for determining the protectiveness of the remedy.

9.2.7 National Priorities List Delisting

The final closeout report documents compliance with the CERCLA decision documents and remedial design report/remedial action work plans for a Superfund site and provides a consolidated record of all removal and remedial actions for the entire NPL (40 CFR 300). The final closeout report describes how the cleanup was accomplished and provides the overall technical justification for site delisting from the National Priorities List by the EPA.

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10.0 REFERENCES

10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," Title 10, *Code of Federal Regulations*, Part 61.

40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities," Title 40, *Code of Federal Regulations*, Part 61.

40 CFR 61, Subpart M, "National Emission Standards for Asbestos," Title 40, *Code of Federal Regulations*, Part 61, Subpart M.

40 CFR 61.52, "National Emission Standards for Hazardous Air Pollutants," "Emission Standard," Title 40, *Code of Federal Regulations*, Part 61.52.

40 CFR 141, "National Primary Drinking Water Regulations," Title 40, *Code of Federal Regulations*, Part 141.

40 CFR 268, "Land Disposal Restrictions," Title 40, *Code of Federal Regulations*, Part 268.

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List," Title 40, *Code of Federal Regulations*, Part 300.

40 CFR 300.400(g), "National Oil and Hazardous Substances Pollution Contingency Plan," "General," "Identification of Applicable or Relevant and Appropriate Requirements," Title 40, *Code of Federal Regulations*, Part 300.400(g).

40 CFR 300.430(a), "Remedial Investigation/Feasibility Study and Selection of Remedy," "General," Title 40, *Code of Federal Regulations*, Part 300.430(a).

40 CFR 300.430(d), "Remedial Investigation/Feasibility Study and Selection of Remedy," "Remedial Investigation," Title 40, *Code of Federal Regulations*, Part 300.430(d).

40 CFR 300.430(e), "Remedial Investigation/Feasibility Study and Selection of Remedy," "Feasibility Study," Title 40, *Code of Federal Regulations*, Part 300.430(e).

40 CFR 300.430(e)(6), "Remedial Investigation/Feasibility Study and Selection of Remedy," "Feasibility Study," "The No-Action Alternative," Title 40, *Code of Federal Regulations*, Part 300.430(e).

40 CFR 300.430(e)(9), "Remedial Investigation/Feasibility Study and Selection of Remedy," "Feasibility Study," "Detailed Analysis of Alternatives," Title 40, *Code of Federal Regulations*, Part 300.430(e)(9).

40 CFR 300.430(f)(1)(ii)(C), "National Oil and Hazardous Substances Pollution Contingency Plan," "Remedial Investigation/Feasibility Study and Selection of Remedy," "Selection of Remedy," "Modifying Criteria," Title 40, *Code of Federal Regulations*, Part 300.430(f)(1)(ii)(C).

40 CFR 300.5, "National Oil and Hazardous Substances Pollution Contingency Plan," "Definitions," Title 40, *Code of Federal Regulations*, Part 300.5.

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APPENDICES A-F

ON CD

(Electronic copy only)

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DOE/RL-2007-40
DRAFT A

Proposed Plan for 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

United States Department of Energy
P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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J. D. Aardal 09/11/2007
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PROPOSED PLAN FOR 200-PW-1, 200-PW-3, and 200-PW-6 OPERABLE UNITS

Hanford Site, Richland, Washington

INTRODUCTION

This **Proposed Plan** identifies the **preferred alternatives** for remediation of the **contaminated subsurface** soil at 17 **waste sites** in the 200-PW-1, 200-PW-3, and 200-PW-6 **Operable Units** (OUs) and the rationale for the identification of the preferred alternatives. The content and format of this Proposed Plan generally follows *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents* (U.S. Environmental Protection Agency [EPA] 540-R-98-031). The identification of preferred alternatives was determined following ***Comprehensive Environmental Response, Compensation, and Liability Act of 1980*** (CERCLA) guidance (EPA 540/G-89/004) using two threshold criteria and five balancing criteria. The summary tables from this analysis are also presented in this document. This document is issued by the U.S. Department of Energy (DOE), Washington State Department of Ecology (Ecology), and the EPA. These three agencies, known collectively as the **Tri-Parties**, will select final remedies for these sites after reviewing and considering all information submitted during the 30-day public comment period.

The Tri-Parties are issuing this Proposed Plan as part of the public participation responsibilities under 40 *Code of Federal Regulations* (CFR) 300.430(f)(2) of the **National Oil and Hazardous Substances Pollution Contingency Plan** (NCP). Selection of an alternate remedy or modification to the preferred alternative may result from new information or public comments. Therefore, the public is encouraged to review and comment on all alternatives presented in this Proposed Plan. A review of the **remedial investigation** (RI) (DOE/RL-2006-51) and **feasibility study** (FS) (DOE/RL-2007-27) reports will provide greater understanding of the OUs and **Superfund** activities that have been conducted at these waste sites. These documents can be obtained from the **Administrative Record** file for the 200-PW-1, 200-PW-3, and 200-PW-6 OUs or by calling the Hanford Cleanup Line at 1-800-321-2008.

MARK YOUR CALENDAR

Public Comment Period: This Proposed Plan is being issued by the Tri-Parties for public comment. The Tribal nations, stakeholders and the general public are encouraged to comment during the public comment period that will run from (start date) to (end date). A remedy will be selected only after the public comment period has ended and comments received have been reviewed and considered. Responses to significant comments will be presented in a Responsiveness Summary that will be part of the Record of Decision.

Written comments on the Proposed Plan will be accepted through (date). Comments should be sent to:

Dennis Faulk
U.S. Environmental Protection Agency
309 Bradley Boulevard, Suite 115
Richland, WA 99352
e-mail: faulk.dennis@epa.gov
fax: (509) 376-2396

Copies of this Proposed Plan can be obtained from the Information Repositories identified at the end of this document, by calling the Hanford Cleanup Line at 1-800-321-2008, or from the website http://www2.hanford.gov/ARPIR/.

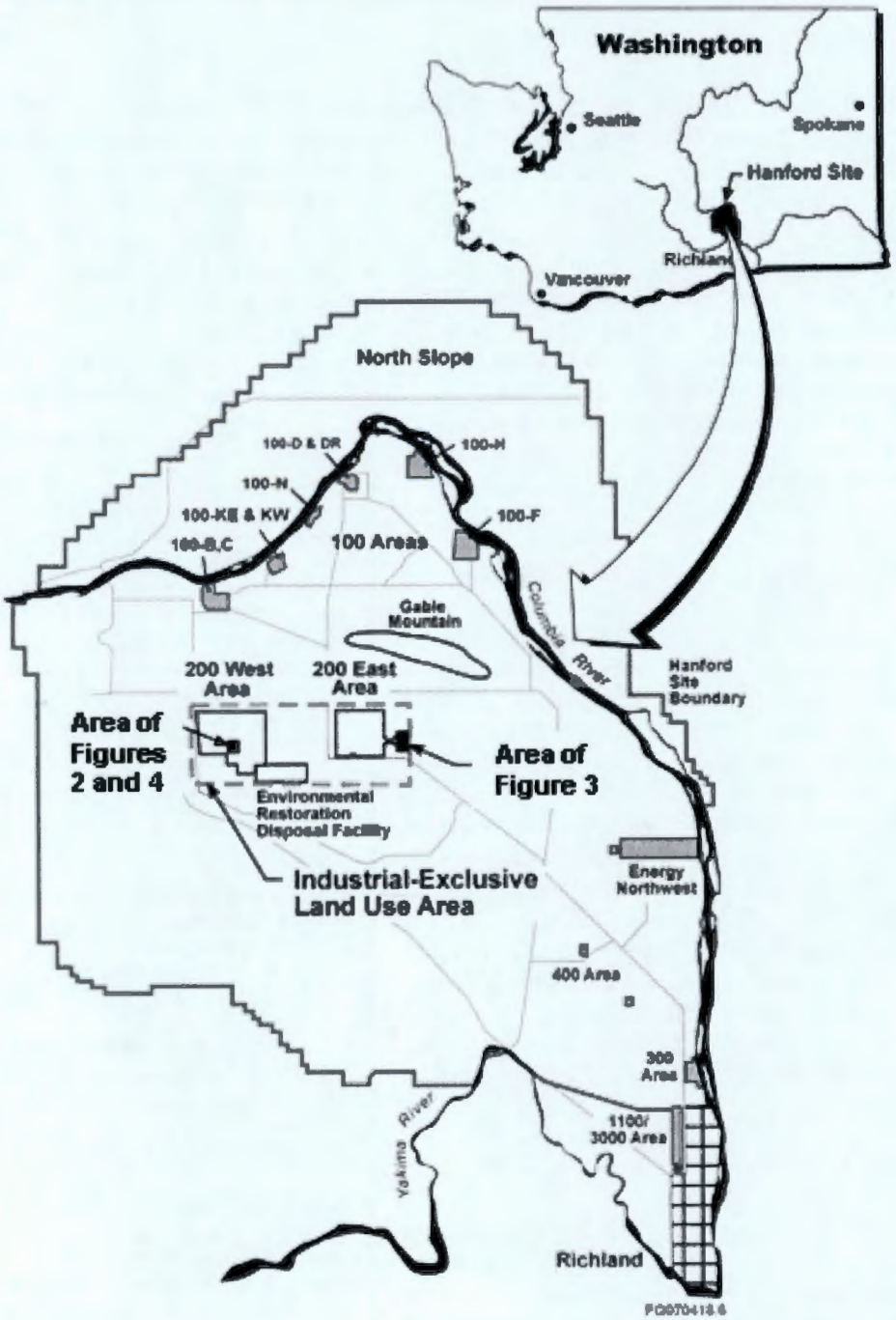
No specific format for the comments is necessary. All comments must be submitted either electronically before midnight (deadline date) or, if comments are submitted by mail, must bear a postmark of no later than (deadline date). Oral and written comments will also be accepted at the public meeting that is scheduled to be held (date) at:

Richland Public Library
955 Northgate Drive
Richland. WA

SITE BACKGROUND

The Hanford Site, managed by DOE, encompasses approximately 1,517 km^2 (586 mi^2) in the Columbia Basin in south-central Washington State (Figure 1). From 1943 to 1990, the primary mission of the Hanford Site was the production of nuclear materials for national defense. In July 1989, the EPA placed the 100, 200, 300, and 1100 Areas of the Hanford Site on the **National Priorities List** (NPL) pursuant to CERCLA.

Figure 1. Location of the Hanford Site.



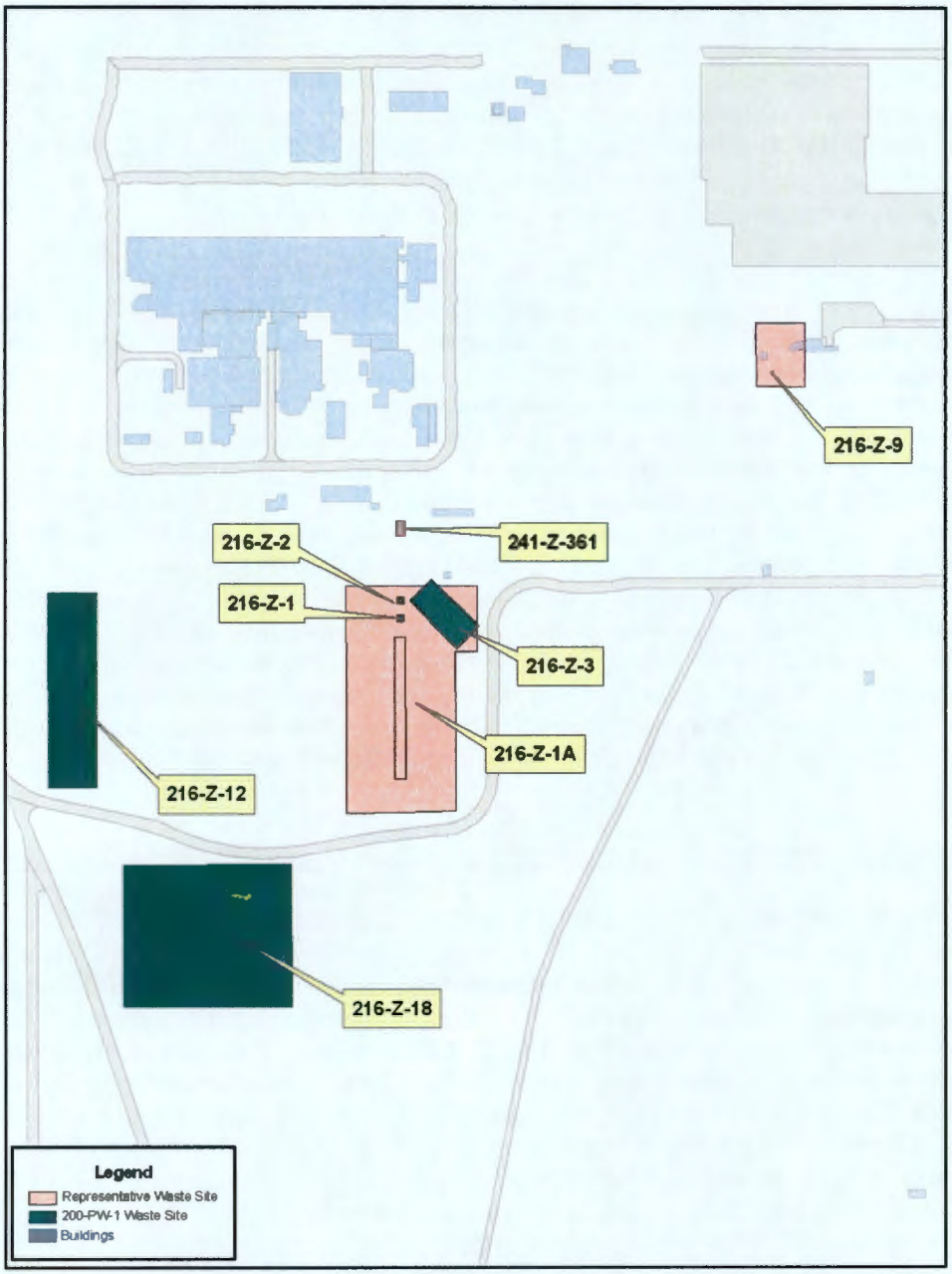
The 200 Areas contain waste management facilities and inactive irradiated nuclear fuel-reprocessing facilities. In 2002, the DOE Richland Operations Office (RL); EPA; and Ecology conducted a thorough review of the cleanup approach that was being applied through the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan - Environmental Restoration Program* (Implementation Plan) (DOE/RL-98-28) and identified improvements to accelerate cleanup of waste sites in the 200 Areas. As part of this improved approach, the Tri-Parties agreed to consolidate the 23 process-based OUs into 12 groups based on similarities between **contaminant** sources (*Hanford Federal Facility Agreement and Consent Order* [**Tri-Party Agreement**] change packages M-13-02-01 and M-15-02-01, approved in June 2002). As a result of this process, the 200-PW-1, 200-PW-3, and 200-PW-6 OUs were grouped together to form the Plutonium/Organic-Rich OU Group, which consists of 17 past-practice liquid waste disposal sites that received wastes between 1945 and 1983.

The RI and FS Reports for the 200-PW-1, 200-PW-3, and 200-PW-6 OU waste sites used the **analogous site approach**. Data from **representative waste sites** are used to evaluate remedial alternatives and to identify a preferred alternative(s) to apply to the representative site and waste sites determined to be analogous to the representative site. Although a degree of uncertainty exists in employing this concept, substantial benefit can be realized in the early identification of a preferred alternative that allows cleanup actions to occur earlier. The preferred alternative identification process considers waste site geometry, contaminant distribution, potential exposure pathways to industrial workers, future land uses, risk to remediation workers, and the permanence of the solution. The CERCLA process is used to judge the various alternatives against the two threshold criteria of protectiveness of the public and the environment and compliance with **applicable or relevant and appropriate requirements** (ARARs). Those alternatives that satisfy both threshold criteria are then judged against the five balancing criteria: long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. Based upon the evaluation of the balancing criteria, a preferred alternative is identified for final remediation and closure of these waste sites. Final remedies are selected following consideration of the two Modifying Criteria (regulatory acceptance and public acceptance) implemented through issuance of the Proposed Plan and consideration of the resulting public response.

