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Revision 0

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Idaho National Engineering and Environmental Laboratory
Environmental Restoration Program
Idaho Falls, Idaho 83415

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Revision 0

December 2002

Approved

Frank L. Webber, Project Manager 12/16/02 Date
Operable Unit 7-13/14 Project

K. Jean Holdren, Technical Lead 12/20/02 Date
Operable Unit 7-13/14
Remedial Investigation/Feasibility Study

ABSTRACT

To satisfy requirements of the Federal Facility Agreement and Consent Order with the State of Idaho and the U.S. Environmental Protection Agency, the U.S. Department of Energy is conducting the Waste Area Group 7 Operable Unit 13/14 comprehensive remedial investigation/feasibility study at the Idaho National Engineering and Environmental Laboratory.

This preliminary evaluation of remedial alternatives supports future development of the Waste Area Group 7 feasibility study. The preliminary evaluation of remedial alternatives identifies and screens potential technologies and assorted process options that could be applied at the Waste Area Group 7 Subsurface Disposal Area, a radioactive and mixed waste landfill. After screening, selected process options are assembled into possible alternatives for remediating the landfill. These alternatives then are evaluated according to their effectiveness, implementability, and cost, as specified by the Comprehensive Environmental Response, Compensation, and Liability Act. Alternatives failing to meet the specified criteria are eliminated from further evaluation. Remaining alternatives then undergo individual and comparative analyses.

Discussions and analyses in this report can be used to define scope for the Waste Area Group 7 remedial investigation/feasibility study and to provide useful information to support future risk management decisions for the site. This study does not promote any single alternative as a candidate for final selection, but identifies a range of alternatives from which the U.S. Department of Energy, the State of Idaho, and the U.S. Environmental Protection Agency can select for remediating Operable Unit 13/14.

EXECUTIVE SUMMARY

E1. SUMMARY OF THE PRELIMINARY EVALUATION OF REMEDIAL ALTENATIVES

This *Preliminary Evaluation of Remedial Alternatives* (PERA) identifies a range of potential remedial options that offer effective treatment for contaminated conditions at the Radioactive Waste Management Complex (RWMC), which has been designated as Waste Area Group (WAG) 7 at the Idaho National Engineering and Environmental Laboratory (INEEL). Evaluation presented in this report is limited to the Subsurface Disposal Area (SDA), a radioactive and mixed waste landfill at the RWMC, to support development of the WAG 7 comprehensive remedial investigation/feasibility study (RI/FS), Operable Unit (OU) 7-13/14. The RI/FS is being conducted under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (42 USC § 9601 et seq.), as implemented by the *Federal Facility Agreement and Consent* Order (DOE-ID 1991). This PERA is a precursor to the RI/FS, and provides a framework for scoping the OU 7-13/14 project and completing the RI/FS.

The primary focus of this PERA is to identify remedial options for buried waste (i.e., source term) within the SDA, an area defined by limits of the pits, trenches, soil vaults, and impacted soil extending to the interface with the underlying basalt. The PERA does not directly address remediation requirements for existing contamination within adjacent media (i.e., surface water, air, vadose zone, and groundwater). Instead, it evaluates remedial options designed to (1) control future human or ecological exposure to the waste, and (2) reduce future contaminant releases from the SDA source term into the surrounding environment. This PERA also does not directly address the adjacent Transuranic Storage Area (TSA). However, as appropriate, DOE will incorporate the final CERCLA remedial alternative in the closure of the Resource Conservation and Recovery Act (42 USC § 6901 et seq.) (RCRA)-permitted storage cells within the TSA.

The PERA follows a step-by-step process to identify remedial alternatives that potentially eliminate, reduce, or mitigate risks posed by WAG 7. This defined approach is designed to methodically screen technologies, assemble and evaluate individual alternatives, and then analyze comparative advantages and disadvantages offered by each possible remedy. Organization of the PERA closely follows the sequenced screening of technologies and development of remedial alternatives prescribed in feasibility study guidance (EPA 1988). The framework of the report along with a summary of the site environmental setting is presented in Section 1.

E2. REMEDIAL ACTION OBJECTIVES

Section 2 has an overview of the CERCLA requirements, remedial action objectives (RAOs), preliminary remediation goals, and applicable or relevant and appropriate requirements (ARARs) for WAG 7. This regulatory framework established the context in which the PERA was developed.

The RAOs for WAG 7 reflect site-specific human health and ecological risk goals specific to contaminants of concern (COCs) and exposure pathways identified in the *Ancillary Basis for Risk Analysis* (ABRA) (Holdren et al. 2002). Achieving these RAOs is predicated on the assumption that previous releases of contaminants from the source term (i.e., postulated contamination within the vadose zone) will not have a significant impact on adjacent environmental media. An additional assumption for this PERA is that DOE or another government agency will retain control of the SDA in perpetuity and that final CERCLA actions will include capping and enforced institutional controls to ensure protectiveness for contamination remaining at the RWMC.

The ABRA (Holdren et al. 2002) concluded that the media of primary concern for the WAG 7 PERA are soil, dust, and groundwater. However, this PERA and the WAG 7 feasibility study will focus on remedial alternatives that mitigate contamination within the source term only; technology applications for remediating area groundwater are not directly addressed. To protect groundwater in the future, this PERA evaluates measures to control the source term through specific technology applications that contain or treat COC-bearing waste streams and inhibit future contaminant migration.

Remedial Action Objectives for WAG 7

- Limit the cumulative human-health cancer risk for soil and groundwater exposure pathways to less than or equal to 1E-04
- Limit the noncancer risk for soil and groundwater exposure pathways to a cumulative hazard index of less than 2 for current and future workers and future residents
- Inhibit migration of contaminants of concern (COCs) to groundwater
- Inhibit ecological receptor exposures to COCs in soil and waste with concentrations greater than or equal to 10 times background values, resulting in a hazard quotient greater than or equal to 10
- Inhibit transport of COCs to the surface by plants and animals.

The final chemical-, location-, and action-specific ARARs ultimately identified for WAG 7 will be selected by the regulatory agencies, with input from project stakeholders. Therefore, the ARARs identified during the PERA serve only as screening criteria for evaluating alternatives. Further, only potential ARARs that protect human health and the environment during and following implementation of a given remedial action alternative are identified. Appendix A contains listings of the preliminary ARARs identified for WAG 7. In addition, the PERA considers other factors, designated as to-be-considered requirements, that may influence elements of an alternative, and include unpromulgated standards, criteria, advisories, and specific U.S. DOE orders. These to-be-considered requirements are not legally binding and are used only for screening purposes.

E3. WASTE STREAMS OF CONCERN

Disposal of transuranic (TRU) and mixed waste, mostly from the Rocky Flats Plant (RFP) in Colorado, occurred at the SDA through 1970. Mixed low-level waste containing hazardous chemical and radioactive contaminants was disposed of through 1984. Since 1985, waste disposals in the SDA have been limited to low-level radioactive waste from the INEEL waste generators. A large volume of waste resulted from construction, operation, and decommissioning of INEEL nuclear reactor testing programs. Various containers were used in shipping and disposing of waste in metal drums, cardboard cartons, and wooden boxes. Larger individual items (e.g., tanks, furniture, process and laboratory equipment, engines, and vehicles) were placed separately as loose trash.

Remedial alternatives presented in this PERA could achieve RAOs by applying specific technologies to treat, isolate, immobilize, or remove waste containing identified COCs. Waste disposal sites within the SDA consist of subsurface pits, trenches, soil vault rows (SVRs), and an aboveground disposal site (Pad A). Figure E-1 shows the general locations of these sites within the SDA.

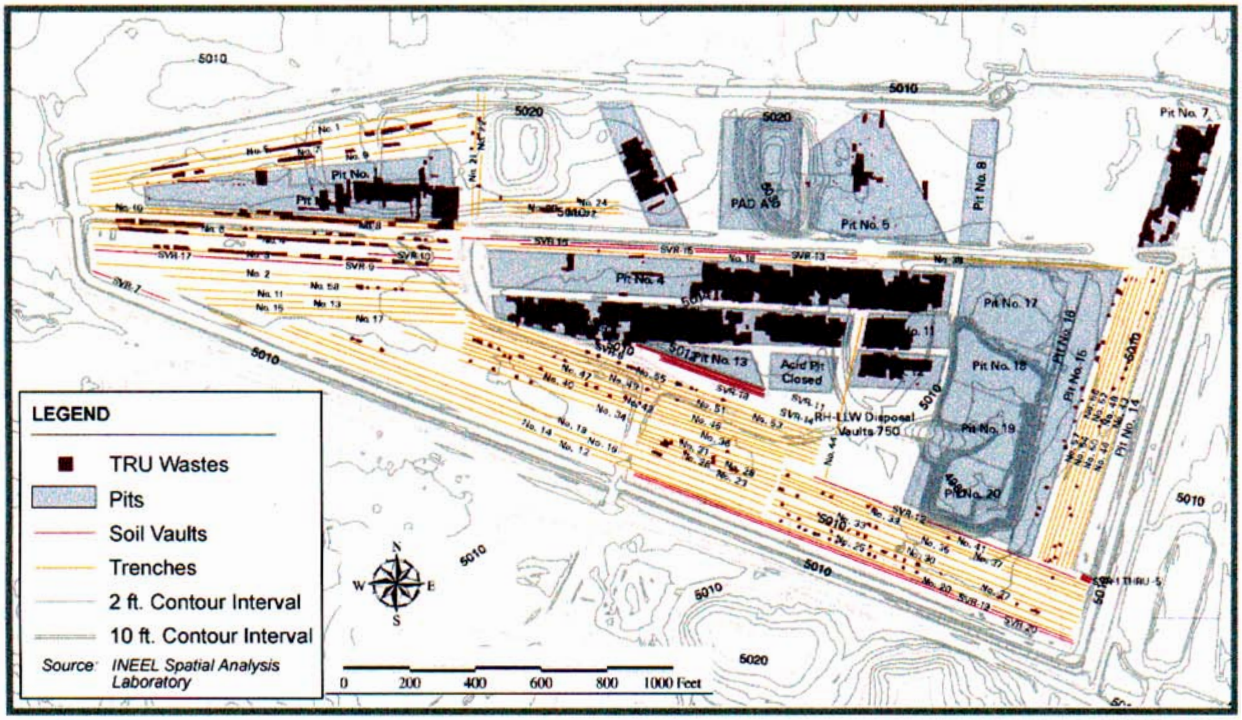

Figure E-1. Subsurface Disposal Area waste disposal units.

The ABRA identified human health and ecological COCs associated with buried waste. A total of 16 human health COCs were identified that exceeded either a 1E-05 carcinogenic risk or contributed to a cumulative noncarcinogenic hazard index of 2. The exposure pathway that contained the majority of the COCs and exhibited the highest degree of risk was groundwater ingestion. Other pathways having unacceptable risks from one or more of the COCs include soil ingestion, inhalation, external exposure, and crop ingestion from surface uptake. The ABRA also identified seven ecological COCs, based on a hazard quotient of 1 for radionuclides and 10 for nonradionuclides. The primary pathways of ecological concern were associated with burrowing animals and insects and plant ingestion.

Except for the No Action alternative, all alternatives include institutional controls and an engineered surface barrier over the SDA to preclude direct access to contamination remaining following remediation (DOE-ID 1998). The engineered barrier would mitigate surface exposure pathways (e.g., external exposure and crop ingestion) that contribute to human health risk. The cover also would address ecological COCs by inhibiting intrusion into the waste by plants, burrowing animals, and insects. Therefore, additional measures to address the surface exposure pathways to protect human health and the environment would not be required.

This PERA focuses on remediating specific COCs that represent groundwater risk drivers. The ABRA identified a number of constituents as groundwater COCs including organics, inorganics, toxic metals, and radionuclides. Based on disposal records, the COCs are concentrated in several waste forms:

- Actinides including Am-241, Np-237, Pu-238, Pu-239, Pu-240, U-233, U-234, U-235, U-236, and U-238—The majority of the long-lived, relatively immobile actinides are contained within the RFP sludge deposited in drums within TRU pits and trenches (i.e., Pits 1 through 6 and 9 through 12, Trenches 1 through 10) and Pad A.

- Activation and fission products including C-14, I-129, and Tc-99—Waste streams containing activation and fission products consist mainly of metal and scrap metal pieces, core loop components, core structural pieces, resins, and irradiated fuel material. These materials were buried in a variety of different container types, primarily as remote-handled waste in the SVRs and trenches.

- Volatile organic contaminants including carbon tetrachloride (CCL_4), tetrachloroethylene (PCE), and methlyene chloride—CCL_4 and PCE are contained almost entirely in drummed or bagged organic sludge (Series 743) from RFP and are located in the TRU pits and trenches. Methylene chloride also is contained almost entirely in the RFP shipments in waste streams consisting of sludge, paper, rags, plastic, equipment, and assorted debris.

- Nitrates—The nitrates within the SDA are located almost entirely in the drummed waste stream (Series 745 sludge) shipped from RFP between 1967 and 1970. Nitrate waste in the SDA is in Pad A; Pits 4, 6, 9, 10, and 11; and in isolated areas within the trenches and SVRs.

In addition to risk-based COCs identified in the ABRA, Am-241 and three plutonium isotopes were included as groundwater COCs. Though Am-241 also was not a direct COC for groundwater ingestion; the majority of Np-237 is created through Am-241 decay. Three plutonium isotopes—Pu-238, Pu-239, and Pu-240—were classified as special case groundwater COCs to acknowledge uncertainties about plutonium mobility in the environment and to reassure stakeholders that risk management decisions for the SDA will be fully protective (Holdren et al. 2002). Because most plutonium in the SDA is collocated with risk-based COCs that have similar properties, treating plutonium isotopes as COCs will have little effect on analysis of alternatives or on risk management decisions.

E4. IDENTIFICATION AND SCREENING OF REMEDIATION TECHNOLOGIES

Section 2 of the PERA considered a range of potential remedial technologies and process options that could be combined to form general response actions (GRAs). The GRAs for WAG 7, originally defined in the *RI/FS Work Plan* (Becker et al. 1996), have been modified and updated to reflect the revised conceptual model and emerging technologies. The GRAs developed as part of this PERA include no action, institutional controls, containment, in situ treatment, retrieval, ex situ treatment, and disposal.

Under each GRA, the PERA identifies numerous approaches and technologies with potential application to buried waste at WAG 7. For example, the containment GRA could be achieved using various remedial technologies, such as surface controls and diversions, surface barriers, lateral barriers, and subsurface horizontal barriers. In turn, these technologies could be implemented with various process options (e.g., possible lateral barriers include slurry walls, grout curtains, in situ soil mixing, sheet piling, in situ vitrification barriers, or ground freezing barriers). In Section 2, the technologies and their associated process options are individually evaluated against the criteria required by CERCLA as listed below:

- Effectiveness—Assesses the ability of each technology or process option to remediate waste media and meet RAOs.

- Implementability—Assesses the technical and administrative feasibility of each technology.

- Cost—Assesses costs, including relative estimates of capital cost and operation and maintenance.

Remedial technologies and process options that fail to adequately meet requirements of the above criteria during initial screening are eliminated from further analyses and consideration. For example, the INEEL Central Facilities Area was considered as an option under the disposal GRA, but was eliminated because the facility is limited to nonhazardous waste. Similarly, for each GRA, the screening process streamlines the list of available remedial technologies and process options, retaining only those that could meet the criteria for subsequent development and screening in Section 3. Appendix B provides details about the various process options and their final elimination or inclusion as part of an alternative.

E5. DEVELOPMENT AND SCREENING OF ALTERNATIVES

Section 3 presents seven preliminary remedial action alternatives assembled from the technologies and process options that passed initial screening. The alternatives provide a range of possible actions that address WAG 7 RAOs. The alternatives span the GRAs and are established around specific technology applications including containment, ISG, ISV, and RTD, as shown in Table E-1. The alternatives are structured to focus these specific technologies on the mitigation of risks resulting from the identified COCs.

Scope of remediation is based on available waste inventory data, which identify the extent and location of the waste streams deposited in the SDA that contain the COCs. Distribution of these contaminants is presented in the ABRA. As shown, the TRU COCs received from RFP are located in Pits 1 through 6, 9 through 12, Trenches 1 through 10, and Pad A. Activation and fission product COCs are located primarily in SVRs and remaining trench areas.

To establish a foundation for developing a comparative analysis, the alternatives apply specific technologies to the RFP TRU. Waste streams associated with the RFP waste contain the majority of the actinides (e.g., americium, neptunium, plutonium, and uranium,), nitrates, and volatile organic compounds (e.g., CCL_4, PCE, and methylene chloride). Each alternative also incorporates several supplemental technologies required to address waste stream-specific issues and achieve RAOs. All the alternatives involve long-term monitoring to evaluate the effectiveness of the remedial measures. All of the alternatives (with the exception of the No Action alternative) also involve institutional controls and placement of a surface barrier to protect any remaining buried waste at the site. In addition, other remedial actions that are common to two more of the alternatives include the following:

- In situ grouting in SVRs and trench areas that contain activation and fission product COCs
- Handling and treating Pad A waste
- Treating high organic waste areas using in situ thermal desorption (ISTD).

A summary of the application of these supplemental technologies for each of the alternatives is in Table E-2.

Following guidance from the U.S. Environmental Protection Agency (EPA 1988), each alternative is evaluated according to its ability to meet the CERCLA evaluation criteria for effectiveness, implementability, and cost in the context of the site conditions and extent of the required remedial action. As shown in Table E-2, the alternative screening process resulted in eliminating two preliminary alternatives. The Limited Action alternative was eliminated because it fails to meet WAG 7 RAOs. The Full Containment alternative was not retained for further analysis because of issues associated with implementation and cost effectiveness.

At the conclusion of the alternative screening processes discussed in Section 3, the five alternatives retained for detailed analysis are (1) no action, (2) surface barrier, (3) ISG, (4) ISV, and (5) RTD.

Table E-1. Alternative components.

Alternatives	Monitoring	Access Controls	Surface Barrier	Subsurface Barrier	In Situ Treatment	Retrieval	Ex Situ Treatment	On-Site Disposal	Off-Site Disposal	Representative Process Options
No Action	✓									
Limited Action	✓	✓	✓*							*Biotic Barrier
Surface Barrier	✓	✓	✓*							*Engineered Multi-Layer Cap
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD
Pad A Waste						✓		✓*		*Placed Beneath Cap
Full Containment	✓	✓	✓*	✓						*Engineered Multi-Layer Cap
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD
Pad A Waste						✓		✓*		*Placed Beneath Cap
In Situ Grouting	✓	✓	✓*							*Engineered Multi-Layer Cap
RFP Waste					✓*					*ISG
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD
Pad A Waste						✓	✓*	✓		*Ex Situ Stabilization
In Situ Vitrification	✓	✓	✓*							*Engineered Multi-Layer Cap
RFP Waste					✓*					*ISV
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD/ISV
Pad A Waste					✓*	✓				*ISV
Retrieval	✓	✓	✓*							*Engineered Multi-Layer Cap
RFP Waste						✓	✓	✓*	✓**	*On-Site Landfill - Non TRU Waste **WIPP Disposal - TRU Waste
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD
Pad A Waste						✓	✓	✓*		*On-Site Landfill

Table E-2. Remedial action alternatives.

Alternatives	Effectiveness	Implementability	Costs	Retained?
No Action	• Does not mitigate site risks	• Maintenance of existing monitoring programs only	• No capital costs • Long term monitoring costs only	Yes - In accordance with EPA directive
Limited Action	• Prevents direct exposure • Does not treat source • Does not mitigate projected groundwater impacts	• Standard earthwork • Does not require intrusion into the waste • Requires future groundwater use restrictions	• Low capital costs • Long term monitoring and maintenance costs	No - Does not achieve RAOs
Surface Barrier	• Prevents direct exposure • Surface Barrier reduces contaminant mobility and minimizes groundwater impacts • Does not reduce toxicity or volume of source • Activation/fission products in SVRs and trenches stabilized with ISG • VOCs in high organic waste streams destroyed with ISTD	• Short implementation period • Standard earthwork • Minor amount of intrusive work • 5M cy of material required for construction	• Capital costs significantly higher than Limited Action • Long term monitoring and maintenance costs	Yes - Achieves RAOs with lowest capital costs
Full Containment	• Prevents direct exposure • Reduction in contaminant mobility similar to surface barrier • Activation/fission products in SVRs and trenches stabilized with ISG • VOCs in high organic waste streams destroyed with ISTD	• Longer implementation period • Requires major extensive intrusive work • Implementation verification difficult	• Capital costs significantly higher than surface barrier • Similar long term monitoring and maintenance costs	No - Minor degree of additional protectiveness does not offset concerns associated with implementability, short term worker exposure and higher costs
In Situ Grouting	• Prevents direct exposure • Reduces contaminant mobility through treatment • Long term stability of grouted matrix • VOCs in high organic waste streams destroyed with ISTD	• Researched for INEEL specific application • Long implementation period • Requires extensive intrusive work • Requires the implementation of ISTD technology to pretreat high organics areas	• Capital costs higher than Surface Barrier • Long term monitoring and maintenance costs	Yes - Alternative meets RAOs and provides for a further reduction in containment mobility
In Situ Vitrification	• Prevents direct exposure • Reduces contaminant toxicity, mobility, and volume through treatment • Provides a more stable long term matrix • Activation/fission products in SVRs and trenches stabilized with ISG	• Specialized equipment required • Long implementation period • Concerns associated with potential worker exposure and contaminant release during implementation • Requires implementation of ISTD technology to pretreat wastes • Site-specific technology applications must be proven	• Capital costs higher than ISG • Long term monitoring and maintenance costs could be reduced	Yes - Alternative meets RAOs and provides for improved stability of waste form
Retrieval/ Treatment/ Disposal	• Prevents long term direct exposure • Highest potential short term exposures • Reduces contaminant toxicity, mobility, and volume through treatment • Removes all TRU wastes from source areas • Activation/fission products in SVRs and trenches stabilized with ISG	• Very long implementation period • Requires specialized contamination control/retrieval equipment • Regulatory concerns associated with off-site disposal of TRU wastes • Site-specific technology applications must be proven	• Highest capital costs associated with contamination control/retrieval equipment, characterization, and treatment • Long term monitoring and maintenance costs can be minimized	Yes - Alternative meets RAOs by removing buried TRU waste

E6. DETAILED ANALYSIS OF ALTERNATIVES

Each of the alternatives retained after the initial screening are feasible for WAG 7. In Section 4, the retained alternatives are subjected to a detailed analysis, which assesses the degree to which an alternative satisfies the CERCLA evaluation criteria. Design elements and strategies are evaluated to determine the projected performance of each alternative against the threshold and balancing criteria shown in Table E-3. The modifying criteria will be applied to each alternative during the proposed plan and record of decision phases of the CERCLA process.

Table E-3. Comprehensive Environmental Response, Compensation and Liability Act evaluation criteria.

Category	Criteria
Evaluated during preliminary evaluation of remedial alternatives	
Threshold	Overall protection of human health and the environment
	Compliance with applicable or relevant and appropriate requirements
Balancing	Long-term effectiveness and permanence
	Reduction of toxicity, mobility, or volume through treatment
	Short-term effectiveness
	Implementability
	Cost
Evaluated during proposed plan and the record of decision	
Modifying	State acceptance
	Community acceptance

Evaluation of each alternative is supported by the tabulated summary presented in Appendix C. A brief synopsis of each alternative is presented below.

E6.1 No Action Alternative

E6.1.1 Alternative Description

A no action alternative is evaluated in accordance with requirements of the National Contingency Plan regulations (40 CFR 300.430[e][6]) and by EPA guidance for conducting feasibility studies under CERCLA (EPA 1988). The alternative serves as the baseline for comparing remedial action alternatives. For WAG 7, this alternative would include only long-term monitoring of groundwater, vadose zone moisture, soil, surface water, and air, with no direct action to treat, stabilize, or remove contaminants.

No Action Alternative Remediation Strategy

Existing site conditions will remain unchanged. No action will be taken to reduce contaminant mobility, toxicity, or volume.

Key Element:
Long-term monitoring.

E6.1.2 Evaluation of Comprehensive Environmental Response, Compensation and Liability Act Criteria

This comparatively inexpensive alternative would be easily implemented, incurring only the costs associated with long-term monitoring. However, the alternative offers no reduction in the mobility, toxicity, or volume of contaminants within the SDA. Therefore, the No Action alternative does not meet RAOs.

E6.2 Surface Barrier Alternative

E6.2.1 Alternative Description

The Surface Barrier alternative consists of institutional controls, physical barriers, and long-term operation and maintenance. The physical barrier is achieved by placing a multilayer, low-permeability cover system over the site. An INEEL-specific design was identified as the representative technology, which consists of interlayered sequences of soil and rock having a minimum overall thickness of approximately 18 ft. Cover layers are designed to prevent human and ecological receptors from direct contact with the buried waste. The cover would stabilize contaminants in place and minimize migration through leaching, volatilization, or biotic uptake. The surface barrier system has a 1,000-year design life.

The Surface Barrier alternative includes ISG on selected waste-disposal areas within the SDA, including locations where elevated levels of C-14 and other COCs are present. Other locations would be subject to foundation grouting as necessary to ensure a stable foundation for a protective cap that would cover the entire SDA. Pad A waste would be retrieved and placed in a more stable configuration within the central portion of the SDA to minimize future subsidence-related damage to the surface barrier. High organic areas would be pretreated with ISTD to minimize future operational requirements for the OCVZ system.

Surface Barrier Alternative Remediation Strategy

The isolation of the buried waste and the reduction of contaminant migration through the placement of a long-term, low-permeability cover system.

Key Elements:

(1) In situ grouting at selected disposal sites
(2) In situ thermal treatment in areas with high volatile organic contaminant
(3) Pad A retrieval and reconfiguration
(4) Foundation stabilization
(5) Long-term multilayer cover
(6) Physical and administrative land-use restrictions
(7) Long-term monitoring and maintenance.

E6.2.2 Evaluation of Comprehensive Environmental Response, Compensation and Liability Act Criteria

The Surface Barrier alternative provides overall protection of human health and the environment, complies with ARARs, offers long-term effectiveness and permanence, and poses few implementation challenges. While it will reduce mobility of contaminants, it will not reduce toxicity or volume. The alternative poses low risk to the community during remediation, and risks to remediation workers can be mitigated with appropriate equipment and training. Though the Surface Barrier alternative meets the RAO limiting incremental excess cancer risk to less than or equal to 1E-04, fate and transport modeling predicts long-term reduction of carcinogenic risk is expected to be less than that for the ISG, ISV, and RTD alternatives. Estimated cost of the Surface Barrier alternative is the lowest of the action remedial alternatives.

E6.3 In Situ Grouting Alternative

E6.3.1 Alternative Description

The ISG alternative would encapsulate buried waste in a stable grout monolith designed and implemented to reduce contaminant migration from the site. Scope of the technology application would encompasses burial sites containing the RFP TRU waste and additional areas containing activation and fission product COCs. Specific areas would require pretreatment before grouting to reduce the mass of organics within the waste. Pad A waste would be retrieved and subjected to ex situ treatment to ensure compliance with RAOs. A low-permeability surface cap would be constructed to isolate the in situ-treated waste from future human and ecological receptors.

In Situ Grouting Alternative Remediation Strategy

Stabilizing buried waste through ISG. Future exposure to the stabilized waste would be prevented through implementing administrative and physical land-use restrictions, including placement of a low-permeability, biotic barrier cover system.

Key Elements:

(1) In situ grouting of buried waste
(2) Retrieval and ex situ stabilization of Pad A waste
(3) Pretreatment of high organic areas using in situ thermal desorption
(4) Placement of low-permeability cover system
(5) Physical and administrative land-use restrictions
(6) Long-term monitoring and maintenance.

E6.3.2 Evaluation of Comprehensive Environmental Response, Compensation and Liability Act Criteria

The ISG alternative provides overall protection of human health and the environment, complies with ARARs, and offers long-term effectiveness and permanence. Specialized equipment would be required for implementation, but such equipment has been researched for use at the INEEL. The alternative would substantially reduce contaminant mobility, but would not reduce toxicity or volume. Uncertainties associated with treatment processes required for Pad A waste to comply with ARARs or achieve risk-based levels have not been resolved. Risks to remediation workers include physical hazards involving equipment operation. Exposed waste poses a low-potential risk of direct radiation or inhalation. These risks would be mitigated with appropriate training, engineering and administrative controls, and personal protective equipment. Estimated cost of the ISG alternative is the second highest of the remedial action alternatives.

E6.4 In Situ Vitrification Alternative

E6.4.1 Alternative Description

The ISV alternative entails in situ treatment of buried waste within the SDA with applications of ISV. The ISV technology would remove and destroy organic constituents waste and encapsulate most inorganic constituents within a durable, glass-like monolith. This stable waste form would reduce the potential of hazardous constituents migrating to adjacent media.

The alternative also includes applying ISG to locations where activation and fission COCs are located. Placement of a low-permeability surface cap over the SDA would further isolate in situ-treated waste from human and ecological receptors. Foundation grouting would be applied as necessary to ensure a stable foundation for the cap.

In Situ Vitrification Alternative Remediation Strategy

Stabilizing and treating buried waste with in situ vitrification and selective in situ grouting. Contaminants would either be destroyed or immobilized in glass-like monoliths (and grout monoliths) reducing migration to adjacent media to acceptable levels. Future exposure to the stabilized waste would be prevented through implementing administrative and physical land-use restrictions and would include placement of a low-permeability and biotic barrier cover system.

Key Elements:

(1) In situ vitrification with in situ thermal desorption pretreatment
(2) Reconfiguration of the Pad A waste for in situ vitrification treatment
(3) Selective in situ grouting of buried waste
(4) Foundation grouting
(5) Placement of low-permeability cover system
(6) Physical and administrative land-use restrictions
(7) Long-term monitoring and maintenance.

E6.4.2 Evaluation of Comprehensive Environmental Response, Compensation and Liability Act Criteria

The ISV alternative provides overall protection of human health and the environment, though uncertainties exist about protecting remediation workers and preventing potential release of contaminants during remediation. It complies with ARARs and offers long-term effectiveness and permanence. The alternative would substantially reduce mobility of contaminants and destroy organics within targeted waste. Toxicity and volume of other contaminants will not be reduced.

Effectiveness and implementability of this technology on variable waste conditions present at the SDA need further verification. Risks to workers include physical hazards involving equipment operation, exposure to fugitive dust during construction, and potential melt expulsion events (contaminated material returning to the surface during the subsurface vitrification process). Risks associated with physical hazards and fugitive dust would be mitigated with appropriate training, engineering and administrative controls, and personal protective equipment. Mitigating melt expulsion events would require pretreating waste (using ISTD) and placing a protective 10-ft soil layer over the melt area. Further research would be needed to establish implementation requirements necessary to apply this technology to the SDA. Estimated cost of the ISV alternative is third highest of the four remedial action alternatives.

E6.5 Retrieval, Treatment, and Disposal Alternative

E6.5.1 Alternative Description

The RTD alternative involves the retrieval, ex situ treatment, and disposal of the RFP TRU waste. The alternative includes applying ISG to the soil vault rows and trench areas containing activation and fission product COCs. In addition, ISTD would be implemented in the high organic waste areas to minimize material handling requirements during retrieval actions.

The basic strategy of this alternative is that TRU waste and soil would be retrieved from the SDA, characterized, treated as required to meet waste acceptance criteria, packaged, and then transported to the deep geologic repository at the Waste Isolation Pilot Plant (WIPP) in New Mexico. All other retrieved material, including low-level waste (LLW) and mixed low-level waste (MLLW), would be treated and disposed of onsite in an engineered disposal facility. Excavated areas sites would be backfilled, and a multilayer low-permeability cap would be constructed over the entire SDA.

Retrieve, Treat, and Disposal Alternative Remediation Strategy

The retrieval and ex situ treatment of buried waste material. Retrieved TRU waste would be transported off-Site to the Waste Isolation Pilot Plant (WIPP) for disposal. All other retrieved waste would be treated and disposed of onsite in an engineered long-term facility.

Key Elements:
(1) Waste retrieval
(2) Ex situ treatment
(3) Transuranic waste disposal at WIPP
(4) Low-level waste and mixed low-level waste disposal at an onsite landfill
(5) Selective in situ grouting at designated waste sites
(6) In situ thermal desorption in areas with high volatile organic contaminants
(7) Installation of cap
(8) Institutional controls
(9) Long-term monitoring and maintenance.

E6.5.2 Evaluation of Comprehensive Environmental Response, Compensation and Liability Act Criteria

The RTD alternative complies with ARARs, offers long-term effectiveness and permanence, and provides protection of human health and the environment. While this alternative involves a highly complex remediation strategy, it would reduce mobility, toxicity, and volume of contaminants through removal, treatment, and disposal of TRU waste. The alternative's ability to retrieve and treat waste to meet regulatory requirements or waste acceptance criteria requires verification. Off-Site disposal of TRU waste poses implementation uncertainties related to available WIPP capacity and required traffic control measures that would be necessary to protect communities through which waste is transported. The alternative includes substantial earthwork and waste excavation operations, which pose short-term risks to the community and remediation workers that are higher than those associated with other alternatives. Risks to workers include physical hazards involving equipment operation and direct radiation and inhalation hazards from the exposed buried waste. Remote-operated and other specialized equipment would be required to reduce risk to workers during retrieval and construction activities. Additional research would be needed to develop appropriate engineering controls to address possible contaminant release events during retrieval and treatment.

The RTD alternative also involves issues of technical and administrative feasibility that include obtaining, designing, and building specialized equipment capable of handling variable waste streams and materials. A high potential exists for schedule delays that may be caused by the numerous systems required and the need for first-of-their kind retrieval and treatment facilities. Administratively, transportation, air emissions, and disposal issues would require negotiation and coordination with multiple agencies across multiple states. Estimated cost of the RTD alternative is the highest of the five remedial action alternatives.

E7. COMPARATIVE ANALYSIS OF ALTERNATIVES

Directly following the detailed analysis, Section 5 provides the comparative analysis of alternatives, which identifies differences between the alternatives that might make one slightly more effective or implementable. However, because of the complexity and inherent uncertainty of comparative evaluations, precise rankings of each alternative based on dissimilar advantages and disadvantages cannot developed. However, the qualitative comparison based on the CERCLA criteria can be used to support remedial decision making for WAG 7. The cost information for each alternative is summarized from the detailed estimates that appear in Appendix D. Table E-4 summarizes results of the comparative analysis process.

Notably, the PERA neither prioritizes the alternatives nor promotes any single one as the preferred remedy. Instead, the PERA provides extensive information for a range of alternatives that decision makers and stakeholders can use to develop informed opinions about advantages and disadvantages of any alternative being considered for WAG 7. Ultimately, the DOE, EPA, and State of Idaho will determine which of the feasible alternatives will be proposed as the preferred alternative for WAG 7 after addressing the modifying CERCLA criteria of state and community acceptance.

Table E-4. Comparative analysis of alternatives.

Criteria	Alternatives: No Action	Surface Barrier	In Situ Grouting	In Situ Vitrification	Retrieval/ Treatment/ Disposal
Overall protection of human health and the environment	• Does not address RAOs • Does not provide for the overall protection of human health and the environment	• Addresses RAOs • Immobilizes and isolates COC bearing wastes through capping • Destroys organic COCs in high concentration waste streams using ISTD • Immobilizes activation/fission product COCs using ISG	• Addresses RAOs • Immobilizes COC bearing wastes using ISG • Destroys organic COCs in high concentration waste streams using ISTD	• Addresses RAOs • Immobilizes and destroys wastes using ISTD/ISV • Immobilizes activation/fission product COCs using ISG	• Addresses RAOs • Removes TRU wastes from site • Non TRU COC bearing waste streams will be retrieved, treated and placed in on-site engineered landfill • Immobilizes remaining COC wastes using ISG
Compliance with ARARs	• Not compliant	• Potentially compliant	• Potentially compliant	• Potentially compliant	• Potentially compliant
Long term protectiveness and permanence	• Does not provide for long term protectiveness	• Provides long term protectiveness • Long term maintenance required to insure protectiveness	• Provides long term protectiveness • Potentially permanent solution • Long term maintenance required to insure protectiveness	• Provides long term protectiveness • Potentially permanent solution • Long term maintenance required to insure protectiveness	• Provides long term protectiveness • Permanently removes risks associated with TRU wastes • Long term maintenance required to insure protectiveness
Reduction of toxicity mobility and volume through treatment	• Does not reduce source toxicity, mobility, or volume	• ISG treatment reduces contaminant mobility in SVRs and trenches. • ISTD treatment reduces organic COC volumes in high concentration waste streams.	• Reduces contaminant mobility in all COC bearing wastes	• Reduces contaminant mobility, toxicity and volume in all COC bearing wastes	• Removes TRU wastes • Ex situ treatment will reduce toxicity, mobility, and volume of retrieved non-TRU wastes from pits, trenches, and Pad A. • ISG treatment reduces contaminant mobility in SVRs and trenches.
Short term effectiveness	• Lowest worker risk	• Minimal intrusive work requirements	• Contamination control for ISG researched for INEEL specific application	• Contamination control for ISV has not been proven. • Higher potential worker risk	• Extensive intrusive work requirements • Highest risks to workers and off-site communities
Implement-ability	• Easily implemented	• Primary technology (surface barrier) consists of standard earthwork operation.	• Primary technology (ISG) has been researched for SDA specific application.	• Primary technology (ISV) requires specialized equipment.	• Requires complex interaction of remedial activities and technologies with site-specific designs
Costs	Total Cost **$ 38.5M** Net Present Value **$ 9.6M**	Total Cost **$841.6M** Net Present Value **$616.1M**	Total Cost **$1,118M** Net Present Value **$ 822.6M**	Total Cost **$1,815.3M** Net Present Value **$1,197.3M**	Total Cost **$6,889.1M** Net Present Value **$3,779.7M**

Initial development of the WAG 7 feasibility study has been completed in the PERA, which provides the basis for developing RAOs, GRAs, technology and process option screening, and assembly of alternatives. The focus of subsequent feasibility study efforts will be to refine and update the detailed analysis of alternatives presented in Section 4 and revise the comparative analysis to present an objective evaluation of benefits, deficiencies, and cost comparison of the respective remedial alternatives. Recommended areas of refinement include:

- Define with more precision waste areas or volumes that require remediation using data from probing and probehole monitoring, waste inventory updates, and updates to WasteOScope (INEEL 2001)
- Identify and quantify waste streams that could impede remediation and identify their locations
- Refine the evaluation of long-term effectiveness and permanence and reduction of mobility, toxicity and volume through treatment using results from the bench-scale tests; in particular enhance the ISTD effectiveness evaluation
- Refine waste form parameters for the feasibility study risk assessment modeling using results from the bench-scale tests and updated information from scientific literature
- Examine in-depth technical and administrative issues associated with implementing the alternatives using results of safety and hazard assessments and revise the short-term effectiveness and implementability evaluations for the alternatives
- Define further the WIPP waste acceptance criteria and process as it would apply to the RTD alternative and define procedures for characterizing and packaging waste
- Review assumptions to cost estimates and revise as required.

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ACRONYMS

ABRA	Ancillary Basis for Risk Analysis of the Subsurface Disposal Area
ALARA	as low as reasonably achievable
AMWTP	Advanced Mixed Waste Treatment Project
AOC	area of contamination
ARAR	applicable or relevant and appropriate requirement
BMP	best management practices
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	contaminant of concern
CSE	criticality safety evaluation
D&D&D	deactivation, decontamination, and decommissioning
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
EPA	U.S. Environmental Protection Agency
ESRP	Eastern Snake River Plain
FFA/CO	Federal Facility Agreement and Consent Order
GRA	general response action
HEPA	high-efficiency particulate air (filter)
ICDF	INEEL CERCLA Disposal Facility
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality
INEEL	Idaho National Engineering and Environmental Laboratory
IRA	Interim Risk Assessment
ISG	in situ grouting
ISTD	in situ thermal desorption

ISV	in situ vitrification
LDR	land disposal restrictions
LLW	low-level waste
MACT	maximum achievable control technology
MCL	maximum contaminant level
MLLW	mixed low-level waste
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
NDA	nondestructive assay
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
OCVZ	organic contamination in the vadose zone
OU	operable unit
PCE	tetrachloroethylene (synonyms: perchloroethylene and tetrachloroethene)
PERA	Preliminary Evaluation of Remedial Alternatives
PPE	personal protective equipment
PRG	preliminary remediation goal
QA	quality assurance
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RFP	Rocky Flats Plant
ROD	record of decision
RI/FS	remedial investigation/feasibility study
RWMC	Radioactive Waste Management Complex
RTD	retrieval, treatment, and disposal
SDA	Subsurface Disposal Area

SOW	scope of work
SVR	soil vault row
SVOC	semivolatile organic compounds
SRPA	Snake River Plain Aquifer
TBC	to be considered
TRAMPAC	TRUPACT-II Authorized Methods for Payload Control
TRUPACT-II	Transuranic Package Transporter Model 2
TSA	Transuranic Storage Area
TSD	treatment, storage, and disposal
TRU	transuranic
VOC	volatile organic compound
WAC	waste acceptance criteria
WAG	waste area group
WIPP	Waste Isolation Pilot Plant

Preliminary Evaluation of Remedial Alternatives for the Subsurface Disposal Area

1. INTRODUCTION

This *Preliminary Evaluation of Remedial Alternatives* (PERA) identifies a range of potential remedial alternatives that could offer effective treatment for contaminated conditions at the Radioactive Waste Management Complex (RWMC), which has been designated as Waste Area Group (WAG) 7 at the Idaho National Engineering and Environmental Laboratory (INEEL). Evaluation in this report is limited to the Subsurface Disposal Area (SDA), which is a radioactive waste landfill at the RWMC, to support development of the WAG 7 comprehensive remedial investigation/feasibility study (RI/FS). The comprehensive RI/FS, designated as Operable Unit (OU) 7-13/14, is being conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC 9601 et seq.). Ultimately, the RI/FS will lead to risk management decisions and remediation of WAG 7, as depicted in Figure 1-1. This PERA is a precursor to the RI/FS and provides a framework for scoping the OU 7-13/14 project and completing the RI/FS.