Plutonium/Organic-Rich Process Condensate/Process Waste Group (200-PW-1 Operable Unit)

The waste sites in this group are associated with the **Plutonium Finishing Plant** (PFP) and **Plutonium Reclamation Facility** (PRF) in the 200 West Area and are known or suspected to have received quantities of organic wastes (mostly **carbon tetrachloride, tributyl phosphate** [TBP], and **lard oil**), as well as **americium** and **plutonium**. The primary source of these organic-rich wastes was the **Recovery of Uranium and Plutonium by Extraction** (RECUPLEX) process. These waste sites overlie the 200-ZP-1 Groundwater OU. Three waste sites were selected as representative waste sites in the 200-PW-1 OU. The 216-Z-1A Tile Field was selected as the "typical" representative waste site because of its plutonium and carbon tetrachloride inventory, as well as its current level of characterization. The waste sites determined to be **analogous sites** to this representative site include the 216-Z-1 Crib, 216-Z-2 Crib, 216-Z-3 Crib, 216-Z-12 Crib, and 216-Z-18 Crib, all in the 200-PW-1 OU (Figure 2), and the 216-Z-5 Crib (in the 200-PW-6 OU, Figure 4). The 216-Z-9 Trench was selected as the "worst-case" representative waste site because it received the largest amount of plutonium and a significant amount of carbon tetrachloride. There are no associated **analogous sites** to the 216-Z-9 Trench. The 241-Z-361 Settling Tank was selected as a representative waste site because it has a high plutonium inventory not released to the environment and because of its current level of characterization. The analogous waste site to this tank is the 241-Z-8 Settling Tank (in the 200-PW-6 OU, Figure 4).

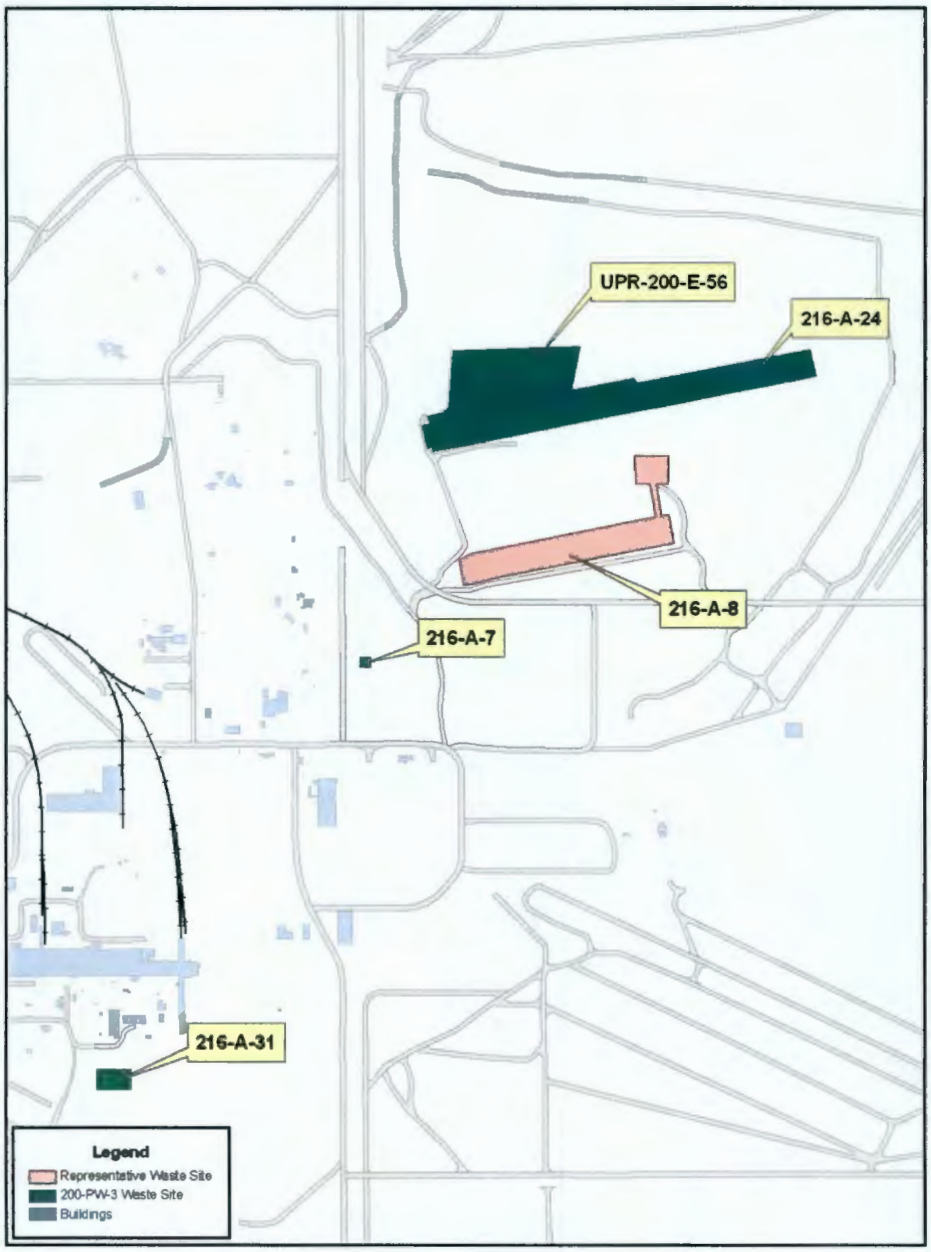
Figure 2. 200-PW-1 Operable Unit Waste Sites in the 200 West Area.



Organic-Rich Process Condensate/Process Waste Group (200-PW-3 Operable Unit)

The waste sites in this group are all located in the 200 East Area and overlie the 200-PO-1 Groundwater OU. The waste sites are known or suspected to have received organic-rich wastes, including refined kerosene (**normal paraffin hydrocarbon** [NPH]), TBP and **butanol** from A Plant (the **Plutonium-Uranium Extraction** [PUREX] process), uranium and plutonium, as well as **fission products**. The 216-A-8 Crib was selected as the "worst-case" representative waste site in the 200-PW-3 OU because it received a relatively high volume of fission-products compared to other waste sites in the group, and it is believed to have received a significant amount of organic wastes. The waste sites determined to be analogous to this representative site include the 216-A-7 Crib, 216-A-24 Crib, 216-A-31 Crib, and the UPR-200-E-56 unplanned release site (Figure 3).

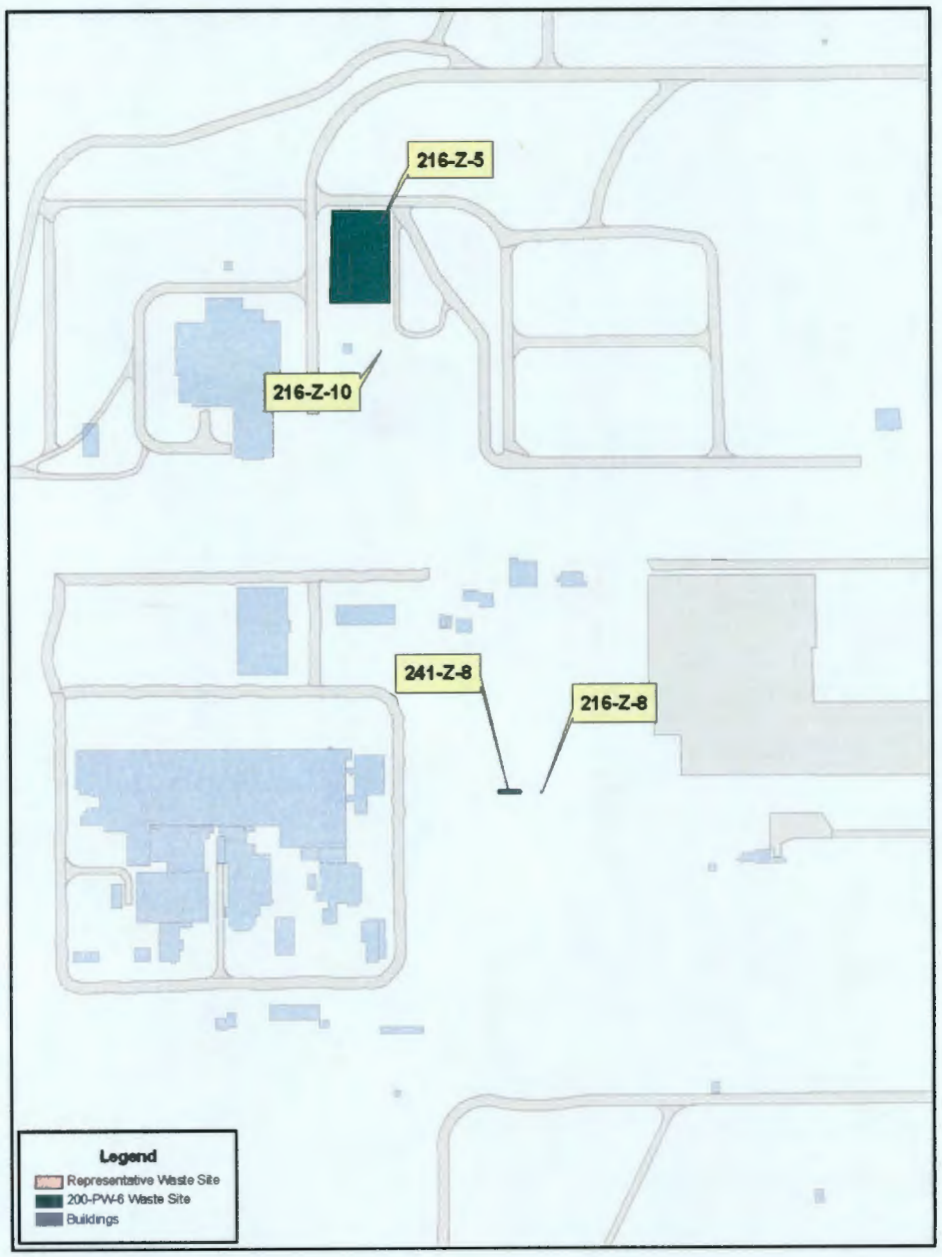
Figure 3. 200-PW-3 Operable Unit Waste Sites in the 200 East Area.



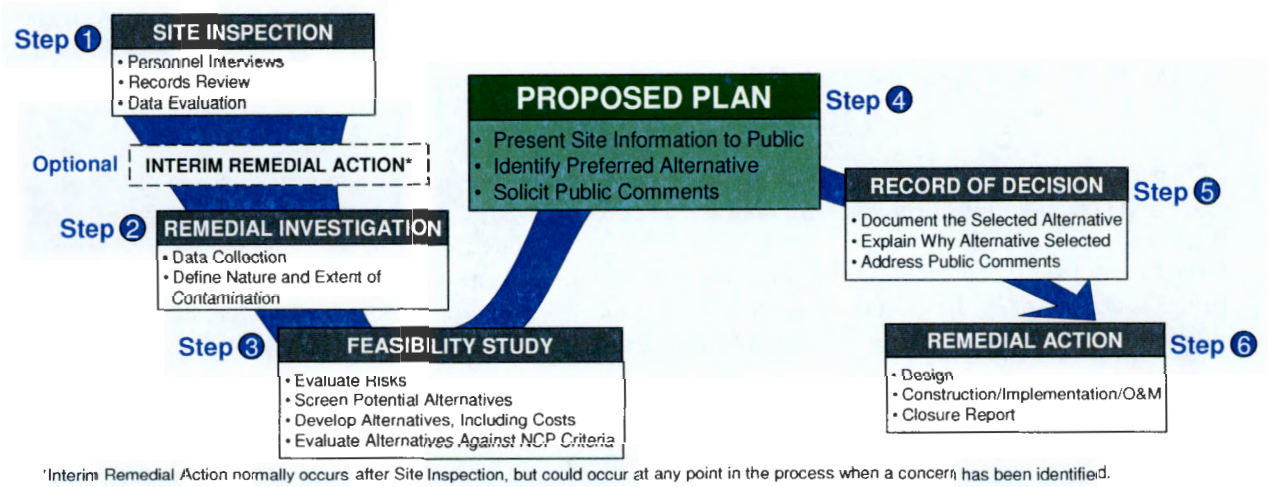
Plutonium Process Condensate/Process Waste Group (200-PW-6 Operable Unit)

Two waste sites in this group, the 216-Z-5 Crib and the 216-Z-10 Injection/Reverse Well, received neutral/basic process wastes containing plutonium and americium from the Plutonium Isolation Facility in the 200 West Area. The other two sites, the 241-Z-8 Settling Tank and the 216-Z-8 French Drain, received filter back-flushes and silica gel (a settling agent) from the RECUPLEX process, which recovered plutonium from PFP liquid and solid scraps. All of these waste sites overlie the 200-ZP-1 Groundwater OU. The 216-Z-8 French Drain and the 216-Z-10 Injection/Reverse Well are unique waste sites with no analogous waste sites. The 216-Z-5 Crib and 241-Z-8 Settling Tank are analogous to representative sites in the 200-PW-1 OU, as previously mentioned (Figure 4).

Figure 4. 200-PW-6 Operable Unit Waste Sites in the 200 West Area.



CERCLA Process



*Interim Remedial Action normally occurs after Site Inspection, but could occur at any point in the process when a concern has been identified.

Step 1. Site Inspection. "Site inspection" includes interviewing site personnel regarding the history of the site, reviewing waste disposal records, and evaluating existing data.

Step 2. Remedial Investigation. "Remedial investigation" consists of conducting an environmental study to identify the nature and extent of contamination and performing a preliminary evaluation of the risk posed to human health and the environment.

Step 3. Feasibility Study. The "feasibility study" (FS) includes the details of a remedial alternatives evaluation, which includes a complete risk assessment of current conditions and an evaluation of the potential risk reduction presented for each of the remedial alternatives that are considered.

Step 4. Proposed Plan. The "Proposed Plan" (this document) is based on previous field investigations and reports that are completed in the first three steps of the CERCLA process described above. The Proposed Plan summarizes the remedial alternative evaluations and presents the preferred alternative recommended in the FS to the public for comments.

Step 5. Record of Decision. The "Record of Decision" (ROD) formally documents the cleanup alternative that was selected after the Tri-Parties reviewed and responded to public comments on the Proposed Plan.

Step 6. Remedial Action. "Remedial action" consists of the actual cleanup activities being performed. When cleanup is completed a final report is written that describes the remedial actions implemented, the result of the actions, and the conclusion of the CERCLA process.

Site Characteristics

The 200-PW-1, 200-PW-3, and 200-PW-6 OUs are located in an area that has a semi-arid climate with an average annual precipitation of 17 cm (6.8 in.). The 200 East and 200 West Areas occupy approximately 51 km^2 (19.5 mi^2) of the Hanford Site. Facilities located in these areas were built to process irradiated nuclear fuel from the production reactors located in the 100 Areas along the Columbia River (Figure 1). The operation of these facilities included discharging liquid wastes directly into the soil at 15 of the 17 waste sites in these OUs (two of the sites are tanks that are not believed to have leaked).

These waste sites are located in the Pasco Basin, one of several structural and topographic basins of the Columbia Plateau in south-central Washington State. Basalts of the Columbia River Basalt Group and a sequence of younger sediments underlie the waste sites.

Remedial efforts for the 200-PW-1, 200-PW-3, and 200-PW-6 OU waste sites focus on the **vadose zone**. The vadose zone is the interval between the ground surface and the water table. The thickness of the vadose zone ranges from 68 to 72 m (223 to 237 ft) beneath the 200-PW-1 OU and 200-PW-6 OU waste sites in the 200 West Area, and from 73 to 97 m (255 to 318 ft) beneath the 200-PW-3 OU waste sites in the 200 East Area.

In general, the highest **concentrations** of radioactive contaminants are located near the base of the waste sites, and concentrations decrease with depth. At some waste sites, contamination extends almost the full thickness of the vadose zone. Some of the more mobile contaminants (e.g., nitrate and carbon tetrachloride) were transported by the liquid wastes into the **groundwater** and/or remain at various depths in the vadose zone. The contaminants that have impacted groundwater are being addressed separately, though in an integrated manner. Groundwater beneath the 200-PW-1 and 200-PW-6 OUs is being addressed by the 200-ZP-1 Groundwater OU; groundwater beneath the 200-PW-3 OU is being addressed by the 200-PO-1 Groundwater OU.

Land Use

Remediation based on site risks depends on the use that will be made of the land; unrestricted land use could require cleanup to stricter standards than land used for industrial purposes and/or could be subject to administrative controls. The 200-PW-1, 200-PW-3, and 200-PW-6 OUs are located within a land-use area (Figure 1) designated as an **industrial-exclusive land use area** in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (referred to as the "CLUP-EIS") (DOE/EIS-0222-F) and the associated "Hanford Comprehensive Land-Use Plan Environmental Impact Statement, Hanford Site, Richland, Washington; **Record of Decision** (ROD)" (64 FR 61615). In the CLUP-EIS, "industrial-exclusive" is defined as "land areas suitable and desirable for treatment, storage, and disposal of hazardous, dangerous, radioactive, nonradioactive wastes, and related activities."

The DOE is expected to continue industrial-exclusive activities for at least 50 years in accordance with the CLUP-EIS and ROD. Active institutional controls (similar to those used on site today) are assumed for approximately another 100 years following termination of operations. Because the 200-PW-1, 200-PW-3, and 200-PW-6 OU waste sites are located within an area that is anticipated to remain industrial with existing institutional controls for the foreseeable future, the cleanup goals and preferred remedial alternatives were developed based on industrial land use exposures and worker risks.

SUMMARY OF SITE RISKS

As part of the FS, a risk assessment was conducted to evaluate the risk from the existing contamination at the representative waste sites. At some of the waste sites, the risks exceed the CERCLA threshold level of 1 in 10,000, requiring the Tri-Parties to take action to further protect human health or welfare and the environment at these waste sites (see Table 1). A risk level of 1 in 10,000 means there is a 1 in 10,000 chance or probability of developing cancer over a lifetime due to exposures at a waste site.

Human Health Risk

A **human health risk assessment** was conducted for five representative waste sites: 216-A-8 Crib, 216-Z-1A Tile Field, 216-Z-8 French Drain, 216-Z-9 Trench, and 216-Z-10 Injection/Reverse Well. These sites, as well as the 241-Z-361 Settling Tank, were identified in the RI Report (DOE/RL-2006-51) as representative or unique waste sites for the 200-PW-1, 200-PW-3, and 200-PW-6 OUs. The risk assessment did not include the 241-Z-361 Settling Tank because there is no evidence of a release at the site (DOE/RL-2006-51). The risk assessment was used to evaluate the need for **remedial action** at the five representative waste sites and to evaluate the protectiveness of certain remedies based on current and potential future uses of the land.

The risk assessment evaluated risks under current and anticipated future conditions (industrial land use), with industrial site construction workers as the population that could be potentially exposed, and it assumed no **institutional controls** (as required by CERCLA for the baseline assessment) would be necessary. For comparison purposes, it also assessed risks for a future unrestricted land-use scenario, occurring after the year 2150 if institutional controls fail in the future, with the potential exposures to a future residential farming population (adults and children) and a future working population (well drillers).

Table 1. Summary of Representative Waste Site Risks (Industrial Land Use) and Need for Action.

Waste Site	Risk-Based Concern	Summary of Representative Waste Site Risks	Need for Action?
216-Z-1A Tile Field	Direct contact	No unacceptable levels of risk identified for nonradionuclides.	No
		Americium-241 and plutonium-239/240 exceed RBCs within 4.6 m (15 ft) of the current ground surface.	Yes
	Ecological exposure	All radionuclide and nonradionuclide constituents meet the RAOs.	No
	Groundwater protection	Though not identified in RI soil samples, soil-vapor recovery efforts continue to remove kilogram quantities of carbon tetrachloride from the vadose zone annually, suggesting that migration to groundwater is possible.	Yes
216-Z-8 French Drain	Direct contact	All radionuclide and nonradionuclide constituents meet the RAOs .	No
	Ecological exposure	All radionuclide and nonradionuclide constituents meet the RAOs.	No
	Groundwater protection	All radionuclide and nonradionuclide constituents meet the RAOs.	No
216-Z-9 Trench	Direct contact	All radionuclide and nonradionuclide constituents meet the RAOs since contaminants are located more than 4.6 m (15 ft) deep.	No[a]
	Ecological exposure	All radionuclide and nonradionuclide constituents meet the RAOs.	No
	Groundwater protection	Model results indicate that carbon tetrachloride, tetrachloroethylene, and hexachloroethane would migrate to groundwater at concentrations exceeding their respective MCLs.	Yes
216-Z-10 Injection/ Reverse Well	Direct contact	All radionuclide and nonradionuclide constituents meet the RAOs because contaminants are located more than below 4.6 m (15 ft) deep.	No
	Ecological exposure	All radionuclide and nonradionuclide constituents meet the RAOs.	No
	Groundwater protection	All radionuclide and nonradionuclide constituents meet the RAOs.	No
216-A-8 Crib	Direct contact	Cesium-137 exceeds RBCs within 4.6 m (15 ft) of the current ground surface.	Yes
	Ecological exposure	All radionuclide and nonradionuclide constituents meet the RAOs.	No
	Groundwater protection	Model results indicate that technetium-99 could migrate to groundwater at concentrations exceeding the MCL.	Yes

Table 1. Summary of Representative Waste Site Risks (Industrial Land Use) and Need for Action.

Waste Site	Risk-Based Concern	Summary of Representative Waste Site Risks	Need for Action?
241-Z-361 Settling Tank[b]	Direct contact	COPCs in the sludge could pose a direct-contact risk if released to the environment.	Yes
	Ecological exposure	COPCs in the sludge could pose unacceptable levels of risk to potential ecological receptors. However, the tank is located in a highly disturbed area with no identified significant ecological receptors.	No
	Groundwater protection	COPCs in the sludge may migrate to groundwater if released to the environment.	Yes

[a] Best management practice warrants a more substantial form of physical separation from the contaminated soils beneath the trench floor.
[b] Assessment did not quantitatively evaluate risks for 241-Z-361, and the RI report documented evidence that the tank is not likely to have leaked.
COC = contaminant of concern
COPC = contaminant of potential concern
MCL = maximum contaminant level
RAO = remedial action objective
RBC = risk-based concentration

Risks (for cancer effects) and hazards (for non-cancer effects) are calculated for a **reasonable maximum exposure** scenario for each exposure pathway, which is a calculation that over-estimates risks for the majority of the population to ensure that public health is protected. The estimates of cancer risk represent the potential for cancer effects by calculating the probability of developing cancer over a lifetime due to site exposures (e.g., a risk of 1 in 1 million chance of developing cancer due to exposures at the site). Non-cancer hazards are assumed to have an acceptable level of chemical intake that will not cause any adverse health effect even in sensitive individuals. U.S. Environmental Protection Agency's (EPA's) target cancer risk goal is a range of 1 in 1,000,000 to 1 in 10,000, with remedial action usually required if risks exceed 1 in 10,000; target health goals for non-cancer risks are a hazard index (HI) less than or equal to 1.

Under current industrial land use and existing institutional controls, there are no uncontrolled exposures to chemicals and radionuclides in the groundwater and soil. Volatile or radiological emissions from the subsurface are insignificant for worker exposure. Institutional controls prevent the use of contaminated groundwater, and access to these waste sites is controlled, ensuring that site activities include appropriate environmental and worker protection controls. If construction workers disturb soil to a depth of 4.6 m (15 ft) below ground surface (bgs) at the 216-Z-1A Tile Field, 216-Z-8 French Drain, or 216-A-8 Crib, they could come into contact with **contaminants of concern** (COCs). Under that unlikely scenario (existing institutional control programs at the Hanford Site are designed to prevent unprotected digging in contaminated soil), health risks would exceed 1 in 10,000 at the 216-Z-1A Tile Field and 216-A-8 Crib, indicating that remedial action would be necessary. Risks from digging in soil at the 216-Z-8 French Drain were less than 1 in 1,000,000, therefore no remedial action is required. Risks from subsurface soil exposures at the 216-Z-1A Tile Field are driven by plutonium-239, followed by plutonium-240, then americium-241. Risks from subsurface soil at the 216-A-8 Crib are driven by cesium-137. No nonradionuclides (e.g., metals, organics, inorganics) in soil pose unacceptable levels of risk to site construction workers.

Ecological Risk

A **screening-level ecological risk assessment** was performed for all 17 waste sites in the 200-PW-1, 200-PW-3, and 200-PW-6 OUs following EPA's *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA 540-R-97-006).

The exposure potential of these waste sites was one of the key considerations in the framework of the Central Plateau ecological risk assessment (ERA) study design and was considered in selecting areas for sampling and analysis. This process started with a master list of sites including all Central Plateau waste sites listed in the Tri-Party Agreement, Appendix C (as amended September 1, 2003). A query of the Hanford Site Waste Information Data System database was used for waste site selection. Given the focus of the Central Plateau ERA to support remediation decisions, considerable effort went into evaluating the soil depth where cleanup is required. The *Washington Administrative Code* (WAC) defines the soil cleanup depth (the standard point of compliance) as extending from the ground surface to 4.6 m (15 ft) bgs (WAC 173-340-7490[4][b]; "Terrestrial Ecological Evaluation Procedures," "Point of Compliance," "Standard Point of Compliance" of "Model Toxics Control Act – Cleanup").

The 200-PW-1, 200-PW-3, and 200-PW-6 OU waste sites were ruled out from further consideration with regard to ecological risk potential because the contaminants are located deeper than plants and animals can access, physical barriers prevent exposure, there is a lack of habitat to support receptors capable of contaminant biointrusion, and an active management program precludes establishment of deeply rooted/burrowing receptors.

Groundwater Protection

To characterize risks to the environment (which includes groundwater beneath the waste sites), evaluations were conducted based on modeling to assess the potential for contaminants currently held within the vadose zone to migrate into the groundwater in the future. An initial screening was conducted for all vadose zone **contaminants of potential concern** (COPCs) by comparing maximum detected concentrations to an EPA soil screening level (SSL). If the maximum soil concentration exceeded the SSL, then further evaluation was conducted as to whether the contaminant exceeded a natural background concentration, and whether its frequency of detection and/or frequency and magnitude in excess of the SSL warranted further evaluation.

Contaminants of potential concern (COPCs) not eliminated by this screening process were evaluated using fate and transport models. Those that the modeling predicted would exceed **maximum contaminant levels** (MCLs) in groundwater (and other COPCs with similar transport properties) were carried forward as COCs for the protection of groundwater pathway. All identified COCs are listed in Table 2.

Table 2. Contaminants of Concern for Representative Waste Sites

Waste Site	Risk Receptor				
	Industrial Site Construction Worker	Ecological Receptor	Future Well Driller	Future Residential Farmer	Groundwater
216-Z-1A Tile Field	^{241}Am $^{239/240}$Pu	None identified	None identified	^{241}Am $^{239/240}$Pu	Carbon tetrachloride[a]
216-Z-8 French Drain	None identified	None identified	None identified	None identified	None Identified

Table 2. Contaminants of Concern for Representative Waste Sites

Waste Site	Risk Receptor				
	Industrial Site Construction Worker	Ecological Receptor	Future Well Driller	Future Residential Farmer	Groundwater
216-Z-9 Trench	^{241}Am $^{239/240}Pu$[b]	None identified	None identified	^{241}Am $^{239/240}Pu$	Carbon tetrachloride, hexachloroethane, and tetrachloroethylene
216-Z-10 Injection/ Reverse Well	None identified	None identified	None identified	None identified	None Identified
241-Z-361 Settling Tank[c]	None identified	None identified	None identified	None identified	None Identified
216-A-8 Crib	^{137}Cs	None identified	None identified	^{137}Cs	^{99}Tc[d]

NOTE: "None identified" indicates that the CERCLA risk assessment process did not identify any condition that would result in unacceptable levels of risk to human health or the environment.

[a] Though not identified in RI soil samples, soil vapor recovery efforts continue to remove kilogram quantities of carbon tetrachloride from the vadose zone annually, suggesting that migration to groundwater is possible.

[b] Not identified as COCs for site construction worker, but best management practice warrants a more substantial form of physical separation from the contaminated soil.

[c] Contaminants of concern (COCs) were not identified for this site because there has been no identified release to the environment.

[d] ^{99}Tc was identified at significant concentrations in one soil sample (79.6 pCi/g at 5.8-6.5 m [19-21.5 ft] bgs). Pending confirmatory soil sampling, the preferred alternative will mitigate the potential future impacts this contaminant may have on groundwater beneath the waste site.

REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are descriptions of what the cleanup is supposed to accomplish. They provide a basis for evaluating the effectiveness of the remedial alternatives being considered. Remedial action objectives (RAOs) address: 1) the unacceptable risks identified through the RI/FS process and 2) the identified potential ARARs. These risks and the potential ARARs are discussed in detail in the FS report. The RAOs for the 200-PW-1, 200-PW-3, and 200-PW-6 OUs are:

- **RAO#1:** Prevent unacceptable risk to human health due to direct contact with COCs in the soil within 4.6 m (15 ft) of the ground surface. Unacceptable risks are: 1) an excess lifetime cancer risk greater than 1 in 10,000 (1×10^{-4}), or 2) a dose exceeding 100 mrem/yr (see **Rem**), consistent with an industrial land use scenario. With respect to this RAO, COCs include americium-241 and plutonium-239/240 at the 200-PW-1 OU and 200-PW-6 OU waste sites, and cesium-137 at the 200-PW-3 OU waste sites.

- **RAO#2:** Prevent migration of COCs to groundwater in concentrations that exceed MCLs. With respect to this RAO, COCs include carbon tetrachloride, hexachloroethane, and tetrachloroethylene (PCE) at the 200-PW-1 OU waste sites, and technetium-99 at 200-PW-3 OU waste sites.

There are two key potential ARARs or standards that are addressed by the RAOs. Performance standards for radioactive waste sites are addressed in *Radioactive Waste Management* (DOE O 435.1,) which, is a to be considered standard. The chemical-specific ARARs likely to be most relevant and appropriate to remediation of the 200-PW-1 OU, 200-PW-3 OU, and 200-PW-6 OU waste sites are federal regulations that implement drinking water standards, "National Primary Drinking Water Regulations" (40 CFR 141). The MCLs in these regulations are used in the FS report for the protection of groundwater evaluation. The potential ARARs are discussed in detail in the FS report.

PRELIMINARY REMEDIATION GOALS

The **Preliminary Remediation Goals** (PRGs) are risk-based values for specific contaminant and exposure pathways that combined with "standard" exposure factors estimate contaminant concentrations considered to be protective of human health and the environment.

The PRGs are based on the results of the risk assessment and evaluation of the expected exposures and risks based on industrial land use. The remediation goals will be used to assess the effectiveness of the identified remedial alternatives in meeting the RAOs.

> ***General Protection PRG***
>
> Maintain at least 4.6 m (15 ft) of separation between soils exceeding risk-based concentrations and the ground surface.

Typically, PRGs are developed for individual hazardous substances identified as COCs. If multiple contaminants are present at a site, the suitability of using individual PRGs as final cleanup values protective of human health and the environment is evaluated based on site-specific information and the potential for contaminant interaction. Meeting these PRGs, the potential ARARs (and by extension, achievement of the RAOs) can be accomplished by reducing concentrations (or activities) of contaminants to remediation goal levels or by eliminating potential exposure pathways/routes (e.g., maintaining at least 4.6 m [15 ft] of separation between contaminated soil and the ground surface).

Construction Worker Preliminary Remediation Goals

Radioactive contaminants. The PRGs were calculated using **risk-based concentrations** (RBCs) for industrial land use for the primary risk drivers (americium-241, plutonium-239/240, and cesium-137) in soil. The PRGs were calculated to be at the maximum acceptable cancer risk for construction workers from the risk assessment at 1 in 10,000 for soils above a depth of 4.6 m (15 ft).

Calculated Risk Based Concentrations

Risk Driver	Based on a Target Annual Risk of 1 in 10,000 (pCi/g)	Based on Target Dose of 100 mrem/yr (pCi/g)
Americium-241	45,000	2,510
Plutonium-239	50,000	2,650
Plutonium-240	50,000	2,650
Cesium-137	1,600	1,220

Nonradioactive contaminants. No risk above 1 in 10,000 or an HI >1 was identified for nonradioactive contaminants for construction workers. Therefore, no PRGs were developed for nonradioactive contaminants for the construction worker pathway.

Protection of Groundwater Preliminary Remediation Goals

Radioactive contaminants. Radioactive COPCs were evaluated for potential future migration to groundwater, as previously discussed and detailed in the FS Report (DOE/RL-2007-27). The evaluation was performed using the **RESidual RADioactivitiy (RESRAD) dose model** (ANL/EAD-4). The only radionuclide or associated daughter products calculated to reach groundwater above the MCL within 1,000 years from present was technetium-99 at the 216-A-8 Crib. The extent of the technetium-99 soil contamination at the 216-A-8 Crib is uncertain due to limited soil sampling conducted during the RI process. A PRG for technetium-99 at the 216-A-8 Crib will be developed during remedial design, after confirmatory soil sampling results are available, to better define the extent and mass of this radionuclide.