The PERA follows the feasibility study organization and processes identified in the "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300) and specified by CERCLA and *Guidance for Conducting RI/FS under CERCLA* (EPA 1988). Section 1 of this report summarizes site conditions, including site setting, site history, nature and extent of contamination, contaminant fate and transport, and risk estimates conducted for WAG 7. The following four subsections discuss the development and screening of remedial alternatives conducted in accordance with the CERCLA feasibility study process.

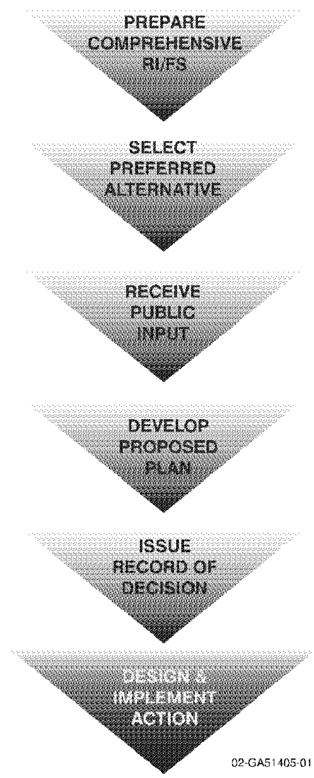

Figure 1-1. The Comprehensive Environmental Response, Compensation and Liability Act process.

During this PERA analysis, potential remediation options are evaluated for their abilities to protect human health and the environment and meet specific regulatory requirements at WAG 7. The evaluation is based on preliminary evaluation of applicable or relevant and appropriate requirements (ARARs), remedial action objectives (RAOs), and preliminary remediation goals (PRGs). Existing, demonstrated remedial technologies and process options are compiled, listed, and evaluated for technical applicability during the initial stage of the analysis presented in Section 2. Any technology or process option that is not applicable to the SDA is removed from further consideration. The remaining remedial technologies and process options form the pool from which assembled alternatives can be developed. A preliminary set of assembled remedial alternatives is presented in Section 2. Assembled alternatives are evaluated initially in Section 3 in terms of their effectiveness, implementability, and relative cost. Though the comparative cost associated with a given alternative is a factor, the primary purpose of the initial screening step is to eliminate alternatives that cannot be implemented or do not effectively mitigate risk. Following initial screening, retained alternatives undergo detailed evaluation in Section 4, in accordance with CERCLA guidance, to address specific elements of each alternative relative to the following criteria:

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

The remaining two CERCLA criteria, state and community acceptance, will be evaluated during development of the record of decision (ROD) for OU 7-13/14 and are not directly addressed in this analysis.

The PERA analysis culminates in Section 5 with a comparative analysis of the assembled remedial alternatives developed and evaluated in Section 4 using the identified CERCLA criteria. A schematic of the general feasibility study process adopted for this PERA, with references to specific sections of this report, is presented in Figure 1-2.

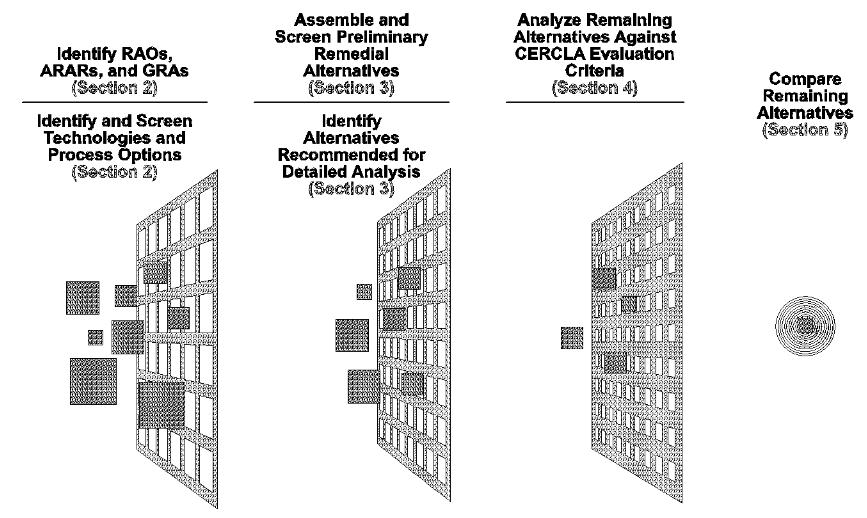

Figure 1-2. The feasibility study process.

Section 6 presents a master list of references cited in the development, screening, evaluation, and analysis of the assembled remedial alternatives. In addition, the following appendices support the analyses presented in the PERA.

- Appendix A—Applicable or Relevant and Appropriate Requirements

- Appendix B—Remedial Technologies and Process Options Identification and Screening
- Appendix C—Detailed Analysis of Alternatives
- Appendix D—Detailed Cost Estimates.

By generating a range of possible remediation approaches, referred to as general response actions (GRAs), the PERA addresses a number of potentially viable technical options for remediation of the SDA waste. Alternatives are not mutually exclusive choices, but represent a framework within which to evaluate various combinations of remedial actions that may be ultimately selected and applied to contaminated media at the SDA. While all of the alternatives (or combinations thereof) are feasible, individual evaluations provide a basis to assess relative performance according to fixed criteria and offer detailed material regarding advantages and disadvantages of each alternative.

1.1 Purpose

The purpose of the PERA is to support future development of the WAG 7 feasibility study and provide an initial assessment of remedial action alternatives for the SDA. Data developed in the PERA will provide U.S. Department of Energy Idaho Operations Office (DOE-ID), the Idaho Department of Environmental Quality (IDEQ), and the U.S. Environmental Protection Agency (EPA) with a basis for defining future OU 7-13/14 scope requirements and for supporting future risk management decisions for WAG 7 under CERCLA (42 USC 9601 et seq.) as outlined in the *Federal Facility Agreement and Consent Order* (FFA/CO) (DOE-ID 1991).

Ultimately, the evaluation of alternatives will be presented in the feasibility study and summarized in a proposed plan that will be disseminated to stakeholders to support selecting final remedial alternatives for WAG 7. A ROD will be developed to document the selected remedies. Therefore, the most critical purpose of the PERA and feasibility study is to provide sufficient information to regulatory agencies and all other stakeholders for remedial decision making.

1.2 Scope

In the decade since the FFA/CO was finalized, the signing agencies (i.e., DOE-ID, IDEQ, and EPA) have modified the scope and schedule for OU 7-13/14 because of the magnitude and duration of the project and to accommodate the scope and schedule for the OU 7-10 interim action for Pit 9 (DOE-ID 1998a, 1993, 1991; DOE 2002). The scope for the OU 7-13/14 RI/FS was outlined originally in the *Scope of Work* (Huntley and Burns 1995) and detailed in the original *Work Plan* (Becker et al. 1996). In 1997, DOE-ID, IDEQ, and EPA collaborated to prepare the *Revised Scope of Work* (LMITCO 1997) and develop the *Addendum to the Work Plan* (DOE-ID 1998b).

The primary focus of this PERA is on developing and evaluating remediation alternatives for the buried transuranic (TRU) waste received from the Rocky Flats Plant (RFP) and disposed of in the SDA from 1955 to 1970. Measures to mitigate risks associated with the remaining buried waste in the SDA are addressed for each alternative through the application of several commonly applied waste zone-specific remedial technologies. As a result, the evaluated alternatives differ only in their approaches to the RFP TRU waste. The buried waste (source term) at the SDA is defined in this PERA by the limits of the pits, trenches, soil vaults, Pad A, and impacted soil that extends to the interface with the underlying basalt layer. When evaluating short- and long-term effectiveness, the risk of each alternative is assessed, including risk associated with implementing the alternative. The assessment considers all hazardous constituents in the SDA.

The scope of the PERA is limited to evaluating alternatives that mitigate future contaminant release from the source term. Measures to address contaminants that have already been released to the environment are outside the scope of this analysis. Alternatives considered in the PERA are limited to existing, demonstrated technologies.

The success of the CERCLA process relies on managing uncertainties associated with data, technologies, and numerous other variables. Therefore, uncertainty-management principles are central considerations throughout the analysis and the design and implementation processes. Though uncertainty cannot be completely eliminated, this analysis provides a reliable basis for the future feasibility study and remedy selection by incorporating the following elements:

- Using available data on conditions and characteristics of waste sites
- Interpreting the data to adequately assess the potential range of uncertainty
- Formulating remedial alternatives to address the potential range of conditions
- Evaluating alternatives based, in part, on their ability to provide a protective remedy throughout the potential range of conditions.

Extensive site-specific information is available to support the preliminary evaluation of remedial alternatives developed in the following subsections. This information was presented in the *Ancillary Basis for Risk Analysis* (ABRA) (Holdren et al. 2002) and includes references to detailed waste inventory records, descriptions of environmental site characteristics (i.e., nature and extent of contamination) physical site properties, and estimates of risks to human health and the environment. A summary of the information is presented in the following subsections.

1.3 Background Information

The INEEL is a U.S. Department of Energy (DOE) facility that has been devoted to energy research and related activities since being established as the National Reactor Testing Station in 1949. The National Reactor Testing Station was renamed as the Idaho National Engineering Laboratory in 1974 to reflect the broad scope of engineering activities taking place at various on-Site facilities. In 1997, the Site was renamed the Idaho National Engineering and Environmental Laboratory in keeping with contemporary emphasis on environmental research. Various programs at the INEEL are conducted under the supervision of three DOE offices: (1) the DOE-ID, (2) the Pittsburgh Naval Reactors Office, and (3) the Chicago Operations Office. With overall responsibility for the INEEL, DOE-ID selects and authorizes government contractors to operate at the facility, which currently provides a variety of programmatic and support services related to nuclear reactor design and development, nonnuclear energy development, materials testing and evaluation, operational safety, radioactive waste management, and environmental restoration.

The INEEL has a number of distinct and geographically separate functional facility areas, which serve or have served a particular programmatic or support activity. These areas have been designated as WAGs as a result of the INEEL being placed on the National Priorities List in 1989. The RWMC is a solid radioactive waste storage and disposal site located in the southwest portion of the INEEL. Waste Area Group 7 is the designation in the FFA/CO for the collective facilities within the perimeter fence at the RWMC, which include the SDA, the Transuranic Storage Area (TSA), and the adjacent administration and operations areas. The general layout of the RWMC is shown in Figure 1-3.

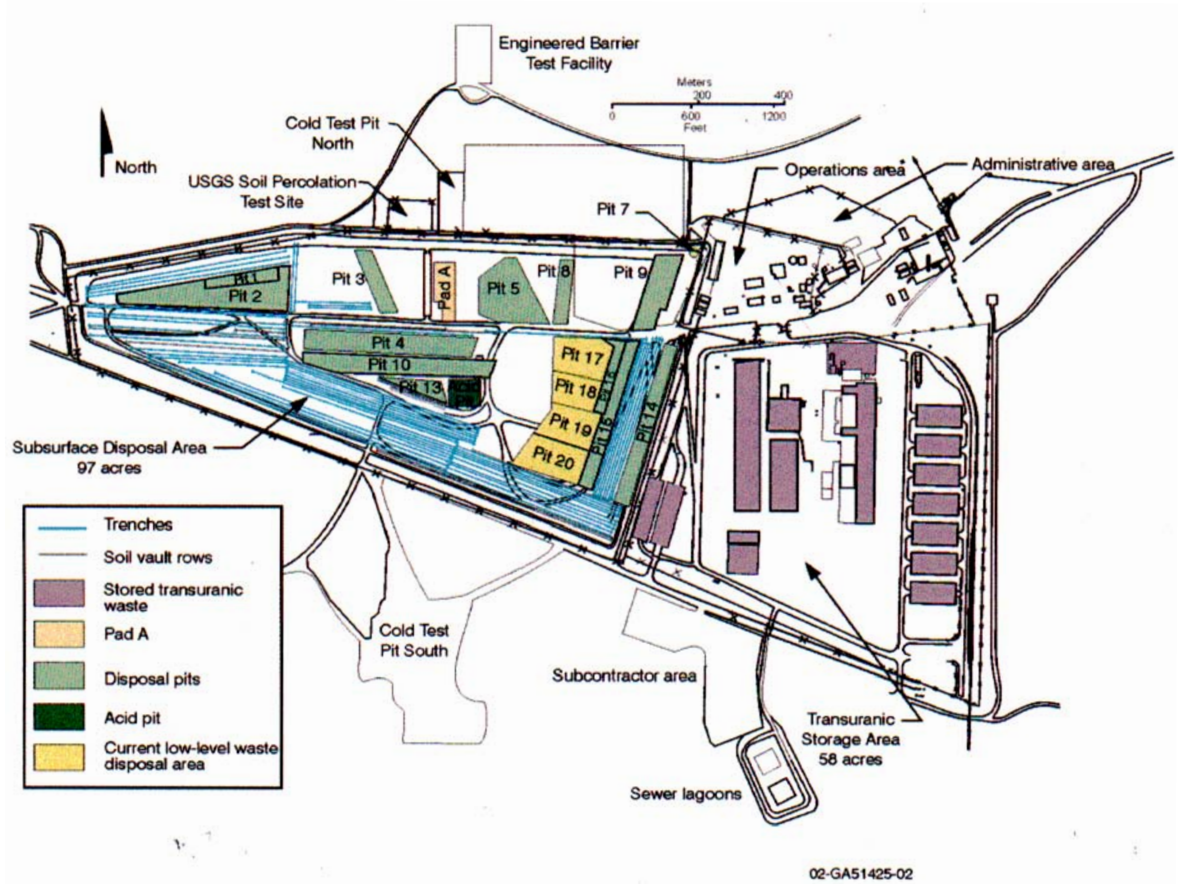

Figure 1-3. Physical layout of the Radioactive Waste Management Complex.

1.3.1 Site Description

The INEEL is located in southeastern Idaho and occupies 2,305 km^2 (890 mi^2) in the northeastern region of the Snake River Plain. Regionally, the INEEL is nearest to the cities of Idaho Falls and Pocatello and to U.S. Interstate Highways I-15 and I-86. The INEEL extends nearly 63 km (39 mi) from north to south, is about 58 km (36 mi) wide in its broadest southern portion, and occupies parts of five southeast Idaho counties. The Experimental Breeder Reactor I, which is a national historic landmark, and public highways (i.e., U.S. 20 and 26 and Idaho 22, 28, and 33) within the INEEL boundary are accessible without restriction. Otherwise, access to the INEEL is controlled. Neighboring lands are used primarily for farming or grazing or are in the public domain (e.g., national forests and state-owned land). The location and general layout of the INEEL facility are shown in Figure 1-4.

1.3.1.1 Physiography. The INEEL is located in the Eastern Snake River Plain, (ESRP). The ESRP is the largest continuous physiographic feature in southern Idaho. This large topographic depression extends from the Oregon border across Idaho to Yellowstone National Park and northwestern Wyoming. The INEEL is located on the northern side of the ESRP and adjoins the Lost River, Lemhi, and Beaverhead mountain ranges to the northwest (see Figure 1-4), which comprise the northern boundary of the plain.

The surface of the INEEL is a relatively flat, semiarid sagebrush desert with an average rainfall of 22.1 cm/year (8.7 in./year). Predominant relief is manifested either as volcanic buttes jutting up from the desert floor or as unevenly surfaced basalt flows or flow vents and fissures. Elevations at the INEEL range from 1,460 m (4,790 ft) in the south to 1,802 m (5,913 ft) in the northeast.

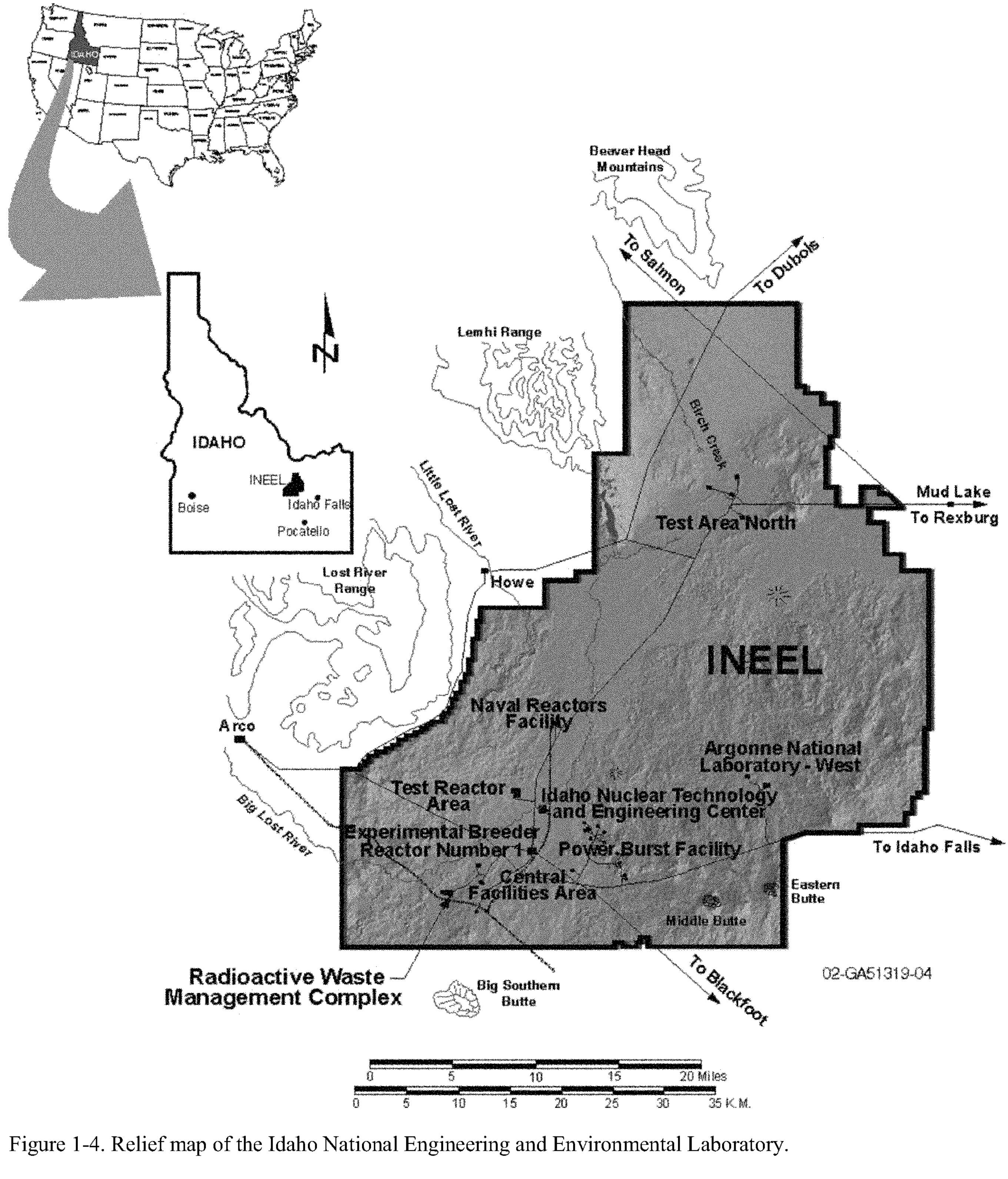

Figure 1-4. Relief map of the Idaho National Engineering and Environmental Laboratory.

The RWMC is located in the southwest portion of the INEEL, southeast of the diversion dam on the Big Lost River and east and northeast of the flood control spreading areas. The RWMC lies within a topographic depression circumscribed by basaltic ridges. Local elevations range from a low of 1,517.3 m (4,978 ft) to a high of 1,544.7 m (5,068 ft).

1.3.1.2 Surface and Subsurface Geology. The surface of the INEEL is covered generally by Pleistocene and Holocene basalt flows ranging in age from 300,000 to 3 million years (Hackett, Pelton, and Brockway 1986). Regional subsurface conditions consist mostly of layered basalt flows with a few comparatively thin layers of sedimentary deposits. Layers of sediment, referred to as interbeds, tend to retard infiltration to the aquifer and are important features in assessing the fate and transport of contaminants.

Undisturbed surficial sediments at the RWMC range in thickness from 0.6 to 7.0 m (2 to 23 ft) and consist primarily of fine-grained playa and alluvial material (Kuntz et al. 1994). The near surface basalt flows erupted from several volcanic vents in the southwestern part of the INEEL. Anderson and Lewis (1989) defined 10 basalt flow groups and seven major sedimentary interbeds in the area. The interbeds generally consist of unconsolidated sediments, cinders, and breccia. In the 177-m (580-ft) interval from the ground surface to the aquifer, three major interbeds are of particular importance. Using nomenclature established by the U.S. Geological Survey, these sedimentary layers are referred to as the A-B, B-C, and C-D interbeds, so named for the basalt flow groups (i.e., A, B, C, and D) that bound the layers above and below. The three uppermost sedimentary layers also are commonly referred to as the 30-, 110-, and 240-ft interbeds. The C-D interbed is by far the most continuous. However, each of the interbeds contains known gaps. The A-B interbed is very discontinuous and generally exists only beneath the northern half of the SDA.

1.3.1.3 Subsurface Hydrology. The crescent-shaped Snake River Plain Aquifer (SRPA) underlies the eastern portion of the ESRP. The aquifer is bounded on the north and south by the edge of the Snake River Plain; on the west by the surface discharge into the Snake River near Twin Falls, Idaho; and on the northeast by the Yellowstone basin. Consisting of a series of water-saturated basalt layers and sediment, the aquifer underlies the RWMC at an approximate depth of 177 m (580 ft) and flows generally from the northeast to the southwest. In the following paragraphs, the subsurface hydrology at the INEEL is discussed as three components: (1) vadose zone, (2) perched water, and (3) the SRPA.

The vadose zone is defined as the unsaturated zone between land surface and water table. Vadose zone thickness near the RWMC is approximately 180 to 186 m (590 to 610 ft). Rates of moisture movement in sediment and basalt under varying moisture conditions have been quantified near WAG 7. These quantified rates vary widely and depend on the location, material type, and timing of infiltration at the surface. Studies by Hubbell (1992) suggested that water moved from the surface to a depth of 221 ft in less than 5 years (12 m/year or 40 ft/year). Bishop (1996) reported a wide variation in net drainage from surficial sediments into underlying basalt, which ranged from a high of 49.4 cm/year (19.5 in./year) to less than 0.3 cm/year (0.1 in./year). A moisture movement rate of 5 m/day (16 ft/day) was measured from land surface to a depth of 55 m (180 ft) through the fractured basalt medium during an aquifer pumping and infiltration test conducted in the summer of 1994 (Porro and Bishop 1995) approximately 2.1 km (1.3 mi) south of the RWMC.

Perched water at the INEEL forms when a layer of dense basalt or fine sedimentary material occurs with a hydraulic conductivity that is sufficiently low so that downward movement of infiltrating water is restricted. Perched water is transitory beneath the RWMC, but has been detected in 11 boreholes at various times. Typically, the perched water wells are dry or contain so little water that the volume collected for analysis is limited. Perched water bodies have been identified at two depth intervals at WAG 7, at depths of approximately 24 to 27 m (80 to 90 ft) and 61 to 67 m (200 to 210 ft), corresponding to the B-C and C-D interbeds, respectively. Perched water typically occurs in fractured basalt above the interbeds.

The SRPA is defined as the saturated portion of a series of basalt flows and interlayered pyroclastic and sedimentary materials that underlie the ESRP. The SRPA arcs approximately 354 km (220 mi) through the eastern Idaho subsurface and varies in width from approximately 80 to 113 km (50 to 70 mi). Total area of the SRPA is estimated at 24,862 km^2 (9,600 mi^2). The SRPA is recharged primarily by infiltration from rain and snowfall that occur within the drainage basin surrounding the ESRP and from deep percolation of irrigation water. Water is pumped from the aquifer primarily for human consumption and irrigation (Irving 1993). In the vicinity of the RWMC, the SRPA lies approximately 180 to 197 m (590 to 610 ft) below land surface (Wood and Wylie 1991). Regional groundwater flow is to the south-southwest; however, the flow direction can be affected locally by recharge from rivers, surface water spreading areas, and heterogeneities in the aquifer. Local groundwater flow direction is north-northeast to south-southwest; however, the water-level map for the RWMC indicates a relatively flat groundwater gradient across the site. Flow velocities within the SRPA range from between 1.5 to 6.1 m/day (5 to 20 ft/day) (Irving 1993).

1.3.1.4 Surface Hydrology. Most of the INEEL is located in the Pioneer Basin into which three streams drain: (1) the Big Lost River, (2) the Little Lost River, and (3) Birch Creek. These streams receive water from mountain watersheds located to the north and northwest of the INEEL. Stream flows often are depleted before reaching the facility by irrigation diversions and infiltration losses along stream channels. The Pioneer Basin has no outlet; thus, when water flows onto the INEEL, it either evaporates or infiltrates into the ground (Irving 1993). The general surface water features of the site are depicted in Figure 1-5.

The Big Lost River is the major surface water feature on the INEEL. Its waters are impounded and regulated by the Mackay Dam, which is located approximately 6 km (4 mi) north of Mackay, Idaho. Flow in the Big Lost River that actually reaches the facility is either diverted at the INEEL diversion dam to spreading areas southwest of the RWMC or flows northward across the INEEL in a shallow channel to its terminus at the Lost River Sinks, at which point, the flow is lost to evaporation and infiltration (Irving 1993).

The RWMC is located within a natural topographic depression with no permanent surface water features. However, the local depression tends to hold precipitation and to collect additional run-off from the surrounding slopes. Surface water either eventually evaporates or infiltrates into the vadose zone (i.e., the unsaturated subsurface) and underlying aquifer. As discussed by Keck (1995), the Big Lost River is not a surface water flow path for contaminant transport at the SDA.

Historically, the SDA has been flooded by local run-off at least three times because of a combination of snowmelt, rain, and warm winds. Dikes and drainage channels were constructed around the perimeter of the SDA in 1962 in response to the first flooding event. Height of the dike was increased and the drainage channel was enlarged, following a second flood in 1969. The dike was breached by accumulated snowmelt in 1982, resulting in a third inundation of the SDA. Significant flood-control improvements were subsequently implemented, which included increasing height and width of the dike, deepening and widening the drainage channel, and surface contouring to eliminate formation of surface ponds within the SDA.

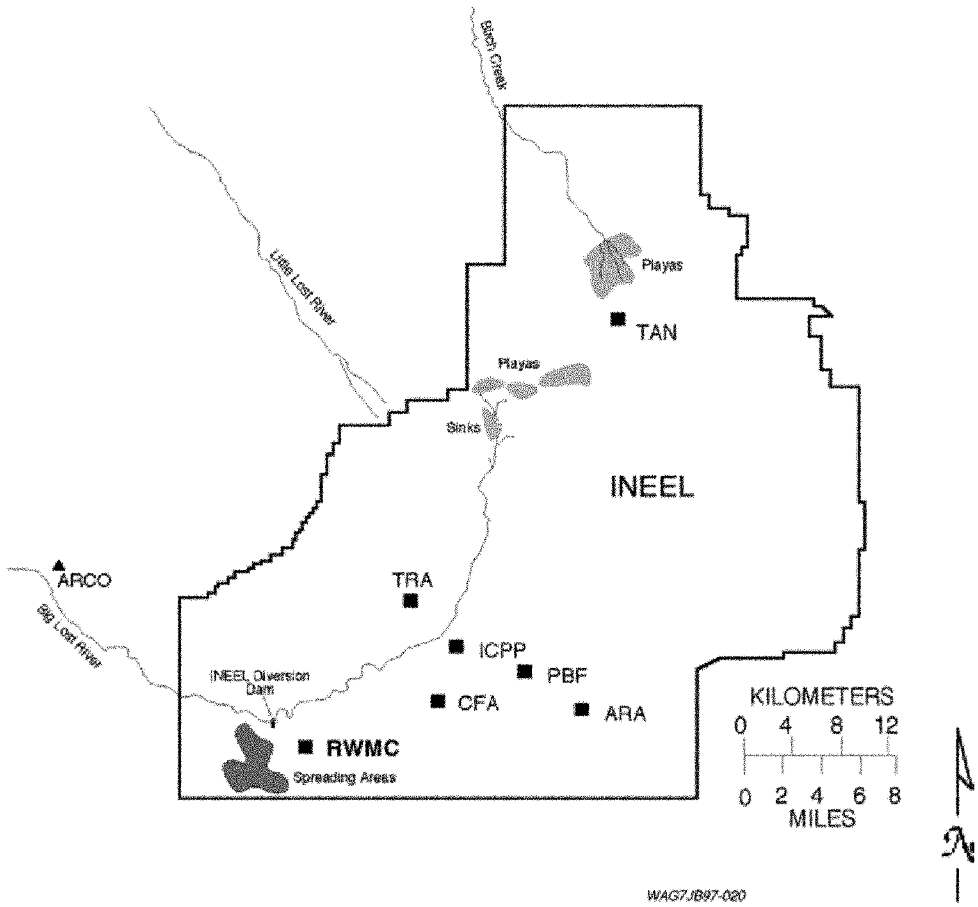

Figure 1-5. Surface water features.

1.3.1.5 Seismic Activity. Seismic activity of eastern Idaho is concentrated along the Intermountain Seismic Belt, which extends more than 1,287 km (800 mi) from southern Arizona through eastern Idaho to western Montana. The RWMC is subject to the same seismic influences. The Idaho Seismic Zone extends westward along the Idaho Seismic Belt from the Yellowstone Plateau area into central Idaho. Though several large magnitude earthquakes have occurred in mountain ranges surrounding the INEEL, earthquakes beneath the Eastern Snake River Plain are rare and have small magnitudes (Jackson et al. 1993). Minor earthquakes have occurred east and north of the INEEL with an average local magnitude of 1.0 on the Richter scale.

1.3.1.6 Volcanic Hazards. The INEEL is located in a region of Pleistocene and Holocene volcanic activity, typically characterized by nonviolent, effusive basalt lava flows (Hackett and Smith 1992). Four to 7 million years ago, explosive rhyolite volcanism occurred beneath the INEEL, forming calderas now buried beneath basalt lava flows. The most recent lava flows within the INEEL boundary occurred 13,000 years ago near the southern boundary—the Cerro Grande flow (Hackett, Pelton, and Brockway 1986). Past patterns of volcanism suggest that future volcanism at the INEEL within the next 1,000 to 10,000 years is very improbable (EG&G 1990). Furthermore, the Volcanism Working Group (EG&G 1990) estimated the probability of RWMC inundation by basalt flow to be less than 1E-05 per year. Even with this unlikely event, the principal effect on the surficial and buried waste would be localized heating to 300°C (572°F) to a depth of less than 3 m (9.8 ft). Other potential effects (i.e., fissuring and gas corrosion) are even more unlikely because the RWMC lies outside known volcanic rift zones (Hackett, Anders, and Walter 1994).

1.3.1.7 Demography. Populations potentially affected by INEEL activities include employees, ranchers who graze livestock in areas on or near the INEEL, hunters, residential populations in neighboring communities, highway traffic along U.S. Highway 20/20, and visitor traffic at the Experimental Breeder Reactor No. 1. Nine separate facilities at the INEEL include a total of approximately 450 buildings and more than 2,000 other support facilities. As of December 2001, the on-Site workforce was estimated at 3,653 employees, including 308 at the RWMC. Authorized groups are occasionally escorted at the RWMC. Subcontract employees and personnel from IDEQ and EPA oversight programs also visit the area.

The nearest community to the INEEL is Atomic City, located south of the site border on U.S. Highway 20/26. Other population centers near the INEEL include Arco, 11 km (7 mi) to the west; Howe, located to the west on U.S. Highway 22/33; and Mud Lake and Terreton on the northeast border. The INEEL has no permanent residents (Hull 1989).

1.3.1.8 Flora and Fauna. The INEEL site serves as a refuge for wildlife habitat. The central core of the site may constitute the largest area of undeveloped and ungrazed sagebrush steppe outside of the national park lands in the Intermountain West. Because the INEEL is located at the mouth of several mountain valleys, large numbers of migratory birds of prey and mammals are funneled into the region. More than 290 vertebrate species—including 45 mammals, 225 birds, 12 reptiles, and 6 fish—have been observed within the INEEL boundaries. Nearly all the avian and mammalian species found across the INEEL could occur in the WAG 7 area. Avian species include game birds, such as sage grouse, and various raptor species. Burrowing rodents (such as ground squirrels and mice) and insects (such as harvester ants) are of particular interest given buried waste conditions at the SDA. Larger mammalian species, such as coyote and antelope, also are present.

Six broad vegetation categories representing nearly 20 distinct habitats have been identified on the INEEL. Nearly 90% of the area is covered by shrub-steppe vegetation, which is dominated by big sagebrush, saltbush, rabbitbrush, and native grasses (DOE-ID 2001). Small riparian and wetland regions also exist along the Big Lost River and Birch Creek.

1.3.1.9 Cultural Resources. Undisturbed sagebrush rangelands and developed facilities found on the INEEL contain sensitive cultural resources reflecting human use of the region for a period in excess of 12,000 years. Ten major archaeological survey projects have identified an inventory of 13 potentially significant prehistoric sites with a 200-m (656-ft) -wide zone surrounding the fenced perimeter of the RWMC and more than 80 additional archaeological resources in the surrounding area. In addition, paleontological remains have been identified in excavations within the facility. Finally, architectural surveys of the DOE-ID administered buildings within the developed portion of the RWMC have identified three buildings that may be eligible for nomination to the National Register.

1.3.1.10 Land Use. The land within the INEEL is administered by DOE and is classified by the Bureau of Land Management as industrial and mixed-use acreage (DOE-ID 2001). The current primary use of INEEL land is to support facility and program objectives. Large tracts of land are reserved as buffer and safety zones around the boundary of the INEEL, while portions within the central area are reserved for INEEL operations. The remaining land within the core of the reservation, which is largely undeveloped, is used for environmental research and to preserve ecological and cultural resources. The U.S. Government owns most of the land immediately adjacent to the INEEL. The perimeter buffer consists of 1,295 km^2 (500 mi^2) of grazing land (DOE-ID 2001) administered by the Bureau of Land Management. In the surrounding counties, approximately 45% of the land is used for agriculture, 45% is undeveloped land, and 10% is urban (DOE-ID 2001).

Land use at the RWMC is limited to industrial applications with present waste management operations and associated expansion expected to continue. The TSA, which is contained within a security fence, is dedicated to the temporary storage of contact- and remote-handled solid TRU waste. The TSA also contains the Advanced Mixed Waste Treatment Project (AMWTP), which is currently under construction. Operations at the AMWTP complex are scheduled to begin in 2003 with the major mission to retrieve and treat 65,000 m^3 of INEEL low-level and TRU waste currently stored at the TSA.

Future land use is addressed in the *Long-Term Stewardship Land Use Future Scenarios for the Idaho National Engineering Laboratory* (DOE-ID 1995), the *Idaho National Engineering and Environmental Laboratory Comprehensive Facility and Land Use Plan* (DOE-ID 2001), and the *Infrastructure Long-Range Plan* (INEEL 2001). The Long-Term Stewardship Initiative will encompass all future activities, including physical and institutional controls, monitoring and surveillance, and other steps necessary to protect human health and the environment from hazards remaining at the INEEL after selected cleanup strategies are compete. Future land use most likely will remain essentially the same as the current use—a research facility within the INEEL boundaries with adjacent areas consisting of primarily agricultural and undeveloped land.

1.3.2 Site History

The RWMC, located in the southwestern quadrant of the INEEL, encompasses a total of 72 ha (177 acres) and is divided into three separate areas by function: (1) the SDA, (2) the TSA, and (3) the administration and operations area. The original landfill, established in 1952, covered 5.2 ha (13 acres) and was used for shallow land disposal of solid radioactive waste. In 1958, the landfill was expanded to 35.6 ha (88 acres). Relocation of the security fence in 1988 to outside the dike surrounding the landfill established the current size of the SDA as 39 ha (97 acres). The TSA was added to the RWMC in 1970. Located adjacent to the east side of the SDA, the TSA encompasses 23 ha (58 acres) and is used to store, prepare, and ship retrievable TRU waste to the Waste Isolation Pilot Plant (WIPP). The 9-ha (22-acre) administration and operations area at the RWMC includes administrative offices, maintenance buildings, equipment storage, and miscellaneous support facilities.

The SDA is a radioactive waste landfill with shallow subsurface disposal units consisting of pits, trenches, and soil vaults. Contaminants in the landfill include hazardous chemicals, remote-handled fission and activation products, and TRU radionuclides. Waste acceptance criteria and record-keeping protocols for the facility have changed over time in keeping with waste management technology and legal requirements. Today's requirements are much more stringent as a result of knowledge developed over the past several decades about potential environmental impacts of waste management techniques. Previously, however, shallow landfill disposal of radioactive and hazardous waste was the technology of choice. The general layout of the SDA, showing relative locations of individual disposal units, is presented in Figure 1-6.

At the SDA, disposals of TRU and mixed waste—mostly from RFP in Colorado—were allowed through 1970. Buried RFP TRU waste, located primarily in Pits 2 through 6 and 9 through 12, and Trenches 1 through 10, is depicted in Figure 1-6. Disposal of mixed waste containing hazardous chemical and radioactive contaminants was allowed through 1984. Since 1985, waste disposals in the SDA have been limited to low-level radioactive waste generated at the INEEL. Construction, operation, and decommissioning of the INEEL nuclear reactor testing programs have resulted in large volumes of waste. Various containers were used in shipping and disposing of the waste, including steel drums (30-, 40-, and 55-gal), cardboard cartons, and wooden boxes (as large as 105 × 105 × 214 in.). Larger individual items—such as tanks, furniture, process and laboratory equipment, engines, and vehicles—were placed separately as loose trash.

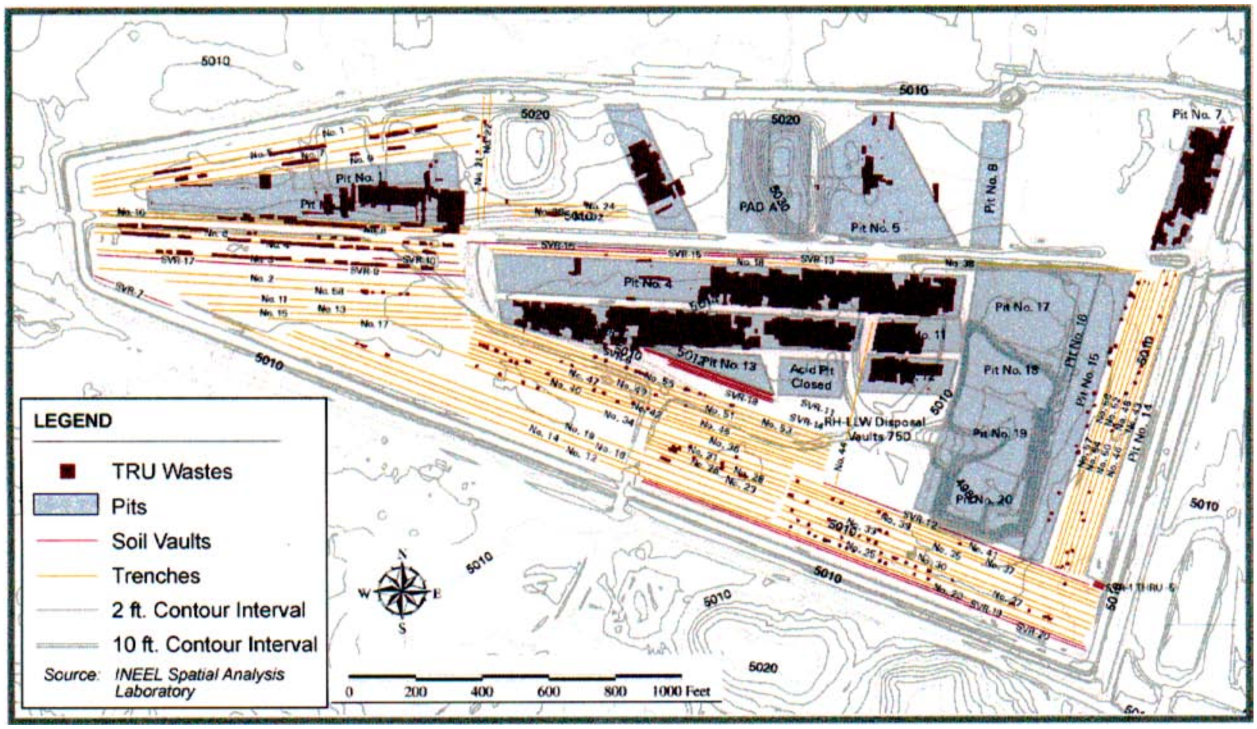

Figure 1-6. Subsurface Disposal Area waste disposal units.