Nonradioactive contaminants. Nonradioactive COPCs were also evaluated for potential future migration to groundwater. Carbon tetrachloride, hexachloroethane, and PCE were identified as COPCs that could migrate to groundwater at the 216-Z-9 Trench. **RESRAD-CHEM** (*RESRAD-CHEM:*

A Computer Code for Chemical Risk Assessment, Cheng 1993) was used to calculate the concentration of carbon tetrachloride in soil at the 216-Z-9 Trench that would not impact groundwater above the MCL of 5 µg/L. However, rather than using the calculated soil concentration (1 mg/kg), the PRG for carbon tetrachloride and the other volatile organic compounds (VOCs) will be developed during remedial design and remedy implementation to demonstrate that the migration to groundwater pathway has been mitigated.

As part of the preferred alternative for soil contaminated with VOCs, **soil vapor extraction** (SVE) is proposed for several 200-PW-1 OU waste sites. The SVE system would be operated until performance metrics (including monitoring) demonstrate that the migration to groundwater pathway has been mitigated, and the system can be safely shut-down without future impact on the groundwater. The implementation, performance monitoring, and end-point of the preferred alternative for soil contaminated with VOCs at several 200-PW-1 OU waste sites must be linked to what is technically practicable for cleaning up carbon tetrachloride in groundwater as part of the 200-ZP-1 OU remedy. The remedies for cleaning up the VOCs in the vadose zone and underlying groundwater will need to be implemented together and have compatible remediation goals so that transfer of the VOCs between the vadose zone and groundwater is minimized. The final performance criteria and remediation goals for VOCs will be selected during the remedial design phase and the assessment of the performance criteria, and achievement of the RAOs will be conducted as part of the required CERCLA 5-year reviews. If in the future it is technically impracticable to clean up the carbon tetrachloride in groundwater to the MCL of 5 µg/L as part of the 200-ZP-1 OU remedy, a waiver of this ARAR may be requested.

Ecological Resource Preliminary Remediation Goals

No unacceptable risks were identified in the screening-level ecological risk assessment for the 200-PW-1, 200-PW-3, and 200-PW-6 OU waste sites. Therefore, no PRGs were developed for protection of ecological receptors.

SUMMARY OF REMEDIAL ALTERNATIVES

All of the waste sites in the 200-PW-1, 200-PW-3, and 200-PW-6 OUs are within the industrial-exclusive land-use area (Figure 1). Each activity-based remedial alternative will establish and maintain institutional controls that include activities to: 1) ensure industrial use only, 2) restrict drilling and use of groundwater, and 3) limit access to areas of residual contamination and to structures or features that are part of ongoing remedial actions. These activities will be implemented through DOE/RL-2001-41, Rev. 2, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions*.

In addition, each activity-based remedial alternative will include ongoing environmental monitoring and, if appropriate, performance monitoring, as appropriate for the site. These monitoring activities will be site-specific to a large extent, as they will address the risks identified at the site and the remedy implemented. Specific monitoring plans will be developed in conjunction with the remedial design.

Plutonium/Organic-Rich Process Condensate/Process Waste Group (200-PW-1 Operable Unit)

216-Z-1A Tile Field. The 216-Z-1A Tile Field was constructed in an excavation with a base area of approximately 79 by 30 m (260 by 100 ft). Wastes were discharged though piping that sits atop approximately 1.5 m (5 ft) of gravel, and were covered with another 1.5 m (5 ft) of fill material. Ground surface above the completed tile field is 2.4 m (8 ft) lower than the original land surface. The site received about 1 million L (264,000 gal) of neutral basic wastes from 1949 to 1959, was taken out of service, and then reactivated in 1964, receiving another 5.2 million L (1.37 million gal) of acidic liquid waste before it was deactivated in 1969.

As discussed in the RI Report, high concentrations of transuranic radionuclides exist in the soils at the 216-Z-1A Tile Field. The highest concentrations typically are found directly below the tile field, near the perforated piping that was used to discharge the liquid wastes to the soil.

Identified radioactive and nonradioactive contaminants were evaluated to determine the level of risk that they pose to human health, ecological receptors, and groundwater. Plutonium-239/240 and americium-241 are found at concentrations that pose an unacceptable level of risk to human health. As documented in the FS report, the risk assessment process identified no other unacceptable levels of risk to human health or ecological receptors, and no potential to adversely impact groundwater. However, though carbon tetrachloride was not identified in RI soil samples (collected to depths of 26 m [85 ft] bgs), soil vapor recovery efforts at the site continue to remove kilogram quantities of this contaminant from the vadose zone annually. This suggests the potential for residual carbon tetrachloride contamination at depths greater than 26 m (85 ft), which may pose a threat to groundwater. Therefore, carbon tetrachloride was identified as a COC with respect to its potential for impacting groundwater.

The direct contact risk posed by the radionuclide COCs and the potential threat to groundwater posed by carbon tetrachloride both require remedial action.

The FS identified the following remedial alternatives for consideration at the 216-Z-1A Tile Field and its analogous waste sites. Each remedy presented (except the no action alternative) includes continued operation of an expanded SVE system and implementation of institutional controls, environmental monitoring, and performance monitoring.

- **Alternative 0 – No Action.** *Comprehensive Environmental Response, Compensation, and Liamility Act of 1980* (CERCLA) requires that a no action alternative be considered as the baseline (minimal) response for each site. By definition, it would include no activities to reduce or mitigate risks. No institutional controls would be established. The EPA allows limited environmental monitoring as part of the no action alternative, which would consist of groundwater monitoring to assess for changes in the identified conditions.

200-PW-1 OU Representative and Analogous Waste Sites

Representative Sites	Analogous Sites
216-Z-1A Tile Field	216-Z-1 Crib
	216-Z-2 Crib
	216-Z-3 Crib
	216-Z-5 Crib*
	216-Z-12 Crib
	216-Z-18 Crib
216-Z-9 Trench	None
241-Z-361 Settling Tank	241-Z-8 Settling Tank*

*200-PW-6 OU Waste Site.

- **Alternative 1 – Soil Backfill plus Expanded SVE.** The SVE system would be expanded by installing ten new vapor extraction wells and replacing the existing 500-cubic feet per minute (cfm) blower with a 1,000-cfm blower. The expanded SVE system would be operated until performance metrics, developed as part of the remedial design, indicated that the SVE remedial objectives had been achieved. Then, the area above the existing surface of the tile field would be backfilled to the level necessary to provide at least 4.6 m (15 ft) of physical separation from the radionuclide concentrations in soil that pose unacceptable risks. After backfilling, the soils posing a direct contact risk would be more than 4.6 m (15 ft) bgs and would require no further remedial action. Institutional controls would ensure ongoing protectiveness.

- **Alternative 2 – Intrusion Prevention Feature plus Expanded SVE.** This alternative would complete SVE operations (as described in Alternative 1) and would also construct an intrusion-prevention feature above the tile field. The actual design would be determined during remedial design. In the FS report, the intrusion-prevention feature was assumed to be a 2-m (6.6-ft) thick layer of coarse, fractured basalt with no fine-grained materials. The basalt would be overlain by materials

intended to limit infiltration of fine-grained soil into the spaces between the basalt. The coarse, fractured basalt would be an effective barrier to burrowing, digging, and well drilling. It would also create a dry rocky environment that would not be conducive to root penetration. This approach also would achieve 4.6 m (15 ft) of physical separation, which makes direct contact with the contaminated soils very unlikely, but would do so in a more robust manner than Alternative 1. Institutional controls would ensure ongoing protectiveness.

- **Alternative 3 – In-Situ Vitrification plus Expanded SVE.** The **in-situ vitrification** alternative would complete SVE operations (as described in Alternative 1) and would then melt the top 6.1 m (20 ft) of contaminated soil. The melted soil would cool to form a large glass block. The vitrified soil would pose significantly lower human health risks. The glass would also be effective at limiting intrusion into the deeper, unvitrified contaminated soil. This alternative would generate a small amount of waste, with little or none requiring off-site disposal. After completion of the in-situ vitrification operations, the depression would be backfilled to the elevation of the original land surface.

- **Alternative 4 – Partial Removal, Treatment, and Disposal plus Expanded SVE.** This alternative would complete SVE operations (as described in Alternative 1) and then dig to a depth of 6.1 m (20 ft) below the current ground surface. A portion of the soil excavated from the 216-Z-1A Tile Field would contain more than 100 nCi/g of alpha-emitting transuranic radioisotopes with half-lives exceeding 20 years. Therefore, some portion of the waste generated by the partial removal, treatment, and disposal (RTD) alternative would likely require disposal at the **Waste Isolation Pilot Plant** (WIPP). Some portion of the remaining excavated soil would be designated as low-level waste or mixed low-level waste and be disposed at the **Environmental Restoration Disposal Facility** (ERDF). Following removal of the contaminated soils, the excavation would be backfilled to the elevation of the surrounding land surface.

216-Z-9 Trench. The 216-Z-9 Trench is a 6.4 m (21 ft)-deep open trench enclosed with a 23 cm (9 in)-thick concrete cover. The cover is supported by six concrete columns. The trench base is 9.1 by 18.3 m (30 by 60 ft). Sampling revealed high concentrations of plutonium-239/240 and americium-241 in soils at several depth intervals at this site to about 36 m (119 ft) bgs. The highest concentrations identified were beneath the floor of the trench. The RI Report also identified high concentrations of these radionuclides, as well as three VOCs, in a thin silt lens roughly 19.8 m (65 ft) beneath the southern end of the trench. Because these contaminants are all more than 4.6 m (15 ft) bgs, no direct contact risk is identified. However, the risk assessment process did determine that the VOCs (carbon tetrachloride, PCE, and hexachloroethane) have the potential to migrate to groundwater. Though no unacceptable risks to human health were identified in association with the contaminated soils, best management practice warrants a more substantial form of physical separation from the contaminated soils beneath the trench floor (the existing concrete cover is not a long term solution).

The following remedial alternatives were identified for consideration at the 216-Z-9 Trench (there are no analogous waste sites). Each alternative except the No Action Alternative will include operation of an expanded SVE system and implementation of institutional controls, environmental monitoring, and performance monitoring.

- **Alternative 0 – No Action.** *Comprehensive Environmental Response, Compensation, and Liamility Act of 1980* (CERCLA) requires that a no action alternative be considered as the baseline (minimal) response for each site. By definition, it would include no activities to reduce or mitigate risks. No institutional controls would be established. The EPA allows limited environmental monitoring as part of the no action alternative, which would consist of groundwater monitoring to assess for changes in the identified conditions.

- **Alternative 1 – Controlled Density Fill plus Targeted SVE.** This alternative would leave the concrete trench cover and support columns in place and would backfill the open trench space with **controlled density fill (CDF)**. A large portion of the site would be revegetated with plants identified

for their ability to capture and transpire water (a soil cover would be placed over the concrete trench cover to support revegetation of that area). This is expected to reduce infiltration so the VOCs would not impact groundwater during the next 1,000 years. The current SVE system at this site would be expanded by adding three new soil vapor extraction wells to penetrate the contaminated silt lens, and replacing the existing 500-cfm blower with a new 1,000-cfm blower. Operation of the targeted SVE system will continue to extract VOCs in the soil vapor, helping to reduce the amount of VOCs in the soil and further reduce the potential for impacts to groundwater. The SVE system would be operated until it is no longer effective, as determined by evaluating performance metrics that would be developed during remedial design.

- **Alternative 2 – Intrusion Prevention Feature plus Targeted SVE.** This alternative would remove the concrete trench cover and columns, disposing of them at the ERDF. Then an intrusion prevention feature would be constructed in the trench to make it difficult for people, burrowing animals, and deep-rooted plants to intrude into the highly contaminated soils at the base of the trench. As discussed for 216-Z-1A Tile Field Alternative 2, the intrusion prevention feature was assumed to be a 2 m (6.6 ft)-thick layer of coarse, fractured basalt, although the remedial design would determine the details of this feature. In addition, the SVE system would be expanded as described in Alternative 1.

- **Alternative 3 – In-Situ Vitrification plus Targeted SVE.** This alternative would remove the concrete cover and columns, disposing of them at the ERDF. Then in-situ vitrification would be employed to melt soils to a depth of approximately 3 m (10 ft) below the trench floor. The melted soil would cool to form a large glass block. Direct contact with the glass would pose significantly lower human health risks. The glass block would be effective at limiting intrusion into the deeper, unvitrified contaminated soil. The site would be backfilled to grade with suitable fill material. Targeted SVE would also be implemented, as described in Alternative 1.

- **Alternative 4 – Partial RTD plus Targeted SVE.** This alternative would remove the concrete cover and support columns, disposing of them at ERDF, and then dig approximately 3 m (10 ft) of soil from beneath the floor of the trench. Then the activities of Alternative 2 would be implemented, which include construction of an intrusion prevention feature, backfilling to grade, and implementation of targeted SVE. This alternative would generate a relatively large volume of waste. A portion of the soil removed from the 216-Z-9 Trench would contain more than 100 nCi/g of alpha-emitting transuranic radioisotopes with half-lives exceeding 20 years. Therefore, some portion of the waste generated by the partial RTD alternative would require disposal at the WIPP. Some portion of the remaining excavated soil would be designated as low-level waste or mixed low-level waste and be disposed at the ERDF. Excavated soil that is not designate as waste would be used in backfilling the trench.

241-Z-361 Settling Tank. The 241-Z-361 Settling Tank is located approximately 35 m (115 ft) north of the 216-Z-1A Tile Field. It is a rectangular underground reinforced-concrete structure with a 1 cm (3/8 in.)-thick steel liner and 0.3 m (1 ft)-thick concrete walls, and internal dimensions of approximately 136 m^3 (178 yd^3). It served as the primary solids settling tank for liquid process wastes from several facilities within the PFP complex from 1949 to 1973, including RECUPLEX. Liquid wastes passing through the tank were directed to the 216-Z-1A Tile Field, 216-Z-1 Crib, 216-Z-2 Crib, or 216-Z-3 Crib, depending on the period of operation.

Tank investigations and characterization activities, discussed in the RI Report (DOE/RL-2006-51), indicate that the settling tank currently contains approximately 75 m^3 (98 yd^3) of sludge. The sludge is contaminated with radionuclides (primarily plutonium-239), metals, organics and polychlorinated biphenyls (PCBs). Available information shows no evidence of leaks to the environment.

Earlier work, documented in *Tank 241-Z-361 Engineering Evaluation/Cost Analysis* (DOE/RL-2003-52), identified potential remedial technologies, developed and evaluated the reasonable alternatives (based on effectiveness, implementability and cost), and recommended a specific remedial alternative. Remedial actions considered in that study included: 1) in-situ vitrification, 2) in-situ solidification with polymers,

and 3) retrieval, stabilization and disposal. Evaluation of the latter action included assessment of numerous mixing and retrieval technologies. No new characterization information has been developed for this tank since 2003, so the remedy recommended in that study is carried forward as the preferred alternative.

The preferred alternative for the 241-Z-361 Settling Tank would employ a **fluidics** system to loosen and homogenize the sludge, and then transferred it to standard waste boxes (SWBs). **Polymer absorbent** would be added to the SWBs to absorb residual liquids and stabilize the sludge. The SWBs would then be transported to the Central Waste Complex (CWC) for storage pending proper waste disposition. Based on available data, the containerized, stabilized sludge would likely contain more than 100 nCi/g of alpha-emitting transuranic isotopes with half-lives exceeding 20 years, which would require disposal at WIPP.

After the sludge has been removed from the tank and transported to the CWC, sampling/surveying of the remaining tank structure (liner and concrete) would be conducted to support compliant closure, and then the tank would be backfilled with CDF.

Organic-Rich Process Condensate/Process Waste Group (200-PW-3 Operable Unit)

216-A-8 Crib. The 216-A-8 Crib is located approximately 177 m (580 ft) east of the A Tank Farm in the 200 East Area. The bottom dimensions of the crib are 259 by 6 m (850 by 20 ft). A single 61 cm (24 in.) diameter perforated distribution line extends the length of the crib and rests on a 2 m (6.5 ft)-thick layer of rock capped by a 30 cm (12 in.)-thick layer of gravel, overlain by clean fill material which brought the site back to its original grade. Over its operational life, the 216-A-8 Crib received an estimated 1.15 billion L (303.8 million gal) of process effluent.

The RI Report documented significant cesium-137 contamination at the 216-A-8 Crib, located between 3.4 and 22.3 m (11 and 73 ft) bgs. The risk assessment process determined that direct contact with the cesium-137 contaminated soils found from 4 to 6.6 m (13 to 22 ft) bgs would pose an unacceptable level of risk to human health. Because direct-contact risks are identified less than 4.6 m (15 ft) bgs, remedial action is required.

In addition, the risk assessment process determined that technetium-99 in soil beneath the 216-A-8 Crib may migrate to groundwater. Technetium-99 was identified at significant concentrations (79.6 pCi/g) in only one soil sample. Additional soil sampling is needed to more accurately estimate the mass of technetium-99 present in the vadose zone so that the potential impact of this contaminant can be better defined. In the interim, migration to groundwater is assumed to be possible, and was considered in the development and evaluation of remedial alternatives for the 216-A-8 Crib.

200-PW-3 OU Representative and Analogous Waste Sites

Representative Site	Analogous Sites
216-A-8 Crib	216-A-7 Crib
	216-A-24 Crib
	216-A-31 Crib
	UPR-200-E-56 unplanned release

The following remedial alternatives were identified for consideration at the 216-A-8 Crib and its analogous waste sites. Each remedy presented, except the No Action Alternative, would include implementation of institutional controls, environmental monitoring, and performance monitoring.

- **Alternative 0 – No Action.** *Comprehensive Environmental Response, Compensation, and Liamility Act of 1980* (CERCLA) requires that a no action alternative be considered as the baseline (minimal) response for each site. By definition, it would include no activities to reduce or mitigate risks. No institutional controls would be established. The EPA allows limited environmental monitoring as part of the no action alternative, which would consist of groundwater monitoring to assess for changes in the identified conditions.

- **Alternative 1 – Monofill Evapotranspiration (ET) Barrier.** This alternative would include construction of an **evapotranspiration** (ET) barrier over the crib. The ET barrier would reduce the amount of precipitation infiltrating into the subsurface, limiting the potential for transporting technetium-99 to groundwater. The barrier would also provide additional physical separation from the cesium-137 contaminated soils that pose a direct-contact risk, helping to control that risk. Institutional controls help to ensure continued protectiveness.

  The cesium-137 has a half-life of approximately 30 years. Radioactive decay will reduce cesium-137 concentrations substantially with time, eliminating unacceptable risks in the upper 4.6 m (15 ft) of the soil within approximately 150 years. However, technetium-99 has a very long half-life (approximately 210,000 years). If the additional evaluation determines that technetium-99 can migrate to groundwater, it would be necessary to maintain the barrier to provide protection of groundwater by reducing infiltration. In that case, contingent actions would be considered that would provide a more timely remedy (e.g., the partial RTD alternative).

- **Alternative 2 – Partial RTD.** This alternative would remove soils that pose an unacceptable level of risk to human health, or pose a potential threat to groundwater. The final excavation would be approximately 9.1 m (30 ft) deep. It would be backfilled to grade with suitable fill material.

This alternative would generate a relatively large volume of waste, much of which would originally require remote handling due to the high dose rates. Excavated soils that are designated as waste would be packaged as appropriate to meet container dose-rate requirements and would be transported to ERDF for disposal. This may require mixing high-dose rate soils with less contaminated soils. No treatment is expected to be necessary to meet the ERDF waste acceptance criteria. Excavated soil not designated as waste would be suitable for use as backfill; most backfill material would need to be imported from borrow pits.

Plutonium Process Condensate/Process Waste Group (200-PW-6 Operable Unit)

216-Z-8 French Drain. The 216-Z-8 French Drain is constructed of two, 0.9 m (3 ft)-long vitrified clay culverts, stacked vertically and filled with gravel. The culverts sit atop a 0.9 m (3 ft)-deep gravel bed that is approximately 4.9 m (16 ft) bgs at the bottom. This site received overflow from the 241-Z-8 Settling Tank.

The COCs at the 216-Z-8 French Drain are plutonium-238, plutonium-239/240, and americium-241. Historical testing results, documented in the RI report, indicate that these contaminants are primarily 5 to 11 m (16 to 35 ft) bgs. The risk assessment process determined that human health risks under the industrial land-use scenario were less than 1 in 10,000, primarily because there were no significant COC concentrations identified within the upper 4.6 m (15 ft) of the soil column. Based on the RESRAD modeling of plutonium and americium at the 216-Z-9 Trench, these contaminants are not likely to migrate to groundwater. Because no unacceptable risk to human health or the environment was identified, there is no regulatory requirement to develop or implement remedial alternatives at the 216-Z-8 French Drain.

200-PW-6 OU Unique and Analogous Sites

Unique Sites	Analogous Sites
216-Z-10 Injection/Reverse Well	None
216-Z-8 French Drain	None

216-Z-10 Injection/Reverse Well. The 216-Z-10 Injection/Reverse Well (also known as well 299-W15-51) is a 0.15 m (6 in)-diameter steel cased well that extends to a depth of 45.7 m (150 ft). The steel casing is perforated continuously between 36 and 45.7 m (118 and 150 ft) bgs to allow discharged waste to flow into the soil. The process waste was jetted directly to the well at a rate of 76 L/min (20 gal/min). This well was plugged after receiving 984,207 L (260,000 gal) over 4 months. Operating history indicates that plutonium (approximately 50 g [1.8 oz]) was the main contaminant released to the 216-Z-10 Injection/Reverse Well. No significant organics are expected.

As discussed in the RI Report, historical soil sampling and geophysical logging in three adjacent boreholes (within 4.6 m [15 ft]) identified no significant soil contamination at the 216-Z-10 Injection/Reverse Well. The RI/FS process identified no record of leaks or spills at the site. Because no contamination has been identified in the upper 4.6 m (15 ft) of the soil column, there is no direct-contact risk to potential human and ecological receptor. The plutonium disposed in this well is expected to be bound to the sediments in close proximity to the perforated well casing. The RESRAD modeling of plutonium and americium at the 216-Z-9 Trench showed no risk to groundwater, so even though there are differences in the depth of the plutonium contamination between these waste sites, the limited amount of plutonium at the 216-Z-10 Injection/Reverse Well is not likely to migrate to groundwater. Because no unacceptable risk to human health or the environment was identified, there is no regulatory requirement to develop or implement remedial alternatives for this waste site.

This waste site will be closed by decommissioning the well in accordance with "Minimum Standards for Construction and Maintenance of Wells," WAC 173-160-381. As a precaution, decommissioning activities will be modified to the extent possible to minimize the volume of liquid in the grout introduced into the well during the decommissioning process. Grouting will seal the well and annular space, precluding infiltration of water from the surface.

INTERIM REMEDIAL ACTIONS AND INTEGRATION OF CARBON TETRACHLORIDE FINAL REMEDIES IN THE VADOSE ZONE AND GROUNDWATER

Carbon tetrachloride that was disposed at several of the 200-PW-1 OU waste sites (primarily 216-Z-9 Trench, 216-Z-1A Tile Field, and 216-Z-18 Crib) migrated through the vadose zone and into the underlying groundwater in the 200-ZP-1 OU. Carbon tetrachloride is volatile and forms vapors that reside in the soil overlying groundwater. Removal of carbon tetrachloride vapor from soil above the groundwater began as an interim cleanup measure in 1992, as authorized by the *Action Memorandum ERA Proposal for Carbon Tetrachloride Plume* (EPA Letter 9200423). The vapor was removed using SVE systems and then treated with **granular activated carbon** (GAC). One SVE system was located near each of the three primary carbon tetrachloride disposal sites (216-Z-1A Tile Field, 216-Z-9 Trench, and 216-Z-18 Crib). Approximately 78,884 kg (87 U.S. tons) of carbon tetrachloride were removed from the vadose zone soil from April 1991, through September 2006.

In 1996, a groundwater pump-and-treat system was also implemented as an interim cleanup measure, as specified by the *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit*. This remediation system extracts water downstream from the 200-PW-1 OU primary disposal sites that contributed the carbon tetrachloride contamination to groundwater. The system treats contaminated water using **air stripping** to remove carbon tetrachloride (and similar constituents) and then reinjects the treated water into groundwater upgradient of the extraction area. The air from the stripping tower is then treated by passing it through GAC canisters.

Groundwater monitoring results for fiscal year 2006 (FY06) show that carbon tetrachloride concentrations continued to decline in groundwater as a result of both interim actions. Between the initiation of pump-and-treat operations in March 1994, and the end of FY06, approximately 3.19 billion L (843 million gal) of water were treated, resulting in the removal of 10,198 kg (11.2 U.S. tons) of carbon tetrachloride.

The final remedies proposed for carbon tetrachloride in the vadose zone (200-PW-1 OU) and groundwater (200-ZP-1 OU) have been carefully integrated through their respective feasibility study evaluations. An RAO for 200-PW-1 OU waste sites where carbon tetrachloride was disposed is to prevent further migration to groundwater in concentrations that exceed MCLs. By meeting this objective, the final vadose zone remedy would mitigate carbon tetrachloride from adding to the contamination already in the groundwater. The final groundwater remedy relies on the final vadose remedy meeting this RAO, so that the groundwater remedy can focus on reducing the remaining mass of carbon tetrachloride in the

groundwater. However, if persistent contamination source areas are identified within the groundwater, the final groundwater remedy includes contingency remedial alternatives to clean up those source areas.

Implementation and performance monitoring of the final remedies in both the vadose zone and groundwater will also require continued integration. Both remedies will need vadose zone and groundwater monitoring to determine when cleanup goals have been achieved and the remedial systems can safely be shut down. Operation of both remedies will also need to be coordinated so that the carbon tetrachloride contamination does not migrate from the vadose zone into groundwater or from the groundwater (as vapor) back into the vadose zone. The cleanup goal for carbon tetrachloride in the vadose zone must also be linked to what is technically practicable for cleaning up the carbon tetrachloride in groundwater as part of the 200-ZP-1 OU remedy. Discussion of the final remedy for the 200-ZP-1 Groundwater OU is in the *Proposed Plan for Remediation of the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-33).

EVALUATION OF REMEDIAL ALTERNATIVES

The EPA has developed nine CERCLA evaluation criteria (defined in EPA 540/G-89/004) to address the statutory requirements, and the technical and policy considerations important for evaluating remedial alternatives. The nine criteria are categorized into three groups: threshold criteria, primary balancing criteria, and modifying criteria. The preferred alternative is selected through a comparative analysis of identified alternatives against these threshold and primary balancing criteria.

The two "modifying criteria" are applied after state and public comments on the Proposed Plan are received. A remedial alternative must meet the first two "threshold criteria," overall protection and compliance with potential ARARs, to be eligible as a preferred remedy. The five "primary balancing criteria" allow for a comparison of major trade-offs among the alternative remedies.

The state and community acceptance of the modifying criteria cannot be fully considered until public comments are received. The modifying criteria are of equal importance to the primary balancing criteria in the final evaluation of remedial alternatives.

In addition to the CERCLA criteria, ***National Environmental Policy Act of 1969*** (NEPA) values (e.g., analysis of cumulative off-site ecological and socioeconomic impacts) are also considered. The NEPA values are discussed in the FS Report and summarized at the end of this plan.

Explanation of the Nine CERCLA Evaluation Criteria

Threshold Criteria

1. ***Overall Protection of Human Health and the Environment*** is the primary objective of a remedial action and addresses whether a remedial action provides adequate overall protection of human health and the environment. This criterion must be met for a remedial alternative to be eligible for consideration.

2. ***Compliance with Applicable or Relevant and Appropriate Requirements*** addresses whether a remedial action will meet all of the applicable or relevant and appropriate requirements and other Federal and state environmental statutes, or provides grounds for invoking a waiver of the requirements. This criterion must be met for a remedial alternative to be eligible for consideration.

Primary Balancing Criteria

3. ***Long–Term Effectiveness and Permanence*** refers to the magnitude of residual risk and the ability of a remedial action to maintain long-term reliable protection of human health and the environment after remedial goals are met.

4. ***Reduction of Toxicity, Mobility, or Volume Through Treatment*** refers to an evaluation of the anticipated performance of treatment technologies that may be employed in a remedy. Reduction of toxicity, mobility, and/or volume contributes toward overall protectiveness.

5. ***Short–Term Effectiveness*** refers to evaluation of the speed with which the remedy achieves protection. It also refers to any potential adverse effects on human health and the environment during the construction and implementation phases of a remedial action.

6. ***Implementability*** refers to the technical and administrative feasibility of a remedial action, including the availability of materials and services needed to implement the selected solution.

7. ***Cost*** refers to an evaluation of the capital, operation and maintenance, and monitoring costs for each alternative.

Modifying Criteria

(These two criteria are applied after state and other public comments on the FS and Proposed Plan are received and compiled.)

8. ***State Acceptance*** indicates whether the state concurs with, opposes, or has no comment on the preferred alternative based on review of the FS and the Proposed Plan.

9. ***Community Acceptance*** assesses the general public response to the Proposed Plan, following a review of public comments that are received during the public comment period and open community meetings. The remedial action is selected only after consideration of this criterion.

Comparative Analysis of Remedial Alternatives

Plutonium/Organic-Rich Process Condensate/Process Waste Group (200-PW-1 Operable Unit)

Preferred Alternative for the 216-Z-1A Tile Field. Based on comparative analysis of the alternatives for the 216-Z-1A Tile Field, Alternative 2 (Intrusion-Prevention Feature plus Expanded SVE) was identified as the preferred alternative, as shown in Table 3. It achieves protectiveness by establishing at least 4.6 m (15 ft) of separation between the radionuclide COCs that exceed the RBCs and providing a durable physical barrier to intrusion that is effective under both industrial-use and unrestricted-use scenarios. Short-term risks are minor, associated with activities that are routine at the Hanford Site and readily and effectively controlled by existing Hanford Site worker protection and environmental protection programs. In addition, the SVE system would be expanded to enhance its ability to reduce carbon tetrachloride mass in the vadose zone, thereby reducing the threat to groundwater. The only significant waste stream from this alternative would come from the SVE system. Total costs for this alternative are estimated at $5,800,000. Waste sites in the 200-PW-1 OU and their identified preferred alternatives are depicted in Figure 5.

Table 3. Comparative Analysis of the 216-Z-1A Tile Field Remedial Alternatives

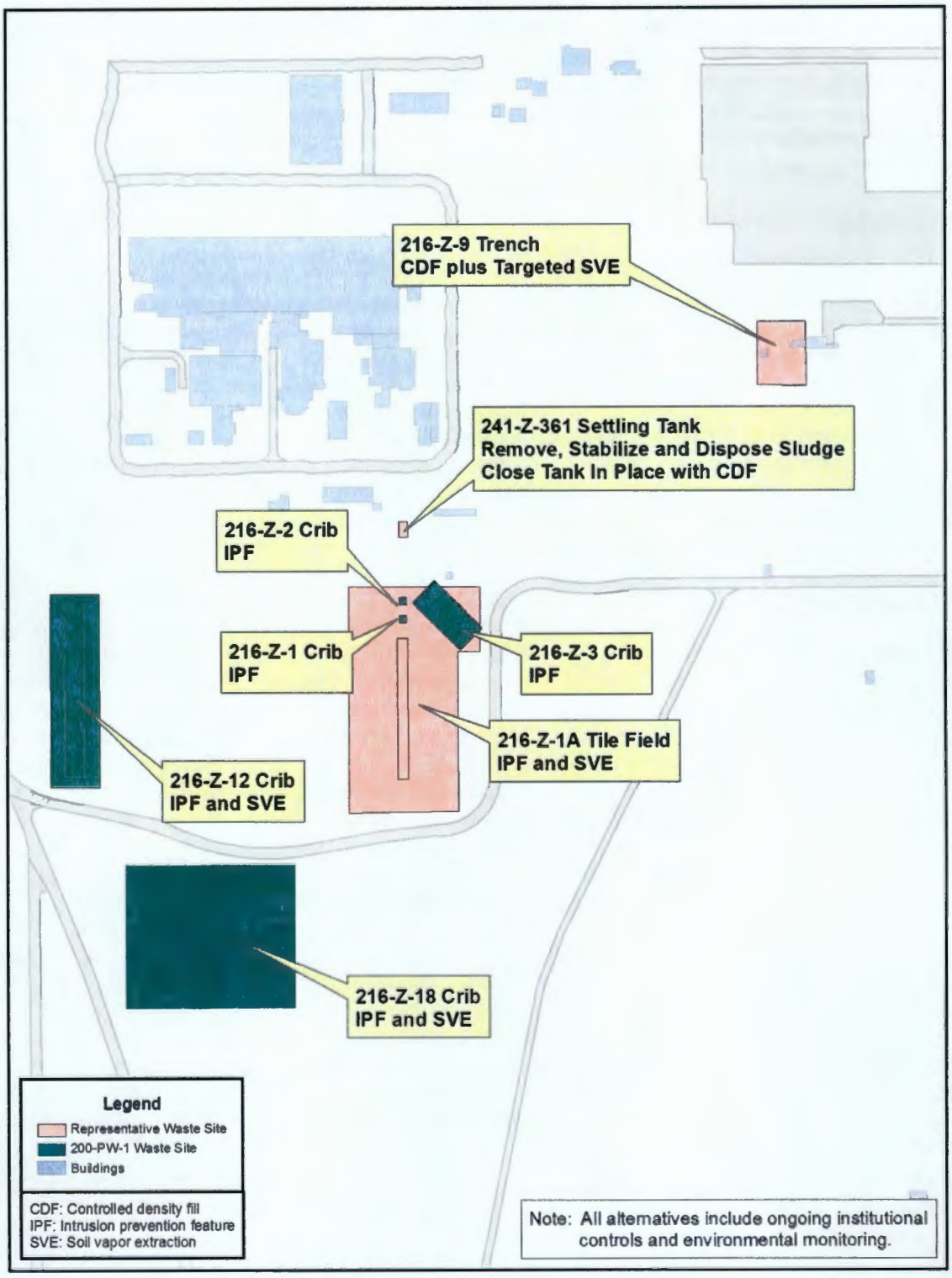
CERCLA Evaluation Criterion	Alternative 0	Alternative 1	Alternative 2[a]	Alternative 3	Alternative 4
			☑		
	No Action	Soil Backfill + Expanded SVE	Intrusion Prevention Feature + Expanded SVE	In-Situ Vitrification + Expanded SVE	Partial Removal, Treatment and Disposal + Expanded SVE
Overall Protection of Human Health and the Environment [b]	*c*	4	1	2	3
ARARs	*c*	*d*	*d*	*d*	*d*
Long-Term Effectiveness and Permanence	N/A	4	3	1	2
Reduction of Toxicity, Mobility or Volume through Treatment	N/A	4	4	1	4
Short-Term Effectiveness	N/A	1	1	3	4
Implementability	N/A	1	2	4	3
Present Worth Cost	$0	$5,600,000	$5,800,000	$207,000,000	$419,000,000

a. Preferred alternative will be contingent upon confirmatory sampling.
b. This criterion does not consider unrestricted land use scenarios (e.g., residential farmer population) or related risks.
c. Alternative does not meet this threshold criterion.
d. Alternative meets this criterion.
N/A Not Applicable
Ranking is relative to the other alternatives, with a rank of "1" being best.
☑ Preferred alternative