Radioactive waste from off-Site sources originated from a variety of facilities, including military and other defense agencies, universities, commercial operations, and the Atomic Energy Commission. The primary off-Site contributor was the RFP, which shipped TRU waste to the SDA between 1954 and 1970. The three primary RFP facilities that generated the radioactive waste were the Aqueous Waste Treatment Facility, the Plutonium Recovery Facility, and the Plutonium Production Facility.

- The Aqueous Treatment Facility treated process waste and other liquid plant waste. Facility waste included several types of sludge and evaporation salt.
- The Plutonium Recovery Facility recovered plutonium from various weapon-production operations using a variety of methods, including incineration, leaching, and ion exchange. The waste produced included glass, combustibles, sand, slag, crucible heels, and process equipment.
- The Plutonium Production Facility produced waste during routine operations, which included combustibles, graphite molds, metals, filters, and glass. Additional waste includes that generated in the 1969 fire that contained foundry and production equipment (e.g., gloveboxes, presses, lathes, furnaces, rolling mills, filters, piping, masonry brick, ducting, and some structural elements).

Between 1954 and 1960, waste shipments from RFP were disposed of in Trenches 1 through 15, interspersing TRU waste with low-level waste (LLW) generated at the INEEL. In 1957, the use of pits for RFP waste was instituted. Initially, waste was stacked in pits and trenches. However, beginning in 1963, waste was simply dumped to reduce labor costs and minimize personal radiation exposures.

1.3.2.1 Disposal Units. Waste in the SDA is buried in pits, trenches, soil vaults, and on an abovegrade pad. A brief description of individual burial sites, along with a discussion of associated waste disposal practices, is presented in the following paragraphs. Conceptual cross-sectional views depicting the types of individual waste units within the SDA are presented in Figure 1-7.

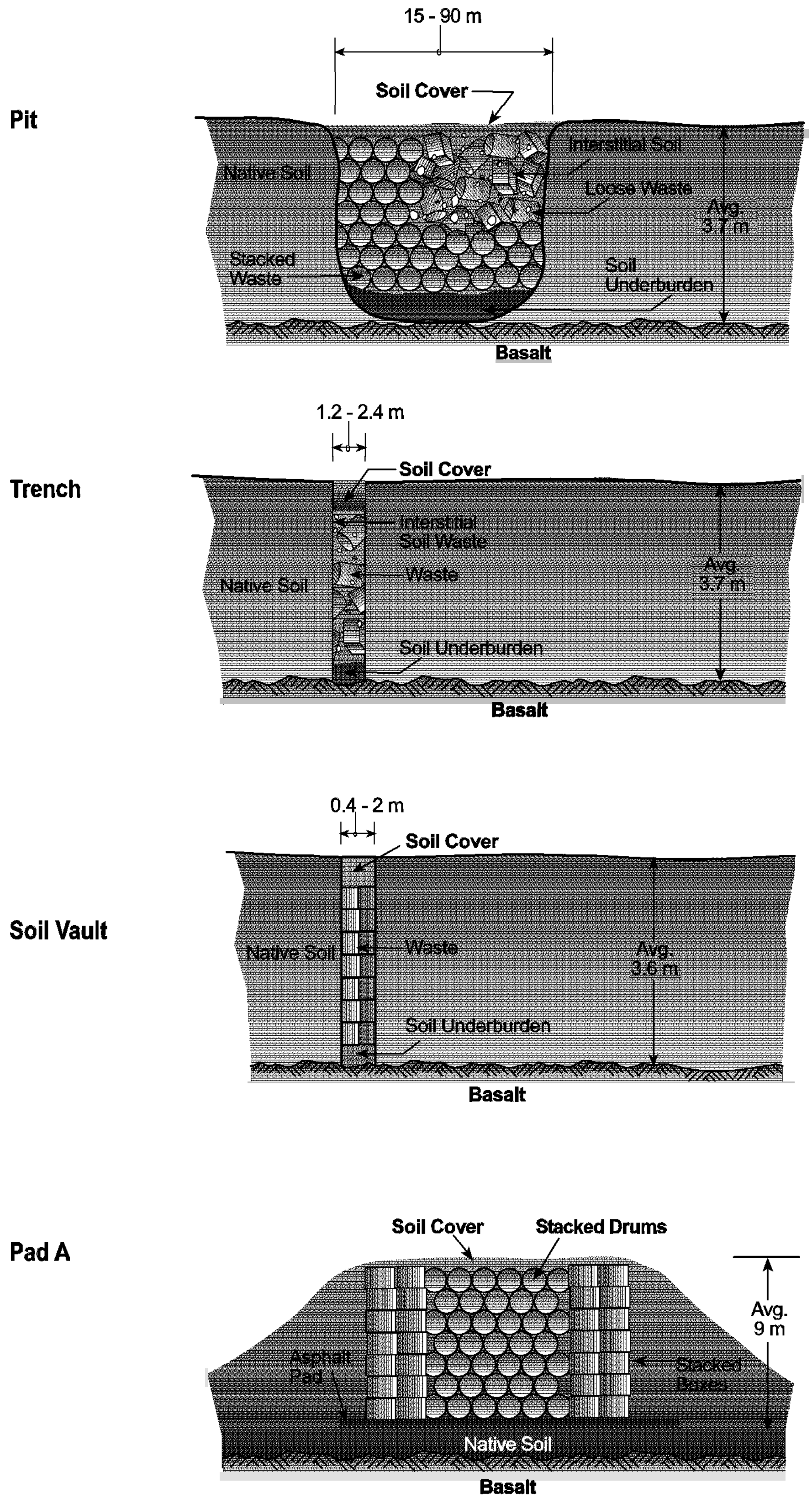

Figure 1-7. Generic cross section of pits, trenches, soil vaults, and Pad A.

1.3.2.1.1 *Pits*—A total of 16 pits were opened, filled, and closed (covered with soil) in the SDA between 1957 and 1984. Pits contain TRU, mixed TRU, mixed low-level waste (MLLW), and LLW—primarily in drums, cardboard boxes, and garbage cans. Many shipments were not in containers and included trucks, tanks, and miscellaneous debris. Drums disposed of in Pits 1, 2, and 3 were stacked from 1957 until 1963. Drums were randomly dumped in Pits 4 through 9 from 1960 to 1969. Pits 1 through 6 and 9 through 12 received TRU waste from RFP, while the remaining pits generally received non-RFP waste. Detailed information regarding the waste is presented in the ABRA (Holdren et al. 2002).

The pits were excavated to various sizes. Dimensions ranged from approximately 15 to 90 m (50 to 300 ft) wide and 75 to 335 m (250 to 1,100 ft) long, averaging approximately 3.7 m (12 ft) deep. In general, pits were excavated to the underlying basalt layer. Beginning in 1970, a minimum of 0.6 m (2 ft) of soil was placed over the exposed basalt before placement of the waste. After waste was emplaced, pits were backfilled and covered with about 1 m (3 ft) of soil (Vigil 1988).

Pits 17 through 20 comprise a single, large, excavated area currently used for LLW disposal. Pits 16 and 17 are closed, and the boxes on the west side of the pits have been covered with soil to shield workers. Waste is stacked in pits using forklifts and cranes. Concrete vaults, used for remote-handled LLW, are located in the southwest corner of Pit 20.

1.3.2.1.2 *Trenches*—Trenches within the SDA have various lengths, up to approximately 304 m (1,000 ft) long. They are on average 1.2 to 2.4 m (5 to 8 ft) wide and 3.7 m (12 ft) deep (Vigil 1988). Trenches 1 through 10 received waste from 1952 until 1957 (Vigil 1988), though shipments from RFP did not begin until 1954. Trenches 11 through 15 received waste from RFP in 1958 and 1959, and minor amounts of RFP waste was place in Trenches 19 and 32. These early trenches received cardboard boxes, wooden boxes, and garbage cans containing mixed fission products and drums and wooden crates containing TRU waste. Trenches 11 through 58 were opened, filled, and closed (covered with soil) from 1958 through 1981 and generally contain drums, boxes, and loose material.

General disposal practices were the same for pits and trenches. Waste was compacted and bailed; larger bulky items were wrapped in plastic; and smaller, noncompactible waste was contained in wooden boxes and covered with fire-retardant paint (Becker et al. 1998). Some waste was disposed of in shielded casks to reduce radiation exposure rates.

1.3.2.1.3 *Soil Vault Rows*—Beginning in 1977, soil vault rows (SVRs) were constructed to dispose of remote-handled, high-radiation LLW (defined as material producing a beta-gamma exposure rate of greater than 500 mR/hr at a distance of 0.9 m [3 ft]). Individual soil vaults are unlined, cylindrical vertical-augured shafts with diameters up to 2 m (6.7 ft) and depths averaging 3.6 m (11.8 ft). Soil Vault Rows 1 to 21 have been closed and covered with soil. Each vault is separated from previously buried waste by approximately 0.6 m (2 ft).

1.3.2.1.4 *Pad A*—Formerly known as the Engineered Waste Storage Area or the Transuranic Disposal Area, Pad A was constructed in 1972. An asphalt pad was built on the ground surface in an area that was unsuitable for subsurface disposal because of near-surface basalt outcroppings. Pad A received waste from 1972 to 1978. Pad A contains TRU alpha-emitting radioisotopes with concentrations less than 10 nCi/g and radiation levels less than 200 mR/hr at the container's surface. Two shipments contained TRU waste at concentrations greater than 100 nCi/g (Halford et al. 1993). Waste drums and plywood boxes were stacked and covered with soil. Each stack at Pad A consisted of as many as 11 drums or 5 boxes—drums were stacked horizontally in staggered layers, and boxes were stacked around the periphery of the pad. The overall dimensions of Pad A are 73 m (240 ft) by 102 m (335 ft).

When Pad A was closed in 1978, waste containers occupied only the eastern half of the pad. During closure activities, exposed waste containers were covered with plywood, polyethylene, and a final soil cover, which consisted of a 1-m (3.3-ft) top cover and side berms having a maximum slope of 3 horizontal to 1 vertical (3H:1V) (LMITCO 1995).

1.3.2.2 Waste Retrieval Activities. The Initial Drum Retrieval Project at the SDA was performed to demonstrate safe retrieval of drums and gain experience in handling and repackaging drums for interim storage. Retrieval operations began in 1974 and were completed in June 1978. Retrieval was limited to Pits 11 and 12 and resulted in retrieval of 20,262 drums with a TRU waste volume of 4,391 m^3 (5,743 yd^3) (McKinley and McKinney 1978).

Another waste retrieval operation, the Early Waste Retrieval Project, was initiated in 1976 to develop methods and equipment for safely retrieving TRU waste that had been buried for 22 to 24 years. The operation, which terminated in 1978, retrieved a total of 170.6 m^3 (223.1 yd^3) of waste from Pits 1 and 2 and Trenches 5, 7, 8, 9, and 10. Retrieved waste included 457 drums, 34.3 m^3 (44.9 yd^3) of loose waste, and 24.3 m^3 (31.8 yd^3) of contaminated soil. All waste was wrapped in plastic before repackaging and placed in drums and steel bins for interim storage in the TSA. All equipment was decontaminated, and excavations were backfilled following completion of retrieval operations.

At the time of this report, plans were in place to retrieve waste from a portion of Pit 9. Retrieval operations were scheduled to begin in 2003 and were designed to demonstrate specific retrieval and material-handling technologies.

1.3.3 Nature and Extent of Contamination

The nature and extent of contamination associated with the SDA in all environmental media were evaluated in the ABRA (Holdren et al. 2002). Human health contaminant screening in the *Interim Risk Assessment* (IRA) (Becker et al. 1998) and the ecological contaminant screening in the *Review of Waste Area Group 7 Ecological Contaminants of Potential Concern* (Hampton and Becker 2000) document was used in the ABRA (Holdren et al. 2002) to define contaminants for analysis. The human health contaminants of potential concern included 20 radionuclides and four chemical contaminants. Many of these contaminants also were identified as ecological contaminants of potential concern.

In addition to routine monitoring at the RWMC, several unique approaches have been adopted to characterize the nature and extent of contamination. A database containing contaminant inventories and waste descriptions was developed to describe the waste zones. A second database was created to map characterization data and disposal locations in the SDA. The mapping software, WasteOScope, is based on historical disposal records, including RFP shipping manifests and trailer load lists. In addition, electromagnetic and soil gas surveys were evaluated against waste zone maps. More than 300 probes were installed to characterize buried waste using instruments developed at the INEEL. Data from surveys and probes were incorporated into WasteOScope to allow visually superimposing various data sets. A new type of tensiometer, referred to as the advanced tensiometer, also was developed at the INEEL to allow deeper tensiometer monitoring in the vadose zone.

The evaluation of nature and extent considered depth intervals as follows: waste zone, interval excluding waste zone and extending from the surface to 11 m (35 ft), from 11 to 43 m (35 to 140 ft), from 43 to 77 m (140 to 250 ft), and depths greater than 77 m (250 ft). These intervals were defined to reflect regions bounded by the A-B, B-C, and C-D interbeds.

Contaminants of potential concern have been detected at low concentrations in the vadose zone and may be migrating toward the aquifer. Most vadose zone detections are in the 0- to 11-m (0- to 35-ft) and

11- to 43-m (35- to 140-ft) intervals above the B-C interbed, with some contaminants detected in deeper intervals. The most frequently detected contaminants in the environment include nitrates, carbon tetrachloride, C-14, Tc-99, and uranium isotopes. Other contaminants including Am-241, I-129, Pu-238, and Pu-239/240 have been detected sporadically at concentrations near detection limits. Carbon tetrachloride has been detected down to the aquifer, though concentrations decrease significantly below the B-C interbed and again below the C-D interbed. Because carbon tetrachloride migrates in the gaseous phase, it also has been detected hundreds of meters laterally away from buried waste.

A conclusion from the ABRA (Holdren et al. 2002) is that low concentrations of carbon tetrachloride, nitrates, and C-14 have been detected in the SRPA near the SDA. Carbon tetrachloride has been measured slightly above the maximum contaminant level. Low concentrations of nitrate and C-14, well below maximum contaminant levels, also have been detected in the region and may be increasing. The SDA is the obvious source of the carbon tetrachloride, but the source of the nitrate and C-14 is not as clear.

Monitoring at the RWMC has been greatly expanded since 1998 with 22 additional vadose zone lysimeters, four upgradient aquifer wells, an aquifer well inside the SDA, and more than 300 probes in the buried waste. Most of these new installations have not been operational long enough to provide substantial quantities of data. The expanded network will continue to produce data for continued evaluation of source release into the vadose zone, contaminant migration through the vadose zone, and potential impacts to the aquifer beneath the SDA. Monitoring data also will support future remediation by providing a baseline for remediation goals.

1.3.4 Contaminant Fate and Transport

Modeling was conducted for the ABRA (Holdren et al. 2002) to simulate release and migration of contaminants from waste buried in the SDA and to estimate future contaminant concentrations in environmental media. Models implemented were essentially the same as those used in the IRA with some improvements to incorporate additional data. Several sensitivity cases were modeled to evaluate effects of variations in several parameters of interest on estimated media concentrations and risk.

Complete exposure pathways defined by the conceptual site model formed the basis for three types of simulations: (1) source release, (2) subsurface transport, and (3) biotic transport. Persistence of contaminants in the environment was evaluated based on contaminant mobility controlled by dissolved-phase transport and biotic transfer by animals and plants intruding into the waste. For radioactive contaminants of potential concern, half-lives also were considered. Chemical degradation was not assessed.

The DUST-MS source-term model was used to simulate release of contaminants from waste and into the subsurface. Based on waste inventory estimates and waste characteristics, the model simulated the release of contaminant mass from buried waste for three types of release mechanisms: (1) surface wash off, (2) diffusion, and (3) dissolution. Once mass was released, it was available for biotic transport to the surface or for migration in the subsurface. Sample data for the shallow subsurface from areas around the SDA were not representative of concentrations beneath the waste and, therefore, were not useful for calibrating the source-term model. Indirect, limited calibration was achieved by comparing measured to simulated aquifer concentrations.

Subsurface fate and transport modeling focused on dissolved-phase transport using the TETRAD simulator. Vapor-phase transport was not specifically modeled for this investigation for contaminants such as C-14. For volatile organic compounds (VOCs), concentrations were estimated by scaling results in the IRA (Becker et al. 1998) on the basis of revised inventory estimates. Using information from the source release model, the TETRAD model simulated migration of dissolved-phase contaminants in the vadose zone and aquifer. The model emulated fate and transport beginning in 1952 and extending until concentrations peaked in the aquifer up to 10,000 years in the future. The model domain was based on interpolations of known characteristics of the subsurface, such as depths and thicknesses of interbeds and water velocity in the aquifer. Other model parameters to describe contaminant migration, such as partition coefficients, were defined using site-specific information. Reasonable values from the literature were selected when site-specific information was unavailable. Estimated media concentrations were compared to monitoring data. However, model calibration beyond limited calibration achieved previously in the IRA (Becker et al. 1998) was not attempted because of the lack of calibration targets provided by monitoring data. In other words, contaminants of particular interest for model calibration—such as C-14, uranium, and other actinides—have been detected sporadically and at very low concentrations that do not describe migration trends. Low concentrations, coupled with lack of trends, cannot be emulated with any confidence.

The DOSTOMAN code was used to simulate transport of contaminants to the surface by plants and animals and to estimate resulting surface soil concentrations. Rate constants and other input parameters used in the code were selected from current literature, with preference given to values specific to the SDA and the INEEL. Though limited comparisons of estimated-to-measured surface soil concentrations were produced, calibration for the biotic model was not pursued. Maintenance, contouring, and subsidence repairs at the landfill disturb the surface of the site, and the sparse data that are available are not representative of biotic uptake. In addition, the analysis adopts the fundamental assumption that future action at the SDA under any remediation scenario will include a cap that would inhibit human intrusion and biotic uptake.

1.3.5 Baseline Risk Assessment

Waste Area Group 7 was considered in a comprehensive manner in the ABRA (Holdren et al. 2002) by evaluating the cumulative, simultaneous risk for all complete exposure pathways for all contaminants of potential concern. The assessment evaluated impacts of exposure to concentrations of contaminants in soil and groundwater estimated by the models described in the preceding section. Estimated current and future impacts to human health and the environment are described below.

1.3.5.1 Human Health Baseline Risk Assessment. Potential risks to human receptors posed by the 24 contaminants of potential concern (COPCs) defined in the WAG 7 IRA (Becker et al. 1998) were quantitatively evaluated in the human health component of the ABRA (Holdren et al. 2002). Exposure and toxicity assessments, risk characterization, and limited evaluation of sensitivity and uncertainty were included. For radionuclides, long-lived decay chain products were considered to assess cumulative effects. Risks from VOCs were scaled from the IRA (Becker et al. 1998) results based on inventory updates.

Exposure scenarios were defined to assess hypothetical current and future occupational receptors and for current and future residential receptors. For the current residential scenario, groundwater ingestion risk at the INEEL boundary was assessed. Surface exposure pathways were not examined for a current residential exposure because residential development near the RWMC is prohibited by site access restrictions. Future residential exposures were simulated to begin in 2110 to reflect a postulated remediation in 2010 followed by an assumed 100-year institutional control period. The future residential analysis reflects assumptions that a cap and institutional controls would preclude access into the waste, but that a location immediately adjacent to the RWMC could be inhabited. Concentrations and risks were simulated out to 1,000 years for all pathways except groundwater ingestion. Groundwater risks were simulated until peak concentrations occurred up to a maximum of 10,000 years.

Risk estimates for a hypothetical, future, residential exposure scenario bounded risks for all scenarios because future residential risk estimates exceed estimates for both occupational scenarios and for the current residential scenario. Of 24 contaminants analyzed in the ABRA, 16 were defined as OU 7-13/14 contaminants of concern (COCs) based on estimated risk in excess of 1E-05 or cumulative hazard index greater than 2. The location of the maximum cumulative risk is near the southeast corner of the SDA, and the primary exposure pathway is groundwater ingestion. A summary of the COCs identified in the human health component of the baseline risk assessment is provided in Table 1-1. The table reflects results for a 1,000-year simulation period.

The future residential risk over time for radionuclides is illustrated in Figure 1-8. The figure reflects the simulated 100-year institutional control period; thus, the hypothetical receptor location changes in 2110 from the boundary of the INEEL to the edge of the SDA. Therefore, discontinuities in Figure 1-8 at 2110 are attributable to the change in location for the hypothetical receptor from the INEEL boundary to the edge of the SDA.

1.3.5.2 Ecological Risk Assessment. Scope of ecological risk assessment conducted in the ABRA (Holdren et al. 2002) was limited because of the fundamental assumption that the SDA will be covered with a cap under any remediation scenario. Current-year and 100-year scenarios were evaluated for representative receptors. Contaminant screening documented in the *Review of Waste Area Group 7 Ecological Contaminants of Potential Concern* (Hampton and Becker 2000) limited the evaluation to those contaminants with a maximum likelihood to pose unacceptable risk. Concentrations in surface soil and subsurface intervals were estimated with the DOSTOMAN biotic uptake model. Ecological COCs were identified based on a hazard quotient in excess of 1 for radionuclides and a hazard quotient of 10 or greater for nonradionuclides. Seven contaminants of concern, which may exceed these hazard quotients, were identified in the ecological risk assessment (see Table 1-2).

Plant uptake and burrowing by animals was not shown to increase current surface soil concentration levels above the screening levels during the next 100 years. However, the assessment identified current and ongoing risk resulting from the following: (1) toxic exposures for plants with roots reaching surface and subsurface contamination; (2) ingestion exposures for animals eating those plants; (3) external and inhalation exposures for burrowing animals that feed above ground; (4) external, inhalation, and ingestion exposures for below ground feeders; and (5) ingestion exposures for predators that prey on animals contaminated on the SDA. Identified ecological risks could be addressed by actions implemented to reduce human health risk. Installation of a cap with a biotic barrier would inhibit plant and animal intrusion into contaminated subsurface soil, protect ecological receptors from contaminants, and reduce human exposures by preventing biotic transport of contamination to the surface.

1.3.5.3 Conclusions. Contaminants of concern were identified initially based on human health and ecological risk estimates. Risk-based criteria for human health of 1E-05 risk and a cumulative hazard index in excess of 2 were applied. Sixteen human health contaminants of concern were identified. In addition, three plutonium isotopes were classified as special case contaminants of concern to acknowledge uncertainties about plutonium mobility in the environment and to reassure stakeholders that risk management decisions for the SDA will be fully protective. Seven ecological contaminants of concern were identified based on a hazard quotient in excess of 1 for radionuclides and a hazard quotient of 10 or greater for nonradionuclides.

Table 1-1. Human health contaminants of concern.

Contaminant	Note	Peak Risk	Year	Peak Hazard Index	Year	Primary 1,000-Year Exposure Pathway
Ac-227		3E-06	3010[a]	NA[b]	NA	Groundwater ingestion
Am-241	1,3	**3E-05**	2953	NA	NA	Soil ingestion, inhalation, external exposure, and crop ingestion
Am-243		4E-08	3010[a]	NA	NA	External exposure
C-14	1,4	**6E-04**	2278	NA	NA	Groundwater ingestion
Cl-36		6E-06	2110	NA	NA	Groundwater ingestion
Cs-137		5E-06	2110	NA	NA	External exposure
I-129	1,3	**6E-05**	2110	NA	NA	Groundwater ingestion
Nb-94	1,3	**8E-05**	3010[a]	NA	NA	External exposure
Np-237	1,4	**4E-04**	3010[a]	NA	NA	Groundwater ingestion
Pa-231		3E-06	3010[a]	NA	NA	Groundwater ingestion
Pb-210		5E-07	3010[a]	NA	NA	Soil and crop ingestion
Pu-238	2	1E-09	2286	NA	NA	Soil and crop ingestion
Pu-239	2	2E-06	3010[a]	NA	NA	Soil and crop ingestion
Pu-240	2	2E-06	3010[a]	NA	NA	Soil and crop ingestion
Ra-226		3E-06	3010[a]	NA	NA	External exposure
Sr-90	1,4	**1E-04**	2110	NA	NA	Crop ingestion
Tc[redacted]	1,4	**04**	2110	NA	NA	Groundwater ingestion and crop ingestion
Th-229		4E-07	3010[a]	NA	NA	Groundwater ingestion
Th-230		7E-07	3010[a]	NA	NA	Groundwater ingestion
Th-232		1E-09	3010[a]	NA	NA	Crop ingestion
U-233	1,3	**3E-05**	3010[a]	NA	NA	Groundwater ingestion
U-234	1,4	**2E-03**	3010[a]	NA	NA	Groundwater ingestion
U-235	1,4	**1E-04**	2662	NA	NA	Groundwater ingestion
U-236	1,4	**1E-04**	3010[a]	NA	NA	Groundwater ingestion
U-238	1,4	**3E-03**	3010[a]	NA	NA	Groundwater ingestion
Carbon tetrachloride	1,5	**2E-03[c]**	2105	**5E+01[c]**	2105	Inhalation and groundwater ingestion
Methylene chloride	1,3	**2E-05[c]**	185	1E-01[c]	2185	Groundwater ingestion
Nitrates	1,6	NA	NA	**1E+00**	2120	Groundwater ingestion
Tetrachloroethylene	1,6	NA	1952	**1E+00[c]**	2137	Groundwater ingestion and dermal exposure to contaminated water

Notes: For toxicological risk, the peak hazard index is given, and for carcinogenic probability, the peak risk is given.

1. **Green** = The contaminant is identified as a human health contaminant of concern based on carcinogenic risk greater than 1E-05 or a hazard index greater than or equal to 1 contributing to a cumulative hazard index greater than 2.

2. **Brown** = Plutonium isotopes are classified as special-case contaminants of concern to acknowledge uncertainties about plutonium mobility in the environment and to reassure stakeholders that risk management decisions for the SDA will be fully protective.

3. **Blue** = Carcinogenic risk is between 1E-05 and 1E-04.

4. **Red** = Carcinogenic risk is greater than 1E-04.

5. **Pink** = Toxicological (noncarcinogenic) hazard index is greater than or equal to 1.

a. The peak groundwater concentration does not occur before the end of the 1,000-year simulation period. Groundwater ingestion risks and hazard indices were simulated for the peak concentration occurring within 10,000 years and are not presented in this table.

b. NA = not applicable.

c. The risk estimates were produced by scaling results from the Interim Risk Assessment (Becker et al. 1998) based on inventory updates.

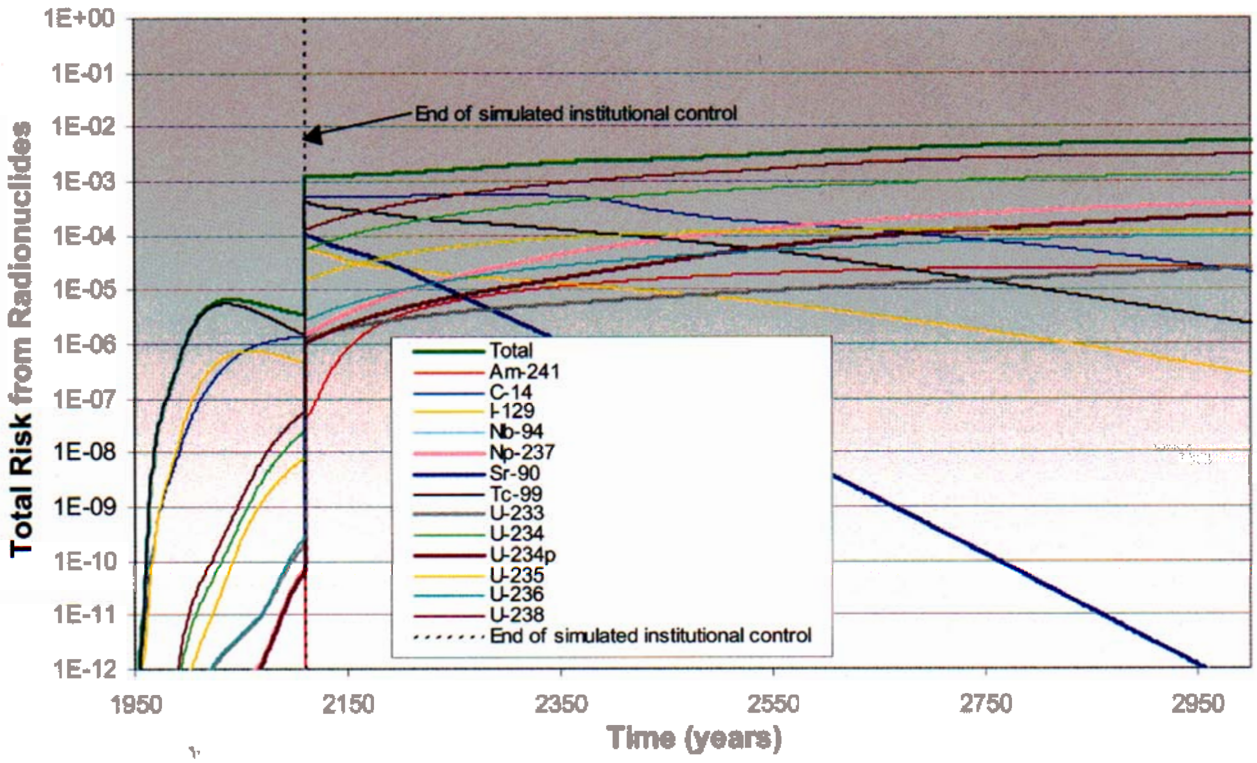

Figure 1-8. Hypothetical, future residential scenario cumulative risk estimates for radionuclides buried in the SDA.

Table 1-2. Ecological contaminants of concern.

	Hazard Quotient[a]			Hazard Quotient[a,b]	
Nonradionuclide Contaminant	Current Scenario	100-year Scenario	Radionuclide Contaminant	Current Scenario	100-year Scenario
Cadmium	<1 to <9	<1 to 20	Am-241	<0.1 to 21	0.7 to 41
Lead	<1 to <6	<1 to 20	Pu-239	NA	<0.1 to >1
Nitrate	<1 to >10	< 0.1	Pu-240	NA	<0.1 to >1
			Sr-90	<0.1 to >25	NA

NA— Concentrations for this contaminant did not exceed the ecologically based screening level. Therefore, it was not evaluated in the ecological assessment as a contaminant of potential concern for the given scenario.

a. The values reported represent the range of maximum hazard quotients calculated across receptor functional groups and species.

b. The range represents hazard quotients for both internal and external exposures.

Volatile organic compounds (i.e., carbon tetrachloride, methylene chloride, and tetrachloroethylene) and nitrates pose the most imminent risk. Nearly all of the volatile organic compounds and nitrates in the SDA originated at the RFP. Carbon tetrachloride has been detected in the aquifer slightly above the maximum contaminant level and is being extracted from the vadose zone to reduce risk. However, volatile organic compound release from waste buried in the SDA is ongoing and, if not sufficiently mitigated by the vadose zone vapor-vacuum extraction, poses the most imminent risk.

Mobile, long-lived fission and activation products are the next and most immediate concern. The majority of the mobile fission and activation products was generated by INEEL reactor operations. The degree of urgency associated with risk estimates for fission and activation products has not been validated because of uncertainties associated with C-14, I-129, and Tc-99 model parameters. Though these contaminants have been detected sporadically in the environment and some trends may be developing, they do not occur at levels predicted by the modeling. Monitoring locations immediately proximal to the waste using waste zone probes are extremely important to assess the rate at which potential contamination in the vadose zone is developing. Interpreting monitoring data can be used to validate the appropriateness of expedited remediation of buried waste to mitigate risk.

Uranium isotopes and Np-237 contribute the majority of the risk several hundred years in the future. Roughly half of the uranium inventories was generated at the INEEL, while the other half was generated off-Site, primarily at the RFP. Evaluating the nature and extent of uranium in the environment is confounded by naturally occurring concentrations of various isotopes in environmental media. Uranium attributable to human activities has been detected in the vadose zone beneath the SDA, indicating that some migration may be occurring. However, all local aquifer concentrations are consistent with natural uranium background values. Most of the original disposals of Np-237 originated at the INEEL, and nearly all of the Am-241 (the parent of Np-237) was generated at the RFP. Though Am-241 has been detected sporadically in the environment, Np-237 has not been detected.

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2. IDENTIFICATION AND SCREENING OF REMEDIATION TECHNOLOGIES

This section presents the first screening stage of the PERA, in which existing, demonstrated remedial technologies and process options are compiled, listed, and evaluated for technical applicability. Identified technologies and process options cover a range of possible remediation approaches, referred to as general response actions (GRAs), and provide a number of potentially viable options capable of meeting project remedial action objectives (RAOs) and specific health-based and regulatory requirements (ARARs) for WAG 7.

2.1 Remedial Action Objectives

Under CERCLA (42 USC § 9601 et seq.), RAOs identify the results desired from a given remedial action to protect human health and the environment. The WAG 7 RAOs were developed in accordance with the "National Oil and Hazardous Substances Pollution Contingency Plan" (NCP) (40 CFR 300) and EPA guidance (EPA 1997; EPA 1988). The RAOs can generally be achieved by either reducing contaminant concentrations, immobilizing contaminants through treatment, or containing contaminants using protective administrative and physical barriers. An assumption for this PERA is that DOE or another government agency will retain control of the SDA in perpetuity and that final CERCLA actions will include capping and institutional controls to ensure protectiveness for contamination remaining at the RWMC.

Because RAOs are target objectives for cleanup activities, they offer a basis for evaluating a remedial alternative's capability to satisfy ARARs and protect human health and the environment. The RAOs specified for protecting human health and the environment are expressed in terms of both risk and exposure pathways and are achieved by reducing contaminant levels and restricting or eliminating exposure pathways. The RAOs identified for this analysis for human health and ecological receptors (specifically flora and wildlife) are presented in Figure 2-1.

Remedial Action Objectives for WAG 7

- Limit the cumulative human-health cancer risk for soil and groundwater exposure pathways to less than or equal to 1E-04
- Limit the noncancer risk for soil and groundwater exposure pathways to a cumulative hazard index of less than 2 for current and future workers and future residents
- Inhibit migration of contaminants of concern (COCs) to groundwater
- Inhibit ecological receptor exposures to COCs in soil and waste with concentrations greater than or equal to 10 times background values, resulting in a hazard quotient greater than or equal to 10
- Inhibit transport of COCs to the surface by plants and animals.

Figure 2-1. Remedial action objectives.

As discussed in Section 1.1, the PERA presented in this report focuses on remediating the source term within the SDA and does not assess specific remedial actions that address contamination previously released to the underlying vadose zone and groundwater. Therefore, in evaluating a remedial action's ability to achieve the RAOs, this PERA considers only influences of future contaminant releases from the source term.

2.2 Assumptions

The principal assumptions used in developing the PERA are these:

1. The PERA will address remediation of buried waste and contaminated soil down to the first basalt interface beneath the SDA. Remediation of groundwater and the vadose zone below the first soil/basalt interface will not be evaluated in the PERA. The OCVZ project is addressing volatile organic compounds (VOCs) in the vadose zone and groundwater.

2. The selected remedial alternative will include a cap over all or part of the SDA. Capping scenarios will include designs appropriate to local SDA conditions, including a biotic barrier.

3. Response actions will be limited to COCs identified in the ABRA (Holdren et al. 2002).

4. Estimates of maximum and average concentrations of the COCs in disposal locations will be based on disposal records and probing data.

5. Preliminary remediation goals will be based on carcinogenic risk of 1E-04 and a hazard index of 1.0. Remedial action will be implemented if media concentrations are greater than background values and one of the following conditions is true:

    a. Estimated carcinogenic risk is greater than 1E-04

    b. Estimated hazard index is greater than 1 for soil pathways, greater than 1 for the groundwater pathway, and greater than 2 for both pathways combined

    c. Simulated groundwater concentrations exceed maximum contaminant levels (MCLs).

6. Waste buried in the SDA before 1970 contains small quantities of irradiated fuel material. Soil vault rows contain high-activity, low-level waste, but no high-level waste.

7. The majority of the VOCs is buried in Pits 2, 4, 5, 6, 9, and 10.

8. Most overburden and soil between waste zones is not contaminated above preliminary remediation goals and therefore will not require remediation. Cost estimates and evaluations for retrieval and ex situ treatment alternatives will be based on the volume defined by multiplying the combined areas of waste zones by the average depth to basalt excluding the clean overburden. Waste volumes will be defined by available inventory data. Contaminated soil volumes will be defined as all interstitial soil within a waste unit plus an additional 0.3 m (1 ft) of soil from the underburden and overburden to account for potential contaminant migration and uncertainty in waste area dimensions.

9. Cost estimates and evaluations of in situ treatment alternatives will be based on the combined areas of the waste zones and the average depth to basalt including the overburden.

10. The PERA will address the total waste unit volume estimates as the WAG 7 ABRA (see Table 3-1).

11. Some of the drums buried in the SDA contain freestanding, potentially flammable liquid.

12. Active low-level waste disposal operations at the SDA will continue until 2020. Any alternative evaluated in the PERA will incorporate measures to accommodate ongoing operations.

13. Any waste retrieved from the SDA containing transuranics in concentrations greater than 100 nCi/g will be shipped to WIPP.

14. Treatment residuals for OU 7-13/14 can be disposed of onsite that have less than 100 nCi/g transuranic waste (TRU) and meet RCRA (42 USC § 6901 et seq.) land disposal restrictions (LDRs) and all risk-based levels established in the OU 7-13/14 ROD.

15. Final closure of ongoing disposal operations (i.e., Pits 17 through 20 including the engineered soil vaults) will be evaluated and implemented under CERCLA as a component of the OU 7-13/14 remedial action.

16. Remedial alternatives evaluated in the PERA for addressing contaminated soil within the SDA are sufficient to address potentially contaminated soil within TSA.

2.3 Project Environmental Standards

Remediation alternatives developed in later sections of this WAG 7 PERA include technologies that treat, contain, or isolate waste to prevent biotic exposures and minimize future contaminant releases to adjacent media. To assess a remedial alternative's ability to provide long-term protection of human health and the environment, preliminary standards and limits must be established to identify ARARs and PRGs that address identified COCs.

2.3.1 Regulatory Status

Developing and evaluating remedial action alternatives for WAG 7 require understanding regulations that govern current RWMC operations and future remediation. Because of the continuing evolution of environmental regulations, managing waste within the RWMC has been subject to varying requirements over time. Currently, both RCRA and CERCLA remedial authority apply, as do DOE directives and orders, with RCRA applied to permitted areas within the active TSA facilities and CERCLA generally applied to areas contaminated by past practices. The PERA presented in this report does not address active operations or facilities currently operating within WAG 7. However, closure of the TSA and the active low-level waste (LLW) disposal operation in Pits 17 through 20 in the SDA will ultimately be incorporated into the final closure for the RWMC under CERCLA.

2.3.2 Applicable or Relevant and Appropriate Requirements

Applicable or relevant and appropriate requirements are regulations that influence the selection and implementation of a remedial action. Such requirements may be either *applicable* or *relevant and appropriate*, but not both. As promulgated under federal or state law, *applicable* requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations that specifically address a hazardous substance, remedial action, location, or other circumstance at a site. *Relevant and appropriate* requirements are those cleanup standards; standards of control; and other substantive environmental protection requirements, criteria, or limitations that address problems and situations sufficiently similar to those encountered at the site that their use is well-suited to the particular circumstance.

A requirement of CERCLA Section 121(d)(2)(A) is that remedial actions comply with federal, state, and tribal government ARARs. To be regarded as ARARs, state and tribal requirements must meet the following three criteria:

- Be a promulgated standard, requirement, criterion, or limitation under a state environmental or facility siting law
- Be more stringent than federal requirements
- Meet the definition of an ARAR (i.e., be either legally applicable or relevant and appropriate).

The ARARs identified by the feasibility study process serve only as screening criteria for evaluating alternatives—the final project ARARs will be identified in the future OU 7-13/14 ROD. The feasibility study process identifies only potential ARARs that protect human health and the environment during and following implementation of a given remedial action. The WAG 7 feasibility study evaluation determines whether a specific alternative can satisfy the potential ARARs while achieving the RAOs.

The ARAR analyses provided in this report compare numerous site-specific factors, including particulars of the remedial action, hazardous substances of concern at the site, and physical characteristics of the site, to those addressed in statutes and regulations. When ARAR analysis indicates that a requirement is applicable or relevant and appropriate, the requirement must be met or must satisfy specific statutory requirements in order to be waived. The ARAR analysis (provided in Appendix A) includes promulgated environmental requirements, criteria, standards, and other limitations, and presents potential WAG 7 ARARs in terms of three primary categories:

- Chemical-specific ARARs—These generally establish media-specific (air, soil, groundwater, and surface water) concentration limits or discharge limitations for specific chemicals. When an individual chemical is subject to more than one limitation, the more stringent requirement is typically used.
- Location-specific ARARs—These relate to geographical or physical position of the site, limit types of remedial action that can be implemented, or may impose additional constraints on some remedial alternatives.
- Action-specific ARARs—These generally establish performance, design, or other similar action-specific controls or restrictions on particular activities, and are activated by specific remedial actions selected to accomplish a remedy. The action-specific requirements themselves do not determine remedial alternatives, but indicate how or to what level selected alternatives must perform.

Other factors in selecting a remedy, designated as "to be considered" (TBCs), might include unpromulgated standards, criteria, advisories, or specific DOE orders. However, TBCs are neither legally binding nor evaluated using the formal process required for ARARs.