Application of the 216-Z-1A Tile Field Preferred Alternative to the Analogous Waste Sites

216-Z-1, 216-Z-2, and 216-Z-3 Cribs: These three cribs are located near the northern end of the 216-Z-1A Tile Field. Waste liquids from each of these cribs overflowed into the tile field. Though all three received significant volumes of plutonium and americium, they did not receive significant quantities of organics (i.e., carbon tetrachloride). All three facilities were constructed in excavations that were at least 6 m (20 ft) deep. Geophysical logging conducted at the 216-Z-3 Crib shows that significant radionuclide contamination begins near the base of the excavation at 5.5 to 6 m (18 to 20 ft) bgs. It is fairly typical for radionuclides to migrate through the coarse-grained material (gravel and cobbles) used to fill the base of the waste site excavations, and to then adhere to the finer-grained native soils. This is assumed to be true for the 216-Z-1 and 216-Z-2 Cribs, where no data were identified to establish a contaminant concentration profile. The 216-Z-1 Crib is located about 7.6 m (25 ft) south of the 216-Z-2 Crib, and roughly 20 m (65 ft) west of the 216-Z-3 Crib. Because the sites are so close, it is possible that contaminants from these three sites are commingled in the subsurface. Confirmatory sampling will be necessary to document the contaminant profile at these three sites.

Figure 5. Preferred Alternatives for 200-PW-1 Operable Unit Waste Sites in the 200 West Area.



Because significant quantities of carbon tetrachloride were not discharged to these three facilities, there is no related threat to groundwater, so SVE is not expected to be necessary to remediate these sites. Radionuclide contamination at the three cribs appears similar to that found at the 216-Z-1A Tile Field in many respects, but it is not anticipated at actionable levels within 4.6 m (15 ft) of the ground surface because the waste was discharged deeper below ground surface. Because the contamination is deeper, it poses no unacceptable direct contact risk to human health, and there is no regulatory requirement for remedial action. Confirmatory sampling would be necessary at all three sites to verify the contaminant distribution. However, in consideration of risk that would exist under a future unrestricted land-use scenario, the intrusion-prevention feature is the preferred alternative for these three cribs. It would reduce the likelihood of inadvertent intrusion into radiologically contaminated soils found at depths greater than 4.6 m (15 ft). Construction of these three waste sites included subsurface voids much larger than distribution pipes. These voids will be backfilled with CDF before implementation of the preferred alternative.

216-Z-5 Crib: This crib is a 200-PW-6 OU waste site. It did not receive organic process waste similar to that discharged to the 216-Z-1A Tile Field, so no related threat to groundwater is expected. Estimates of the types and quantities of radionuclides discharged to the crib do not correlate well with geophysical logging results for the site. Geophysical logging conducted at the perimeter of the crib to a depth of 46 m (150 ft) identified cesium-137 (up to 314 pCi/g) and europium-154 (up to 2 pCi/g), both found at depths greater than 15 m (50 ft). The available data suggest that any direct-contact risks would be associated with soils at depths greater than 4.6 m (15 ft), so there is no regulatory requirement for remedial action at this site. Institutional controls will be implemented to ensure ongoing industrial use of the site. Confirmatory soil sampling will be necessary to verify that contaminant levels at the site pose no unacceptable risks to human health or the environment.

216-Z-12 and 216-Z-18 Cribs: These two cribs received radionuclide and organic waste streams. The 216-Z-18 Crib received acidic waste, like the 216-Z-1A Tile Field. The 216-Z-12 Crib received neutral/basic wastes. Geophysical logging results at both cribs show no significant radiological contamination in the upper 4.6 m (15 ft) of the subsurface. Significant radionuclide contamination was not detected above 5.3 m (17.5 ft) in the 216-Z-12 Crib and was not found until 7.3 m (24 ft) bgs at the 216-Z-18 Crib. Confirmatory sampling would be required, but the limited data suggest that there would be no regulatory requirement to address direct-contact risks posed by radionuclide-contaminated soils at these two sites. However, in consideration of the risk that would exist under a future unrestricted land-use scenario, the 216-Z-1A Tile Field preferred alternative is identified as the preferred alternative for the 216-Z-12 and 216-Z-18 Cribs. This would include operation of the expanded SVE system (which currently includes SVE wells in the vicinity of these two cribs) and construction of intrusion prevention features to impede access to the subsurface contaminants at these two sites.

Preferred Alternative for the 216-Z-9 Trench. Based on comparative analysis of the remedial alternatives carried forward for the 216-Z-9 Trench, Alternative 1 – CDF plus Targeted SVE was identified as the preferred alternative, as shown in Table 4. It achieves protectiveness upon implementation, upgrading the SVE system to enhance its ability to reduce contaminant mass in the source area, and controlling infiltration by establishing a selected plant community at the site. It also backfills the trench void space with CDF, leaving the concrete cover and columns in place, which ensures acceptable levels of risk for the site construction worker and effectively mitigates the exposure pathways under the future unrestricted land-use scenario. All short-term risks unique to this alternative (i.e., associated with placement of the CDF) are minor and readily mitigated. Total costs for this alternative are estimated at $4,700,000. The 216-Z-9 Trench has no identified analogous waste sites.

Table 4. Comparative Analysis of Alternatives for the 216-Z-9 Trench.

CERCLA Evaluation Criterion	Alternative 0	Alternative 1[a]	Alternative 2	Alternative 3	Alternative 4
		☑			
	No Action	Controlled Density Fill + Targeted SVE	Intrusion-Prevention Feature + Targeted SVE	In Situ Vitrification ++ Targeted SVE	Partial RTD + Targeted SVE
Overall protection of human health and the environment[b]	*c*	1	2	3	4
ARARs	*c*	*d*	*d*	*d*	*d*
Long-term effectiveness and permanence	N/A	4	3	1	2
Reduction of toxicity, mobility and volume through treatment	N/A	2	2	1	2
Short-term effectiveness	N/A	1	2	3	4
Implementability	N/A	1	2	4	3
Present-worth cost[b]	$0	$4,700,000	$4,700,000	$27,000,000	$28,000,000

NOTE: Ranking is relative to the other alternatives, with a rank of "1" being best.
☑ Preferred alternative.
[a] Preferred alternative will be contingent upon confirmatory sampling.
[b] This criterion does not consider unrestricted land use scenarios (e.g., residential farmer population) or related risks.
[c] Alternative does not meet this threshold criterion.
[d] Alternative meets this threshold criterion.
N/A Not Applicable
RTD = removal, treatment, and disposal
SVE = soil vapor extraction

Preferred Alternative for the 241-Z-361 Settling Tank. As discussed earlier, a previous study evaluated remedial alternatives for this tank and identified a preferred remedial alternative. That alternative would employ a fluidics system to loosen and homogenize the sludge and then transfer it to SWBs. A polymer absorbent would be added to the SWBs to absorb residual liquids and stabilize the sludge. The SWBs would then be transported to the CWC for storage pending proper disposition, with final disposal most likely at WIPP. Once the sludge is removed from the tank, the tank would be left in place and backfilled with CDF. Confirmatory sampling would be conducted to ensure compliant site closure. The present worth cost for this alternative is estimated at $13,000,000.

Application of the 241-Z-361 Settling Tank Preferred Alternative to the Analogous Waste Site

<u>241-Z-8 Settling Tank</u>: The 241-Z-8 Settling Tank is a metal underground tank that received liquid wastes generated by back-flushing RECUPLEX process filters with a nitric acid solution. In addition to the nitric acid, the effluent contained back-flushed solids and silica gel, which was used as a settling agent. When the tank reached capacity (58,430 L [15,430 gal]), overflow was piped to the 216-Z-8 French Drain, which is about 11 m (36 ft) east of the settling tank.

The tank was taken out of service in 1962. Inventory measurements taken in 1974 indicated that the tank was only half full, containing approximately 27,580 L (7,285 gal) less than expected. A subsequent investigation of surrounding soils identified no significant soil contamination, suggesting that the discrepancy in waste volume was not the result of a tank leak.

In 1974, pumpable liquid was removed from that tank, leaving approximately 18 cm (7 in) of sludge amounting to 1,890 L (500 gallons). Various sources discuss the amount of plutonium remaining in the tank, with the quantities ranging from 38 g (1.3 oz) to 1.5 kg. (3.3 lb).

The 241-Z-361 Settling Tank preferred alternative is also identified as the preferred alternative for the 241-Z-8 Settling Tank. This would include: 1) using a fluidics system to mobilize and homogenize the sludge, and then transfer it to appropriate disposal containers; and 2) adding a polymer absorbent to the waste containers to absorb residual liquids and stabilize the sludge. There is not enough information at this time to determine what portion of the waste generated by this action would require disposal at the WIPP. Any portion of this waste that meets ERDF waste acceptance criteria will be disposed at ERDF. After sludge removal the tank will be left in pace and backfilled with CDF.

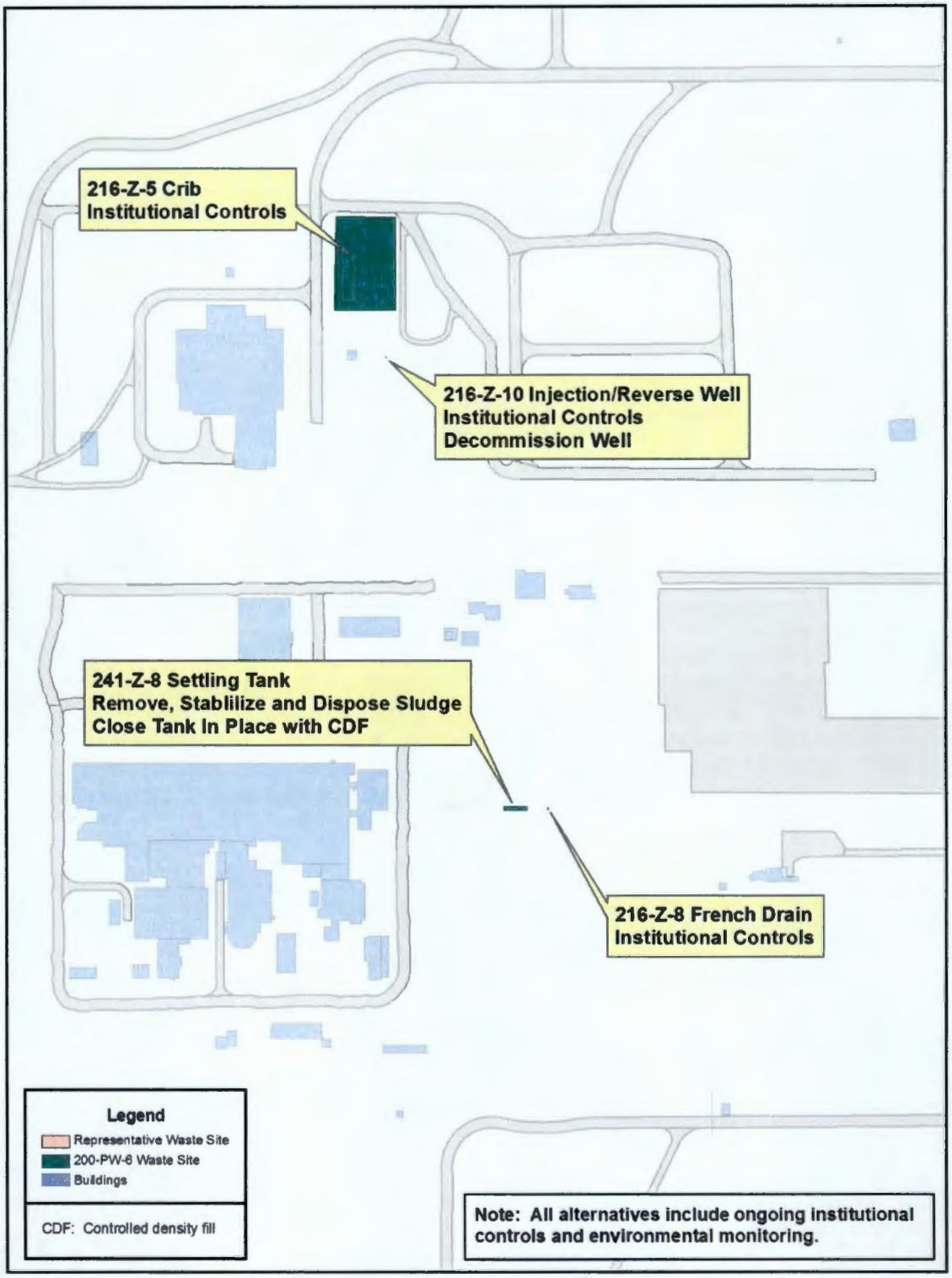
Plutonium Process Condensate/Process Waste Group (200-PW-6 Operable Unit)

Remedies for two of the four 200-PW-6 OU waste sites, the 216-Z-5 Crib, and the 241-Z-8 Settling Tank, were addressed previously based on their analogy with waste sites in the 200-PW-1 OU. The two remaining 200-PW-6 OU waste sites (the 216-Z-8 French Drain, and the 216-Z-10 Injection/Reverse Well) are addressed below. Waste sites in the 200-PW-6 OU and their associated preferred remedies are depicted in Figure 6.

216-Z-8 French Drain. The risk assessment identified no unacceptable risks to human health or the environment at this site; therefore, no remedial action is required. Institutional controls would be implemented in accordance with the site wide institutional controls plan.

216-Z-10 Injection/Reverse Well. Based on available data, no remedial action is required at the 216-Z-10 Injection/Reverse Well. The path forward would be to decommission the well in accordance with WAC 173-160-381. This would include pressure-grouting the well to limit infiltration adjacent to the well. Institutional controls would be implemented in accordance with the site wide institutional controls plan.

Figure 6. Preferred Alternatives for the 200-PW-6 Operable Unit Waste Sites in the 200 West Area.