2.3.3 Contaminants of Interest

The ABRA (Holdren et al. 2002) identified human health and ecological COCs for buried waste within the SDA. A total of 16 human health COCs were identified that exceeded either a 1E-05 carcinogenic risk or contributed to a cumulative noncarcinogenic hazard index of 2 or more. As shown in Table 1-1, the exposure pathway that contained the majority of the COCs and exhibited the highest degree of risk was groundwater ingestion. Other pathways that exhibit unacceptable risks from one or more of the COCs include soil ingestion, inhalation, external exposure, and crop ingestion from surface uptake. The ABRA also identified seven ecological COCs (See Table 1-2), based on a hazard quotient of 1 for radionuclides and 10 for nonradionuclides. The primary pathways of ecological concern were associated with burrowing animals and insects and plant ingestion.

Remedial alternatives presented in this PERA are designed to achieve the RAOs by applying specific technologies to treat, isolate, immobilize, or remove waste streams containing the COCs. Technologies mitigate risks by directly treating COC-bearing waste or by inhibiting potential exposure pathways.

2.3.3.1 Cover Placement. After remedial measures are completed, all the alternatives presented in this PERA (with the exception of the No Action alternative) include employing institutional controls and placing a cover over the SDA to preclude direct access to any waste or areas of contamination (DOE-ID 1998). Placement of this cover would mitigate a number of exposure pathways identified in the ABRA as contributing to human health risk. Properly designed covers would mitigate human health COC risks associated with soil ingestion, inhalation, external exposure, and crop ingestion. Cover systems would also mitigate ecological COC risks related to vegetation uptake and burrowing animals and insects. It is assumed in this PERA that additional measures to address the COC risk associated with these pathways will not be necessary. Therefore, COC waste that exhibits ecological risks only, such as lead and cadmium, will not be targeted for additional remedial measures. Further, waste that poses risk only via soil ingestion, inhalation, crop ingestion, or external exposure will not be targeted for additional remedial measures. Alternatives assembled in subsequent sections of this PERA are, therefore, primarily focused on developing methods to mitigate contaminant migration that may affect groundwater exposure pathways.

2.3.3.2 Protection of Groundwater. Development and analysis of remedial action alternatives, presented in following sections, focus on remediating the source term waste, through either containment, in situ treatment, or retrieval, as required to address risks identified in the ABRA (Holdren et al. 2002) associated with the groundwater ingestion pathway. The COCs identified for this pathway are listed below.

- C-14
- I-129
- Np-237 (and parent Am-241)
- Tc-99
- U-233, U-234, U-235, U-236, U-238
- Carbon tetrachloride
- Methylene chloride
- Nitrates
- Tetrachloroethylene.

In addition to risk-based COCs listed above, Am-241 and three plutonium isotopes are groundwater COCs. Though Am-241 also was not a direct COC for groundwater ingestion, the majority of Np-237 is created through Am-241 decay. The three plutonium isotopes, Pu-238, Pu-239, and Pu-240, were classified as special case groundwater COCs to acknowledge uncertainties about plutonium mobility in the environment and to reassure stakeholders that risk management decisions for the SDA will be fully protective (Holdren et al. 2002). Because most plutonium in the SDA is collocated with risk-based COCs that have similar properties, treating plutonium isotopes as COCs will have little effect on analysis of alternatives or on risk management decisions.

Based on disposal records, the COCs are concentrated in several waste forms. A discussion of waste forms along with their distribution within the SDA is presented in the following subsections.

2.3.3.2.1 Actinides—Based upon results of fate and transport modeling conducted for the ABRA, actinide COCs were identified as representing the greatest long-term risks to area groundwater. As shown in Table 1-1, peak cumulative groundwater risk, occurring approximately in 3110, is primarily attributable to uranium and Np-237. Risk attributed to Np-237 is 4E-04, while risks attributed to uranium isotopes range up to 3E-03 for U-238.

Actinide COCs include Am-241, U-233, U-234, U-235, U-236, U-238, Pu-238, Pu-239, Pu-240, and Np-237. The majority of the long-lived, relatively immobile actinides are contained within the RFP sludge deposited in drums within the pits, Pad A, and Trenches 1 through 10. Distribution of actinide waste in the SDA is depicted in Figure 2-2.

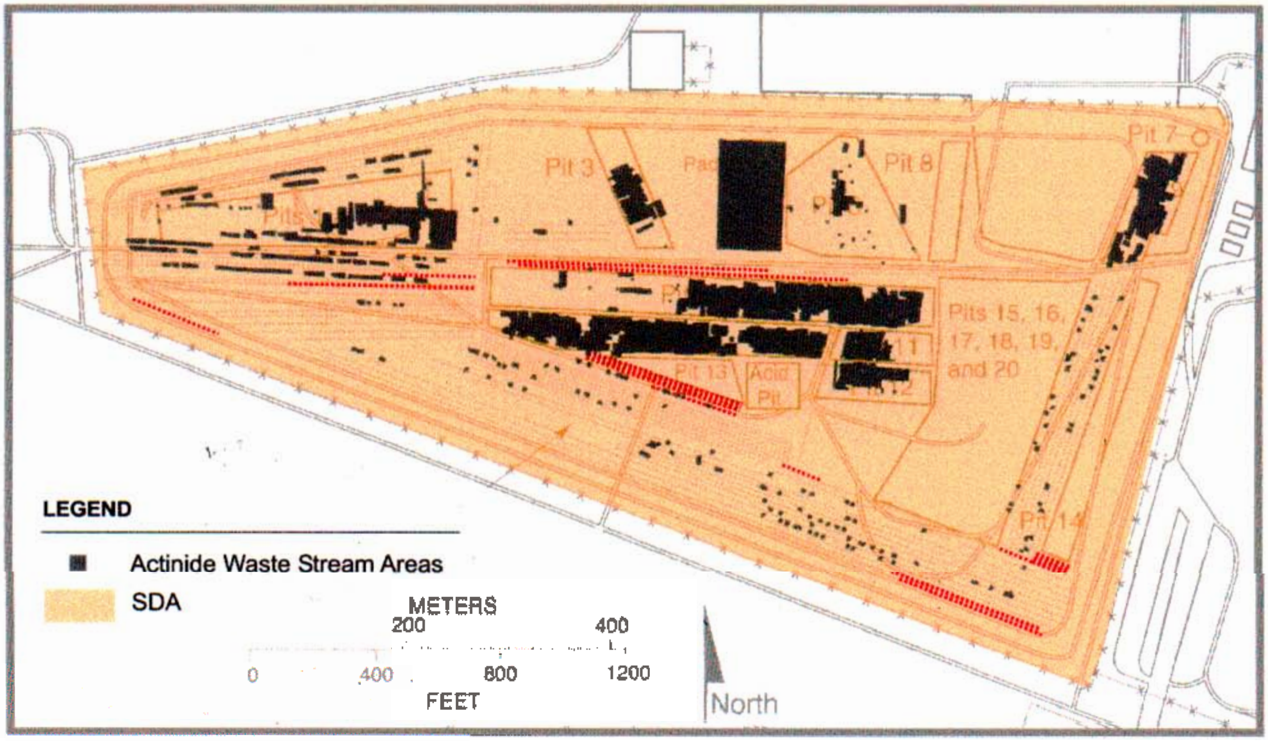


Figure 2-2. Actinide waste distribution in the Subsurface Disposal Area.

2.3.3.2.2 Activation and Fission Products—As shown in the ABRA, mobile long-lived fission and activation products constitute a significant contribution to near-term risk. As shown in Table 1-1, peak near-term groundwater risk in 2110 is primarily attributable to C-14, I-129, and Tc-99.

Activation product waste streams include C-14, Nb-94, and Tc-99, and fission product waste streams include I-129. Both waste streams were generated primarily from INEEL reactor operations and consist mainly of metal and scrap metal pieces, core loop components, core structural pieces, resins, and irradiated fuel material. Waste was buried in various container types, primarily in the trenches and as remote-handled waste in the SVRs. Distribution of waste is depicted in Figure 2-3.

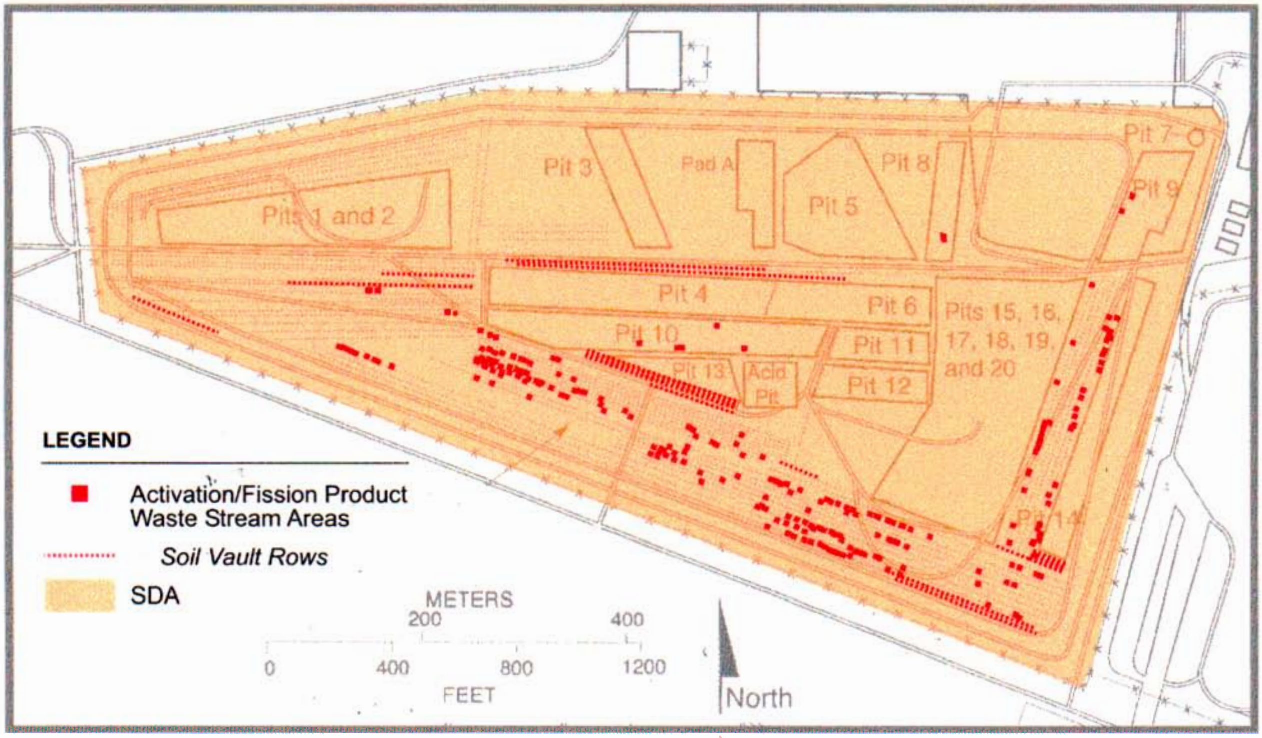


Figure 2-3. Activation and fission waste distribution in the Subsurface Disposal Area.

2.3.3.2.3 Volatile Organic Compounds—Volatile organic compound COCs include carbon tetrachloride (CCl_4), tetrachlorethylene (PCE), and methlyene chloride. Carbon tetrachloride, which was identified in the ABRA as the contaminant potentially posing the most imminent groundwater risk, has been previously detected in the underlying aquifer at concentrations slightly above drinking water standards and is being actively extracted from the vadose zone beneath the SDA. As shown in Table 1-1, the projected peak risks for CCl_4 occur in 2105 with a carcinogenic risk of 2E-03 and a hazard index of 50.

Almost all CCL_4 and PCE are contained in the bagged and drummed organic sludge (Series 743 Sludge) from the RFP. Methylene chloride is also contained almost entirely in the RFP waste streams consisting of sludge, paper, rags, plastic, equipment, and assorted debris. Distribution of VOC waste within the SDA is presented on Figure 2-4. As is shown, waste streams are primarily located in Pits 1 through 6 and 9 through 12 and Trenches 1 through 10.

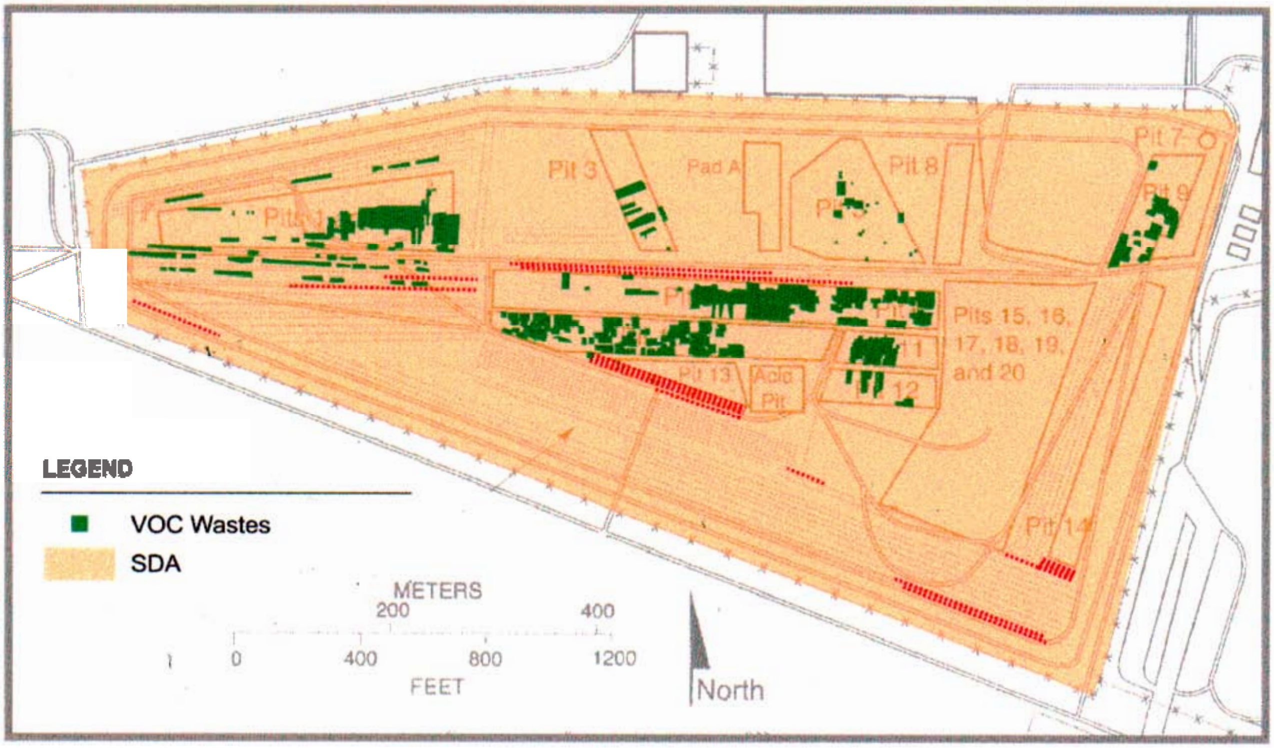


Figure 2-4. Volatile organic compound waste distribution in the Subsurface Disposal Area.

2.3.3.2.4 Nitrates—Nitrate was identified in the ABRA as a groundwater COC with a projected hazard index at the threshold value of 1.0 occurring in 2120. Nitrates within the SDA are located almost entirely in the drummed waste stream (Series 745 Sludge) shipped from the RFP between 1967 and 1970. Nitrate waste in the SDA is located within Pad A, and Pits 4, 6, 9, 10 and 11 as shown on Figure 2-5.

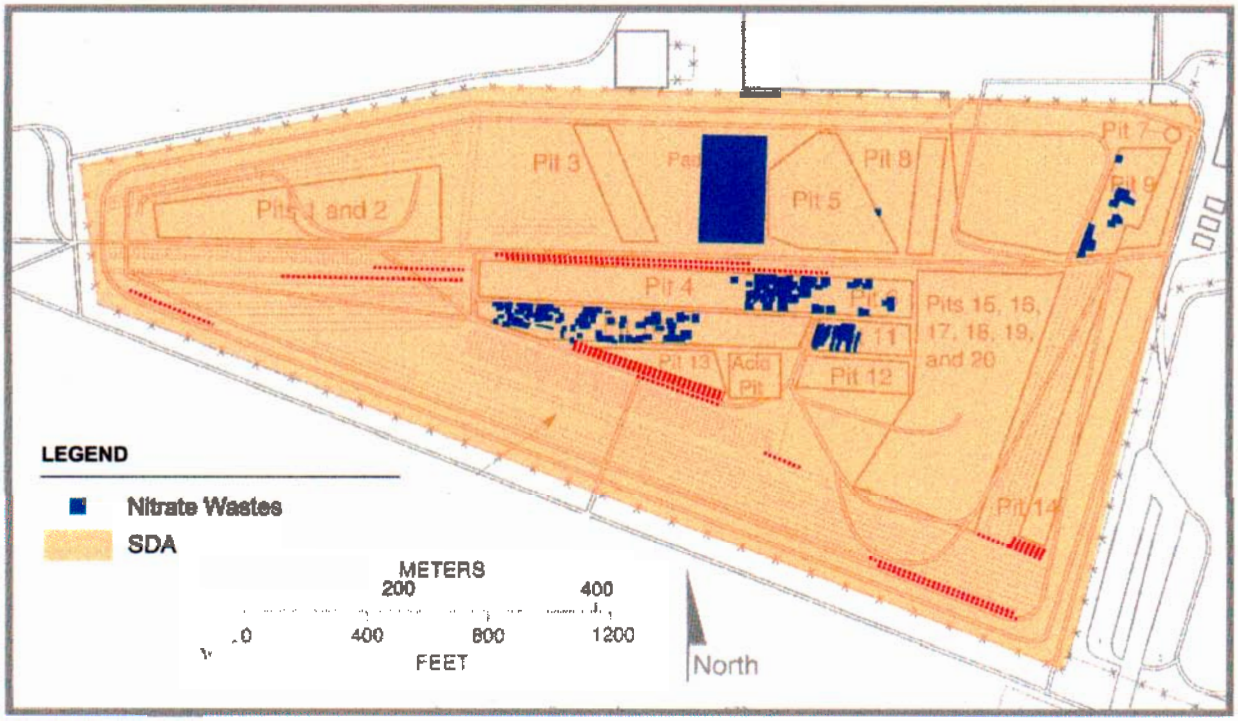


Figure 2-5. Nitrate waste distribution in the Subsurface Disposal Area.

2.3.4 Preliminary Remediation Goals

A PRG is a risk-based goal that is based on available site information. Specifically, PRGs focus on protecting human health and the environment and are therefore statements of desired endpoint concentrations or risk levels that provide adequate protection. In accordance with NCP guidance (40 CFR 300), PRGs are generated from readily available toxicity and exposure factor information (including contaminants, media, and pathways), reasonable exposure assumptions, frequently used standards (e.g., ARARs), and probable future land use. For probable future land use for parts of the INEEL site, including WAG 7, this analysis assumes continuing government control and ownership in perpetuity. Further, it is assumed that future residential development may occur within current INEEL boundaries and immediately adjacent to the RWMC, but not within the RWMC. Therefore, a residential scenario for possible exposure should be assumed for identifying PRG risks in the WAG 7 feasibility study. Final remediation levels, which are determined when a remedy is selected, will be presented in the future ROD.

In the feasibility study process, PRGs are used to quantify the extent of a remedial action that would be required to achieve the project RAOs. The ABRA concluded that the media of primary concern for future risk associated with the SDA are contaminated soil and groundwater. However, as discussed in Section 1.1, this PERA and the WAG 7 feasibility study will focus on remedial alternatives that mitigate release of contamination from the source term only. Therefore, technology applications for remediating area groundwater are not directly addressed. To protect future groundwater impacts, this PERA evaluates measures to control the source term through specific technology applications that contain or treat COC-bearing waste streams within the SDA and inhibit contaminant migration to the aquifer.

The source term is defined by dimensions of waste disposal units and contaminated soil extending down to the upper basalt zone interface. The volume of contaminated soil and waste requiring remediation is estimated based on historical records and available inventory data that define the volume and extent of COC-bearing waste streams.

Remedial alternatives are designed to protect groundwater through controlling future releases of contaminants from the source term. For the WAG 7 feasibility study, the effectiveness of a remedial action will be evaluated based on ability to achieve an acceptable release rate for each of the groundwater COCs, as required to meet groundwater quality standards and to protect human health and the environment. Developing contaminant-specific release rates was not within the scope of this PERA.

2.4 General Response Actions

Defined as general approaches that can be implemented to achieve RAOs, GRAs encompass a broad range of activities, including institutional controls, containment, in situ treatment, retrieval, ex situ treatment, and disposal. In some cases, multiple GRAs can be combined to form an individual assembled alternative (e.g., an alternative that retrieves, ex situ treats, and disposes of contaminated soil and waste).

The GRAs for WAG 7 are discussed briefly in following sections. Each GRA is defined by a number of specific remedial technologies and process options. Remedial technologies are methods for resolving specific technical problems within the GRA approach. For example, a GRA of containment could be accomplished with various remedial technologies: a surface barrier, surface controls, or subsurface horizontal and lateral barriers. In turn, process options are specific techniques that achieve the selected remedial technology. For example, the remedial technology of lateral barriers consists of a number of process options: slurry walls, grout curtains, sheet piles, or in situ soil vitrification.

2.4.1 No Action

The No Action GRA serves as a base comparison for other remedial actions and involves no specific technologies to treat, stabilize, or retrieve site contaminants, or to reduce potential exposure pathways with methods such as fencing or administrative controls.

2.4.2 Institutional Controls

The Institutional Controls GRA imposes physical or regulatory restrictions to prevent or limit access to contaminated areas for as long as DOE or another government agency owns the INEEL. DOE Order 5400.5, "Radiation Protection of the Public and the Environment," which states that DOE must maintain control of the site for as long as the waste left after remediation remains hazardous, would necessitate implementing administrative procedures, deed restrictions, fences or other barriers, signs, and security until the site could be released for unrestricted use. Monitoring is also a technology within the Institutional Controls GRA and is used as an element in all the alternatives (including No Action) to evaluate future environmental conditions.

2.4.3 Containment

The Containment GRA mitigates risks posed by chemical and radiological contaminants at the site by constructing physical barriers that prevent direct human and biotic contact and minimize and control contaminant migration to groundwater, surface water, or air. Specific containment technologies that potentially satisfy the WAG 7 RAOs include surface control or diversions, capping, lateral barriers, biotic barriers, and bottom sealing. Containment technologies prevent soil erosion, reduce infiltration of moisture that can transport contaminants to the groundwater, and eliminate surface exposure pathways.

2.4.4 In Situ Treatment

The In Situ Treatment GRA involves technologies that reduce risks posed by chemical and radiological contaminants while the waste remains in-place (in situ). Treatment technologies include physical, chemical, thermal, electrokinetic, and biological treatment to modify waste in-place and reduce contaminant mobility, toxicity, or volume by degradation, fixation, or destruction. In situ technologies are available that reduce mobility, toxicity, and volume of nonradiological waste and soil impacted by either inorganic or organic contaminants. However, no technology exists to destroy or reduce toxicity of radionuclides. Detailed discussions of two possible in situ treatments—in situ grouting (ISG) and in situ vitrification (ISV)—that address radionuclide mobility are presented in two reports prepared specifically for the PERA (Armstrong, Arrenholz, and Weidner 2002; Thomas and Treat 2002).

2.4.5 Retrieval

The Retrieval GRA involves physically removing overburden soil, interstitial soil, waste, and any impacted soil immediately beneath buried waste. Because of radioactive and hazardous characteristics of the SDA waste, retrieval systems that minimize worker exposure and maximize source control are required. Retrieval process options include traditional earth-moving equipment (e.g., backhoes, front-end loaders, and cranes), standard construction equipment with modifications, and remote techniques (e.g., robotics). A supporting report prepared for this analysis discusses potentially applicable retrieval process options and screening criteria in further detail (Sykes 2002).

2.4.6 Ex Situ Treatment

The Ex Situ Treatment GRA entails treating retrieved soil and waste via chemical, physical, thermal, electrokinetic, or biological technologies. The technologies focus on physical waste segregation (hazardous constituents versus nonhazardous), radiological segregation (e.g., TRU, LLW, and mixed low-level waste ([MLLW]), and processing to reduce toxicity, mobility, and volume of contaminants. The type of processing depends on governing requirements for specific waste, but could include sizing, treatment to remove or destroy organics, treatment to stabilize heavy metals, absorption of liquids, and repackaging. Depending on method of treatment, waste volume could either decrease or increase. For the assembled alternatives, treatment technologies evaluated for reducing mobility, toxicity, and volume are focused on retrieved MLLW, as required to meet specific regulatory requirements. Ex situ treatment for TRU waste and soil are focused primarily on segregation and sizing technologies to provide for off-Site disposal.

2.4.7 Disposal

The Disposal GRA involves the placement of retrieved waste and contaminated soil in on-Site and off-Site permanent waste management facilities to restrict contaminant mobility and mitigate exposure routes.

2.5 Remedial Technology Identification and Screening

In accordance with CERCLA feasibility study guidelines (EPA 1988), the preliminary technology screening evaluates effectiveness, implementability (technical and administrative), and relative cost of potentially applicable remedial technologies and process options that mitigate exposure risks associated with the WAG 7 COCs. Given the complexity of waste streams buried in the SDA, some uncertainties exist regarding the potential effectiveness, implementation, and cost of a specific technology or process option. Significant uncertainties are noted in the technology descriptions provided below and in the development and screening of alternatives presented in Sections 3 and 4.

A series of technical reports, as listed below, specifically support the PERA evaluations of effectiveness, implementability, and cost for a number of the process options.

- *Operable Unit 7-13/14 Evaluation of In Situ Grouting* (Armstrong, Arrenholz, and Weidner 2002)—The report focuses on applying ISG as a remediation technology for mixed radioactive waste landfills, evaluates the effectiveness and implementability of the technology, and summarizes previous applications of ISG.

- *Operable Unit 7-13/14 Evaluation of In Situ Vitrification* (Thomas and Treat 2002)—The report details potential ISV applicability to waste and conditions documented at the SDA and evaluates issues of effectiveness and implementability, previous applications, and data gaps associated with the technology.

- *Operable Unit 7-13/14 Evaluation of Soil and Buried Transuranic Waste Retrieval Technologies* (Sykes 2002)—The report presents soil and buried TRU waste retrieval alternatives applicable to the SDA and identifies issues at the SDA, including effectiveness, implementability, and cost of retrieval actions.

- *Operable Unit 7-13/14 Evaluation of Short-Term Risks* (Schofield 2002)—The report assesses the short-term effectiveness of each alternative in protecting human health and the environment during preconstruction, construction, operation, and deactivation, decontamination, and decommissioning (D&D&D) phases until response objectives have been met.

Evaluation of effectiveness assesses the ability of each technology or process option to remediate waste media and meet RAOs. Specific assessments include:

- Ability of the technology to handle the types and volumes of contaminated media

- Reliability of the technology relative to contaminants and conditions at the sites

- Potential impact on human health and the environment resulting from implementing the technology.

Evaluating implementability assesses technical and administrative aspects of each technology. *Technical* implementability refers to technology-specific parameters that constrain effective construction and operation of the technology relative to site-specific conditions. *Administrative* implementability refers to the success in obtaining required permits for on-Site and off-Site actions, the availability of treatment, storage, and disposal services; the availability of equipment and personnel required for implementing the technology; and the ability to meet ES&H requirements.

Considerations of cost include relative estimates of capital and operation and maintenance costs. Engineering judgment is used to gauge costs as high, moderate, or low relative to other process options in the same technology.

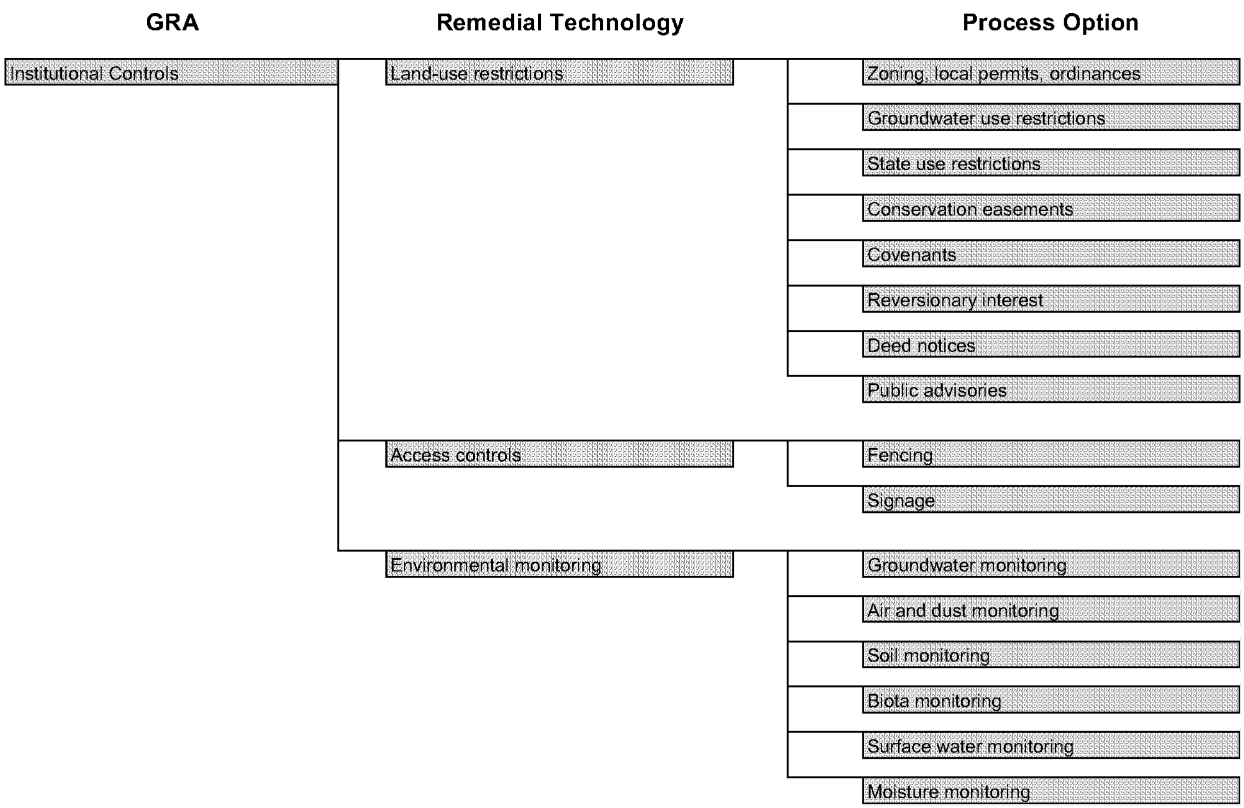
Remedial technologies and process options identified for each GRA, along with results of the screening evaluations, are described in following sections and summarized in Appendix B. Following sections also identify representative process options and designs for a technology or GRA, where applicable.

2.5.1 No Action

No specific technologies directly relate to the No Action GRA. However, EPA guidance for developing an RI/FS indicates that monitoring is an appropriate element in a No Action alternative (EPA 1988). Therefore, an environmental monitoring component has been included in the No Action alternative presented in Sections 3 and 4.

2.5.2 Institutional Controls

Three basic remedial technologies were evaluated for the Institutional Controls GRA: land-use restrictions, access controls, and environmental monitoring. Process options associated with each technology are presented on Figure 2-6. Descriptions and results of preliminary screening for each of the remedial technologies are presented in following subsections.



NOTE: Shading indicates technologies and process options retained for evaluation.

Figure 2-6. Institutional controls screening summary.

2.5.2.1 Land-Use Restrictions. Future land use at the site could be controlled with a number of projected process options. Measures that DOE could use to implement long-term stewardship of the SDA involve various options:

- Zoning, local permits, ordinances—Primary vehicles used by local governments to control land use. Zoning regulations are not necessarily permanent because they can be repealed or local governments can obtain exemptions after public hearings. In addition, zoning regulations might not be fully effective unless monitored and enforced.

- Groundwater-use restrictions—Restrictions include limitations or restrictions on well drilling in the affected area or buffer zone. Local governments could impose such restrictions to limit or prohibit certain uses of groundwater.

- State-use restrictions—State statutes could be imposed that authorize DOE to establish use restrictions specifically for contaminated property. Such statutes would override common law impediments to allow long-term enforceability of the property interests. The state or the federal government may shoulder the role for enforcement.

- Conservation (positive and negative) easements—State statutes could be imposed to establish easements to conserve and protect the property and limit future construction activities. Positive easements could be imposed to allow monitoring access. Negative easements could be imposed to prohibit drilling or other activity.

- Covenants—An agreement could be made upon conveyance of the property to use or refrain from using the property in a certain manner.

- Reversionary interest—A clause could be placed in a deed specifying that the property would revert to the original owner under certain conditions. Such a clause might further place conditions on the transferee's right to own and occupy the property and could be binding upon any subsequent purchasers.

- Deed notices—A deed notice commonly refers to a nonenforceable, purely informational document filed in public land records that alerts anyone researching records to information about the property. Notices could discourage inappropriate land use, but would have little or no effect on a property owner's legal rights concerning the property.

- Public advisories—Public advisories could be issued by public health agencies at federal, state, or local levels warning potential users of the land, surface water, or groundwater of existing or impending risk associated with that use. Such advisories have no legal or enforceable effects, but might reduce certain uses of a site and could provide information to the public.

All land-use restriction measures discussed above have been retained as potential components of a remedial action alternative. The identified measures can be used in combination with other action-specific technologies to prevent compromising associated site controls, minimize future maintenance requirements, and provide control for potential exposure pathways that might result in an unacceptable risk to human health. Notably, however, the measures focus on controlling human access to the site and do not address potential ecological exposures.

2.5.2.2 Access Controls. Process options associated with Access Control technology include fencing and signage to reduce risks to human health by inhibiting exposure to contaminants in the SDA. Fencing involves enclosing individual or contiguous areas inside a fence with a locking gate. Signage offers posted warnings that inform potential intruders of site dangers. Process options primarily focus on potential human intruders, but also could be effective in limiting exposure to some animals. Fencing and signage are viable technologies for surface contamination that is neither a groundwater exposure risk nor likely to become airborne if undisturbed.

Access controls have been retained for assembly into potential remedial alternatives. Both fencing and signage are easily implemented and can be combined with other remedial actions to add an additional degree of protectiveness and minimize future damage associated with site intrusions.

2.5.2.3 Environmental Monitoring. Monitoring of potentially affected environmental media could be used to evaluate the effectiveness of an alternative in achieving RAOs. Environmental monitoring can include a number of process options:

- Groundwater monitoring—Groundwater monitoring could be performed to assess the effectiveness of remedial measures in inhibiting contaminant migration to the aquifer.

- Air monitoring—Air monitoring could include using high- and low-volume air samplers to determine if fugitive radionuclides escape sites where contaminated surface soil exists.

- Soil monitoring—Soil monitoring could include radiation surveys over and around sites where contaminated soil and debris are left in-place to determine whether radionuclides have been transported to the surface by plants or animals.

- Biotic sampling—Animal tissue could be analyzed for bioaccumulation of COCs. Vegetation also could be analyzed to evaluate contaminant uptake.

- Surface water monitoring—Surface water sampling could be performed to monitor effectiveness of remediation during runoff events.

- Moisture monitoring—Monitoring perched water and soil moisture within the vadose zone could be used to provide an early warning of infiltration and contaminant migration. Moisture monitoring in surface barriers and underlying vadose-zone soil could be performed to assess effectiveness of remedial measures.

Environmental monitoring provides for future assessment of environmental conditions and evaluation of the effectiveness of action-specific remedial alternatives, and has been retained for potential incorporation into the proposed remedial alternatives.

2.5.3 Containment

Containment technologies focus on constructing physical barriers to prevent direct contact with site contaminants and to minimize future contaminant migration. Technologies and process options for the containment GRA are divided into four areas:

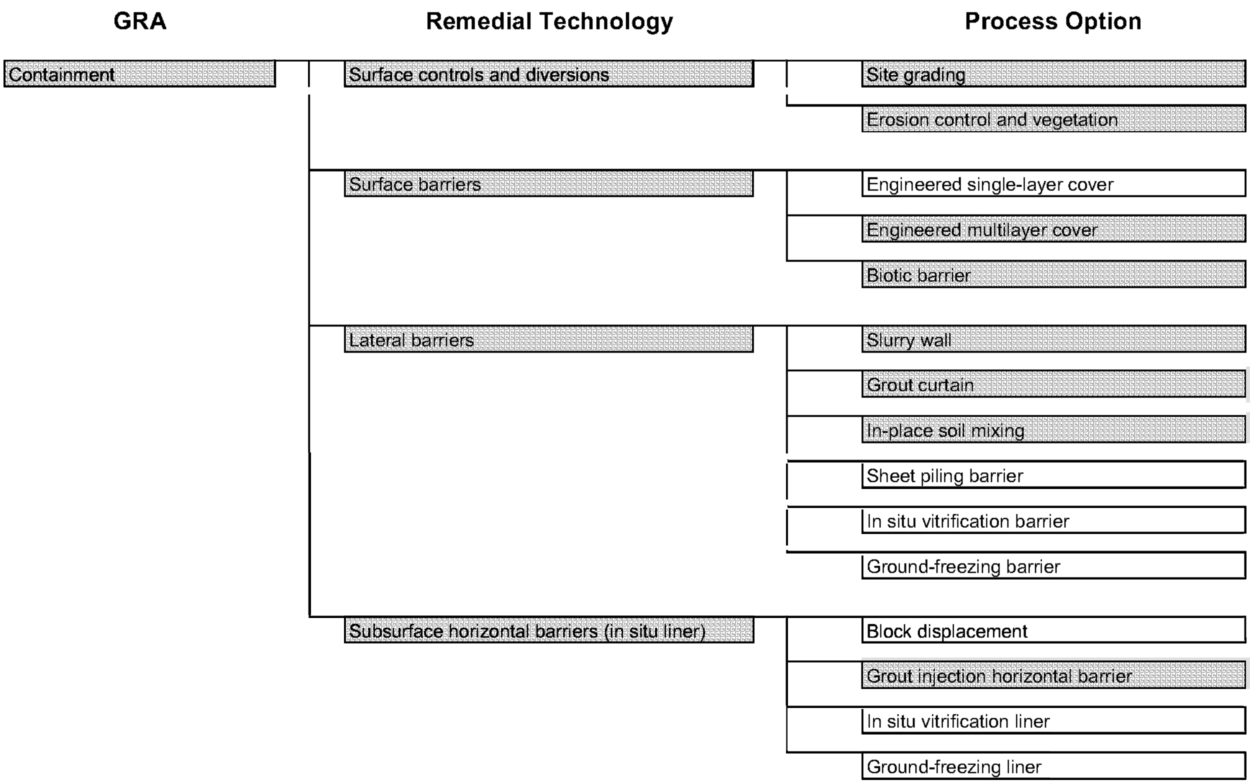
- Surface controls and diversions—Include measures to control surface water and minimize effects of erosion

- Surface barriers—Include measures to minimize surface water infiltration and inhibit biotic intrusion

- Lateral barriers—Include measures to control the lateral movement of moisture

- Horizontal barriers—Include measures to minimize the vertical movement of leachate from the source term.

Evaluated process options and screening related to effectiveness, implementability, and costs are presented in Appendix B. Figure 2-7 presents a summary of the screening. Descriptions and results of preliminary screening for each of the remedial technologies are presented below.



NOTE: Shading indicates technologies and process options retained for evaluation.

Figure 2-7. Containment technologies screening summary.

2.5.3.1 Surface Controls and Diversions. Surface controls and diversion consist of two process options—site grading and erosion control. The site grading process option would contour the ground surface of the SDA or individual disposal pits, trenches, and soil vaults to route water away from waste zones to reduce infiltration. Required slope of the contoured surface would depend on a number of factors including gradational characteristics of surface materials, nature of surface vegetation, and potential for future foundation subsidence. Site grading also could entail creating drainage swales or berms to control surface water flow. Drainage swales in combination with surface grading could be used to route surface water away from the SDA. Berms around the perimeter of the SDA could be used to prevent surface water run-on from adjacent areas.

Erosion-control measures include a physical cover to protect the soil from mobilization by precipitation and wind. Vegetation could function as erosion control and also provide physical cover. Vegetation generates transpiration, which removes water from the surface to a relatively shallow depth and reduces infiltration of surface water. A vegetated surface, if properly designed, is self-sustaining and long-lasting within a given climatic zone. Rock surfacing could also offer a means to minimize erosion from surface water runoff or wind, but may enhance infiltration.

Both the site-grading and erosion-control process options have been retained for developing remedial alternatives. Surface controls and diversions are essential to successfully implement any of the surface-barrier technologies discussed below.

2.5.3.2 Surface Barriers. Surface-barrier technology focuses on minimizing surface water infiltration into the waste, providing a biotic barrier to inhibit direct contact and intrusions by plants and animals, and inhibiting inadvertent human intrusion. As discussed previously in this PERA, the required construction of a surface barrier within the SDA is a basic assumption of the ABRA and has been incorporated as an element of all the alternatives (with the exception of No Action) assembled and evaluated in Sections 3 and 4. Three surface barrier process options have been identified: engineered single-layer covers, engineered multilayer covers, and biotic barriers. Specific design options associated with the process options are discussed below.