Organic-Rich Process Condensate/Process Waste Group (200-PW-3 Operable Unit)

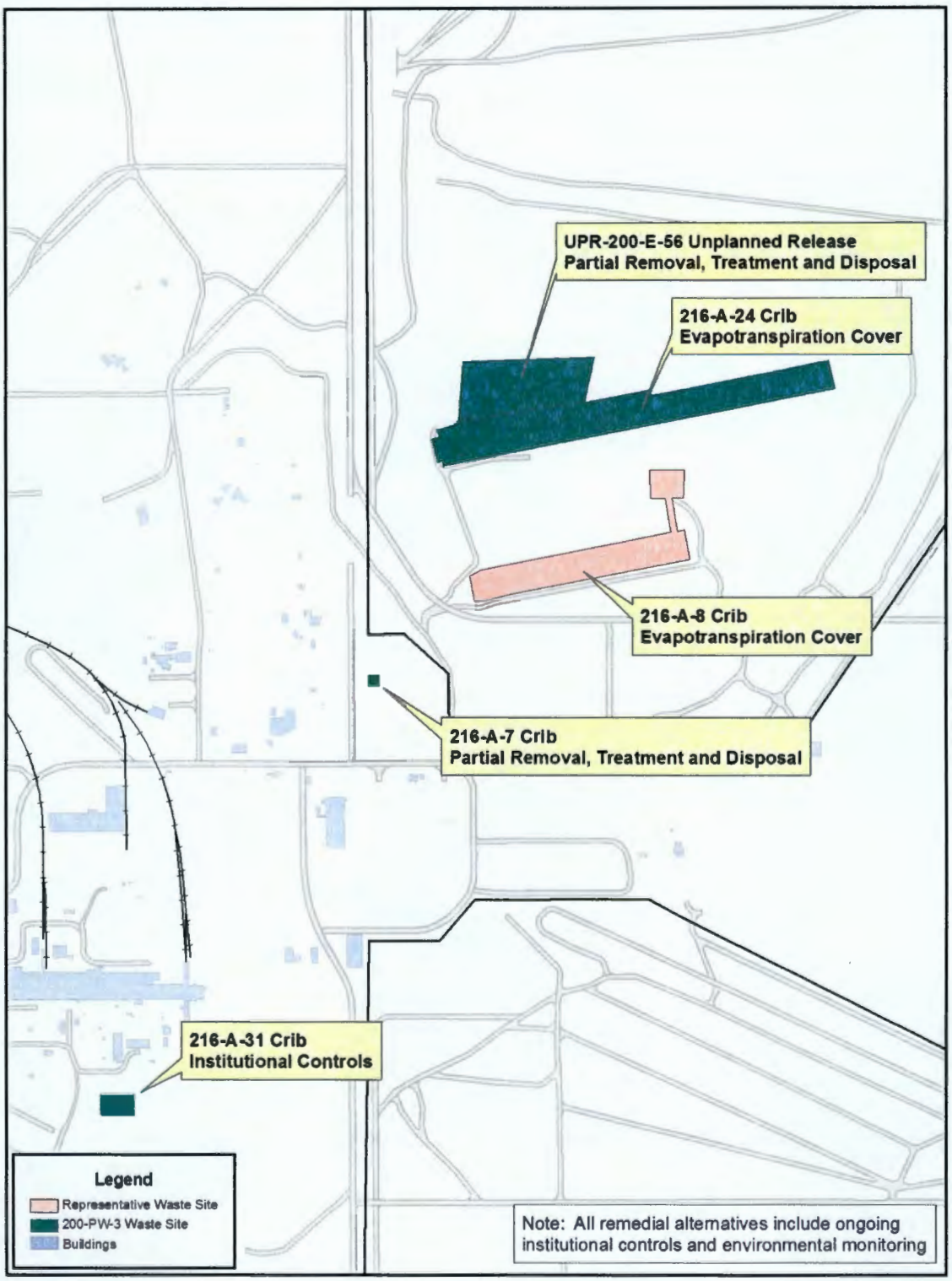
Preferred Alternative for the 216-A-8 Crib. Based on comparative analysis of the alternatives for the 216-A-8 Crib, Alternative 1 (Monofill ET Barrier) was identified as the preferred alternative as shown in Table 5. It achieves protectiveness by controlling access to the principal threat contaminant and limits infiltration and, thus, migration of the more mobile contaminants. The principal threat contaminant, cesium-137, is expected to decay to levels that pose no unacceptable risk to the industrial site construction worker within approximately 150 years. Institutional controls will ensure that the barrier is protected and maintained during that time period. The potential migration to groundwater by technetium-99 requires additional evaluation. In the interim, the ET monofill barrier will limit infiltration into the subsurface and reduce the potential for migration of the technetium-99 to groundwater. Total costs for this alternative are estimated at $4,000,000. Waste sites in the 200-PW-3 OU and their associated preferred remedies are depicted in Figure 7.

Table 5. Comparative Analysis of Alternatives for the 216-A-8 Crib.

CERCLA Evaluation Criterion	Alternative 0	Alternative 1[a]	Alternative 2
		☑	
	No Action	Monofill Evapotranspiration Barrier	Partial Removal, Treatment, and Disposal
Overall protection of human health and the environment[b]	*c*	1	2
ARARs	*c*	*d*	*d*
Long-term effectiveness and permanence	N/A	2	1
Reduction of toxicity, mobility and volume through treatment	N/A	N/A	2
Short-term effectiveness	N/A	1	2
Implementability	N/A	1	2
Present-worth cost	$0	$4,000,000	$51,000,000

NOTE: Ranking is relative to the other alternatives, with a rank of "1" being best.
☑ Preferred alternative
[a.] Preferred alternative will be contingent upon confirmatory sampling.
[b.] This criterion does not consider unrestricted land use scenarios (e.g., residential farmer population) or related risks.
[c.] Alternative does not meet this threshold criterion.
[d.] Alternative meets this threshold criterion.

Figure 7. Preferred Alternatives for the 200-PW-3 Operable Unit Waste Sites in the 200 East Area.



Application of the 216-A-8 Crib Preferred Alternative to the Analogous Waste Sites

216-A-7 Crib. This crib was constructed in a 4.9 m (16 ft)-deep excavation with a 3 by 3 m (10 by 10 ft) base. The elevation of the current ground surface is about 1 m (3 ft) higher than the surrounding land surface due, in part, to the addition of 46 to 61 cm (18 to 24 in.) of stabilization soil cover. Perforated 15 cm (6 in.) vitrified clay pipe was used to distribute discharged liquids within the 216-A-7 Crib. The base of the piping is about 3.7 m (12 ft) bgs and sits atop a 2.1 m (7 ft)-thick layer of coarse rock. Native soils are about 5.8 m (19 ft) bgs.

Estimates of discharged inventory in the *Hanford Soil Inventory Model, Rev. 1* (RPP-26744) indicate that this site received cesium-137, NPH, and technetium-99 in quantities greater than those discharged to the 216-A-8 Crib. No analytical data exist for this site, but geophysical logging of well 299-E25-54 (just inside the eastern perimeter of the original crib excavation) identified a continuous zone of cesium-137 from 1.9 to 2.9 m (6.2 to 9.5 ft) bgs, with the highest concentrations between 1.9 to 2.9 m (6.2 to 9.5 ft) (*Log Data Report for Well 299-E25-54* [HGLP-LDR-024]). The maximum cesium-137 concentration was about 600 pCi/g, detected at 2.6 m (8.5 ft) bgs.

Available information and analogy with the 216-A-8 Crib indicate that the 216-A-7 Crib may pose both a direct-contact risk to human health (associated with cesium-137) and potential migration to groundwater by technetium-99 and possibly NPH. However, the 216-A-7 Crib is substantially smaller than its representative site, covering less than 400 m^2 (4,300 ft^2). For that reason, subject to confirmatory soil testing results, the preferred alternative is identified as Alternative 2 (Partial RTD). This would include excavation to a depth that provides sufficient protectiveness of human health and groundwater, backfilling the excavation to grade, and implementing institutional controls. Excavated soil that designates as low-level or low-level mixed waste would be disposed at ERDF. The remaining soils would be used for backfilling. Additional backfill material will be necessary. However, if it is not practical to excavate to a sufficient depth to mitigate the migration to groundwater pathway, no excavation would be conducted, and the contingent preferred alternative would be implemented (Alternative 1 – Monofill ET Barrier).

216-A-24 Crib. The 216-A-24 Crib is composed of four cells, each 107 m (350 ft) long, and each sequentially 1.8 m (6 ft) lower than the previous cell, and separated from the next by a soil berm. Waste was introduced at the western end of the crib, and distributed along its length through a 38-cm (15-in.)-diameter, corrugated galvanized pipe that is perforated on the bottom half. The waste distribution line in each cell is horizontal, rises to clear the soil berm, and then drops into the next cell at a level 1.5 m (5 ft) lower than its previous elevation. The overlying ground surface slopes to the east, so the distribution line is approximately 1.5 m (5 ft) closer to the surface at the end of each cell than it is at the beginning. The base of the piping ranges between 2.7 and 4.3 m (9 and 14 ft) bgs.

Due to the waste site design and the low-flow rates, most of the waste volume was discharged to the first two cells. A number of boreholes are located along the discharge pipe. Geophysical data, available for a number of the borings, show that most residual cesium-137 is located in the two western cells. Well 299-E26-74, near the eastern end of the first cell, shows cesium-137 at less than 20 pCi/g to a depth of about 3 m (10 ft) bgs, and then concentrations exceeding the dose-based RBC (1,220 pCi/g) at 4 m (13 ft) bgs and reaching a maximum of 1,000,000 pCi/g at 4.9 m (16 ft) bgs. For the most part, the cesium-137 concentration remains above the RBC to a depth of 12 m (40 ft) and then decreases. Geophysical logging data indicate that cesium-137 has not spread outside the crib boundaries, except at the adjacent UPR-200-E-56 unplanned release site, where the identified cesium-137 did not exceed 80 pCi/g. Organics and tritium were also discharged to this crib. Boreholes drilled in 1981 (well 299-E26-53) emitted organic odors from 4.6 to 12 m (15 to 40 ft) and a liquid, blue-green sample at 10 m (33 ft).

Based on available information, and analogy to the 216-A-8 Crib, this site is likely to pose both a direct-contact risk to human health (associated with cesium-137) and a potential migration to groundwater (from the organics).

Because this site poses similar risks and is similar in size to the 216-A-8 Crib, the 216-A-8 Crib preferred alternative is also identified as the preferred alternative for the 216-A-24 Crib, pending the results of confirmatory sampling. Implementation would include construction of an ET monofill barrier to provide physical separation from soils with cesium-137 concentrations and to limit infiltration of precipitation into soils that contain contaminants that could potentially migrate to groundwater.

216-A-31 Crib. The 216-A-31 Crib was constructed in a 7.3 m (24 ft)-deep excavation with a base of 21 m by 3.1 m (70 ft by 10 ft). Waste was distributed to the crib soils through a perforated 7.6 cm (3 in.)-stainless-steel pipe placed horizontally 6.4 m (21 ft) bgs, within a 1.8 m (6 ft)-thick bed of gravel. The area above the gravel was backfilled to grade with clean soil.

Discharge inventory estimates indicate that this site received much smaller quantities of the COCs than the other waste sites in this group, with cesium-137, NPH, and technetium-99 quantities about an order of magnitude less than those discharged to the 216-A-8 Crib and 216-A-7 Crib. No site-specific soil analyses or geophysical logging results were identified for this waste site.

Because the 216-A-31 Crib received relatively small quantities of the COCs and discharged them at more than 6 m (20 ft) bgs, no direct-contact risk to human health is anticipated. Due to the low quantities of organics and technetium-99 identified in the discharge inventory, no potential migration to groundwater is anticipated. Pending the results of confirmatory sampling, the identified preferred alternative for this site is implementation of institutional controls, to limit any risk posed by the residual contamination, and limited environmental monitoring to assess for evidence of COC migration to groundwater.

UPR-200-E-56 Unplanned Release. The unplanned release site is an area that served as a source for borrow material. Excavation activities were halted when contamination was discovered, and the area was then backfilled. The contamination was determined to be liquid waste discharged to the adjacent 216-A-24 Crib that had subsequently migrated laterally to the north on a 10 cm (4 in.)-thick caliche layer located about 4.6 m (15 ft) bgs.

Geophysical logging identified very low cesium-137 concentrations, with the maximum at approximately 80 pCi/g, which is below the RBC of 1,220 pCi/g, so no direct-contact risk is anticipated at this site. No soil analytical results were identified for this site.

Based on the geophysical logging results, the estimated discharge inventory for the 216-A-24 Crib, and analogy with the 216-A-8 Crib, organic contamination at this site may migrate to groundwater. Available information indicates that the contamination is shallow and that direct-contact risks are very low and easily mitigated.

The identified preferred remedy for the UPR-200-E-56 unplanned release site is Alternative 2 (Partial RTD). Because the volume of waste that migrated to the site was small, and the contamination is very shallow, it appears that RTD would be effective in reducing all identified and potential risks to acceptable levels. Additional confirmatory sampling will be necessary to determine the extent of excavation, and to determine if the waste will need to be treated to meet ERDF waste acceptance criteria.

Contingent Remedial Alternatives

If new COCs or risks are identified at any of the waste sites covered under this CERCLA action by post-ROD confirmatory soil sampling, or if the implemented remedies are determined to be ineffective, contingent remedial alternatives will be implemented, as discussed in this section. The FS report

identified contingent remedies for the representative and unique waste sites. Contingent remedies considered for the analogous waste sites will be identical for the same type of situation.

Potential migration to groundwater from VOCs or semi-volatile organic compounds (SVOCs) in soil. In the event that VOCs or SVOCs are found in concentrations that may migrate to groundwater, or if monitoring confirms that an implemented remedy is not performing as planned, contingent remedial alternatives may include the following:

- Implementation of SVE, expansion of an existing SVE system, or implementation of enhanced SVE technologies (e.g., using electrical resistance heating to warm the soil so contaminants volatilize more quickly).
- Excavation to remove contaminant mass to eliminate the threat to groundwater, treatment of the soils as necessary to meet waste disposal criteria, disposal of wastes at an appropriate facility, and backfilling the excavation.
- Construction of an ET barrier, or enhancement of an existing ET barrier, to limit the amount of precipitation that infiltrates from the ground surface (this limits the potential for transporting the contaminants to groundwater).
- Implementation of dry air barrier technology, which removes moisture from the soils above and/or below the contaminants, which limits the ability of the contaminants to move downward to groundwater. (This technology also enhances volatilization and removal of VOCs and SVOCs.)

Potential migration to groundwater by radionuclides (technetium-99), metals, or inorganics. In the event that radionuclides (technetium-99), metals, or inorganics are found in concentrations that may migrate to groundwater, or if monitoring confirms that an implemented remedy is not performing as planned, contingent remedial alternatives may include the following:

- Excavation to remove contaminant mass to eliminate the threat to groundwater, treatment of the soils as necessary to meet waste disposal criteria, disposal of the wastes at an appropriate facility, and then backfilling of the excavation.
- Construction of an ET barrier, or enhancement of an existing ET barrier, to limit the amount of precipitation that infiltrates from the ground surface (this limits the potential for transporting the contaminants to groundwater).
- Implementation of dry air barrier technology, which removes moisture from the soils above and/or below the contaminants, which limits the ability of the contaminants to move downward to groundwater.
- In-situ treatment of the contaminants to reduce their mobility (e.g., in-situ vitrification)

Direct-contact risk to human health or ecological receptors by contaminants within 4.6 m (15 ft) of the ground surface. In the event of a newly discovered, direct-contact risk to human health or ecological receptors, or if monitoring confirms that an implemented remedy is not performing as planned, contingent remedial alternatives may include the following:

- Excavation to remove contaminant mass to eliminate the risk, treatment of the soils as necessary to meet waste disposal criteria, disposal of the wastes at an appropriate facility, and then backfilling of the excavation.
- Construction of an intrusion prevention feature, or enhancement of an existing intrusion prevention feature, to reduce the possibility of accidental intrusion into the contaminated soil (the level of protection and design of this feature will vary depending on the level of risk and the likelihood of intrusion).
- In-situ vitrification to reduce the effects of direct contact and to impede inadvertent intrusion.

NATIONAL ENVIRONMENTAL POLICY ACT

The "*National Environmental Policy Act of 1969*" (NEPA) values will be evaluated as part of DOE's responsibility. NEPA and its implementing regulations, the *National Environmental Policy Act Compliance Program* (DOE Order 451.1B), *DOE Policies on Application of NEPA to Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and Resource Conservation and Recovery Act of 1976 (RCRA) Actions* (DOE Memorandum 2002) and DOE guidance for decommissioning (DOE G 430.1-4) require that NEPA values be incorporated into decisions and documents as part of the CERCLA process. These values include, but are not limited to, cumulative, ecological, cultural, historical, and socioeconomic impacts and Irreversible and Irretrievable (I&I) statements in lieu of preparing separate NEPA documentation. The impacts of these aspects of the human environment usually are not otherwise addressed within the CERCLA process. This integration provides a more comprehensive analysis of potential impacts resulting from the proposed cleanup activities in the 200-PW-1 OU, 200-PW-3 OU, and 200-PW-6 OU. To support the CERCLA decision-making process the NEPA value analysis was included in the FS and will be addressed in resulting CERCLA decisions.

The NEPA process is intended to help Federal agencies with the following:

- Make decisions that are based on understanding environmental consequences
- Take actions that protect, restore, and enhance the environment.