2.5.3.2.1 Engineered Single-Layer Cover—Engineered single-layer cover systems consist of a designed thickness of a single material such as compacted fine-grained soil, asphalt, concrete, and geomembranes. A single-layer cover was not retained for assembly into the remedial alternatives as a stand-alone design because of concerns associated with long-term effectiveness (i.e., the ability to achieve project RAOs and meet ARARs) and the availability of multilayer long-term cover systems (discussed in the following subsection), which are specifically designed to minimize long-term maintenance requirements. Single-layer cover systems considered in this PERA include:

- Soil cover—A soil cover alone would be susceptible to erosion, subsidence, biotic intrusion, and desiccation cracking, which would affect its long-term effectiveness. However, a soil cover could be used as a temporary option to facilitate implementing specific remedial alternatives. For the long-term, a soil cover is not suitable as a stand-alone process option.

- Asphalt cover—Asphalt is a flexible cover that can be designed to control surface-water infiltration, but environmental forces will degrade its integrity over time, and thus the cover would require continuous long-term maintenance to ensure compliance with RAOs.

- Concrete cover—A concrete cover would inhibit biotic intrusion into the waste until it cracks. Because concrete is rigid and subject to cracking, it cannot achieve RAOs and thus is eliminated from consideration.

- Geomembrane cover—Geomembranes show limited effective lives when exposed to the environment and would, therefore, require periodic replacement.

Though not retained as standalone process options, the basic design elements of the single layer cover systems, as presented above (i.e., soil, concrete, asphalt, and geomembranes), have been retained for incorporation into the design of the engineered multilayer cover systems discussed in the following subsection.

2.5.3.2.2 Engineered Multilayer Cover—The designs for engineered multilayer cover process options involve using different rock, soil, and synthetic materials to control surface water infiltration and prevent biotic (animal and plant) intrusions. Designs also offer varying degrees of protectiveness to inhibit future human intrusion into the waste. Individual layers within the cover systems incorporate drainage and filter zones, capillary breaks, low-permeability (infiltration control) zones, biotic barriers, and gas collection zones. Four available designs representative of the technology are discussed below.

- Standard RCRA Subtitle C Cap—The standard RCRA Subtitle C cap is designed to provide containment and hydraulic protection for a performance period of 30 years (DOE-RL 1993). The surface barrier comprises five layers with a combined minimum thickness of 1.65 m (5.5 ft) and a vegetated erosion-control surface. Additional optional layers for gas venting or biointrusion may be added.

- Modified RCRA Subtitle C Cap—The modified RCRA Subtitle C cap is designed for long-term containment and hydraulic protection for a performance period of 500 years, including provisions to control biointrusion. The surface barrier is composed of seven layers with a combined minimum thickness of 1.7 m (5.6 ft) and a vegetated erosion-control surface. Layers include topsoil with or without pea gravel, sand filter, gravel filter, lateral drainage layer, asphalt, and base course over grading fill. The asphalt layer controls both drainage and biotic intrusion. An optional gravel layer can be included in the design to control future gas migration from the waste.

- Long-term composite cover—The design of the long-term composite cover provides long-term isolation for radiological waste sites at the Hanford, Washington, DOE site for a performance period of 1,000 years. The cover is composed of nine layers of durable material with a combined thickness of 4.5 m (15 ft) and a vegetated erosion-control surface. Layers include topsoil with or without pea gravel, sand filter, gravel filter, fractured basalt, lateral drainage, asphalt, and base course over grading fill. The 1.5-m (5-ft) layer of fractured basalt is designed to prevent biotic intrusion. The overall thickness of the cover system also inhibits human intrusion. An optional gravel layer can be included in the design to control future gas migration from the waste.

- Idaho National Engineering and Environmental Laboratory Site Composite Cover—The INEEL CERCLA Disposal Facility (ICDF) cover is designed to provide containment and hydraulic protection for a performance period of 1,000 years (Crouse 2002). The barrier is composed of nine layers with a combined thickness of 5.25 m (17.5 ft) and a vegetated erosion control surface. Layers include silt loam topsoil, sand and gravel filter layers, a cobble biointrusion layer, drainage gravel, a geomembrane, and compacted silt loam over a site-grading fill. The INEEL-specific design includes a 0.75 m (2.5 ft) layer of fractured basalt to prevent biotic intrusion. An optional gravel layer can be included in the design to control future gas migration from the waste.

Typical sections for each of the four designs are presented on Figure 2-8.

Engineered multilayer cover designs are all potentially implementable at the site. Preliminary borrow source evaluations indicate that suitable soil and rock construction materials are available either within the INEEL or from adjacent off-Site sources. A more detailed evaluation of suitability and volume of materials will have to be conducted. All identified cover systems would be effective in controlling surface water infiltration. The primary difference in potential effectiveness of the systems is projected design life.

The standard RCRA Subtitle C cap, with a projected design life of 30 years, represents a minimum requirement for hazardous waste landfills and is insufficient to address contamination within the SDA. Extensive maintenance and periodic replacement to address the project RAOs would be required. For this reason, the Standard Subtitle C cap was not retained for consideration in developing remedial alternatives at the site.

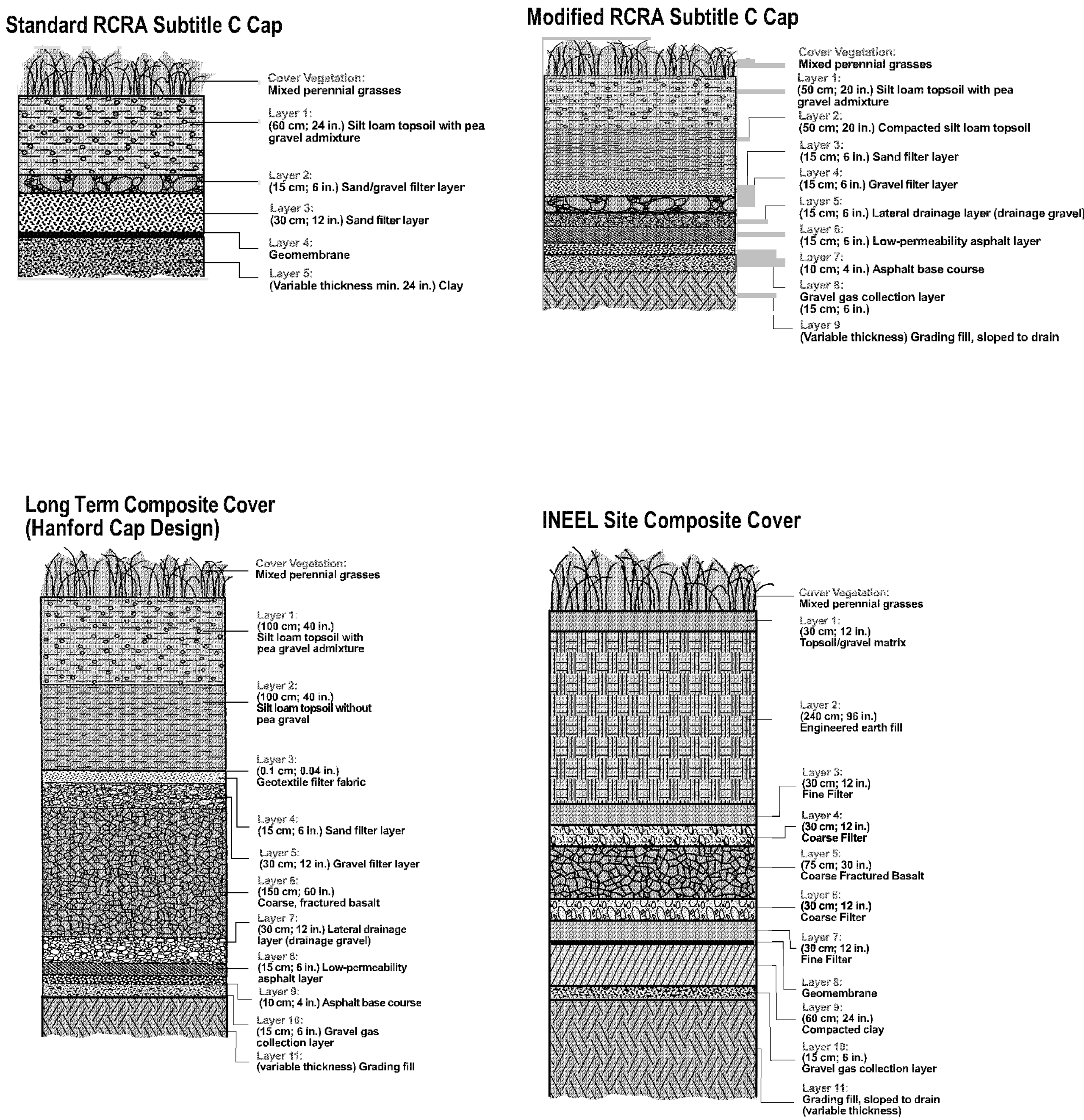


Figure 2-8. Engineered multilayer cover designs.

The modified RCRA Subtitle C cap provides an upgraded design life of 500 years that addresses long-term containment and the hydrologic protection requirements for sites containing LLW and MLLW. The upgraded design includes provisions to control biotic intrusion and incorporates RCRA minimum technology guidance with modifications for extended performance. One major change is elimination of the clay layer, which may desiccate and crack over time. The upgraded cap design (DOE-RL 1993) has been retained for consideration in developing remedial alternatives for the site. Its primary application will focus on alternatives that include either retrieval or in situ treatment for the LLW and MLLW components of buried waste. The cap will require periodic maintenance to ensure conformance with the RAOs with a full replacement every 500 years.

The long-term composite cover system was designed for the Hanford DOE facility to provide 1,000-year isolation of sites with greater-than-Class C waste, greater than Class C mixed waste, or significant inventories of TRU waste. The Hanford barrier is designed to provide the maximum available degree of containment and hydrologic protection. Evaluation of barrier needs for the national environmental restoration program identified the Hanford cover system as the baseline barrier design for cover alternatives at sites containing this type of waste. The ICDF cover system is a modification of the Hanford system designed to address site-specific environmental conditions and provide a 1,000-year design life. The ICDF cover system has been retained for consideration in developing remedial alternatives. Its primary application will focus on alternatives that involve TRU components of waste remaining in-place in an untreated state. The cap would require periodic maintenance to ensure conformance with the RAOs with a full replacement every 1,000 years.

2.5.3.2.3 Biotic Barrier—A biotic barrier is an engineered cover system designed to prevent direct contact with site contaminants and future intrusions into waste by plants and animals. Only one design, the Stationary Low-Power Reactor No. 1 (SL-1) Burial Ground cap, is evaluated. Designed for the INEEL WAG 5 Auxiliary Reactor Area, the SL-1 cap involves layers of basalt cobbles underlain and overlain by gravel, with a rock-armor surface designed to inhibit biotic intrusion. The design provides a total minimum thickness of 1.8 m (6 ft) to control surface exposures to radionuclides and inhibit biotic intrusion for approximately 400 years (INEEL 1996). A typical section depicting the biotic barrier design is presented in Figure 2-9.

The biotic barrier process option has been retained for assembly into remediation alternatives. The cover design will provide a degree of protection in restricting future biotic intrusions but increases surface water infiltration relative to undisturbed soil; any rainfall or snowmelt on the barrier rapidly moves through the depth of the very porous rock-armor and gravel-cobble layers beyond the depth of evaporation. The placement of SL-1 cap alone, therefore, would increase risk of future leaching of contaminants from the source term to underlying groundwater.

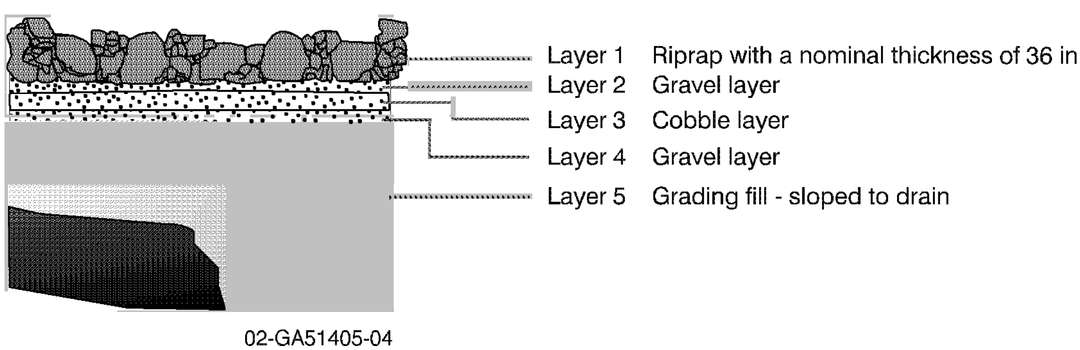


Figure 2-9. Biotic barrier (Stationary Low-Power Reactor No. 1 cap).

2.5.3.3 Lateral Barriers. The lateral-barrier technology focuses on controlling lateral movement of moisture into and out of the SDA. Barriers would be constructed within the upper vadose zone soil extending from ground surface down to a design depth below bottom of waste zones, as required to control moisture movement. As shown in Figure 2-7, six basic process options for lateral barriers have been identified.

2.5.3.3.1 Slurry Walls—Slurry walls are a proven technology that can be readily implemented at the SDA with conventional earthwork equipment. Slurry walls are constructed by excavating a vertical trench around waste areas to a depth that is at or below bottom elevations of contaminated soil or waste materials. Trench stability is maintained by placing a liquid slurry of bentonite and water in the trench as excavation progresses. When the trench reaches the proposed maximum depth, the slurry is displaced from the bottom up with a dense barrier material consisting of soil bentonite, cement grout, polymers, plastic concrete, or other low-permeability materials. Using a continuous trenching construction method, cavities for slurry walls can be continuously excavated with a backhoe or excavator, filled with slurry, and backfilled with low-permeability material until waste disposal areas are completely encircled. Slurry walls can be excavated to depths of more than 30 m (100 ft) and can have a permeability as low as 1E-06 to 1E-07 cm/sec.

The slurry wall process option is implementable within the SDA and should provide an effective barrier to control lateral movement of water in upper vadose zone soil and underlying basalt. Conventional earthwork equipment, if properly sized, would be able to penetrate the near surface basalt layer and install the wall to the required design depth.

2.5.3.3.2 Soil Mixing—The in-place, soil-mixing process option uses multistemmed augers and mixing paddles to construct overlapping columns of soil mixed with cement, bentonite, or other admixtures. Soil columns are formed by pumping grout through hollow drill shafts and injecting grout into soil at the pilot bit. Grout is mixed with soil by the augers and mixing paddles as the augers are advanced. Once one series of columns is completed, additional columns are drilled using a specified overlapping pattern. The overlapping columns form a continuous wall of low-permeability material. Barriers are generally 0.5- to 0.9-m (1.5- to 3-ft) thick and can reach depths of more than 30 m (100 ft) depending on soil conditions.

A proven technology, soil mixing could be implemented at the SDA though overall costs are projected to be higher than costs for slurry wall technologies. Multiple auger systems have been designed to penetrate most geologic conditions, enabling this technology to achieve required design depths in the underlying basalt layer.

2.5.3.3.3 Grout Curtains—The grout curtain process option involves drilling around perimeters of waste disposal areas from ground surface to an elevation at or below bottoms of waste materials and injecting grout at high pressures (jet grouting) into each drill hole. A heavy duty, direct-push drill rig is used to advance casing to the specified depth. The casing tip is removed and grout is injected at discrete intervals from the bottom up as the casing is removed. Injection rates are carefully monitored to ensure that casings do not fill and that maximum dispersion of grout is achieved. A thrust block system would be required at ground surface to control grout flow. Intervals between grout injection holes would depend on hydrogeologic properties controlling dispersion of the grout. Multiple column layers form the wall or grout curtain.

While the grout injection process could be carefully monitored to achieve a minimum permeability and maximum continuity of the grout curtain, the ability to verify continuity at depth is difficult. Installation of the curtain would be further complicated by subsurface conditions and the irregular nature of the basalt soil interface. Lack of continuity in the grout curtain could substantially influence effective permeability.

2.5.3.3.4 Sheet Piling—Sheet-piling consists of constructing a vertical cutoff wall by driving vertical strips of steel, precast concrete, aluminum, or wood into the soil. Sheet-metal piling with sealable joints is commonly used. Interlocking sheets are assembled before installation and driven or vibrated into the ground a few feet at a time until the desired depth is achieved. Sheets are sealed by injecting grout in the joints between the metal sheet piles. Continuous sheet piling walls can potentially be driven to depths of 91 m (300 ft) in unconsolidated deposits lacking boulders. Bulk hydraulic conductivities of 1E-08 to 1E-10 cm/sec have been achieved in test cells constructed of joint sealed sheet pile.

Sheet piling is not applicable at the SDA because of the shallow, irregular nature of the upper basalt layer, which could preclude installation of the piling to required design depths. In addition, the cost for construction of sheet pile walls is high relative to the cost for other types of lateral barriers.

2.5.3.3.5 In Situ Vitrification—In situ vitrification, as described in Section 2.5.4.2, has been investigated for potential use as a lateral barrier but is not a proven technology for this application. Cost for constructing ISV barriers is high relative to costs for other types of lateral barriers.

2.5.3.3.6 Ground-Freezing —The ground-freezing process option involves drilling and installing rows of pipes to a specified depth around a waste containment area. Within each pipe, a smaller diameter feed pipe is installed, permitting circulation of cooling medium that freezes soil between the pipes. A large portable refrigeration plant would be needed to cool and circulate the brine. The ground-freezing system would operate continuously as a closed system requiring constant monitoring. Barrier thickness is 9 to 12 m (30 to 40 ft), with the depth limited only by well drilling capabilities.

Ground-freezing has been implemented as a containment technology and has the advantage of being able to be turned off if new requirements are necessary or new technologies become available. However, its application in shallow bedrock areas and the complex subsurface conditions of the SDA is questionable. In addition, ground-freezing has a high capital cost relative to the cost for other types of lateral barriers and has a high projected operation and maintenance cost.

2.5.3.3.7 Lateral Barrier Screening Summary—As a result of the screening process for the lateral barrier technology (summarized in Appendix B), slurry wall construction using continuous trenching has been identified as the representative process option. This technology is commonly used when installing shallow barrier walls and is well suited for variable subsurface conditions within the SDA. The grout curtain process option also has been retained for consideration in developing remedial alternatives, though slurry walls are preferred because of complex subsurface conditions and concerns over verifying the integrity of a grout curtain. The in-place soil mixing process option is also potentially implementable at the SDA, though implementation costs are projected to be higher than the preferred slurry wall option. Sheet-piling was not retained for consideration in developing remedial alternatives because of the shallow basalt layer and projected high relative capital cost. The ISV and the ground-freezing process options were not retained because of developmental issues and their high relative costs.

2.5.3.4 Subsurface Horizontal Barrier (In Situ Liner). Subsurface horizontal barriers control vertical movement of leachate from the source term. The technology involves constructing the barrier in situ (i.e., with the waste materials in-place). Four basic process options have been identified (see Figure 2-7) and are briefly summarized in the following sections.

2.5.3.4.1 Block Displacement—Block displacement involves vertically displacing a large mass of earth with a low permeability material. One construction technique is forming a horizontal barrier below the surface by pumping soil bentonite slurry into a gridded series of notched injection holes. To create a horizontal barrier, high-pressure air is pumped through a notching nozzle in the bottom of a borehole to displace mud and groundwater. Sand is injected through the nozzle to erode a radial notch around the base of the borehole. When the desired notch size is attained, slurry is pumped through the borehole until the notch and casing are filled, and additional slurry is pumped under low pressure to lift the soil. The subsurface barrier thickness constructed is generally 0.15 to 0.3 m (0.5 to 1 foot). Block displacement has been demonstrated only on a small scale, where subsurface conditions consist of uniform soil.

Implementing this technology at the SDA is questionable because of complex subsurface conditions (i.e., the shallow and irregular nature the upper basalt layer which immediately underlies waste) and the large size of individual disposal units.

2.5.3.4.2 Grout Injection—The grout injection horizontal barrier process option requires vertical drilling through the bottom of waste disposal areas within the SDA and grouting the underlying basalt layer. Grout would be injected into basalt through vertical boreholes drilled in a gridded pattern, with overlap, as required, to achieve horizontal continuity. The potential application of horizontal drilling and grouting could also be evaluated during final design of a barrier system. However, for this PERA, horizontal grout injection was not identified as a preferred approach because of the sizes of the waste units and the ability to maintain horizontal and vertical control of drilling and grout placement in fractured basalt.

2.5.3.4.3 In Situ Vitrification—A horizontal barrier beneath the waste could possibly be constructed. The construction technique would involve injecting the starter path at depth and beginning the melting process below the base of the waste. Though ISV has been investigated for potential use as a horizontal barrier, it is not a proven technology.

2.5.3.4.4 Ground-Freezing—A subsurface liner using ground-freezing would be constructed by drilling horizontally beneath waste disposal areas or vertically through the waste and installing cooling piping. As stated previously, ground-freezing has been implemented as a lateral containment technology, but has not been successfully implemented as a horizontal subsurface barrier. Disadvantages of ground-freezing include the difficulty and uncertainty involved with horizontal installation of coolant piping in subsurface basalt and high relative operational and maintenance costs.

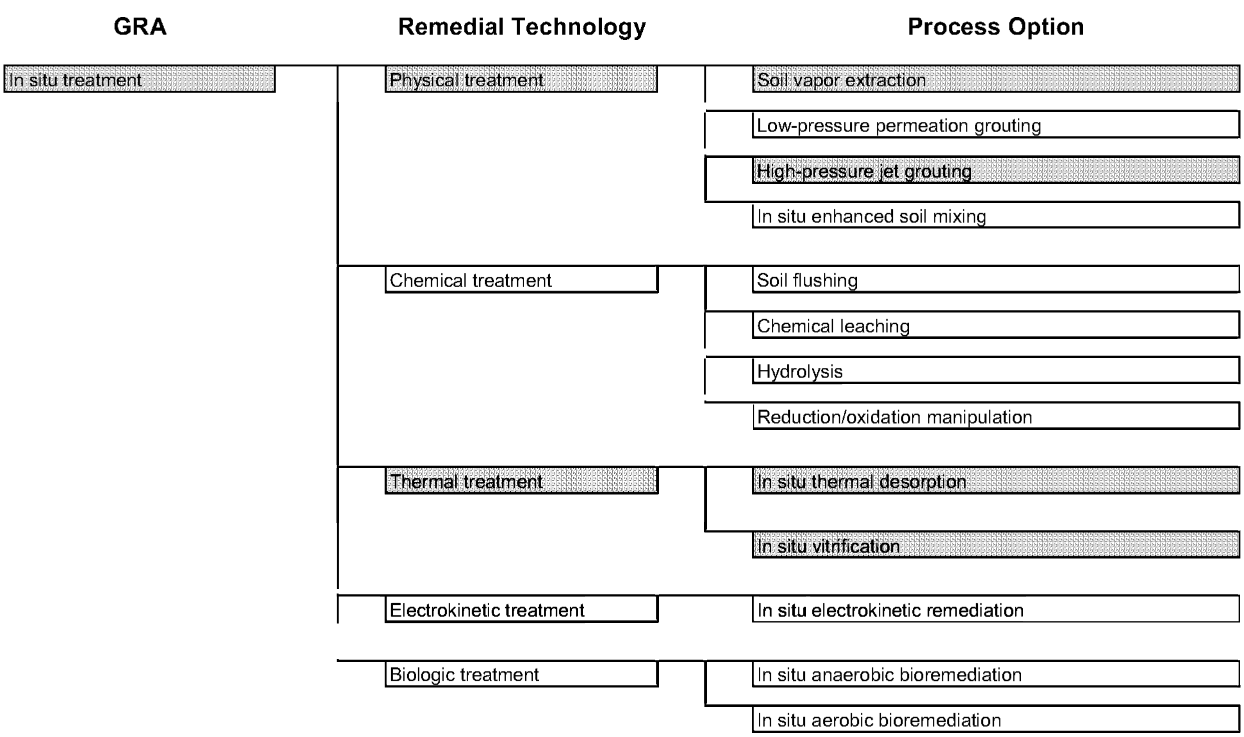
2.5.3.4.5 Subsurface Lateral Barrier Screening Summary—Though concerns exist about the difficulty of verifying continuity of the barrier, grout injection has been identified as the representative process option for constructing a subsurface horizontal barrier. Block displacement was not retained for consideration in developing remedial alternatives because of compatibility issues associated with either basalt present at the base of many disposal areas within the SDA or the unconsolidated waste (buried drums, vaults, and voids) contained in the SDA. In situ vitrification is not a proven technology for this application and was not retained. Ground-freezing also was not retained because of high relative operation and maintenance costs and uncertainty concerning implementability and effectiveness in basalt.

2.5.4 In Situ Treatment

In situ technologies are used to reduce volume, mobility, or toxicity of waste in-place (in situ). A major advantage is eliminating material handling requirements and short-term risks associated with excavation, ex situ treatment, and subsequent disposal of contaminated soil and waste. Process options have been grouped under five basic technology categories:

- Physical treatment—Employs mechanical processes to either extract contaminants from affected media or immobilize contaminants through blending or injecting a fixating agent
- Chemical treatment—Employs chemicals to either extract or degrade contaminants in affected media
- Thermal treatment—Employs heat to either extract or destroy contaminants in affected media
- Electrokinetic treatment—Employs electrical energy to extract contaminants from affected media
- Biologic treatment —Employs biological processes to degrade contaminants in affected media.

Process options evaluated for each in situ technology, along with specific screening comments related to effectiveness, implementability, and cost, are presented in Appendix B. A listing of the process options summarizing results of the screening evaluation is presented on Figure 2-10.



NOTE: Shading indicates technologies and process options retained for evaluation.

Figure 2-10. In situ treatment screening summary.

All process options for chemical, electrokinetic, and biologic treatment were eliminated during initial screening summarized in Appendix B. In situ chemical treatment includes four process options as shown on Figure 2-10. Soil leaching and chemical flushing were eliminated during the screening evaluation because of concerns associated with mobilizing contaminants and further impacting the underlying vadose zone and groundwater. Hydrolysis and reduction/oxidation manipulation were eliminated because of their experimental nature and unproven applicability to contaminants within the SDA. The electrokinetic technology is primarily effective in fine-grained soil and would not be applicable to buried waste in the SDA. Biological technologies could be effective on some organic waste; however, the technology is not applicable to containerized buried waste.

A total of four physical and thermal in situ treatment process options have been retained for developing remedial alternatives. Two of the retained in situ treatment process options, ISV and ISG, have been extensively researched for application at the SDA and have been retained as representative technologies for treating waste in the SDA. Two supporting reports present detailed descriptions of ISV and ISG technology (Thomas and Treat 2002; Armstrong, Arrenholz, and Weidner 2002) and provide case studies that detail implementations of the technologies, including results of previous INEEL studies directed at developing site-specific design criteria. The remaining two process options, soil vapor extraction and thermal desorption, also have been retained to specifically address areas within the SDA containing high concentrations of VOCs. A discussion of each retained process option is provided in following subsections.

2.5.4.1 High-Pressure Jet Grouting. High-pressure grouting, commonly referred to as jet grouting or in situ grouting (ISG), is a process that entails injecting a slurry-like mixture of cements, chemical polymers, or petroleum-based waxes into contaminated media. Grouts are specially formulated to encapsulate contaminants, isolating them from the surrounding environment. Grouting is accomplished without displacing contaminants or debris or causing the ground to heave. Overall volume of the waste site remains constant, but density of the site is substantially increased as grout fills void spaces between discreet waste components.

As summarized by Armstrong, Arrenholz, and Weidner (2002), ISG has been approved by regulating agencies and implemented at several small-scale sites across the DOE complex, including successful deployment at the SDA Acid Pit (Loomis et al. 1998). Though ISG has not been applied to sites as large and with as many radiological and chemical hazards as the SDA, research has been conducted at the INEEL using simulated buried waste pits in an effort to evaluate efficacy of ISG. Results of past applications at other sites and the INEEL research are promising.

As a result of evaluating grouting process options, high-pressure grouting was identified as a representative process option. Low-pressure or permeation grouting is typically applied in areas with high soil permeability and is, therefore, not widely applicable at the SDA. Though some areas may exist in the SDA with large void space and may technically be groutable by low pressures, the persistence of fine-grained soil and clay mixed with the waste would preclude permeation grouting. Therefore, jet grouting was evaluated as a universally applicable process option.

2.5.4.2 In Situ Vitrification. In situ vitrification is a process wherein electrodes are inserted into the ground to generate very high temperatures that convert buried waste and contaminated soil into a glass-like substance. Off-gases from the process are drawn into a large hood and treated before the cleaned gas is discharged to the atmosphere. Most nonmetallic, inorganic materials, such as soil and sludge, would melt and subsequently solidify into a hard, dense material resembling obsidian. Metallic materials would melt and settle to the bottom of the zone. The process destroys organic contaminants and immobilizes inorganic contaminants in a very durable and leach-resistant form. Though still an innovative technology, ISV has been implemented at a number of contaminated soil and waste sites worldwide. Full-scale melts ranging from 200 tons to 1,400 tons, with depths exceeding 6 m (20 ft), have been completed. An evaluation of ISV applicability to the SDA, including a summary of four recent deployments, is provided in the comprehensive report developed for this PERA (Thomas and Treat 2002).

Numerous investigations have been conducted to evaluate ISV applicability to the SDA. Because it can be applied to a wide variety of waste streams and is compatible with the type of interstitial soil found at the SDA, ISV was retained as a representative process option. Some problems have been encountered with the technology, primarily safety concerns controlling the molten material and associated off gases, but recent advances have improved it. The modified approach, referred to as subsurface planar ISV, has potential application at the SDA, by allowing melting to be conducted entirely belowground, under a layer of unmelted soil. This would mitigate many of the hazards associated with traditional ISV.

The ISV technology has been shown to be effective on various waste types and is potentially applicable at most areas within the SDA; however, site-specific treatability tests would be required to verify specific design and implementation requirements. Further, because highly metallic waste streams remain separated, even after melting, ISV would not be applied to high steel content waste streams in certain SVRs, trenches, and pits.

2.5.4.3 Soil Vapor Extraction. For soil vapor extraction (SVE), also known as soil venting or vacuum extraction, a vacuum is applied through wells near or within the contamination source. Volatile constituents of contaminant mass evaporate, and vapors are drawn toward extraction wells. Extracted vapor is then treated, commonly with carbon adsorption, then released to the atmosphere. Alternatively, treated vapor can be injected to the subsurface if permitted by applicable state laws. Increased airflow through the subsurface also can stimulate biodegradation of some contaminants, especially those that are less volatile. Extraction and injection wells may be installed either vertically or horizontally.

Permeability of soil or waste media affects rates of air and vapor movement—the higher the permeability, the faster the movement and (ideally) the greater the amount of vapors that can be extracted. The structure and stratification of soil or waste media are important to SVE effectiveness because they can affect how and where soil vapors will flow under extraction conditions. Structural characteristics (e.g., layering and fractures) can result in preferential flow behavior that can lead to ineffective or significantly extended remedial times, if preferential flows are positioned so that induced airflow occurs outside the area of contamination. Other factors, such as the moisture content and organic content, will also affect effectiveness of extraction. Reductions in VOC concentrations in excess of 90% are difficult to achieve using SVE.

The technology is typically applicable only to volatile compounds with a Henry's law constant greater than 0.01 or a vapor pressure greater than 0.5 mm (0.02 in) Hg. In situ SVE will not remove heavy oils, metals, polychlorinated biphenyls (PCBs), or dioxins. Given available historical records and soil gas surveys, SVE would be effective for the majority of the VOCs (CCl_4, tetrachloroethylene (PCE), and methylene chloride) in the SDA. Advantages of the SVE technology include easy installation, minimal disturbance to site operations, short treatment times (usually 6 months to 2 years under optimal conditions), and relatively low capital and maintenance costs.

Soil vapor extraction has proven effective in reducing concentrations of VOCs and certain semivolatile organic compounds (SVOCs) and petroleum-based contaminants at numerous hazardous waste sites in the United States, including the SDA. The existing Organic Contamination in the Vadose Zone (OCVZ) treatment system at the SDA employs the SVE technology and has been successful in removing dispersed VOC contamination. The OCVZ system consists of five vapor extraction wells, an off-gas treatment system to destroy organic contaminants present in the vapor removed from the extraction wells, and soil vapor monitoring wells to monitor performance of extraction wells and verify attainment of the RAOs for OU7-08. The OCVZ project is limited to remediating the vadose zone and does not directly address either buried waste or groundwater.

Vapor extraction without thermal enhancements has been retained for developing remedial action alternatives requiring pretreatment to reduce VOC concentrations. Thermal enhancements for SVE, as discussed in the following subsection, were retained for consideration in waste areas where additional or accelerated removal of VOCs may be warranted.

2.5.4.4 In Situ Thermal Desorption. In situ thermal desorption is a developed technology that uses various sources of electrical heat or injection of hot air or steam to increase volatilization of VOCs and SVOCs and thereby facilitate extraction by conventional SVE systems. The process requires heat-resistant extraction wells to withstand the higher operating temperatures. Thermal desorption is normally a short- to medium-term technology that includes various suboptions:

- Thermal conduction—Thermal conduction uses electrical resistance heating elements installed in waste in a thermal-well array. Waste and contaminated soil are heated to temperatures between 600 and 1,000°F to vaporize and destroy most organic materials. Achieving temperatures up to 800°F may take three months or longer.

- Electrical resistance heating—Electrical resistance heating uses electrical current to heat less permeable but relatively electrically conductive media such as clay and fine-grained materials. Electrodes are placed directly into the affected media and activated, creating an electrical current that passes through the media to generate heat. The heat dries out the media, resulting in fracturing, which makes the media more permeable and allows SVE to more readily remove contaminants.

- Radio frequency and electromagnetic heating—Radio frequency heating uses electromagnetic energy to heat soil and waste to enhance SVE. The technique entails heating soil or waste using rows of vertically embedded electrodes. Heated soil or waste volumes are bounded by two rows of ground electrodes with energy applied to a third row midway between the ground rows. The three rows act as a buried triplate capacitor. When energy is applied to the electrode array, heating begins at the top center and proceeds vertically downward and laterally outward through the media between the ground electrodes. The technique can heat soil to approximately 600°F.

- Hot air or steam injection—The hot air or steam injection process employs hot air or steam injected below the contaminated zone. Some VOCs and SVOCs are stripped from the contaminated zone and removed using SVE. Achieving temperatures up to 800°F may take three months or longer. Forced injection of hot air or steam could mobilize contaminants either to the underlying vadose zone or in contaminated gases to the environment if the gas-capture zone of the SVE system is not sufficient.

Using in situ thermal desorbtion (ISTD) would increase the rate and degree of extraction of VOCs and SVOCs over that achievable by conventional SVE and potentially destroy other hazardous organic materials by oxidation or pyrolysis. The results of the screening identified thermal conductance as the representative technology for ISTD. ISTD is potentially implementable at the SDA, however, treatability tests would be necessary to confirm that the technology could achieve required performance objectives at the SDA. The likelihood of an underground fire in dried waste consisting of combustible materials is increased for all options, especially in areas that contain significant amounts of combustibles and sodium nitrate, an oxidizing salt. Additional safety analyses and testing may be required during the design phase.

2.5.5 Retrieval

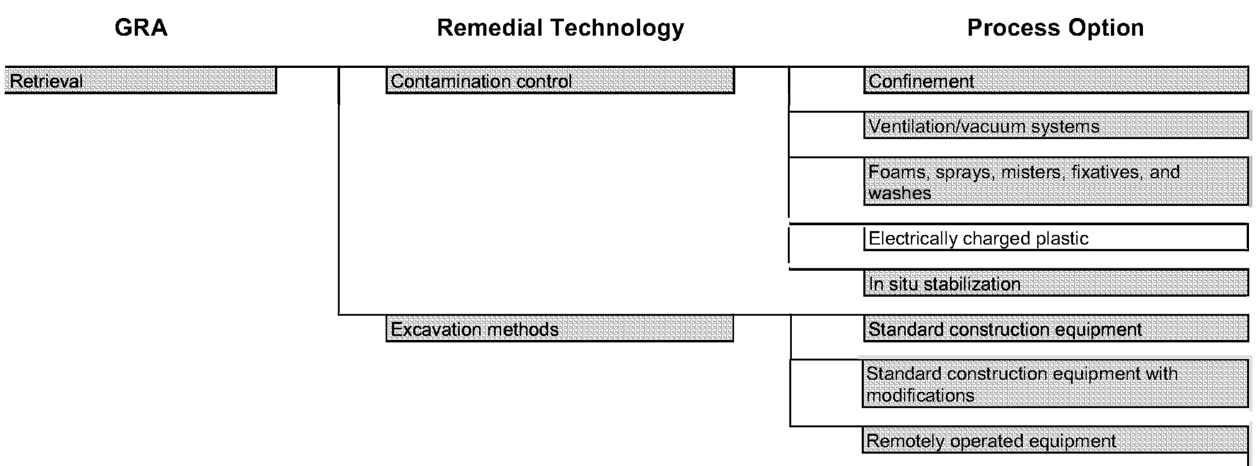
The retrieval GRA consists of excavating and removing pits and trenches containing the Rocky Flats Plant TRU waste within the SDA. Overburden soil, interstitial soil, and possibly impacted underlying soil over the waste would be removed as well. TRU pits (Pits 1 through 6 and 9 through 12) and trenches (Trenches 1 through 10) contain TRU, LLW, and mixed waste. Retrieving low-level radioactive and hazardous soil and buried waste from a site is a proven and reliable approach that offers many potential benefits. A summary of historic retrieval actions conducted at DOE facilities, including Hanford, Rocky Flats, Los Alamos, Fernald, and the INEEL, is provided in the supporting report (Sykes 2002). The report additionally offers a summary of special excavators used at different facilities.

However, retrieval techniques for TRU waste have not been proven to the same extent and will require site-specific and innovative design elements to ensure protection of human health and the environment.

Either completely or partially removing waste from a site allows it to be treated to reduce toxicity and mobility of many chemicals. Removed and treated material can then be disposed of in an approved engineered facility. Retrieval removes or greatly reduces risk associated with the site if the retrieved waste is disposed of off-Site or isolated from the environment. Typically, by removing waste and reducing the contaminant source, long-term site monitoring and maintenance requirements can be reduced. Further, with complete removal of waste, the site could be released for unrestricted access following the CERCLA 5-year review.

However, retrieving and disposing of waste materials, such as those buried in the SDA, are time-consuming and expensive. One of the greatest concerns in retrieving buried radioactive waste and soil is increased potential for worker exposure, contamination spread, and off-Site release. Waste poses a significant risk of inhalation; to accidentally inhale even minute quantities of TRU materials such as those present at the SDA would be dangerous. Technologies such as supplied air excavators, foggers, and ventilation systems are available and have been demonstrated to reduce worker risk.

The retrieval GRA has been divided into two technology types—contamination control and excavation. Descriptions of individual process options and results of the screening evaluation are provided in Appendix B. A summary of results of e screening is provided in Figure 2-11 and the following subsections.



NOTE: Shading indicates the technologies and process options retained for evaluation

Figure 2-11. Retrieval screening summary.

2.5.5.1 Contamination Control. Controls during waste retrieval are needed to minimize the spread of contamination and control the source. Depending on site-specific conditions and materials present (e.g., boxes, tanks, and plastic debris), various different controls may be used. In general, controls are grouped into two categories—those used before retrieval and those used during retrieval. Both types can be effective at controlling contamination, thus decreasing the potential for exposure, the costs of operation and maintenance of equipment, and the cost for decontamination. Process options for contamination control include the following:

- Confinement—Confinement enclosures constructed from plastic, metal, fiberglass or other materials are used to prevent spreading airborne contaminants by enclosing a piece of equipment, work area, or an entire site. Enclosures may be relatively lightweight and portable (e.g., Moducon) or may be substantially sturdier and less portable (e.g., Butler Building). Enclosures are typically double-walled to minimize potential for contaminant releases.

- Ventilation and vacuum systems—Ventilation systems use laminar airflow at the dig-face of an excavation and within enclosures to direct dust to high-efficiency particulate air (HEPA) filter units. Vacuum systems are used to remove loose particles from equipment and structures and draw in dust and debris generated during excavation activities.

- Foams, sprays, misters, fixatives, and washes—Identified process options can be applied to perform various functions including controlling odors, VOCs, dust, and other emissions; creating a barrier between work surface and the atmosphere; settling loose airborne contamination; and decontaminating personnel and equipment. Processes are readily available in nontoxic, nonhazardous, nonflammable, and biodegradable forms consisting of water and polymer mixtures.

- Electrostatics—Electrically charged plastic and electrostatic curtains can be used as barrier walls to minimize spread of contamination from enclosed areas. Curtains can be used upstream of emission filtering systems to neutralize charged dust particles.

- In situ stabilization —In situ stabilization can be performed before initiating excavation operations to control contamination in the soil and waste matrix. Grout, resin or polymer (e.g., EKOR) may be injected into waste or soil to solidify material and minimize contaminant releases during retrieval. Stabilization also could be performed using ISV and ground-freezing technologies.

With one exception, all process options identified have been retained for consideration in developing remedial action alternatives. Electrically charged plastic is not applicable in the large open excavation area required for retrieving the SDA waste and therefore was not retained. Appendix B contains details about all process options.

2.5.5.2 Excavation. Retrieving soil and buried waste can be achieved with a number of different technologies, including conventional heavy equipment, standard construction equipment with modifications (e.g., sealed and pressurized cabins with filtered intakes and extracts or supplied air), and remotely operated equipment and controls. Most equipment used for excavation of soil and buried waste is standard heavy construction equipment proven for use at hazardous waste sites across the nation. Given the nature of material and chemicals present at the SDA, technologies such as remotely operated equipment and hermetically (airtight) sealed equipment with filtered or supplied air also apply. Radioactive material present in the SDA is a significant external exposure concern for remediation workers, has potential for airborne release and internal exposures (e.g., inhalation and ingestion), and may be difficult to control during retrieval actions, as demonstrated by past retrieval efforts. However, technologies are available to address these issues and protect workers and the environment. A summary of potentially available remote excavators and modified standard equipment is presented in Table 2-1.

A number of end effectors with specialized designs have been developed to facilitate retrieving various waste forms. Designs include grappling devices for waste containers and debris, water jets, magnets, and vacuum systems. A summary of potentially available end-effectors is presented in Table 2-2.

Table 2-1. Description of retrieval equipment.

Technology	Description
Remote Excavators	
Brokk	Remote-controlled excavator with telescoping arm capable of full articulation. Available with several different end-effectors that could be used for hammering, cutting, and scooping waste. The largest Brokk can reach approximately 4 m (13 ft) belowground surface (bgs).
Keibler Thompson	Remote-controlled excavator with telescopic boom capable of moving in three dimensions. Available with several end-effectors. The largest Keibler Thompson machine can reach approximately 4.9 (16 ft) bgs.
Remote-operated excavator	Excavator mounted on a wheeled undercarriage that was developed to retrieve unexploded ordnance. A television provides images for remote excavation. The only such excavator in existence is currently used at an air force base.
T-Rex, front shovel excavator that requires modification for use	A teleoperated, heavy-lift, long-reach excavator designed to retrieve boxes, drums, and containers with a front shovel excavator. Controls can be operated up to 381 m (1,250 ft) from the excavator.
Front-end loader with a 2.1 m^3 (2.75 yd^3) bucket	Remote control developed for use on front-end loader. Provides 3-D color video/audio feedback and can be controlled from 457 (1,500 ft) away. System could be modified for use on excavators.
Teleoperated excavator using T-Rex remote control kit	Remote-controlled excavator (bucket and thumb) adapted for hazardous environments, such as UXO, through sensors, controllers, and hydraulic components.
Remote excavator vehicle system experimental platform based on an excavator	Remote-controlled, tethered platform for excavator. Attachments can grasp objects, sift soil, and make excavator act as a bulldozer. A clamshell and air-jet vacuum system can also be attached.
Automated ordnance excavator	Remote-controlled excavator with extended reach capability, developed for UXO removal. Can grasp objects such as drums and boxes.
Small emplacement excavator	Military tractor with front-end loader and backhoe remote operation for retrieving buried waste and soil. System can be controlled from 0.8 km (.5 mi) away.
Remote excavator, Hitachi excavator, innovative end-effector, and self-guided transport vehicle	Standard excavator with end-effectors (such as buckets, rippers, and breakers) used for buried waste retrieval. System can be controlled inside cab, via a remote tether, or from 762 m (2,500 ft) away.
Modified bobcat	Remote-controlled skid steer loader with a Bobcat vehicle base with barrel grapple, sweeper and bucket attachments. Modified for hazardous environments, remote kit for other excavators.
Standard Construction Equipment With Modifications	
Sealed and pressurized cabin, with filtered air intakes and extracts	Standard construction equipment with modifications made to the cabins. The sealed and pressurized cabin uses filtered air (through HEPA filtration).
Sealed and pressurized cabin, with supplied air	Standard construction equipment with modifications made to the cabins. The sealed and pressurized cabin uses supplied air.

UXO=unexploded ordinance; HEPA=high efficiency particulate air

Table 2-2. Remote end-effectors.

Technology	Description
Safe excavation	High-pressure probe dislodges compacted soil, other hardened materials using an air-jet/vacuum end-effector system. Vacuums up soil.
2-armed, tethered hydraulically powered interstitial conveyance system	Crane-deployed with two excavators and vacuums designed for low-level radiation fields. Maximum pickup load of 700 lb.
Tentacle, highly manipulative	Teleoperated manipulator and bellows actuator.
Hydraulic impact end-effector	Water cannon for tank applications, which is attached to a robotic manipulator arm and used to break up monolithic hard cake forming around risers in tanks.
Schilling Tital II	Manipulators deployed by crane for selective retrieval. Basic components include hydraulic system, positioning system, electronics module, and mechanical interface.
Mineclaw	Manipulator with strong electro-magnet to pick up barrels. Custom grapple with a several hundred pound payload and an electro-magnet to retrieve metals.
Confined sluicing end-effector	Water-jet designed for waste tank clean-out. Uses high-pressure water-jets to cut material into small pieces and evacuate with a vacuum jet pump. Captures slurry water.
Soil skimmer	Skimmer removes soil overburden in 8-, 10-, 15-cm (3-, 4-, and 6-in.) increments. Adjustable depth controls the depth of cut without disturbing soil underneath.
Innovative end-effector	Consists of three assemblies: a thumb, an attachable/detachable integrated transfer module, and a shovel assembly capable of soil retrieval and dust-free waste dumping.
Couplers, quick-change	Available in manual and hydraulic versions. Used on various buckets, rakes, clamps, rippers, and other end-effectors.
Vacuum systems	Nuclear-grade vacuum systems for contamination control and retrieval of soil with HEPA filtration and critically safe waste containers.

HEPA=high efficiency particulate air

Most of the required equipment and technologies for excavation or retrieval have been proven in highly contaminated environments. For example, remote excavators have been proven successful in waste retrieval simulations and have been used throughout DOE facilities for D&D&D. In addition, shielded excavators have also been used successfully (e.g., Hanford), and hermetically sealed vehicles have been used successfully (e.g., Maralinga). Generally, hermetically sealed retrieval equipment is less expensive, needs less maintenance, is capable of more precise digging, and can be operated faster than remote equipment. In some environments, shielding (e.g., Lexan windows) is required on equipment to protect workers from potential explosions and radiation. Shielded excavators have been proven at Hanford in the 100 N-Reactor Area. Filtered or supplied air can be added to equipment to protect operators, as has been proven at many sites, including Maralinga and Calvert City. A more detailed discussion of conventional heavy equipment, hermetically sealed equipment, and remote technologies and their potential applicability to the SDA is presented in a supporting report (Sykes 2002). Additional information can be found in *Survey of Materials-Handling Technologies Used at Hazardous Waste Site* (EPA 1991), *Hot Spot Removal System: System Description* (INEEL 1997), and *Technical Alternatives Baseline Report* (BHI 2000).

All excavation process options have been retained to offer the flexibility to address potentially diverse SDA waste.

2.5.6 Ex Situ Treatment

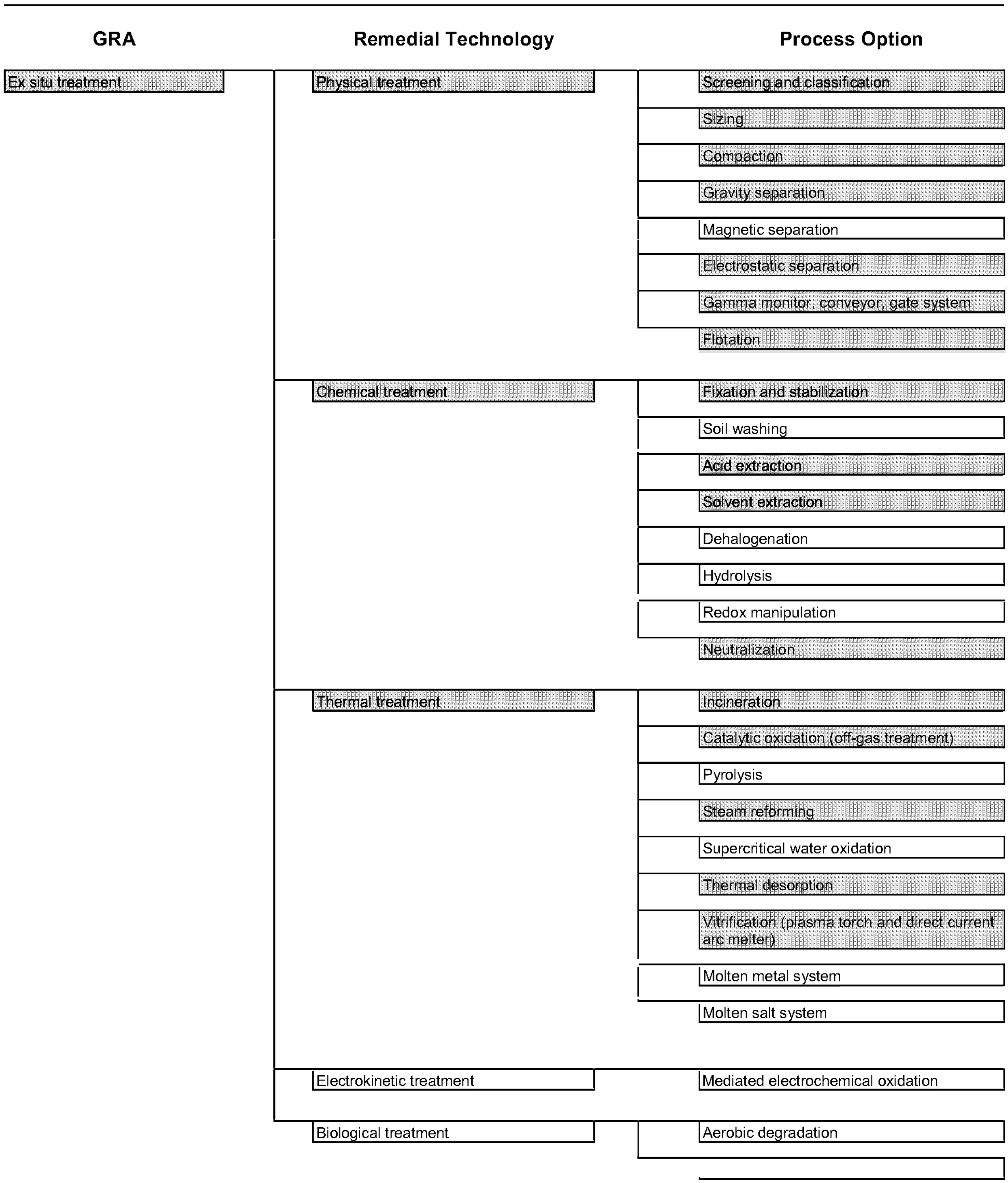
Ex situ treatment technologies are included in developing remedial alternatives for their ability to reduce toxicity, mobility, or volume of contaminants, as required to meet specific disposal and transportation requirements. Regulatory requirements for TRU disposal and transportation are different than for non-TRU waste. Therefore, treatment requirements are correspondingly different. All retrieved waste would be transported to a new waste processing facility to be constructed on or adjacent to the SDA, where any required ex situ treatment would take place. Transuranic waste would undergo packaging and characterization necessary to satisfy the waste acceptance criteria (WAC) of the Waste Isolation Pilot Plant (WIPP). Treatment requirements include solidifying liquids, removing prohibited items, and eliminating any ignitability, corrosive, or reactive characteristics. Because WIPP is exempt from Resource Conservation and Recovery Act (RCRA) LDRs, specific ex situ treatment of mixed TRU waste for organic and inorganic contaminants will not be necessary. Conversely, non-TRU waste separated from the TRU waste would undergo various types of physical, chemical, and thermal treatments to remove hazardous organics, to fixate regulated metals and radionuclides, and to prepare waste for onsite disposal. The WAC for an onsite landfill would be based on regulatory requirements (i.e., RCRA LDRs) and risk-based considerations for long-term protection of human health and the environment.

The Advanced Mixed Waste Treatment Facility (AMWTF), recently constructed within the TSA, will primarily treat TRU waste, alpha-contaminated LLW, contact-handled mixed waste, and other selected waste stored at the TSA. The AMWTF is scheduled to start shipping waste to the WIPP in 2003, in accordance with the September 1995 INEEL Settlement Agreement. Though the AMWTF has some similar capabilities to those required for ex situ treatment of the SDA waste, the facility does not have aggressive treatments for hazardous waste necessary to satisfy RCRA LDRs for disposal of mixed, low-level, RCRA-regulated waste. As such, the facility will not be suitable for treating MLLW retrieved from the SDA. Furthermore, it is assumed that facilities within the AMWTF are fully dedicated to treating TSA waste and that additional capacity is unavailable for treating any TRU waste retrieved from the SDA.

Potential process options for onsite ex situ treatment are grouped under five general technology types: (1) physical, (2) chemical, (3), thermal, (4) electrokinetic, and (5) biological. A list of ex situ treatment process options associated with each technology, along with specific screening comments related to effectiveness, implementability, and cost, is presented in Appendix B. Screening was based on each technology's applicability to the waste to be processed, degree of proven technical development, safety, capital and operating costs, complexity, reliability, perceived public acceptance, and ability to handle the expected volume of waste. Figure 2-12 summarizes the screening.

Screening eliminated two of five remedial technologies identified. Biological treatment was not retained for consideration in developing remedial alternatives. Though it is potentially effective for VOC COCs (CCl_4, PCE, and methylene chloride), biological treatment is more suitable for semivolatile organic contaminants. Biological treatment generally requires extensive pretreatment of contaminated media and is frequently a time-consuming process requiring large areas to facilitate treatment. Electrokinetic treatment was eliminated based on complexity, the need for two secondary recovery systems, significant waste pretreatment requirements, and an unproven record for the type of waste to be processed.

Of the three remaining remedial technologies, physical, chemical, and thermal treatment, 16 process options were retained for potential assembly into remedial alternatives.



NOTE: Shading indicates technologies and process options retained for evaluation.

Figure 2-12. Ex situ treatment screening summary.

2.5.6.1 *Physical Treatment.*

Physical treatment involves separating and sorting waste stream material according to physical and radiological characteristics. Physical treatment process options also include waste compaction for volume reduction. Of the identified physical treatment process options, only magnetic separation was screened out because of its developmental status and its poor suitability for SDA waste characteristics. Remaining process options were all retained for potential incorporation into retrieval alternatives.

2.5.6.2 *Chemical Treatment.*

Chemical treatment entails separating and extracting organic and radioactive constituents from waste, neutralizing acid and caustic substances, and stabilizing treated waste. Four of eight process options for chemical treatment passed the screening. Soil washing, dehalogenation, hydrolysis, and redox manipulation were eliminated for reasons of limited applicability to the SDA waste, state of technical development, and cost-effectiveness.

Stabilization has been identified as the representative technology to treat MLLW streams, which contain a number of RCRA metals including mercury and lead. The RCRA LDRs are assumed to apply to the MLLW that will be disposed of in an on-Site or off-Site disposal facility. This process option effectively immobilizes radioactive and hazardous constituents in waste by mixing additives that bind waste into a stable waste form. Stabilization has been researched at INEEL in site-specific applications, but additional remedial design studies would be needed to define process variables, such as type of additives, concentrations, and mixing times (Armstrong, Arrenholz, and Weidner 2002).

2.5.6.3 *Thermal Treatment.*

Thermal treatment removes and destroys hazardous chemical constituents of waste and enables volume reduction. The evaluation presented herein assumes ex situ thermal treatment of the waste will be necessary only for the non-TRU fraction of the waste, because thermal treatment is not required for TRU waste. It is also assumed that WIPP will be granted approval to receive nonliquid PCB-contaminated waste before operating the treatment facility.

Five of nine process options for thermal treatment passed the screening. Retained technologies include incineration, steam reforming, thermal desorption, vitrification, and chemical oxidation, which was retained as an off-gas treatment. Pyrolysis, supercritical water oxidation, molten metal system, and molten salt system were eliminated for reasons including state of technical development, volume of secondary waste generation, safety and reliability, and lack of applicability to the SDA waste.

Incineration has been widely used as an effective process option to treat potentially variable waste streams such as those in the SDA. This process option, however, is generally considered nonimplementable at the INEEL because of concerns expressed by the agencies and major stakeholders, including neighboring communities, over the incinerator proposed as part of the AMWTF. As a result, the DOE continues to extensively research existing and emerging process options to identify potential alternatives to incineration. In a study conducted by the Secretary of Energy Advisory Board (DOE 2000), a number of potential process options were identified as promising, including thermal desorption, plasma torch, direct current arc melter, and steam reforming. Additional testing of specific technologies as planned in the April 2001 Action Plan (DOE 2001) will further refine the list. However, because results of this continuing research are currently unavailable, all process options have been retained for consideration in the final alternative design. Incineration—based solely on technical and economic reasons—passed the screening; therefore, it has been retained for consideration but was not selected as the representative technology.

Steam reforming has been identified as the representative technology and with its associated off-gas treatment system, the technology has the ability to treat the waste and destroy the VOCs and SVOCs. Peak temperature of waste is significantly lower than for incineration, which would allow plutonium and most other radionuclides and heavy metals to be retained with the solids and ash. The option also involves lower off-gas volumes than incineration, which minimizes potential for particulate transport to the off-gas system. High-temperature steam reforming of volatile gases, generated from the waste in a separate chamber, completes destruction of the organics. Resulting gases are H_2, CO, H_2O, and CO_2, and these can be directly discharged to the atmosphere after off-gas cleanup. Because a thermal oxidizer is not used, steam reforming is not incineration.

2.5.7 Disposal

The Disposal GRA has been divided into two primary technologies—onsite storage or disposal, and off-Site disposal. A discussion of process options, along with specific screening comments related to effectiveness, implementability, and cost, is provided in Appendix B. A listing of the process options summarizing results of the screening process is presented in Figure 2-13.

Capabilities of identified on-Site and off-Site disposal facilities in terms of their acceptance of LLW, MLLW, high-level mixed waste (HLMW), and high-level waste (HLW) are summarized on Figure 2-14. As shown, a number of on-Site and off-Site facilities are potentially capable of disposing of retrieved waste from the SDA. However, the only location currently permitted to receive TRU waste is the WIPP facility located near Carlsbad, New Mexico. For HLW and HLMW, the only potential disposal site is the Yucca Mountain facility located in Nye, Nevada. Currently, however, this facility is being further evaluated and is unavailable for waste disposal.

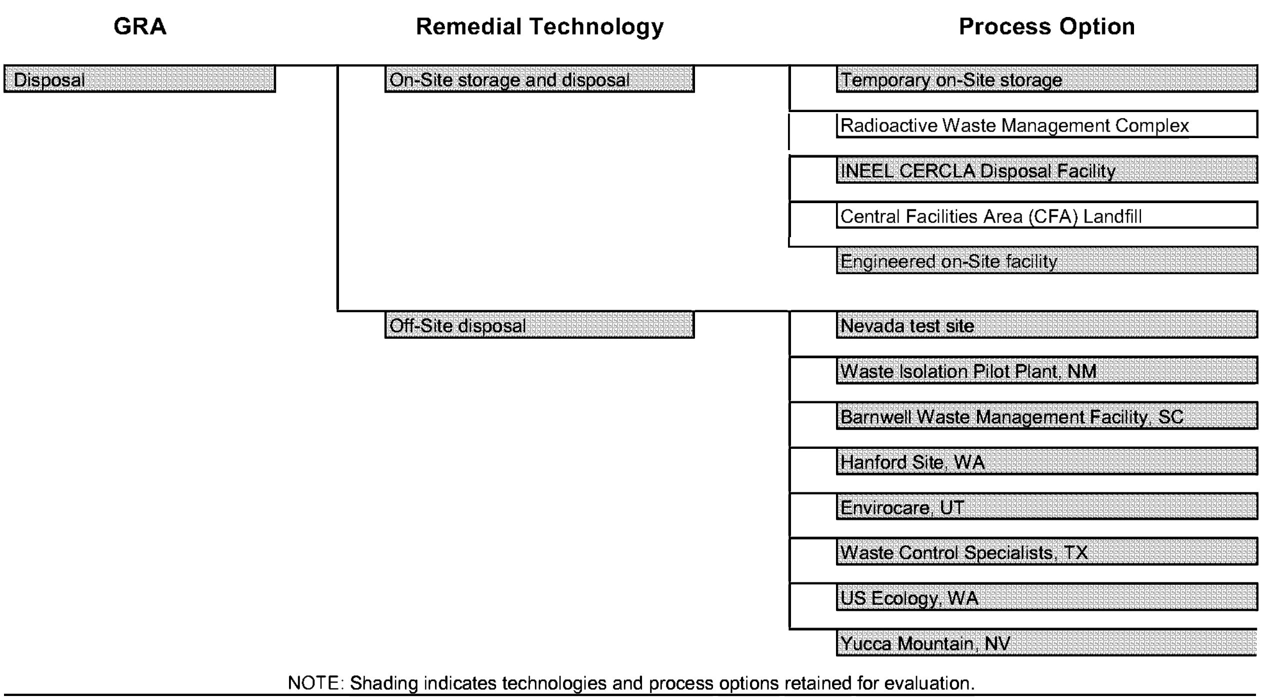


Figure 2-13. Disposal screening summary.

Disposal Site	Waste Type						
	Debris		Soil			LLW	HLW
	TRU	MLLW	TRU	MLLW	HLMW		
On-Site Disposal							
SDA[a, b]				X[c]		X	
CFA							
ICDF		X		X		X	
Off-Site Disposal							
Waste Isolation Pilot Plant[d]	X		X				
Barnwell Waste Management Facility						X	
US Ecology, Inc.						X	
Envirocare of Utah		X		X		X	
Hanford Site		X		X		X	
Nevada Test Site		X		X		X	
Yucca Mountain					X		X
Waste Control Specialists[e]							

a. Storage for TRU available at the TSA in the RWMC.

b. Advanced Mixed Waste Treatment Facility (AMWTF) available in 2003 at the RWMC for treatment of TRU waste.

c. After treatment for mixed waste characteristics to meet LDRs.

d. Staging, Storage, Sizing and Treatment Facility (SSSTF) available for on-Site treatment.

e. TRU storage available on-Site. LLW and MLLW disposal permits are pending. Currently, only available for disposal of exempt level of radioactive material.

Figure 2-14. Disposal site options.

2.5.7.1 On-Site Disposal Options. On-Site disposal options potentially include temporary storage, construction of engineered disposal facility within the RWMC, and the following three active or proposed landfill operations:

- Radioactive Waste Management Complex—Active cells in the SDA make up a shallow landfill, which currently accepts LLW for disposal. The SDA can receive waste that began as RCRA-characteristic waste, has been subsequently treated to remove the characteristic, and now meets LDRs. The SDA is not permitted for RCRA-listed mixed waste. Upon arrival, waste is examined, and radiological surveys are performed to ensure that radiation and contamination meet requirements. The TSA, also located in WAG 7, accepts TRU waste for storage. Current operations at the TSA include examination, segregation, certification, and interim storage of solid contact-handled and remote-handled TRU waste.

- Central Facilities Area landfill—This unlined landfill accepts nonhazardous industrial waste generated at the INEEL site.

- INEEL CERCLA Disposal Facility landfill—Located at the Idaho Nuclear Technology and Engineering Center for WAG 3, the ICDF landfill is currently under design and is scheduled to accept LLW beginning in 2003. The facility is intended for the disposal of contaminated soil and debris resulting from waste generated within the INEEL during CERCLA cleanup actions. The ICDF facility will include a landfill, an evaporation pond, a treatment facility, and an associated staging and storage annex. The facility will accept RCRA-characteristic and listed waste in accordance with its specified WAC. If waste is not from WAG 3, then the characteristic that made the waste hazardous must generally be removed as specified by the WAC.

The ICDF landfill has been retained as a potentially viable option for the disposal of retrieved LLW waste and soil. However, available capacity within the landfill to accommodate waste and soil from WAG 7 is uncertain. Based upon current information, active storage facilities within the SDA and TSA will be unavailable for consideration when developing alternatives because of capacity and operational constraints. Because the Central Facilities Area landfill facility can accept only nonhazardous waste, it also is eliminated from further consideration.

Temporary onsite storage for TRU and non-TRU waste streams within the RWMC was retained as a process option to provide staging and accommodate material handling requirements during retrieval, treatment, and permanent disposal activities. Temporary storage facilities would be designed in accordance with regulatory standards to protect workers and the environment.

An engineered on-Site disposal facility at the RWMC was retained for developing remedial alternatives. The facility would be designed for permanent storage of LLW and MLLW and soil retrieved from the SDA. Because of regulatory constraints and potential design requirements, constructing a permanent onsite storage facility for retrieved TRU waste was not considered in this PERA. A number of potential design options are available for constructing a permanent onsite LLW disposal facility having concrete vaults and engineered disposal cells. The design recently established for the ICDF landfill was identified as the representative technology retained for developing an onsite disposal alternative. The facility would be constructed within limits of the SDA and sized to accommodate projected volume of retrieved LLW and treated MLLW and contaminated soil. A cross section showing specific design elements is provided in Figure 2-15.

2.5.7.2 Off-Site Disposal Options. Off-Site disposal involves shipping waste to an approved facility outside the INEEL. Several off-Site disposal options are available. A list of the facilities, along with their waste acceptance considerations, is presented in Figure 2-14. The general location of each facility is shown on Figure 2-16. Each facility is described briefly below.

- Waste Isolation Pilot Plant—Located in Carlsbad, New Mexico, WIPP is an underground repository that accepts defense-generated, contact-handled TRU waste for disposal. Remote-handled TRU waste is expected to be accepted in the near future, following approval of a proposed RCRA permit modification. Mixed TRU waste is acceptable under specified waste codes. Waste that exhibits RCRA characteristics of ignitability, corrosivity, or reactivity is unacceptable. Total capacity of the facility, as currently designed, is estimated at 175,600 m^3 (229,676 yd^3), which is expected to be filled to capacity by 2034. Transportation to the WIPP from the SDA will be by truck.

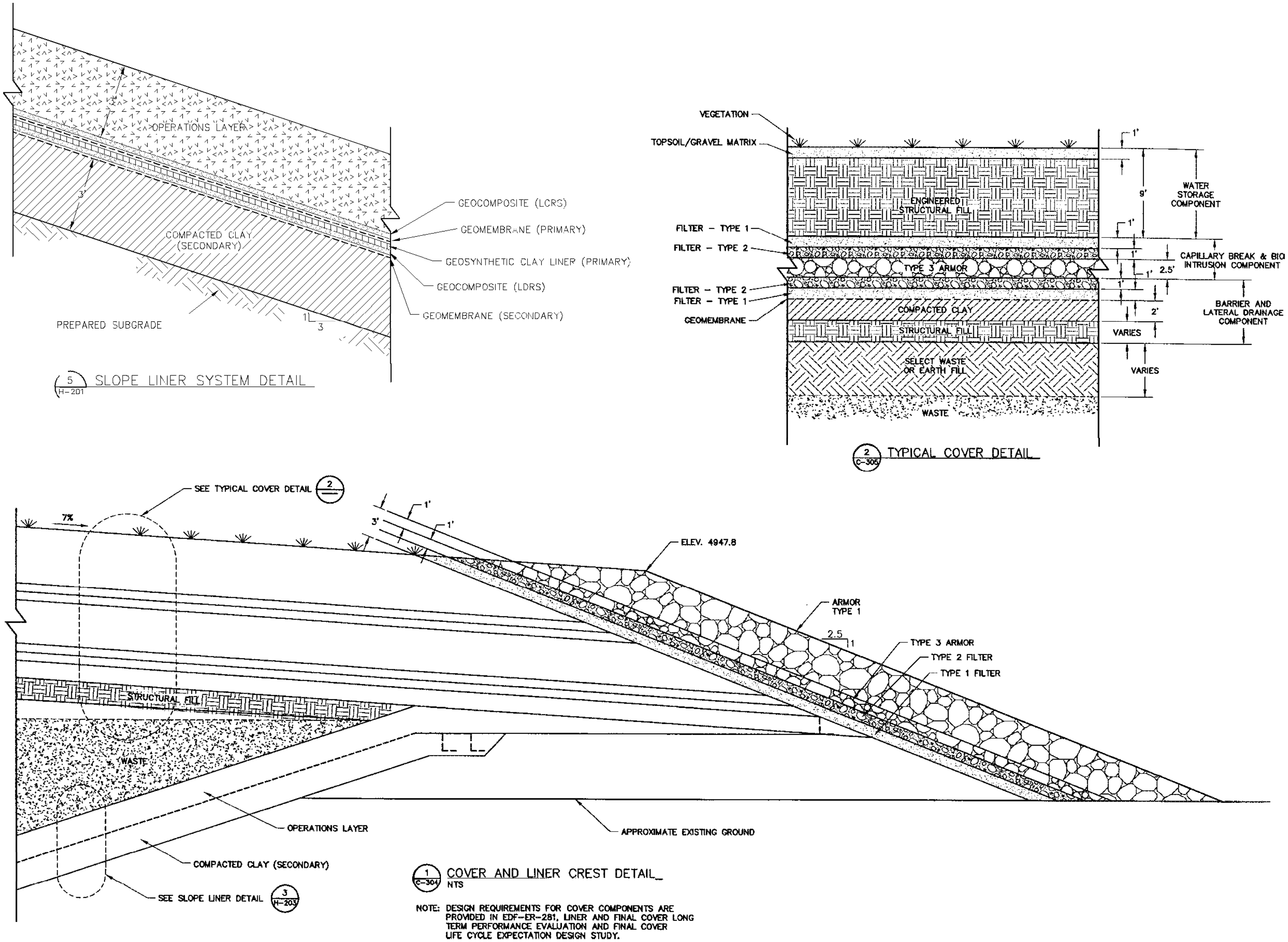


Figure 2-15. INEEL CERCLA Disposal Facility landfill design elements.

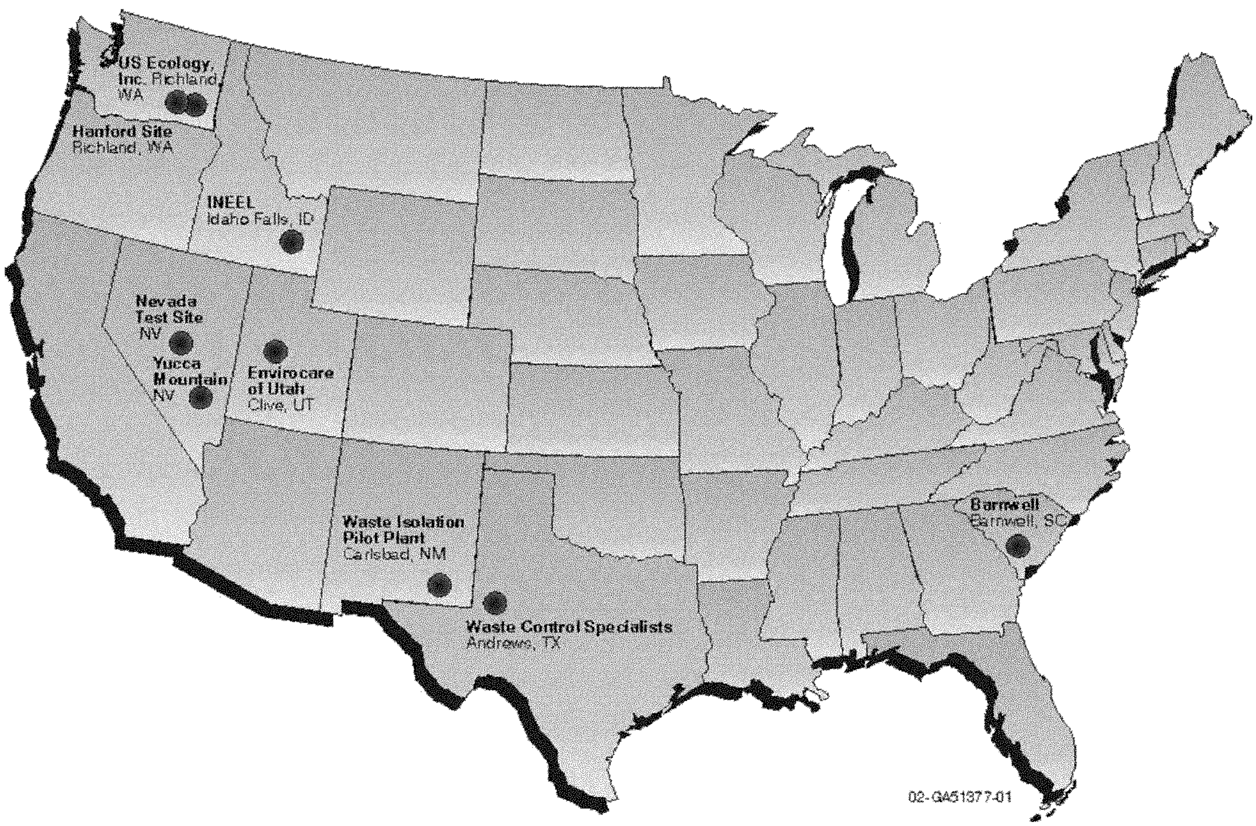


Figure 2-16. Disposal site locations.

- Barnwell—Located in Barnwell, South Carolina, this facility is a 235-acre commercial operation that accepts LLW. Waste shipments are accepted by public highway only. Site disposal consists of shallow land burial in concrete vaults located in engineered earthen trenches. No MLLW is accepted. Waste containing TRU radionuclides is acceptable in accordance with facility WAC. Stabilization is required for waste containing isotopes with greater than 5-year half-lives having a total specific gravity greater than 1 µ/cc. Treatment is unavailable at Barnwell. In 2000, South Carolina passed a law limiting annual volume of waste accepted at Barnwell from any generator through June 30, 2008. Limits are based on a declining annual volume of 2,265 m^3 (2,963 yd^3) in 2002 to 991 m^3 (1,296 yd^3) in 2008. After June 30, 2008, only waste generated by the Atlantic Compact Region will be accepted for disposal at Barnwell.

- US Ecology, Inc.—Located in Richland, Washington, US Ecology is a 100-acre commercial facility that accepts LLW for disposal in shallow trenches. Since 1993, the site has been the regional commercial LLW disposal site for 11 western states (Northwest and Rocky Mountain Compact States). Mixed low-level waste is not accepted and treatment is unavailable at the facility. Radioactive waste containing radium or TRU radionuclides is acceptable in accordance with the facility WAC. The site, which is scheduled for closure in 2056, has a remaining capacity of approximately 1,245,942 m^3 (1,629,630 yd^3). Currently, a 2,832 m^3 (3,704 yd^3) annual limit applies to the site. The site is accessible only by truck.

- Envirocare of Utah—Located in Clive, Utah, Envirocare is a commercial LLW disposal facility that began operations in 1988. The facility contains a mixed-waste treatment facility that offers stabilization, reduction/oxidation, deactivation, chemical fixation, neutralization, macroencapsulation, and microencapsulation. Waste is disposed of in aboveground-engineered disposal cells. Both public highway and rail provide access to the facility.

- Hanford Site—Located in Richland, Washington, the Hanford site, referred to as the Environmental Restoration Disposal Facility (ERDF), currently accepts MLLW for disposal in RCRA Subtitle C compliant land disposal units (mixed waste trenches) and in unlined units for MLLW. The site currently does not accept mixed waste from other DOE sites, pending completion of the Hanford Solid Waste Environmental Impact Statement (currently being prepared). The site is accessible only by truck.

- Nevada Test Site (NTS)—The NTS site is located in southwestern Nevada and has a total capacity of approximately 3 million m^3 (3,923,852 yd^3) with a projected operational design life of 100 years. Remaining capacity of the site is estimated at approximately 1.8 million m^3 (2,354,311 yd^3). The site currently accepts LLW and MLLW from DOE-Nevada (DOE-NV) activities and other approved generators. Approved generators are generally those defined as DOE sites and contractors that historically shipped waste to NTS. Waste profiles must be prepared and submitted to DOE-NV for each waste stream before disposal. Mixed LLW is unacceptable.

- Yucca Mountain—The Yucca Mountain facility, located in Nye County, Nevada, is under consideration as a permanent geologic repository for high-level waste and could provide a disposal option for irradiated fuel materials identified in the SDA inventory records. A portion of the facility has been built for testing purposes only.

- Waste Control Specialists—The Waste Control Specialists facility, located in Andrews, Texas, accepts LLW and MLLW for treatment. Waste disposal permits are pending. Currently, treated waste is returned to the generator or sent to another site for disposal if, after treatment, it still exceeds the exempt definition established by the Texas Administrative Code. Rail access is available directly to the site.

All the identified off-Site waste repositories have been retained to address the volume and variability of SDA waste. The WIPP facility in Carlsbad, New Mexico, is a primary element in developing retrieval alternatives as it is currently the only facility that can receive contact-handled TRU waste for disposal. Remote-handled TRU waste also will be accepted following approval of current RCRA-permit modifications. Currently, no sites are available that can receive HLW and MHLW for permanent disposal. For the disposal of LLW, both the U.S. Ecology site in Richland, Washington, and Envirocare of Utah in Clive, Utah, are currently licensed commercial facilities. The Barnwell site in South Carolina also is licensed for LLW, but its East Coast location would be logistically less desirable. The only site that is currently licensed to accept MLLW is the Envirocare site in Utah.

2.5.7.3 Disposal GRA Screening Summary. As discussed in preceding sections, a number of disposal options are available for waste and soil retrieved from the SDA. For this PERA, construction of an engineered onsite disposal facility was identified as the representative process option for disposal of retrieved LLW and treated MLLW and soil. The cost-effectiveness of on-Site versus off-Site disposal at one of the licensed facilities discussed in the preceding section, of all or a portion of the projected waste stream, should be further assessed during remedial design.

For retrieved TRU waste, off-Site disposal at WIPP was identified as the representative process option. For HLW and MHLW, no operating facilities are currently licensed to receive waste. It is assumed for this PERA that, if encountered, during retrieval activities, any HLW and MHLW would be classified and reburied in individual disposal units.

2.6 References

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3. DEVELOPMENT AND SCREENING OF ALTERNATIVES

This section presents initial development and screening of a series of remedial action alternatives that span the GRAs and address the identified WAG 7 RAOs. Alternatives were assembled from technologies and process options retained after evaluations presented in Section 2. This initial alternative screening process was conducted to identify the most appropriate remedial action alternatives to be retained for a more detailed analysis in accordance with CERCLA (42 USC § 9601 et seq.) feasibility study guidelines. More detailed analysis of retained alternatives is presented in Section 4 of this report.

For this initial screening analysis, seven remedial action alternatives were assembled to facilitate general comparative assessments and provide a perspective for implementing each of the GRAs. Assembled alternatives, with their primary technology applications, are summarized in Figure 3-1.

- A No Action alternative—Provides a basis for comparative analyses in accordance with CERCLA guidance. This alternative includes an environmental monitoring component to facilitate future assessments of site impacts.
- A Limited Action alternative—Relies on site access controls, a surface barrier, and land-use restrictions to protect human health.
- Two containment alternatives—Rely primarily on constructing surface and subsurface barriers to prevent access to waste and control future contaminant migration.

		Preliminary Remedial Action Alternatives						
		No Action	Limited Action	Surface Barrier	Full Containment	In Situ Grouting	In Situ Vitrification	Retrieval/Treatment/Disposal
Institutional Control	Environmental Monitoring	✓	✓	✓	✓	✓	✓	✓
	Access Controls		✓	✓	✓	✓	✓	✓
	Land Use Restrictions		✓	✓	✓	✓	✓	✓
Containment	Surface Barriers		✓	✓	✓	✓	✓	✓
	Subsurface Barriers				✓			
In Situ Treatment	Physical Treatment					✓		
	Thermal Treatment						✓	
Retrieval	Contamination Control							✓
Ex Situ Treatment	Physical/Chemical/Thermal							✓
Disposal	Off-Site Disposal of TRU Waste							✓
	On-Site Storage/Disposal							✓

Figure 3-1. Remedial action alternatives.

- Two in situ treatment alternatives—Focus on applying either ISV or ISG technology to treat and stabilize waste and contaminated soil in place.
- A Retrieval, Treatment, and Disposal (RTD) alternative—Focuses on retrieving and treating waste and contaminated soil with off-Site disposal of TRU material and onsite disposal of LLW and treated MLLW material.

As shown in Figure 3-1, the alternatives comprise a number of common technology applications. All of the alternatives include a monitoring component and, except for the No Action alternative, require implementing institutional controls and placement of a cap to prevent future access to waste. Alternatives primarily differ in approach to stabilizing and treating RFP TRU waste streams, which contain the majority of the actinide-, VOC-, and nitrate-bearing waste. Each alternative features a primary technology (containment, ISG, ISV, or RTD) to remediate these waste streams. However, it should be noted that in considering either technology limitations or pretreatment requirements, supplemental technologies have been included in the alternatives to address site-specific needs. Remediation of non-RFP waste streams containing groundwater COCs also is addressed in each alternative either through applying primary or supplemental technologies.

In following sections, preliminary remedial alternatives are described and screened, either individually or by GRA, to identify candidate remedial alternatives. Remaining alternatives will undergo a more detailed analysis and comparative evaluation in Section 4, in accordance with CERCLA feasibility study evaluation criteria. Alternatives presented in this chapter incorporate representative technologies and process options, identified and screened in Section 2, to provide a comparative assessment of effectiveness, implementability, and cost.