NEPA Values Encompass a Range of Environmental Concerns:

- Transportation impacts
- Air quality
- Natural, cultural, and historical resources
- Noise, visual, and aesthetic effects
- Socioeconomic impacts
- Environmental justice
- Cumulative impacts (direct and indirect)
- Mitigation
- Irreversible and irretrievable commitment of resources

The NEPA-related resources and values considered for the 200-PW-1 OU, 200-PW-3 OU, and 200-PW-6 OU waste sites support the CERCLA decision-making processes. For the remedies evaluated, NEPA impacts include temporary short-term disturbance (e.g., increased traffic, noise levels, and fugitive dust) of approximately 0.07 km^2 (0.03 mi^2) for a disturbed industrial area that has low to marginal habitat quality.

Irreversible and Irretrievable (I&I) impacts for the RTD alternative and the barrier and intrusion prevention feature alternatives would result from the use of natural resource materials (sand, gravel, silty loam, basalt, etc.) during construction. An evaluation of available NEPA documentation concerning these natural resource materials from on-site or off-site sources will be conducted before implementation. The necessary NEPA documentation for the use of these natural resource materials will be described in the Remedial Design/Remedial Action Work Plan.

Long-term impacts identified for the remedies evaluated include potential aesthetic and visual impacts, should the barriers or backfilled areas not be adequately contoured and vegetated to blend with the surrounding area. Minimal or no impacts are expected for air quality; natural, cultural, and historical resources; transportation; socioeconomics; environmental justice; or cumulative impacts.

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GLOSSARY OF TERMS

The first usage of technical terms and other specialized text in this Proposed Plan are shown in bold in the text of this document, and the terms are defined below:

Administrative Record – The files containing all of the documents used to select a response action at a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remedial action site. Locations for the Hanford Site Administrative Record are provided at the end of this Proposed Plan.

Air stripping – A treatment system that removes volatile organic chemicals from contaminated groundwater or surface water by forcing an air stream through the water and causing the compounds to evaporate. The air can be further treated (e.g., using granular activated carbon) before it is released into the atmosphere.

Americium – A radioactive man-made metal produced in nuclear reactors and in nuclear weapon detonations. One of the isotopes at some waste sites is americium-241, a daughter product of plutonium-241.

Analogous site approach – A streamlined approach to the remedial investigation / feasibility study process wherein waste sites are grouped by function, waste type and site characteristics, and only a few sites are investigated in detail, under the assumption that other sites with similar history and conditions will have similar contamination conditions.

Analogous site – A waste site that is similar (analogous) to a representative waste site based on similar attributes (e.g., configuration, function, waste disposed, geology, etc.).

Applicable or relevant and appropriate requirement (ARAR) – Standards, criteria, or limitations under Federal or more stringent state environmental laws, including the *Resourced Conservation and Recovery Act of 1976* (RCRA), that may be required during a Superfund remedial action, unless site-specific waivers are obtained.

Butanol – Also called butyl alcohol, is a flammable liquid which evaporates quickly when exposed to air. It accumulated in the condensate of single shell tanks, which was drained to some of the 200-PW-3 Operable Unit waste sites.

Carbon tetrachloride – A poisonous, nonflammable, colorless liquid, used at the Hanford Site as a process chemical in the production of plutonium.

***Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) – (also known as "Superfund")** – A Federal law that establishes a program that addresses liability, enforcement, and cleanup of Federal and commercial facilities and allows government entities to evaluate damages to natural resources.

Concentration – A measure of the amount of a substance in soil, water, or soil vapor.

Contaminant – Any substance that is expected to be present at a site based upon past and current land uses and associated releases based upon reasonable inquiry, and which presents a threat to human health and/or the environment.

Contaminants of concern (COCs) – Any contaminant expected to be present at a waste site based upon past and current land uses and associated releases based upon reasonable inquiry, and which presents a threat to human health and/or the environment above CERCLA risk levels.

Contaminants of potential concern (COPCs) – The list of all hazardous substances potentially present at a waste site.

Contaminated subsurface – Contamination that presents a threat to human health and the environment in the unsaturated zone between the ground surface and the permanent, continuous water table (e.g., the vadose zone).

Controlled density fill (CDF) – Typically a blend of cement, fly ash, sand, and water, usually employed as a low-strength, flowable backfilling material. It can be pumped into place. Controlled density fill (CDF) is self-leveling and self-compacting. Formulation can be varied to modify several parameters including strength and excavatability. It is most often used in situations where physical access for backfilling is restricted.

Environmental Restoration Disposal Facility (ERDF) – The Hanford Site's disposal facility for most CERCLA waste and contaminated environmental media (contingent upon meeting the ERDF waste acceptance criteria) generated under a CERCLA remedial or removal action.

Evapotranspiration (ET) – The portion of precipitation returned to the air through direct evaporation and by transpiration from vegetation.

Feasibility study (FS) – A CERCLA study undertaken to develop and evaluate options for remedial action. The FS emphasizes data analysis and is generally performed concurrently and in an interactive fashion with the remedial investigation, using data gathered during the remedial investigation. The remedial investigation data are used to define the objectives of the response action, to develop remedial action alternatives, and to undertake an initial screening and detailed analysis of the alternatives. The term also refers to a report that describes the results of the study.

Fission products – Byproducts of the process by which a heavier nucleus splits into lighter nuclei with the release of energy. Fission products include cesium-137 and technetium-99.

Fluidics –As used here, fluidics is a process that uses directed, pulsed jets of liquid to breakup tank sludge, mix it to the extent desired, and than transfer it from the tank as a liquid or slurry. Minimal additional liquid is added to the tank for this process.

Granular activated carbon (GAC) – A type of carbon that is used to adsorb organic compounds.

Groundwater – Subsurface water within the saturated zone. The upper surface of groundwater is called the water table.

***Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (HCP EIS)** – This document evaluates the potential environmental impacts associated with implementing a comprehensive land-use plan for the Hanford Site for at least the next 50 years by U.S. Department of Energy.

Human health risk assessment – An assessment that includes incorporation of the current industrial land-use exposure assessment, as well as an unrestricted land-use scenario after the year 2150, should institutional controls fail in the future to determine the human health risk, from contaminants of potential concern at the waste sites.

Industrial-exclusive land-use area – A land–use designation under the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS–0222–F; CLUP EIS) that applies to the 200 Areas core zone. Under this land–use designation, waste management activities would continue. This land use assumes an industrial worker scenario, in which the receptor works onsite on a full–time basis (i.e., the worker spends 2,000 hours per year onsite over the duration of his/her entire career). It assumes that the land use at the 200 Area exposure pathways evaluated include direct exposure to radiation, incidental ingestion of soil, and inhalation of resuspended dust and volatile constituents. Exposure to groundwater is not considered. (See Figure 1 for general location.)

In situ vitrification – An electric melting process used to treat hazardous and radioactive contaminants through heating, which melts the soil and contaminants into a durable glass block.

Institutional controls – Non-engineered instruments, such as administrative and/or legal controls, that minimize the potential for exposure to contamination by limiting land or resource use. The State of Washington also considers physical controls (e.g., fencing and signs) to be institutional controls as well.

Lard oil – Liquid pig fat. Mixed with carbon tetrachloride for use as a cutting oil for plutonium metal machining operations. Spent product was discharged to 200-PW-1 OU waste sites.

Maximum contaminant level (MCL) – The maximum concentration of a contaminant allowed in water used as public drinking water.

***National Environmental Policy Act of 1969* (NEPA)** – A Federal law that establishes a program to promote efforts to prevent or eliminate damage to the environment. Values for this act encompass a range of environmental concerns and cumulative impacts.

National Oil and Hazardous Substances Pollution Contingency Plan (NCP) – A plan for preparing for, and responding to, discharges of oil and releases of hazardous substances, pollutants, and contaminants.

National Priorities List (NPL) – A list compiled by the U.S. Environmental Protection Agency of uncontrolled hazardous substance releases in the United States that are priorities for long–term remedial evaluation and response.

Normal paraffin hydrocarbon (NPH) – A clear, oily, water-white liquid, that is essentially odorless, that was discharged to some of the 200-PW-3 Operable Unit waste sites.

Operable unit (OU) – As applied at the Hanford Site, an OU is a group of land disposal sites or groundwater plumes placed together for the purposes of investigation and evaluation of subsequent cleanup actions.

Plutonium – A radioactive metal created from uranium in nuclear reactors.

Plutonium Finishing Plant (PFP) – A facility that processed plutonium from the 200 East and 200 West Area separation facilities into a plutonium metal and/or plutonium oxide. Primary waste streams from the PFP included process waste and wastewaters that were discharged to cribs, tanks, ponds, ditches, and seepage basins.

Plutonium Reclamation Facility (PRF) – A facility that recovered plutonium from the Plutonium Finishing Plant liquid waste stream. The primary waste streams from the PRF included aqueous process waste and organic process waste that were discharged to trenches, cribs, and tile fields.

Plutonium-uranium extraction (PUREX) – A process that used a recoverable salting agent to separate plutonium and uranium products from irradiated fuel.

Polymer absorbent – polymers that can absorb and retain extremely large amounts of a liquid relative to their own mass

Preferred alternative(s) – Remedy identified according to the CERCLA process as a path forward to remediate the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Unit waste sites. A preferred alternative is presented for public review and comment in the Proposed Plan.

Preliminary Remediation Goal (PRG) – Initial cleanup levels that are developed during the CERCLA decision–making process. The PRGs may be refined in the Record of Decision to become final cleanup levels (i.e., remedial action goals).

Proposed Plan – A document that summarizes the analysis of different cleanup options and explains which option (called the "preferred alternative") is being recommended for public review and comment.

Reasonable maximum exposure – An exposure calculation that over-estimates risks for the majority of the population in order to ensure that public health is protected

Record of Decision (ROD) – The formal document in which a regulatory agency sets forth the selected remedial measure and the reasons for its selection.

Recovery of Uranium and Plutonium by Extraction (RECUPLEX) – A process that recovered plutonium from the Plutonium Finishing Plant liquid and solid scraps from 1955 to 1962. The facility used organic solvents in the recovery process.

Rem (roentgen equivalent man) – A unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the damage caused by the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of thousandths of a rem, which are millirems (mrem).

Remedial action – A cleanup remedy that is implemented at a site to address one or more of the contamination problems.

Remedial action objective (RAO) – General descriptions of what the remedial action will accomplish (e.g., restoration of a waste site). The RAOs are media–specific or operable unit–specific objectives for protecting human health and the environment. They are developed considering the land use, contaminants of potential concern, potential applicable or relevant and appropriate requirements, and exposure pathways via a conceptual model. They also specify remediation goals so an appropriate range of remedial options can be developed for evaluation.

Remedial investigation (RI) – Mechanism to characterize site conditions and determine the nature and extent of contamination present at a site.

Representative waste site – Under the analogous sites approach (see definition), similar waste sites are grouped and one site is chosen as representative of the group. This representative waste site serves as a surrogate for the other waste sites in the initial portions of the remedial investigation / feasibility study process. It is investigated in detail and remedies are identified and evaluated for its identified risks.

RESidual RADioactivity (RESRAD) dose model – A computer model designed to estimate radiation doses and risks from residual radioactive materials.

RESRAD-CHEM – A computer based model to evaluate the fate and transport, including migration to groundwater, of nonradiological chemicals.

Risk-based concentration (RBC) – A calculated soil concentration or dose from individual contaminants of concern in soil above a depth of 4.6 m (15 ft) that would result in a risk level of 1 in 10,000 for the industrial site construction worker.

Screening-level ecological risk assessment – An assessment of the likelihood of exposure potential to ecological receptors.

Soil vapor extraction (SVE) – A system that uses a blower to draw air (soil vapor) from wells drilled into unsaturated soils. The system typically incorporates treatment technologies to capture or destroy contaminants in the extracted soil vapor.

Superfund – See also *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA).

Tetrachloroethylene (also called perchloroethene or PCE) – A colorless, nonflammable organic solvent used at Hanford as a degreasing agent to clean equipment and in some manufacturing processes.

Tributyl phosphate (TBP) – A viscous (thick), colorless, odorless organic liquid used in separations processes. Spent TBP was discharged at some of the 200-PW-1 and 200-PW-3 Operable Unit waste sites.

Tri-Parties – Includes the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology.

Tri–Party Agreement (*Hanford Federal Facility Agreement and Consent Order*) – An agreement and consent order between the Tri-Parties that details the process to be used to address CERCLA, RCRA, and state requirements for cleaning up the Hanford Site.

Vadose zone – The unsaturated soil between the ground surface and the permanent, continuous water table.

Waste sites – Sites that are contaminated or potentially contaminated from past operations. Contamination may be contained in environmental media (e.g., soil or groundwater) or in man-made structures or solid waste (e.g., debris).

Waste Isolation Pilot Plant (WIPP) – The disposal facility for transuranic radioactive waste located outside of Carlsbad, New Mexico.

ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CDF	controlled density fill
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
cfm	cubic feet per minute
CFR	*Code of Federal Regulations*
CLUP EIS	*Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*
cm	centimeter
COC	contaminant of concern
COPC	contaminant of potential concern
CWC	Central Waste Complex
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ERDF	Environmental Restoration Disposal Facility
ET	evapotranspiration
FS	feasibility study
ft	foot
ft^2	square foot
FY	fiscal year
g	gram
GAC	granular activated carbon
gal	gallon
gal/min	gallons per minute
HCP EIS	*Hanford Comprehensive Land-Use Plan Environmental Impact Statement*
HI	hazard index
in	inch
kg	kilogram
km^2	square kilometer
L	liter
L/min	liters per minute
lb	pound
m	meter
m^2	square meter
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mi^2	square mile
m^3	cubic meters
mrem/yr	millirem per year
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	*National Environmental Policy Act of 1969*
NPH	normal paraffin hydrocarbon
NPL	National Priorities List
OU	operable unit
oz	ounce
PCE	tetrachloroethylene

nCi/g	nanocuries per gram
pCi/g	picocuries per gram
PFP	Plutonium Finishing Plant
PRF	Plutonium Reclamation Facility
PRG	preliminary remediation goal
PUREX	plutonium-uranium extraction
RAO	remedial action objective
RBC	risk-based concentration
RCRA	*Resource Conservation and Recovery Act of 1976*
RECUPLEX	Recovery of Uranium and Plutonium by Extraction
RESRAD	RESidual RADioactivity dose model
RI	remedial investigation
RL	U.S. Department of Energy, Richland Operations Office
ROD	Record of Decision
RTD	removal, treatment, and disposal
SSL	soil screening level
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
SWB	standard waste box
TBP	tributyl phosphate
Tri-Parties	U.S. Department of Energy, Washington State Department of Ecology, and U.S. Environmental Protection Agency
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
VOC	volatile organic compound
WAC	*Washington Administrative Code*
WIPP	Waste Isolation Pilot Plant
yd^3	cubic yards

PUBLIC INFORMATION REPOSITORIES

U.S. Department of Energy Public Reading Room – The collection includes technical reports, administrative materials, fact sheets, and handouts. The catalog is searchable via the website http://rrcatalog.pnl.gov/default.cfm.

For questions or assistance in using the catalog, please contact the Public Reading Room staff at (509) 372-7443 between the hours of 10 a.m. and 5 p.m. (Pacific Standard Time), Monday through Friday, or e-mail doe.reading.room@pnl.gov.

All items in the collection are for use in the Reading Room only. If extra copies are available, they are distributed free, and photocopying is available for a charge. Requests by phone, fax, mail, or e-mail are welcome, as well as requests made in person.

Administrative Record – The Administrative Record is the body of documents and information that are considered or relied upon to arrive at a final decision for remedial action or hazardous waste management. An Administrative Record is established for each OU and will contain all documents having information considered in arriving at a ROD or permit. The Administrative Record also is available at website http://www2.hanford.gov/ARPIR/.

Documents become part of the Administrative Record by a variety of means, such as follows:

- The information has been designated as an Administrative Record document by the Tri-Party Agreement, per Table 9-3, pp. 9-11 to 9-12. (The Tri-Party Agreement is available at website http://www.hanford.gov/tpa.)
- The EPA, Ecology, or DOE Richland Operations Office Project Manager has identified the document for inclusion in the Administrative Record system.

Public Information Repository – The necessity of keeping a collection of documents and information known as the Public Information Repository was established by the *Community Relations Plan for the Federal Facility Agreement and Consent Order* (available at website http://www.hanford.gov/?page=113&parent=91). Information needs to be readily available to the public to ensure meaningful public participation. One mechanism for accomplishing this goal is the establishment of Public Information Repositories at major population centers. There are four Public Information Repositories located outside of the Hanford Site and one onsite location:

Public Information Repository locations:

This Proposed Plan is available for viewing at the following public information repositories:

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