3.1 Scope of Remedial Action

The primary focus of this analysis is to identify and evaluate remedial alternatives that address potential human health and ecological risks associated with buried waste (source term) within the SDA. Alternatives are structured to focus specific technologies on mitigating risks resulting from identified COCs. Scope of required remedial measures is based on available waste inventory data, which identify extent and location of waste streams in the SDA that contain the primary COCs. Distribution of these contaminants was presented in the ABRA (Holdren et al. 2002) and is summarized in Section 2 of this report.

Given the general distribution of the COCs and level of health risks identified in the ABRA, alternatives developed for this analysis were structured to address all the COC-bearing waste streams within the SDA. Alternatives focusing on hot spot treatment or retrieval actions could not be developed to a level that would achieve the required risk reduction needed for conformance with project RAOs. As noted in the ABRA, waste containing identified COCs is widely distributed in disposal sites within the SDA. The actinide COCs (i.e., americium, uranium, neptunium, and plutonium) are distributed primarily in the RFP waste located in Pits 1 through 6 and 9 through 12, Trenches 1 through 10, and Pad A. These disposal sites also contain the nitrate- and VOC-bearing COC waste. Activation and fission product COCs are primarily located in the SVRs and the remaining trench areas, though some also have been disposed of in Pits 8, 9, and 10.

As discussed in the preceding section, in addition to the No Action and the Limited Action alternatives, two containment alternatives, two in situ treatment alternatives (ISV and ISG), and one RTD alternative were developed for this initial screening. The first two alternatives involve remedial actions that address the SDA on the whole, and are not focused on preventing or reducing future contaminant migration and do not stabilize or treat specific groundwater COCs within buried waste. As such, these two alternatives are not burial-site-specific (i.e., applicable to individual pits or trenches). However, for the remaining alternatives, including the containment alternatives, the in situ treatment alternatives (ISG and ISV), and the RTD alternative, site-specific applications of individual technologies are considered to address groundwater risk associated with both TRU and non-TRU waste.

3.1.1 Rocky Flats Plant Waste Locations

To provide a comparative perspective for this PERA, alternatives will apply specific in situ treatment and retrieval technologies on burial sites containing TRU waste received from the RFP. Available inventory data indicate that the following disposal units contain these types of waste.

- Pits 1 through 6 and 9 through 12
- Trenches 1 through 10
- Pad A.

As shown in contaminant distribution maps presented in the ABRA (Holdren et al. 2002), waste streams associated with RFP waste contain the majority of actinides (e.g., plutonium, uranium, americium, and neptunium), nitrates, and VOCs (e.g., CCl_4, PCE, and methylene chloride). General locations of these burial sites along with the distribution of actinide-, VOC-, and nitrate-bearing streams are shown on Figure 3-2.

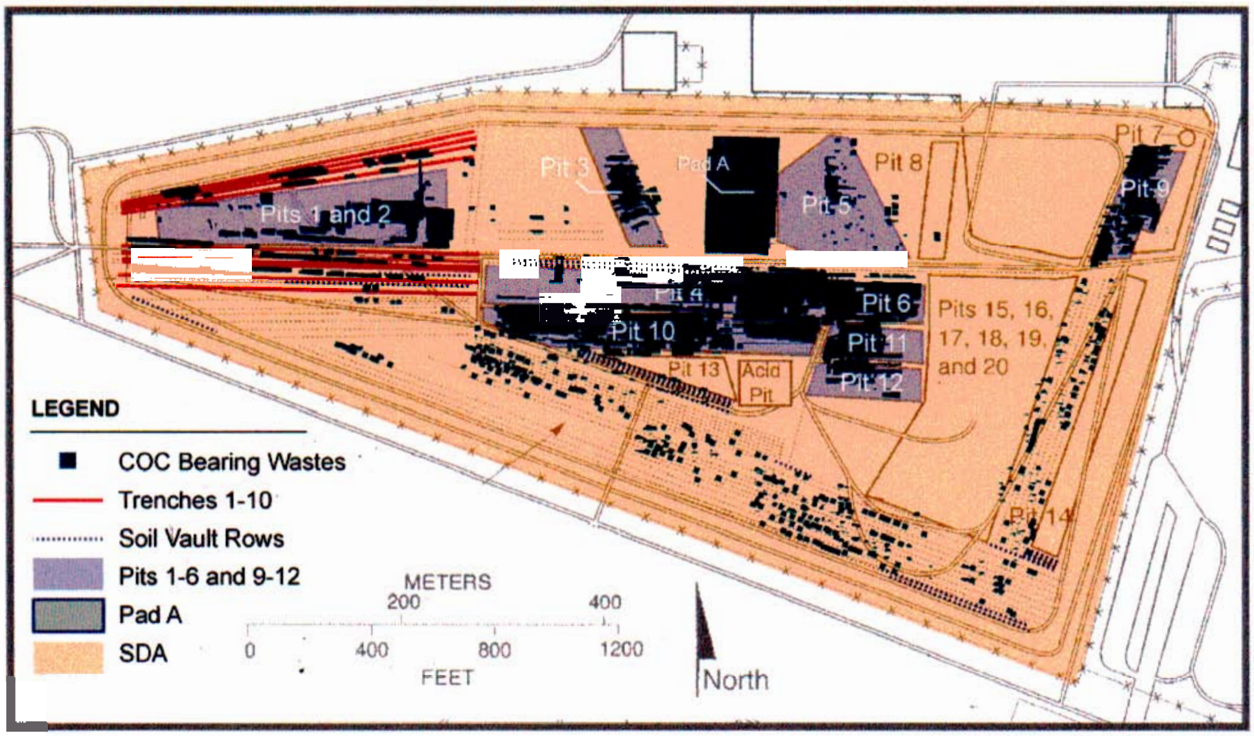

Figure 3-2. Selected waste disposal units at the Radioactive Waste Management Complex.

Based upon available disposal records and inventory data, areas within disposal units containing higher and lower concentrations of COC-bearing waste can be identified. However, for the purpose of this analysis, it is assumed that applying in situ treatment and retrieval technologies that target the RFP waste would address each disposal unit as a whole (i.e., the full extent of each pit and trench).

Identified waste disposal units contain both RFP and non-RFP waste, which can be characterized as either TRU waste, LLW, or MLLW. Volumes in each of the units were estimated based on available inventory data. For the RFP waste, the percentage of TRU versus non-TRU waste is uncertain. However, for this initial analysis, it is assumed that 50% of the RFP waste could be characterized as TRU waste with the remainder classified as either LLW or MLLW. The non-RFP waste within disposal sites would be considered as either LLW or MMLW. It also is assumed for this analysis that the interstitial soil, (i.e., 30 cm [1 ft] of the overburden and 30 cm [1 ft] of underburden soil) are contaminated. Figure 3-3 illustrates the surface area and capacity for each of the RFP waste units along with estimated volumes of TRU and non-TRU waste.

Pit/Trench Number	(1) Total Volume of Pit/Trench[a] (m^3)	(2) Surface Area of Pit/Trench (m^2)	(3) Volume of Non-RFP Waste (m^3)	(4) Volume of RFP Waste (m^3)	(5) Total Waste Volume[b] (m^3)	(5) Total TRU Waste Volume[c] (m^3)	(6) Total NonTRU Waste Volume (m^3)
1	5,850	2,310	1,460	4,380	5,840	2,190	3,650
2	18,430	7,290	2,820	6,500	9,320	3,250	6,070
3	9,830	3,890	620	1,370	2,000	685	1,305
4	26,250	10,380	1,580	9,320	10,900	4,660	6,240
5	25,550	10,100	780	7,000	7,780	3,500	4,280
6	12,920	5,110	650	6,210	6,860	3,105	3,755
9	10,700	4,230	620	3,400	4,020	1,700	2,320
10	26,250	10,380	2,610	13,300	15,910	6,650	9,260
11	5,840	2,310	3	420	420	210	213
12	7,030	2,780	120	1,770	1,890	885	1,005
Pits Total	**148,650**	**58,780**	**11,260**	**53,670**	**64,940**	**26,835**	**38,098**
PAD A	16,990	NA	0	10,200	10,200	6	10,200
Pad A Total	**16,990**	**NA**	**0**	**10,200**	**10,200**	**6**	**10,200**
T1	1,890	750	130	390	520	195	325
T2	1,860	750	70	200	270	100	170
T3	1,830	720	150	440	590	220	370
T4	1,840	730	160	480	640	240	400
T5	1,920	760	170	510	680	255	425
T6	1,840	730	160	480	640	240	400
T7	1,910	750	110	320	430	160	270
T8	1,840	730	160	490	650	245	405
T9	2,020	800	10	30	40	15	25
T10	1,900	750	80	250	330	125	205
Trenches Total	**18,850**	**7,470**	**1,200**	**3,590**	**4,790**	**1,800**	**2,990**
Volumes Total	**184,000**	**66,000**	**12,460**	**67,460**	**79,930**	**28,640**	**51,290**

a. Total Volume of Pit/Trench (from Interim Baseline Risk Assessment); for Pad A the total volume was assumed based upon storage configuration
b. Total Waste Volume equals the sum of Volume of Non-RFP Waste (3) and Volume of RFP Waste (4)
c. Total TRU waste volume assumes 50% of RFP Waste (4) except for Pad A where only limited shipments were noted.

Figure 3-3. Disposal unit waste volume estimates.

As shown in Figure 3-3, based upon available inventory data, the disposal units contain approximately 67,460 m^3 (88,230 yd^3) of RFP waste and approximately 12,460 m^3 (16,300 yd^3) of nonRFP waste. With the assumption that 50% of the RFP waste in the pits and trenches and approximately 6 m^3 (8 yd^3) of the waste on Pad A will be classified as TRU waste, the total volume of TRU waste is projected at 28,640 m^3 (37,460 yd^3). The total volume of non-TRU waste, which will be classified as either MLLW or LLW, is estimated at 51,290 m^3 (67,080 yd^3).

An estimate of potentially contaminated soil and total TRU and non-TRU waste streams within the disposal units is provided in Figure 3-4.

Pit/Trench Number	(1) Volume of Non-TRU Waste (m^3)	(2) Volume of TRU Waste (m^3)	(3) Total Waste Volume[a] (m^3)	(4) Volume Contaminated Soil[b] (m^3)	(5) Volume of TRU-Contaminated Soil[c] (m^3)	(6) Volume of NonTRU-Contaminated Soil[d] (m^3)	(7) Volume TRU Waste and Soil[e] (m^3)	(8) Volume Non-TRU Waste and Soil[f] (m^3)	(9) Volume Clean Overburden (m^3)
1	3,650	2,190	5,840	1,410	705	705	2,895	4,355	3,520
2	6,070	3,250	9,320	13,550	3,250	10,300	6,500	16,370	11,110
3	1,305	685	2,000	10,200	685	9,515	1,370	10,820	5,930
4	6,240	4,660	10,900	21,670	4,660	17,010	9,320	23,250	15,820
5	4,280	3,500	7,780	23,930	3,500	20,430	7,000	24,710	15,390
6	3,755	3,105	6,860	9,180	3,105	6,075	6,210	9,830	7,790
9	2,320	1,700	4,020	9,260	1,700	7,560	3,400	9,880	6,450
10	9,260	6,650	15,910	16,660	6,650	10,010	13,300	19,270	15,820
11	213	210	420	6,820	210	6,610	420	6,823	3,520
12	1,005	885	1,890	6,830	885	5,945	1,770	6,950	4,240
Pits Total	**38,100**	**26,835**	**64,940**	**119,510**	**25,350**	**94,160**	**52,200**	**132,300**	**89,590**
PAD A	10,200	6	10,210	11,740	6	11,734	12	21,930	12,120
Pad A Total	**10,200**	**6**	**10,210**	**11,740**	**6**	**11,734**	**12**	**21,930**	**12,120**
T1	325	195	520	1,830	195	1,635	390	1,960	1,140
T2	170	100	270	2,050	100	1,950	200	2,120	1,140
T3	370	220	590	1,680	220	1,460	440	1,830	1,100
T4	400	240	640	1,650	240	1,410	480	1,810	1,110
T5	425	255	680	1,700	255	1,445	510	1,870	1,160
T6	400	240	640	1,650	240	1,410	480	1,810	1,110
T7	270	160	430	1,940	160	1,780	320	2,050	1,140
T8	405	245	650	1,640	245	1,395	490	1,800	1,110
T9	25	15	40	2,460	15	2,445	30	2,470	1,220
T10	205	125	330	2,030	125	1,905	250	2,110	1,140
Trenches Total	**3,000**	**1,795**	**4,790**	**18,630**	**1,800**	**16,840**	**3,590**	**19,830**	**11,370**
Volumes Total	**51,300**	**28,600**	**79,900**	**149,900**	**27,200**	**122,700**	**55,800**	**174,100**	**113,000**

a. Total Waste Volume equals the sum of Volume of Non-TRU Waste (1) and Volume of TRU Waste (2)
b. Total Volume Contaminated Soil equals insterstitial soil plus 1 ft contaminated underburden plus 1 ft contaminated overburden
c. Volume TRU Contaminated Soil equals the volume of contaminated TRU Waste
d. Volume Non-TRU contaminated Soil equals the total Volume of contaminated soil (column 4) minus the volume of TRU contaminated soil (column 5)
e. Total Volume of TRU Waste and Soil equals sum of columns 2 and 5
f. Total Volume of Non-TRU Waste and Soil equals sum of columns 1 and 6

Figure 3-4. Disposal unit waste and soil volume estimates.

As shown in Figure 3-4, it is estimated that the designated pits, trenches, and Pad A contain approximately 149,900 m^3 (196,060 yd^3) of potentially contaminated soil, which includes interstitial soil and 1 ft of overburden and underburden soil. The amount of TRU-contaminated soil was considered to be equivalent to the TRU waste volume in each of the disposal units, which results in a combined total of 55,800 m^3 (73,000 yd^3) of TRU waste and soil. The remaining 174,000 m^3 (227,600 yd^3) of waste and soil was considered to consist of both MLLW and LLW. It is also estimated that a retrieval action would require removing approximately 113,000 m^3 (147,800 yd^3) of clean overburden soil.

3.1.2 Soil Vault Rows and Remaining Trenches

As discussed in the previous section, identified RFP waste disposal sites primarily contain the actinide, nitrate, and VOC COCs. However, certain COCs (e.g., C-14, I-129, Nb-94, and Tc-99) were disposed of primarily as remote-handled waste in the SVRs and within the remaining trenches (Trenches 11 through 58) and pits. Some quantity of waste containing fission and activation products also was disposed of in Pits 8, 9, and 10. The general distribution of COC-bearing waste is shown on Figure 3-5, which is based on partial mapping data that were available at the time this report was being prepared. Because work is still ongoing to map the SDA, all locations and quantities of waste containing fission and activation products in the SDA have not been identified.

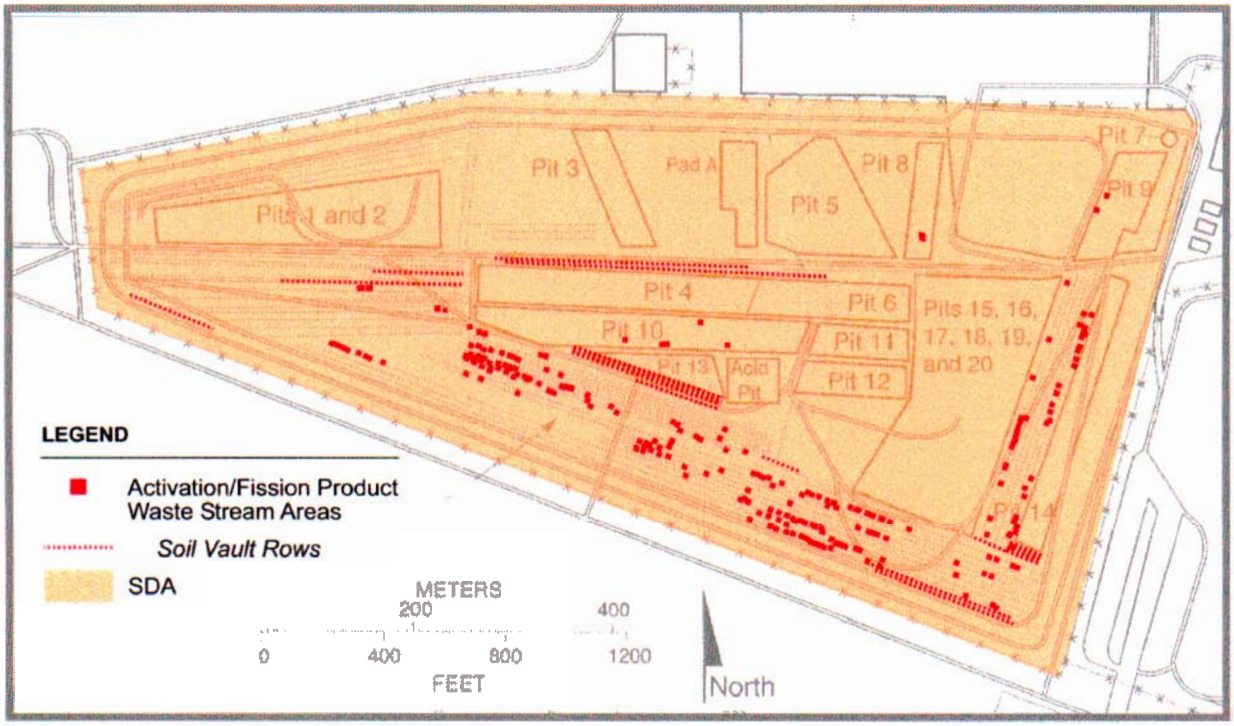

Figure 3-5. Distribution of activation and fission products based on a partial mapping data set.

For each alternative, specific remedial actions also would be directed at these areas. For this analysis, it is assumed that additional remedial measures would encompass all of the SVRs (approximately 550 individual vaults) and selected areas within the trenches, amounting to approximately 1,500 m^2 (15,900 ft^2) of trench.

3.1.3 Special Waste Forms

Research is currently being conducted to verify and quantify special waste forms in the SDA (e.g., irradiated fuel materials and beryllium blocks), which could require specific remediation. Presently, the nature and extent of special waste forms within the SDA are uncertain and therefore will not be directly addressed in this PERA. Remediation requirements for special waste forms will be evaluated during preparation of the WAG 7 feasibility study.

3.2 Assembly of Alternatives

Alternatives presented in this section are developed around specific technology applications, including containment, ISG, ISV, and RTD. These alternatives provide a comparative perspective regarding potential implementation of these technological approaches and their ability to address risks associated with buried waste within the SDA. Therefore, each of the technologies is principally featured in its respective alternative and is primarily focused on remediating RFP waste, as described in the previous section. However, because of variability of waste in the SDA and unique capabilities of featured technologies, using supplemental technologies was required to assemble alternatives to adequately address site risks and achieve the RAOs defined in Section 1. Supplemental technologies have been evaluated for the following:

- Trench and SVR areas containing the activation and fission products

- Disposal sites containing high concentrations of VOCs
- Pad A waste.

The application of these supplemental technologies for each of the alternatives is summarized in Figure 3-6.

As shown in Figure 3-6, the No Action and the Limited Action alternatives do not include supplemental technologies that specifically address activation products, fission products, high VOC areas, and Pad A. Summary discussions of the application of the supplemental technologies for each of the remaining alternatives are presented in the following subsections.

3.2.1 Containment Alternatives

Containment alternatives, which include both Surface Barrier and Full Containment alternatives, are primarily developed to address buried waste within the SDA as a whole, and therefore are not waste-site-specific technology applications. However, fate and transport modeling indicates that containment alone will not adequately address long-term groundwater risks. For this reason, containment alternatives as presented in this analysis, also include applying ISG in the SVRs and selected trench areas to augment containment technologies and minimize future activation and fission product COC releases from the source term. Containment alternatives also include applying ISTD to address high VOC areas within the source term by extracting and treating organic contamination in these areas.

	Monitoring	Access Controls	Surface Barrier	Subsurface Barrier	In Situ Treatment	Retrieval	Ex Situ Treatment	On-Site Disposal	Off-Site Disposal	Representative Process Options
No Action	✓									
Limited Action	✓	✓	✓*							*Biotic Barrier
Surface Barrier	✓	✓	✓*							*Engineered Multi-Layer Cap
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD
Pad A Waste						✓		✓*		*Placed Beneath Cap
Full Containment	✓	✓	✓*	✓						*Engineered Multi-Layer Cap
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD
Pad A Waste						✓		✓*		*Placed Beneath Cap
In Situ Grouting	✓	✓	✓*							*Engineered Multi-Layer Cap
RFP Waste					✓*					*ISG
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD
Pad A Waste						✓	✓*	✓		*Ex Situ Stabilization
In Situ Vitrification	✓	✓	✓*							*Engineered Multi-Layer Cap
RFP Waste					✓*					*ISV
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD/ISV
Pad A Waste					✓*	✓				*ISV
Retrieval	✓	✓	✓*							*Engineered Multi-Layer Cap
RFP Waste						✓	✓	✓*	✓**	*On-Site Landfill - Non TRU Waste **WIPP Disposal - TRU Waste
Activation/Fission Waste					✓*					*ISG
VOC Waste					✓*					*ISTD
Pad A Waste						✓	✓	✓*		*On-Site Landfill

Figure 3-6. Alternative components.

For both containment alternatives, it is assumed that ISG would be used to stabilize any untreated waste units within the SDA, as required to minimize any future subsidence-related damages to the cover system. Further, Pad A waste, as currently configured, is potentially unstable and its ability to support the proposed cover system is questionable. For this reason, containment alternatives assume that the Pad A waste will be retrieved and placed in a compact and more stable configuration within the SDA before constructing the cover system.

3.2.2 In Situ Grouting Alternative

The ISG alternative is focused on remediating groundwater COCs within the SDA. In general, ISG has been shown to be highly effective in immobilizing a wide range of contaminants and will adequately address the majority of waste streams identified in the SDA. However, high concentrations of salt compounds have been found to interfere with curing cementitious grouts. Past work has demonstrated that, with certain grout formations, competent waste forms could be achieved with waste loading approaching 50 wt% nitrate salt (Loomis et al. 1997a, Spence et al. 1999). For this analysis, it is assumed that nitrate salt waste buried within pits would be effectively stabilized in place using ISG. However, for the Pad A area where a high concentration of stacked drums contains the 745 waste, the effectiveness of ISG is questionable. It is therefore assumed for this alternative that the Pad A waste would be retrieved, processed as required, and stabilized ex situ. Stabilized waste would then be placed back onsite before constructing the final cover system over the entire SDA.

High organic content waste also has been shown to interfere with curing the grout matrix (Armstrong, Arrenholz, and Weidner 2002). A predominant waste type within the SDA consists of contaminated oil and other hazardous chemicals that were stabilized in an absorbent and packaged in drums. It is assumed for this alternative that the areas of high organic concentrations will require pretreatment using ISTD.

3.2.3 In Situ Vitrification Alternative

The ISV alternative is focused on the TRU pits and trenches and Pad A. ISV would remove and destroy organic constituents and encapsulate most of the inorganic constituents within a durable glass-like monolith. This technology will address all of the COCs identified in the ABRA, with the exception of C-14. Potentially this contaminant would not be incorporated into a melt, but instead would remain associated with the metal and pool at the base of the melt. Metal in this pool would be expected to leach at a higher rate, with potentially adverse future effects on groundwater. For this reason, it is assumed for this alternative that waste streams containing C-14 will be treated in place using ISG.

Pad A waste consists largely of closely stacked drums with minimal interstitial soil. This configuration, especially in considering the high-alkali nature of some of the waste, makes successfully applying ISV questionable. It was therefore assumed that the Pad A waste would be retrieved and reconfigured in a subsurface pit within the SDA as required for safe and effective treatment.

It is also assumed that, before implementing ISV at any of the disposal sites, waste would be pretreated to remove most of the water and VOCs using ISTD. This pretreatment is necessary to preclude the potential for a steam or gas explosion when using ISV.

At the completion of in situ treatment operations, this alternative includes constructing an engineered surface barrier over the entire SDA. Before constructing this surface barrier, any untreated waste units would be stabilized using ISG to minimize any future subsidence-related damage.

3.2.4 Retrieval, Treatment, and Disposal Alternative

The RTD alternative is directed at the RFP waste streams located in the TRU pits and trenches and Pad A. However, for this alternative to address RAOs, it must also mitigate activation and fission products located in the SVRs and the remaining trenches. Waste in these areas is primarily remote-handled waste, for which no disposal sites are presently available. Thus, the assumption is that this waste would not be retrieved, but would be encapsulated or stabilized in place using ISG.

An additional assumption for this alternative is that the high organics areas within the SDA would require ISTD before initiating retrieval activities to minimize VOC management and contaminant control requirements during retrieval.

For this alternative, the retrieved waste will include both TRU and collocated non-TRU (LLW and MLLW) waste. The TRU waste will be packaged for off-Site disposal at WIPP. The non-TRU waste will be treated and placed in an onsite landfill constructed within the limits of the SDA. At completion of retrieval activities, the entire SDA will be covered with an engineered surface barrier to provide long-term stability of the site. Before constructing this surface barrier, any untreated waste units would be stabilized using ISG to minimize any future subsidence-related damage.

3.3 Common Remediation Elements

Alternatives described in the preceding section have a number of common elements, which are required to address waste stream-specific issues and achieve compliance with the RAOs. All alternatives involve implementing a long-term monitoring program to evaluate effectiveness of remedial measures. All alternatives (with the exception of the No Action alternative) also involve implementing institutional controls in perpetuity and placement of a surface barrier to protect any remaining buried waste at the site. In addition, a number of other elements or considerations are common to two or more of the alternatives, including:

- In situ grouting of the SVRs and trench areas containing activation and fission product COC waste.
- Handling and treating Pad A waste.
- Treating high organic waste areas using ISTD
- Controlling emissions from thermal treatment units
- Continuing operation of existing the OCVZ system
- Continuing operation of active disposal cells
- Maintaining and constructing haul roads.

A discussion of common elements associated with each alternative is presented in following subsections.

3.3.1 Long-Term Monitoring

Each alternative would include implementing a long-term monitoring program, which would involve groundwater, vadose zone moisture, surface soil, surface water, and air. It is assumed that monitoring would be performed under INEEL ongoing Site-wide programs. It is also assumed that any future monitoring program would involve existing monitoring locations and new installations would not be necessary. For costing purposes, it was assumed that a monitoring program would extend for a period of 100 years following completion of the ROD. Every 5 years, site reviews would be conducted to evaluate effectiveness of alternatives and the need for any additional monitoring.

3.3.2 Institutional Controls

Institutional controls (e.g., future land-use and site access restrictions) are key components of each of the action-related remedial alternatives. For each alternative, evaluations assume that a perimeter fence system, with appropriate warning signs, would be established and maintained. For evaluation purposes, the system would presumably consist of an 8-ft chain-link fence, with security gates, extending around the entire perimeter of the SDA and completely encompassing any remaining buried waste and constructed surface barriers.

Evaluations also assume that the SDA would be maintained in perpetuity by DOE or other federal agencies. Institutional control measures would be enforced to prevent inappropriate future use of the site and direct contact with remaining contaminants.

The extent of these controls would depend on the aggressiveness of the remedial action. Controls could include specific restrictions on future development of the waste area and designated buffer areas in response to the nature and extent of remaining waste materials. Controls also could include restrictions on groundwater use.

3.3.3 Surface Barriers and Foundation Stabilization

All the alternatives (with the exception of the No Action alternative) include constructing a surface barrier to control future exposure to waste and identified COCs. Cover designs vary, as summarized in Figure 3-7, based on alternative-specific features and nature of waste remaining within the SDA following remediation. An assumption of the evaluations is that design requirements for the surface barrier would be consistent with criteria recently established for the ICDF design, which considered a 500-year flood event, a probable maximum precipitation (PMP) event for surface scour, and a seismic event corresponding to a return period of 10,000 years.

As shown in Figure 3-7, the No Action alternative does not include constructing a surface barrier. For the Limited Action alternative, a biotic barrier is proposed to deter future biotic intrusions into waste. The SL-1 design was identified as the proposed barrier for this alternative, which consists of approximately 6 ft of gravel and cobbles and requires approximately 1.1 million m^3 (1.5 million yd^3) of material.

Alternative	Surface Barrier
No Action	None
Limited Action	Biotic Barrier
Surface Barrier	ICDF Cover
Full Containment	ICDF Cover
In Situ Grouting	RCRA Modified C
In Situ Vitrification	RCRA Modified C
Retrieval	RCRA Modified C

Figure 3-7. Surface barriers.

For both containment alternatives, the ICDF cover was identified as the proposed surface barrier. This INEEL-specific design is intended to provide containment and hydraulic protection for buried TRU waste for a performance period of 1,000 years. The proposed design includes a vegetative erosion control layer, a biointrusion layer, drainage and filtration layers, and a low-permeability membrane resulting in an overall thickness of approximately 5.5 m (18 ft). Approximately 4.1 million m^3 (5.3 million yd^3) of material would be required to construct the barrier.

In situ treatment alternatives (ISV and ISG) and the RTD alternative also include constructing a low-permeability, multilayered cap over the SDA to protect any remaining waste and residual soil contamination by deterring biotic intrusion, facilitating runoff of precipitation, and further reducing infiltration of moisture into the waste zone. As noted in Section 2, the RCRA (42 USC § 6901 et seq.) Modified Subtitle C cap system was identified as the representative cover for these alternatives where

TRU waste would either be treated in place or retrieved. This cover design consists of layers of earth fill, top soil, sand, gravel, and asphalt, with a combined thickness of approximately 1.7 m (5.5 ft). An estimated 2.4 million m^3 (3.2 million yd^3) of material would be required to construct this cover over the entire SDA.

3.3.3.1 Construction Requirements. Surface barriers primarily consist of interlayered sequences of soil and rock materials. For evaluation purposes, cover systems for each alternative are assumed to encompass approximately 110 acres of surface area, comprising the 97-acre SDA with a 13-acre toe. Evaluations assume that the cap would be initially sloped with placing a site-grading fill to facilitate positive perimeter drainage. This fill would crown the 97-area and create a sloping foundation with a minimum surface gradient of 2%. In addition, a perimeter berm would be installed to minimize inundation or damage during possible flooding events. The perimeter berm would be constructed with silt loam obtained from adjacent areas. The berm would extend approximately 30 m (100 ft) from the toe of the cap and would be 2 m (6.5 ft) high, with side slopes of 2 horizontal to 1 vertical (2H:1V). The total length of the berm around the perimeter of the SDA is estimated to be approximately 3,048 m (10,000 ft). Details regarding design elements for the surface barriers, including layer thicknesses and approximate volumes, is presented on Table 3-1.

Table 3-1. Cover design requirements.

Design Element	Material Description	Thickness (in.)	Volume (yd^3)
Modified RCRA Subtitle C Cap			
Cover Layer 1	Topsoil with gravel	20	296,000
Cover Layer 2	Compacted topsoil	20	296,000
Cover Layer 3	Sand filter	6	89,000
Cover Layer 4	Gravel filter	6	89,000
Cover Layer 5	Gravel drainage	6	89,000
Cover Layer 6	Low-permeability asphalt	6	89,000
Cover Layer 7	Asphalt base course	4	59,000
Cover Layer 8	Gravel gas collection	6	89,000
Cover Layer 9	Grading fill—silt loam	120	1,775,000
Slope armor	Fine filter—sand	12	6,000
Slope armor	Coarse filter—gravel	12	6,000
Slope armor	Coarse-fractured basalt	12	6,000
Slope armor	Riprap	36	18,000
Perimeter berm	Unprocessed silt loam	NA	244,200
Berm armor	Riprap	36	15,600
INEEL Site Composite Cover			
Cover Layer 1	Topsoil	12	177,000
Cover Layer 2	Engineered fill—silt loam	96	1,420,000
Cover Layer 3	Fine filter—sand	12	177,000
Cover Layer 4	Coarse filter—gravel	12	177,000
Cover Layer 5	Bio-intrusion barrier—coarse basalt	30	444,000
Cover Layer 6	Coarse filter—gravel	12	177,000
Cover Layer 7	Fine filter—sand	12	177,000
Cover Layer 8	Geomembrane	60 mil	532,000 yd^2

Table 3-1. (continued).

Design Element	Material Description	Thickness (in.)	Volume (yd^3)
Cover Layer 9	Compacted clay	24	355,000
Cover Layer 10	Gas collection—gravel	6	89,000
Cover Layer 11	Grading fill—silt loam	120	1,775,000
Slope armor	Fine filter	12	15,200
Slope armor	Coarse filter	12	15,200
Slope armor	Coarse basalt	12	15,200
Slope armor	Riprap	36	45,600
Perimeter berm	Perimeter berm	NA	244,200
Berm armor	Riprap	36	15,600

INEEL = Idaho National Engineering and Environmental Laboratory
NA = not applicable
RCRA – Resource Conservation and Recovery Act

3.3.3.2 Borrow Source Evaluation. Material required to construct the surface barriers includes fine-grained, low-permeability soil, sand, gravel, coarse-fractured basalt, and riprap, in the estimated volumes listed in Table 3-1. A preliminary borrow search was conducted to evaluate availability of onsite or off-Site sources and identify proposed borrow sources for each of the required construction materials. Results of the evaluation are summarized in Table 3-2.

Table 3-2. Required materials for surface barriers.

Material	Function	Haul (mi)	Source
Topsoil	Organic silt loam used to support surficial vegetation.	1.5	This material would be unprocessed organic silt loam obtained from Spreading Area B.
Silt loam (fine grain)	Material used for site grading, berm construction and fine-grained layers within the caps.	1.5	If necessary permits and approvals can be obtained, the majority of material would be unprocessed borrow from Spreading Area B. Suitable material also available from Spreading Area A, Ryegrass Flats, and the Water Reactor Research Test Facility area.
Gravel	Material used for the coarse filter layers within the caps.	2.5	This material would be processed gravel obtained from the Borax Gravel Pit.
Sand	Material used for the fine filter layers within the caps.	2.5	No identified bank run borrow areas are available within the INEEL boundary. This material would be processed sand obtained from the Borax Gravel Pit.
Riprap	Material used for erosion control.	5	The majority of the mined riprap material at the INEEL has been used. This material would be processed material mined from a basalt outcropping 5 mi west of the site
Coarse-fractured basalt	Material used as biobarrier within the caps.	5	This material would be processed material mined from a basalt outcropping identified 5 mi west of the site.
Cobbles	This material would be used as biobarrier material if coarse-fractured basalt is unavailable or is not allowed for such use.	45	The majority of the mined riprap material at the INEEL has been used for other remedial actions at the INEEL. This material would be processed material transported from Idaho Falls.

The primary borrow material required for constructing surface barriers is silt loam. Figure 3-8 shows locations of three potentially available silt-loam borrow sites on the INEEL. These areas are estimated to have available soil volume in excess of 3.5 million m^3 (4.6 million yd^3). The closest borrow areas to the SDA are Spreading Areas A and B (1.5 mi southwest), Ryegrass Flats (15 mi northeast), and the Water Reactor Research Test Facility (40 mi north). The PERA evaluations assume that the majority of silt loam for barrier layers will be obtained from Spreading Area B, but additional evaluations must be performed to validate this assumption. Additional information about borrow sources can be found in the *Environmental Assessment and Plan for New Silt/Clay Source Development and Use at the Idaho National Engineering and Environmental Laboratory* (DOE 1997).

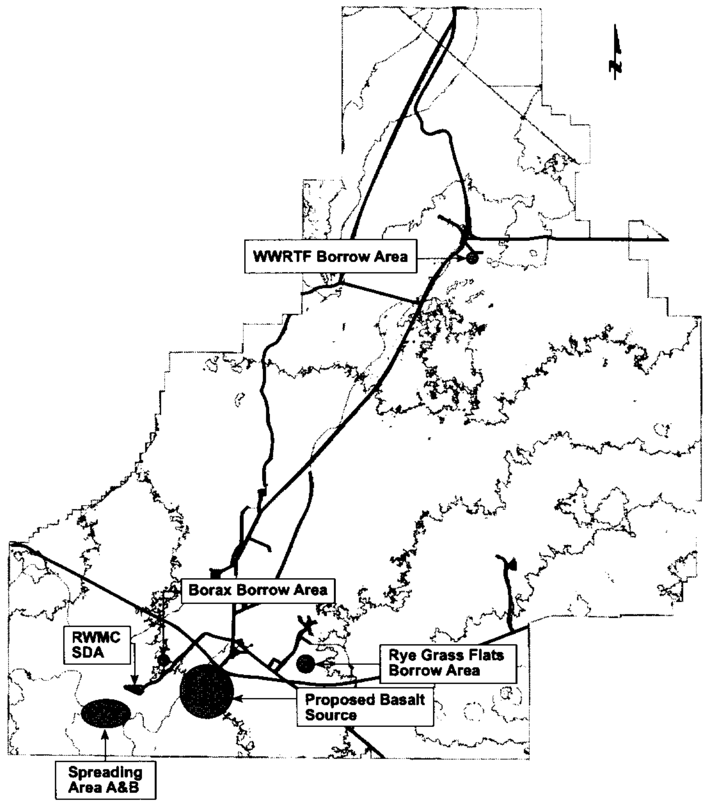

Figure 3-8. Potential borrow sources.

Spreading Area B, which is currently not used as a borrow source, contains deposits of the silt loam material considered most suitable for constructing the compacted clay layer. Over 765,000 m^3 (1 million yd^3) of material are estimated to be available at this location. An assumption for the evaluations is that the regulatory process for allowing borrow activities at Spreading Area B would be successful and the area would be available for WAG 7. Because borrow activities are not currently allowed at Spreading Area B, using this area as a borrow source may entail the following requirements:

- The area must be test drilled to estimate volume.

- The Environmental Assessment Plan must be revised.

- Requirements for an Army Corps of Engineer Section 404 Permit must be considered. Section 404 of the Clean Water Act (EPA 1987) regulates the discharge of dredged or filled material into U.S. waters, including wetlands. Substantive and administrative Clean Water Act dredge-and-fill requirements are applicable or relevant and appropriate to many CERCLA actions, including excavation and disposal of contaminated soil or sediments. However, if excavation activities take place offsite of the RWMC, then the Section 404 administrative permit requirements may also apply.

- Proper handling and disposal of any dewatering fluids from excavating borrow material from the Big Lost River Corridor must be demonstrated.

Processed sand and gravel would be needed for constructing the coarse filter, fine filter, and gravel gas collection layers. These materials would be obtainable from the Borax Gravel Pit located about 2.5 mi from the SDA.

Coarse-fractured basalt will be needed for constructing biotic barriers, and riprap will be needed for erosion control. Because the majority of rock (basalt) once available at the INEEL has been used for other remedial actions at the INEEL, a basalt outcrop about 5 mi from the SDA has been identified for mining to supply these materials. Though cobbles also could be used for the biotic barriers, the nearest apparent source for cobbles is located approximately 45 mi from the SDA in Idaho Falls. The additional cost of this longer haul distance would make cobbles a significantly more expensive construction material than coarse-fractured basalt. Evaluations therefore assume that the basalt outcrop will be mined and the rock will be processed to provide coarse-fractured basalt and rip rap for constructing surface barriers.

3.3.3.3 Foundation Stabilization. The major implementability issues associated with multilayered, low-permeability capping are the amount of subsidence that can be allowed without damaging the cover, and mitigating measures that must be applied before the cover is constructed. Subsidence is a well-documented, annual occurrence at the SDA. For example, a visual inspection of the SDA performed in April 1999 identified 13 subsidences across a number of pits, trenches, and Pad A. Subsidences ranged from 8 to 300 ft long, 4 to 37 ft wide, and 8 in. to 12 ft deep. Average subsidence length is 60 ft and average subsidence width is 15 ft. The deepest subsidences, however, were approximately 12 ft.

Though modern geosynthetics (e.g., low linear polyethylene) have the high tensile strength and flexibility to accommodate substantial settling, long-lived low-permeability caps generally require a stabilized foundation. Even if subsidences can be bridged by cover materials, sagging and eventual collapse over long time periods should be expected. The low-permeability cap design requires a stable foundation to preserve integrity of infiltration-inhibiting layers. The substantial subsidence currently being experienced could reduce effectiveness of the cap and would be difficult to repair, given the layered nature of the design. Methods to control subsidence will need to be developed and implemented before constructing the cap. Actual foundation requirements will have to be developed as part of remedial design. At this time, grouting is incorporated to stabilize the cap foundation. However, other pretreatments (e.g., dynamic compaction and preloading) could be considered.

Grouting for foundation stabilization would be nonreplacement in situ jet grouting as developed at the INEEL (Armstrong, Arrenholz, and Weidner 2002). This technique, which is described in subsequent sections of this PERA, employs a modified drill rig to inject grout under high pressures into the waste seam. The grout fills all readily accessible void space and cures into a solid monolith. Because the waste and grout monolith is supported on five sides and void space is filled, subsidence is eliminated regardless of the final compressive strength of the grouted media. This principle permits using widely available, inexpensive grouts (e.g., Portland cement) as the solidifying agent.

Unlike grouting for waste treatment, stabilization grouting would not require that grout be intimately mixed with waste or soil, nor would it be required that the grout fill soil pore space or other small void space inside individual waste drums. The assumption for the evaluations is that voids that threaten integrity of the cap are fairly large and would be intersected if grout was injected on an 4-ft center-to-center spacing across the areas requiring stabilization. This spacing does not ensure that every container is intersected, but would be adequate to support the cap. During remedial design, a records review and geophysical program may be performed in an attempt to characterize the size and extent of the large void areas.

During past field trials in simulated buried waste, researchers found that the maximum volume of grout that could be injected using a dense, 0.5 m (20-in.) grid injection spacing was approximately 60% of waste volume. Therefore, it is projected that grouting for foundation stabilization would require approximately 10,300 m^3 (13,500 yd^3) of grout per acre of waste, given the assumption that the volume of the large voids equals 60% of waste volume and that the waste seam is (on average) 4.3 m (14 ft) thick. It is projected that the production rate for foundation preparation would be substantially greater than that required for waste encapsulation, because of increased spacing and fewer number of required grout holes.

3.3.4 Grouting of Soil Vaults Rows and Trenches Containing Activation and Fission Products

A common element for containment, in situ treatment, and RTD alternatives is in situ grouting of the SVRs and trench areas containing activation and fission product waste. Fate and transport modeling indicates that containment alone (i.e., the construction of engineered low-permeability surface and subsurface barriers) would not sufficiently reduce the release rates of the activation and fission product COCs to protect area groundwater. Furthermore, ISV was not regarded as an effective solution, given the high metal content and concerns that C-14 would not be effectively treated (Thomas and Treat 2002).

Though a detailed analysis of waste streams and engineering design have not been performed, ISG has been identified as the most effective and implementable option. The predominant waste form in these areas is high-activity, remote-handled waste, primarily activated metals. In the SVRs waste was typically dropped into augured holes with heavily shielded or remote discharge equipment. Because of safety concerns when handling high-activity waste and the absence of available disposal options, retrieval was not considered.

Grouted waste forms have been extensively researched for activation and fission products from nuclear reactors, and available data show that COCs (e.g., C-14) have extremely low diffusion coefficients through cementitious grout (Armstrong, Arrenholz, and Weidner 2002). These data suggest that cementitious grout would not only reduce infiltration, slowing corrosion and contaminant release, but would also chemically bind with the COCs. Significantly, past ISG testing has focused on sludge types of waste as found in the TRU pits and trenches. The injection process has not been tested on simulated soil vaults. However, because injection has been used successfully in INEEL soil, the process will be implementable for applying grout in a v-trough pattern around individual vaults.

3.3.5 Handling and Treating Pad A Waste

Pad A waste represents a unique challenge to each remedial alternative. As described in Section 2, the asphalt pad, which is located in the north-central portion of the SDA, was constructed for disposal of packaged, solid, and mixed waste primarily from the RFP. Over 20,000 waste containers, including 55-gal drums and plywood boxes, were placed on the pad. Stacked waste consists primarily of nitrate salt, depleted uranium, and sewage sludge. In 1994, the Pad A cover was reinforced with a 3- to 5-ft-thick vegetated soil layer and a rock armor cover on the south face as a remedial action in accordance with the OU 7-12 ROD (DOE 1994). The covered waste area extends to an average height of 9 m. Since remediation, annual maintenance activities have included repairing subsidence-related damage to the soil cover.

With the exception of the No Action and the Limited Action alternatives, all of the alternatives presented in this analysis are based on the assumption that the Pad A waste would be retrieved, treated, and reconfigured in a compacted layer within the center of the SDA before the placement of the final cover. This action would address the unstable nature of the surface of the Pad A waste pile and potential design issues associated with incorporating the pile into the final cover system. For containment alternatives, preventing future subsidence-related damage to the final surface barrier is critical to ensure its long-term integrity and minimize future maintenance requirements. For the in situ treatment alternatives (ISG and ISV), the assumption was that retrieval of the Pad A waste would facilitate treatment. For the ISG alternative, it was assumed that waste would require specialized grout with an ex situ application to ensure proper treatment, given the high nitrate concentrations in the waste. For the

ISV alternative, the amount of interstitial soil was deemed insufficient to ensure effective vitrification. Therefore, the analysis included the assumption that waste would be retrieved, blended with soil, and restaged in an onsite pit. The restaged waste would then be vitrified in place.

3.3.6 Treating High Volatile Organic Compound Waste

With the exception of the No Action and the Limited Action alternatives, all of the alternatives include the assumption that in situ treatment of the high VOC areas would be required. Such treatment would focus on reducing future operational requirements for the OCVZ system and facilitating the implementation of specific technologies. As discussed in Section 2, though a number of technologies that could provide for in situ treatment of this waste are potentially applicable to the SDA, ISTD by thermal conduction was selected as the representative technology.

The ISTD pretreatment would employ a 2.4 × 2.4-m (8 × 8-ft) array of heated pipes inserted into the ground. Gas extraction pipes inserted next to the heating pipes would be used to collect steam, volatile organic carbon gases, acid gases, and mercury vapors. Each extraction pipe would be equipped with an integral filter to prevent radioactive particles from migrating into the off-gas treatment system. The pressure of the soil overburden and the high temperatures achieved during ISTD would ensure that liquids in sealed containers boil and breach their containers. The maximum temperature that would be reached (800°C) is well below that at which soil and steel melt. The minimum temperature that would be reached (360°C) is that at which metallic mercury boils. Heating would occur over about a 3-month period. Gas cylinders should also be safely breached, because they are constructed with gas vent plugs designed to slowly relieve pressure at approximately 200°C.

From a risk perspective, VOCs of primary concern include CCl_4, PCE, and methylene chloride. Distribution of these compounds is presented in Section 2 (Figure 2-4). As shown, the VOCs are located within portions of the TRU pits and trenches. The highest concentrations of VOCs, including CCl_4, have been noted within the Series 743 organic waste stream from the RFP. Figure 3-9 depicts the general locations of this waste within the SDA. Also indicated on the figure are areas containing stacked Series 743 waste drums where the higher concentrations of VOCs are expected.

The extent of the ISTD application as a pretreatment to address VOCs in the waste is different for each of the alternatives and depends on specific technology requirements and the need to ensure compliance with RAOs. For containment alternatives, it is assumed that ISTD would be implemented to address the full extent of the CCl_4 distribution as depicted on Figure 3-9, which amounts to a total area of approximately 5 acres. Identified in the ABRA as a major contributor to future groundwater risks, CCl_4 is the primary focus of the OCVZ system currently operating at the RWMC to remove VOCs from the underlying vadose zone (see Section 3.3.8). For the ISV alternative, where ISTD is used as a supplemental technology to precondition the waste and minimize the possibility of explosion, the application will be performed over the full extent of the TRU pits and trenches, approximately 17 acres. For ISG, pretreatment is required only in high organic areas to ensure proper implementation of the technology. Pretreatment for the retrieval alternative is required only to minimize material handling requirements. For both of these alternatives, only high organic areas (approximately 1 acre) depicted on Figure 3-9 will be targeted.

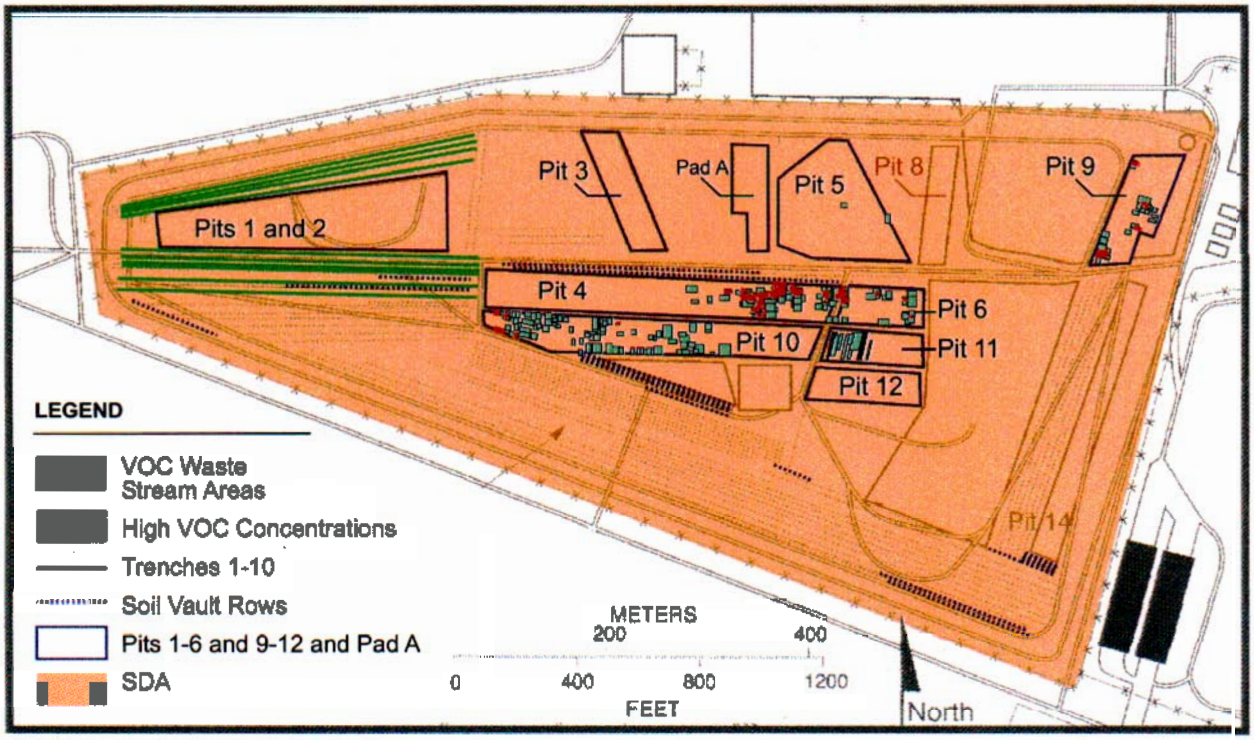

Figure 3-9. High volatile organic compound waste stream areas.

3.3.7 Air Emissions

Air emissions from the ex situ and in situ treatment systems identified for the alternatives will occur as point and fugitive sources. Systems will be designed to capture air emissions with a negative pressure ventilation system, minimizing the amount of fugitive emissions. Captured pollutants will be directed to an emission control system for treatment. Controlled emission rates of regulated pollutants (nitrogen dioxide, carbon monoxide, sulfur dioxide, particulates, ozone and lead) will be calculated and compared against State of Idaho and federal standards. Emission control systems will be used to control pollutants found to exceed significant levels. It is also assumed that emission controls employed will meet Best Available Control Technology standards for these pollutants. Particulate and nitrogen oxide emissions are anticipated to be primary pollutants of concern.

For the alternatives, air dispersion modeling will be performed on all criteria pollutant emissions to determine potential ambient impact of ISTD and ISV operations on local and regional air quality. Refined modeling using the dispersion model will yield short-range (approximately 50 km) air quality impacts. Compliance with the National Ambient Air Quality Standards (NAAQS) (EPA 1990) will be demonstrated through the modeling. The regional air quality impacts can be determined using the CALPUFF model (Earth Tech 2002), which could also be used to evaluate the potential impacts of system operations on visibility in the regional Class I air quality areas (e.g., Yellowstone National Park, Grand Teton National Park, and Craters of the Moon). In addition, modeling will be used to demonstrate compliance with the Prevention of Significant Deterioration increments on the regional Class I areas. Proposed system designs described in these alternatives are expected to enable the facility to meet the standards. However, if modeling later shows a potential significant impact or violation of the NAAQS, the air pollution control system design will be modified.

Toxic air pollutant standards are given in the Idaho Department of Environmental Quality regulations (IDAPA 58.01.01). The standards consist of emission limits and acceptable ambient air concentrations. Compliance with these standards will be demonstrated to ensure the emissions will not injure or unreasonably affect human or animal life or vegetation. In addition, the IDEQ references EPA regulations and emission standards for radionuclides, including 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides" under the National Emission Standards for Hazardous Air Pollutants." Compliance with these standards will also be demonstrated through using emission controls and exposure assessment modeling.

3.3.8 Organic Contamination in the Vadose Zone System

The vadose zone beneath the SDA contains VOCs, primarily in the form of vapors, which have migrated from waste buried in the SDA. In accordance with the FFA/CO (DOE-ID 1991), the OCVZ was identified as OU 7-08. Operable Unit 7-08 addresses organic contamination in the vadose zone beneath the SDA, which extends to the top of the Snake River Plain Aquifer approximately 177 m (580 ft) bgs. The primary source of VOC waste within the SDA is associated with containerized Series 743 organic waste from the RFP (EG&G 1993). Initially, estimates for this waste stream were approximately 335,000 L (88,400 gal) of Texaco Regal Oil, CCl_4, and other miscellaneous organics. However, recent analysis of data indicates that a much larger initial source estimate in the volume of CCl_4 (Miller and Varvel 2001). Completion of an RI/FS for OU 7-08 led to a final ROD in 1994, which identified extraction and destruction of the organic vapors as the selected remedy. A series of vapor extraction wells was installed within the SDA with an off-gas treatment system designed to destroy extracted vapors. Since January 1996, when remediation began, approximately 105,000 lb of total VOCs have been removed and treated.

The primary RAO identified in the OU 7-08 ROD is to ensure that risks to future groundwater users are within acceptable guidelines and that future VOC concentrations in the aquifer remain below federal and state drinking water standards. All of the alternatives are designed to accommodate the continued operation of this OCVZ system. Cost estimates for alternatives include capital costs to extend extraction wells, reconstruct header lines, and relocate treatment units as required for the continued operation of the system. No costs, however, were assumed for any future operation and maintenance requirements.

3.3.9 Active Disposal Cells

Current operations within the SDA consist of subsurface disposal of LLW in Pits 17 through 20. Waste materials that meet WAC are currently stacked in the pits to a maximum height of 24 ft with forklifts and cranes. As areas become full, waste is covered with a minimum of 3 ft of soil and the area is seeded. The closure date is uncertain. For this PERA, it is assumed that that the final surface cap systems proposed for individual alternatives would be extended to cover active cells and a staged approach to accommodate continued operation of these active disposal sites would be required. Specifically, installing the final cap identified for each remedial alternative includes a construction phase for these active areas with a start date of 2020.

3.3.10 Haul Roads

Evaluations presented in this PERA assume that the existing road system within the INEEL would be used to transport materials to and from WAG 7, and the cost estimate for each of the alternatives includes the expense for maintaining these roads. A secondary assumption for each of the alternatives is that approximately 2 mi of new gravel haul road would be required to obtain access to additional borrow sites.

3.4 Initial Screening Criteria

The initial screening of alternatives follows CERCLA guidance to identify an appropriate number and range of remedial alternatives to be retained for detailed analysis. As outlined in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988), the evaluations assess each alternative's performance according to three general screening criteria, which are detailed in Figure 3-10:

- Effectiveness—These criteria refer to short-term and long-term protection of human health and the environment that an alternative provides. In this application, short-term refers to the implementation period (the duration of the remedial action) and includes potential worker exposure issues and potential uncontrolled releases to the environment. Long-term refers to the period following remediation and includes considerations for permanence and reversibility. Reduction of toxicity, mobility, and volume of contaminated material is also a measure of an alternative's long-term effectiveness.

Screening Criteria Parameters		
Criterion	**Time Interval**	**Parameters**
Effectiveness		
	Short-Term (Implementation Period)	**Protection of:** • Human health • Environment
	Long-Term	**Reduction of:** • Mobility • Toxicity • Volume
Implementability		
	Short-Term (Implementation Period)	**Technical Feasibility** • Construction • Operation • Maintenance
	Long-Term	**Administrative Feasibility** • Availability of: – Services – Equipment – Personnel – Stakeholder acceptance
Costs		
	100 Years	• Capital costs • Operating costs • Monitoring and maintenance

Figure 3-10. Screening criteria parameters.

- Implementability—These criteria refer to technical and administrative issues pertaining to the feasibility of implementing an alternative. *Technical* feasibility includes construction, operation, and maintenance required for remediation. *Administrative* feasibility includes regulatory and public acceptance, availability of services and specialized equipment, and personnel requirements. Short-term implementability refers specifically to the duration of the implementation period, while long-term implementability refers to the operation, maintenance, and institutional control period thereafter. Uncertainty management concerns and the alternative's flexibility in response to varied and unanticipated future conditions are also elements of the long-term implementability assessments.

- Cost—This criterion refers to the relative magnitude of capital and operating costs for an alternative. For this analysis, operational costs are estimated for a 100-year period following the initiation of the remedial action. Both capital and O&M cost estimates are developed and presented in terms of total dollars and net present value. Costs also include a contingency, which was developed for each alternative based upon complexity and uncertainty associated with implementation. A detailed breakdown of the cost basis for each alternative is presented in Appendix D.

Brief descriptions of the alternatives, along with results of comparative screening analyses, are presented below.

3.5 No Action Alternative

3.5.1 Alternative Description

Formulating a No Action alternative is required by the NCP (40 CFR 300.430[e][6]) and by EPA *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988).

The No Action alternative serves as the baseline for comparing remedial action alternatives. For WAG 7, this alternative would include only monitoring and require no direct action to treat, stabilize, or remove contaminants. It is assumed for this alternative that long-term monitoring would be conducted on groundwater, vadose zone moisture, surface soil, surface water, and air for a period of 100 years. Details regarding extent of the assumed program are provided in Section 4 and Appendix D.

3.5.2 Effectiveness, Implementability, and Cost

This comparatively inexpensive alternative would be easily implemented, incurring only costs associated with long-term monitoring. However, the alternative offers no reduction in mobility, toxicity, or volume of contaminants within the SDA. Because the site presents unacceptable risks to human health and the environment, the No Action alternative does not satisfy the RAOs. The estimated total monitoring cost for this alternative is $38.5 million. Net present value cost for the alternative is estimated at $9.6 million.

3.6 Limited Action Alternative

3.6.1 Alternative Description

The Limited Action alternative addresses the RAOs by first establishing administrative policies and restrictions that limit and control access to site contaminants. Various local and state ordinances and statutes, deed notices, and public advisories would be combined to control future site use. For WAG 7, the Limited Action alternative would further establish groundwater use restrictions to prevent future well drilling and prohibit future use of groundwater within the potentially affected area of the Snake River Plain Aquifer.

This alternative entails no treatment or disposal of source materials and would not result in any reduction in mobility of contaminants. However, as indicated in Figure 3-11, other components of this alternative involve placing and maintaining a biotic surface barrier and a perimeter fence to control site access and prevent direct intrusion into waste. As presented in Section 2, the SL-1 design (WAG 5) was identified as the representative biotic barrier for purposes of this analysis. This established cover design, which has been used at other INEEL sites, consists of approximately 6 ft of granular materials, including gravel, and cobble layers with a protective riprap cover. An estimated 1.1 million m^3 (1.5 million yd^3) of granular material would be required to complete constructing a barrier over the entire SDA. During cover placement, surface water controls and diversion systems needed to prevent inundation and damage during projected future flooding events would also be constructed. This cover system is designed to prevent biotic intrusion, but does enhance surface water infiltration.

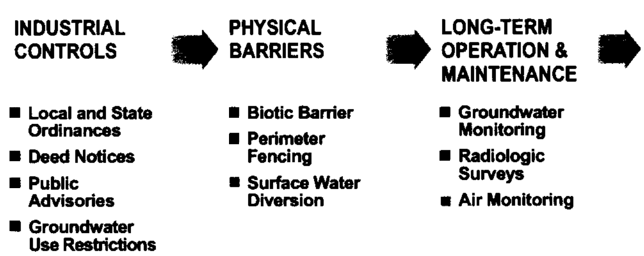

Figure 3-11. Limited Action Alternative schematic.

Long-term monitoring conducted through aquifer well sampling, lysimeter sampling, radiological surveys, and air sampling are long-term protective measures of this alternative. The DOE-ID, IDEQ, and EPA would evaluate effectiveness of the Limited Action alternative components during subsequent 5-year reviews, and would define any additional environmental monitoring necessary. Routine maintenance—a basic assumption of this alternative—would be performed to address potential problems (e.g., burrowing animals and erosion).

3.6.2 Effectiveness, Implementability, and Cost

The Limited Action alternative is potentially effective in protecting human health because institutional controls and biotic barrier operate in conjunction to prevent direct access to site contaminants. However, the alternative does not achieve full compliance with the RAOs. It neither reduces mobility, toxicity, or volume of contamination within the SDA nor directly addresses or inhibits the groundwater migration pathway. Further, placement of the biotic barrier system will result in an increase in infiltration rates. Given this alternative, the site would continue to affect water quality with future contaminant levels exceeding acceptable human health risk levels.

The Limited Action alternative is easily implemented because specified actions would essentially continue existing management practices at the site. Construction of the biotic barrier involves conventional earthwork operations with suitable construction materials readily available from either on-Site or off-Site borrow sources. Worker protection measures currently implemented under DOE orders would remain in effect for the duration of occupational activities. Groundwater and vadose zone monitoring would be performed in accordance with current site practices. Site inspections would be performed twice a year, with cover maintenance, surface water diversion, and fence maintenance performed on an as-needed basis.

The capital cost for this alternative is projected to be relatively low compared to the assembled containment, in situ treatment, and retrieval alternatives. Cost for installing the barrier itself is estimated to be $144 million, including contingency. Because this installation primarily involves a standard earthwork operation requiring no intrusive work, the potential for a significant cost increase resulting from uncertainties in subsurface conditions, technology application, and waste inventory is minor compared to the more extensive in situ treatment or retrieval alternatives. In addition, because this barrier is relatively self-healing, only minor maintenance costs are anticipated. Long-term monitoring and maintenance costs are estimated to total approximately $38 million, including contingency.

3.7 Containment Alternatives

Containment alternatives address WAG 7 RAOs by inhibiting human and environmental exposure pathways to buried waste. Physical barrier(s) and other controls will be designed to deter human and biotic intrusion into waste and control contaminant migration by minimizing surface water infiltration. For the purpose of this initial screening activity, two containment alternatives, structured to provide a range of protectiveness, were developed, as follows:

- Surface Barrier alternative—This alternative requires placement of a long-term, multilayer, low-permeability cap over the SDA. For purposes of this analysis, the cap design for the ICDF landfill was selected. This design includes a low-permeability layer to control surface water infiltration and a biotic barrier to prevent intrusion into waste by burrowing animals and deep-rooted plants. The cap design also includes a gas collection layer to address any future VOC releases from buried waste.

- Full Containment alternative (encapsulation)—This alternative prescribes the multilayer, low-permeability cap, as identified for the Surface Barrier alternative, with adding a perimeter bentonite slurry wall tied to an underlying horizontal grout barrier to attain full containment of the contaminated area.

Institutional controls would be added to these alternatives to restrict site access and future land uses in perpetuity. As part of either alternative, environmental monitoring, cap integrity monitoring, and maintenance (e.g., repair of any observable degradation such as cracks, erosion, and biotic intrusion) would be conducted on an annual basis, and provisions would be established for physical access restrictions (e.g., fencing).

To meet RAOs, a number of other supplemental technology applications are required that are common to both containment alternatives, as discussed in Section 3.3. These technology applications are designed to treat specific COC waste within the SDA that could pose a future threat to human health and the environment and provide a stable foundation area for constructing a surface barrier. Common supplemental technology applications for containment alternatives include:

- Treating activation and fission products—Fate and transport modeling indicates that containment technologies alone will not be sufficient for mitigating future impacts on area groundwater from the more mobile fission and activation products within the SDA. Therefore, waste streams containing these COCs within the SVRs and trenches, as shown in Figure 3-5, would be treated in place with the ISG technology.

- Treating VOCs—The assumption for both of the containment alternatives is that high VOC areas within the SDA, shown on Figure 3-9, would be pretreated by ISTD before the surface barrier construction.

- Foundation stabilization—Site preparation for both containment alternatives includes subsurface stabilization to ensure a solid foundation for the cap and minimize future subsidence-related maintenance requirements. Evaluations include the assumption that a grouting program would be designed and implemented as required to specifically stabilize individual subsurface disposal areas.

- Pad A retrieval and placement—Given the unstable nature of the surface of the Pad A and waste pile and potential design issues associated with incorporating the pile into the final cover system, the assumption for both alternatives is that waste and soil on the pad would be retrieved and reconfigured in a compacted layer within the center of the SDA before the initial cap layers are placed.

Site preparation for both alternatives includes initial site grading to facilitate pretreatment operations, preparation of borrow sites, and abandonment and either relocation or extension of existing well systems (monitoring and vapor extraction wells) within the SDA boundary.

Following subsections provide descriptions of both containment alternatives.

3.7.1 Surface Barrier Alternative Description

This Surface Barrier alternative would include constructing a multilayer, low-permeability cap over the entire SDA. An overview of the construction processes of this cap and other technology applications required for this alternative are shown in Figure 3-12. Design elements of the surface barrier include:

- Control surface water infiltration to minimize future releases from source term to the underlying vadose zone and area groundwater
- Facilitate and control surface water runoff from the SDA
- Incorporate surface water diversion systems to prevent inundation and damage during potential future flooding events
- Employ both a biotic barrier to prevent direct intrusion into waste and a gas extraction and treatment system to control gas emissions from the landfill.

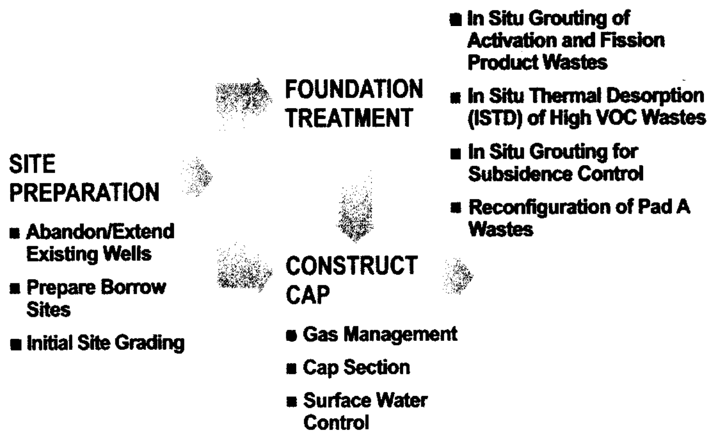

Figure 3-12. Surface Barrier alternative schematic.

To provide long-term protection, the cap system must be designed to address potential catastrophic events (e.g., design-life earthquakes, projected maximum flood events, and other natural occurrences). As discussed in Section 2, the proposed long-term cap design for the ICDF landfill (shown in Figure 3-13) was selected as the representative option for this analysis. Designed to address INEEL-specific environmental considerations, this long-term cap provides a degree of protectiveness similar to that of the design for the DOE Hanford CERCLA Disposal Facility. The established Hanford design, having received agency approval, has been successfully installed at waste sites similar to the SDA. The ICDF cap design also was preferable because it uses a geomembrane and clay layer that is more resistant to damage from subsidence than the asphalt layer of the Hanford cap design.

With a projected design life initially estimated at 1,000 years, the cap is structured to minimize surface water infiltration and maximize runoff. The design itself includes a soil cover over a capillary break. The soil serves to store infiltrating water and then release it by evaporation and transpiration via plant roots. This basic design has been shown to be effective in minimizing infiltration into underlying waste in arid and semiarid regions (Khire, Benson, and Boscher 2000). In its simplest form, the design concept relies on fine-grained soil overlying a coarser grained layer. The contrast in unsaturated hydraulic properties between the layers restricts water movement across the interface. In a recent study prepared for the ICDF design (Crouse 2002), the soil cover model was used to evaluate long-term infiltration rates through the proposed ICDF cover. The model was used to simulate average and extreme climactic conditions. Results for extreme climactic conditions show a maximum infiltration rate of 0.49 mm/year (1.5E-09 cm/second).

As shown in Figure 3-13, the proposed design includes a vegetated erosion control layer, a biointrusion barrier, drainage and filtration layers, and a low-permeability geomembrane layer. These layers of fine- and coarse-grained soil and rock over a thick layer of earth fill result in a cap system with a maximum overall thickness of approximately 5.5 m (18 ft). An estimated 2.7 million m^3 (3.5 million yd^3) of material would be required to construct a barrier over the entire SDA, with an additional 1.4 million m^3 (1.8 million yd^3) needed for placement of grading fill required to initially crown the site. It is assumed for this analysis that sufficient suitable cap materials are available from either on-Site or nearby off-Site sources. However, a detailed borrow-source evaluation will be required to verify availability of specific materials required for construction.

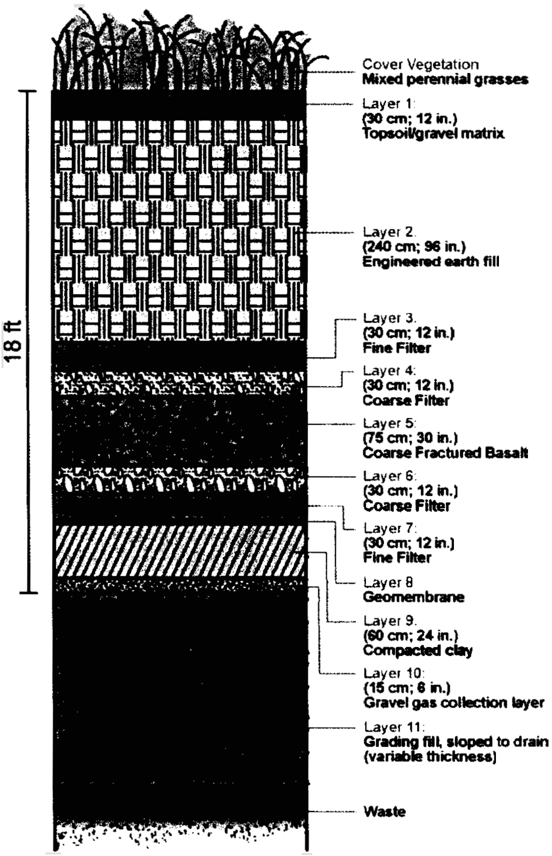

Figure 3-13. INEEL CERCLA cover system.

3.7.2 Full Containment (Encapsulation) Alternative Description

The Full Containment alternative includes complete encapsulation of the SDA waste within low-permeability horizontal and vertical barriers. Figure 3-14 presents an overview of the sequenced construction activities required for Full Containment, and Figure 3-15 provides a conceptual view of the alternative. The surface barrier design would be identical to that of the long-term composite cap design presented for the previously discussed Surface Barrier alternative. However, this alternative would add a vertical, low-permeability barrier to the cap to bound the perimeter of the source term, preventing lateral moisture infiltration. This vertical barrier would be anchored in an underlying horizontal grout barrier, which would extend completely beneath the SDA and fully encapsulate buried waste.

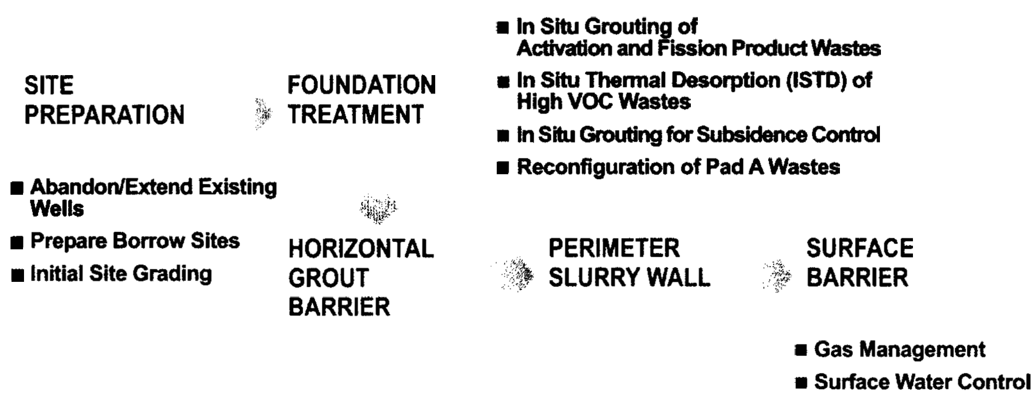

Figure 3-14. Full Containment alternative schematic.

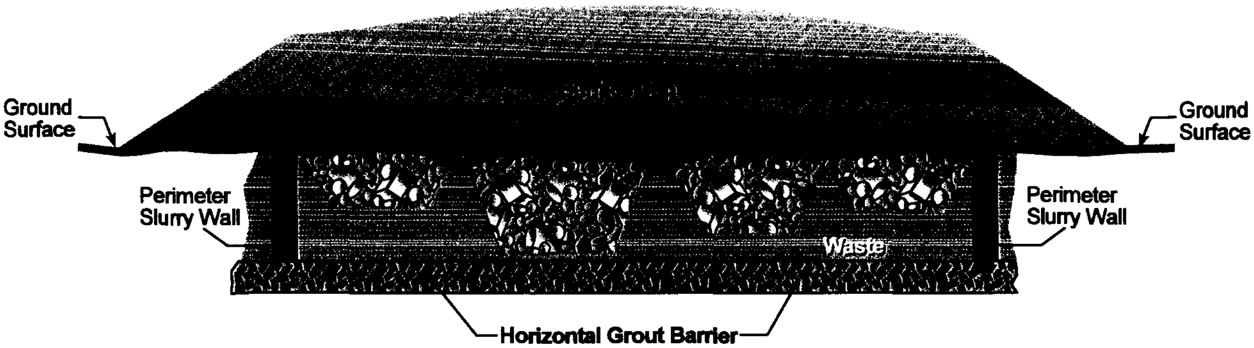

Figure 3-15. Full Containment alternative section view.

Following sections describe construction steps needed for this alternative in addition to those described for the Surface Barrier alternative.

3.7.2.1 Vertical Perimeter Barrier. The technology screening evaluation conducted in Section 2 identified the bentonite slurry wall as the preferred technology for constructing the subsurface vertical perimeter barrier. Slurry wall construction is a well-established barrier technology commonly used at hazardous waste sites to prevent and control the lateral spread of contaminants. The wall would extend around the entire perimeter of the SDA—a distance of approximately 3,048 m (10,000 ft). The required maximum depth of the wall is 9.1 m (30 ft).

Standard earthwork equipment could be used for wall construction, which involves a 0.9-m (3-ft) minimum-thickness trench being continuously excavated and backfilled with a slurry of bentonite and soil. When properly installed, a slurry wall can achieve permeability values of 1E-07 cm/second or less.

3.7.2.2 Horizontal Subsurface Barrier. A number of construction approaches could be considered for encapsulating grout beneath the SDA, but as described in Section 2, a jet grouting vertical technique was identified for this analysis. The technology involves injecting the grout into the underlying formation at high pressures in a grid pattern with overlap to achieve continuity. The horizontal barrier would extend beyond the edge of waste and out to the proposed location of the vertical slurry wall. The slurry wall would be excavated into the grout layer to provide continuous vertical and horizontal barriers.

Vertical drilling and grouting would be used to install a horizontal barrier beneath the SDA. In an effort to minimize the potential for surface contamination spread, grouting could be accomplished using a sonic drilling rig to install 6-in. casing equipped with a manufactured cement plug and drive point. Casing containing the grout plug would be direct-driven through waste to the basalt-alluvium contact without generating drill cuttings or drilling fluids. After the 6-in. casing is secure, a 5-in. rotary drill could be run through the casing. The grout plug would be drilled out of the bottom of the casing, and drilling would be continued up to 1.5 m (5 ft) beyond the basalt-alluvium contact. On reaching desired depth, the drill stem would be removed and grout would be injected into the hole under pressure to construct a continuous horizontal barrier. Grout pressures and uptake into the formation would be monitored during construction to determine borehole spacing needed at various locations in the basalt formation. For this analysis, an average borehole spacing of 3 m (10 ft) was assumed for installing the horizontal barrier.

Several types of grout could be considered, including cement-based and chemical-based grouts. Cement-based grout is commonly used for grouting in highly permeable formations. However, selecting an appropriate grout type may require a substantial amount of testing because the SDA basalts are highly variable in porosity and permeability. Despite the fact that permeabilities ranging from 1E-04 to 1E-12 cm/sec have been achieved in some formation grouting applications, the effectiveness of such grouts beneath the SDA is difficult to predict. Because the soil and basalt subsurface is so variable, complete containment would potentially not be achieved.

3.7.3 Evaluation of Containment Alternatives

A comparison of the containment alternatives based on initial screening criteria of effectiveness, implementability, and cost is presented below.

3.7.3.1 Effectiveness. Both of the containment alternatives, if properly designed and maintained, would be effective, as both address the project RAOs and protect human health and the environment. Placement of the long-term cap would prevent direct access to waste by both human and ecological receptors. The cap would be designed to control migration of contaminants and protect groundwater. In addition, both alternatives include ISG treatment to reduce mobility of activation and fission product COCs within the SDA source term. Alternatives also include application of ISTD within areas containing organic waste to reduce future VOC releases to the vadose zone and minimize future operational requirements for the OCVZ system. Fate and transport modeling shows that the cap, in conjunction with proposed ISG and ISTD treatments, would be protective.

The relative effectiveness of the Surface Barrier alternative compared to the effectiveness of the Full Containment alternative is difficult to quantify. As a stand-alone alternative, the long-term surface barrier can achieve project RAOs and maintain risk levels within acceptable limits. The perimeter slurry wall of the Full Containment alternative would provide an additional degree of protectiveness by preventing lateral moisture migration or groundwater flow from encroaching beneath the cap. However, given subsurface hydrologic conditions within the SDA, little lateral groundwater flow exists in the shallow vadose zone soil. The only documented perched water conditions beneath the SDA are associated with sedimentary interbeds, at depths of 100 to 220 ft below existing grade. Previous infiltration studies conducted in the area indicate that flow in this soil is primarily vertical. Consequently, surface water would have to be ponded in an area immediately adjacent to the cap for infiltrating water to have any potential impact on waste. To account for this potential condition, appropriate surface water control measures will be incorporated into the design of the cover system.

Additional protection afforded by the underlying horizontal grout barrier is also questionable. This barrier would protect against source term inundation by any upwardly moving groundwater—a condition that could be caused in this area by rising perched water conditions resulting from temporary flooding events. However, given that the shallow vadose zone does not support developing perched water conditions near the surface, this situation is unlikely to arise. Furthermore, infiltration rates projected for the proposed surface cap system indicate that any overall decrease in vertical release rates from the source term resulting from the placement of the grout barrier would be minimal. Using cement-based grout, overall permeability of the horizontal subsurface barrier would be unlikely to approach that of the surface barrier; possibly, some zones or fractures would not be fully sealed by grout. Therefore, vertical infiltration in the waste zone would be primarily controlled by the integrity and permeability characteristics of the surface barrier. An additional concern with installing the subsurface barrier is the bath tub effect that could be created in localized areas where moisture would tend to collect, which potentially could result in saturating portions of the source term.

The short-term effectiveness concerns associated with the Full Containment alternative would be significantly greater than for the Surface Barrier alternative. Potential worker exposure during implementation is the primary issue. During constructing the surface barrier for either of the alternatives, workers may be exposed to radiation, VOCs in the breathing zone, and construction hazards. Both of the alternatives also include localized applications of ISTD and ISG, posing short-term risks associated with these intrusive activities. The Full Encapsulation alternative, however, would also require an extensive drilling program throughout the full extent of the SDA for installing a subsurface horizontal barrier. This installation would present workers with a significantly higher potential of direct contact with buried waste.

3.7.3.2 *Implementability.* The technical feasibility of implementing the Surface Barrier alternative is high compared to the Full Containment alternative. For the Surface Barrier, implementation would not depend on specific waste stream or inventory information and thus would not require specific source term definition. As a result, implementing the technology would not be subject to delays and additional costs resulting from field modifications caused by unexpected variations in the waste stream or the inability of specific treatment technologies to achieve remedial design requirements. However, for installing the subsurface horizontal barrier required in the Full Containment alternative, construction delays could be experienced if the actual borehole spacing is significantly different from the spacing estimated during design, or if problems are encountered in providing the required spacing because of waste obstructions.

For the Surface Barrier alternative, construction could be executed with standard earthwork equipment, as demonstrated by the successful construction of similar barriers at other DOE facilities. It is assumed for this analysis that material required to construct the barrier for both containment alternatives is available from suitable soil and rock borrow sources located within a 20-mi radius of the SDA. A detailed borrow source evaluation will be necessary to assess suitability of local materials and identify specific borrow sites.

Conversely, installing the subsurface horizontal barrier for the Full Containment alternative would require specialized drilling and grout injection equipment. In addition, ensuring the successful completion of a continuous horizontal barrier beneath the SDA source term would be difficult. Verifying the integrity of the horizontal barrier could require installing and monitoring neutron probes and possibly lysimeters.

3.7.3.3 *Cost.* An initial cost estimate was performed for this initial screening to provide a comparative perspective of construction-related costs for each of the two containment alternatives. Estimated total costs for the alternatives, in fiscal year (FY) 2002 dollars, are provided in Table 3-3.

Table 3-3. Total estimated costs for the Surface Barrier and Full Containment alternatives.

Cost Element (FY 2002 dollars)	Surface Barrier ($M)	Full Containment ($M)
Capital costs	796	1,146
Operation and maintenance costs	46	46

Both alternatives would incur costs for constructing the surface barrier—estimated at approximately $796 million. This cost includes the required ISG programs for waste treatment and foundation stabilization, the ISTD pretreatment program, and the processing of the Pad A waste. Additional costs for the Full Containment alternative are projected to be relatively high because of contaminant control and worker protection requirements for constructing the slurry wall and horizontal barrier systems. Capital costs for this alternative are estimated at approximately $1,146 million, which could be subject to increases related to uncertainties in subsurface conditions and requirements to maintain worker safety and contaminant control. Monitoring, access restrictions, and maintenance costs should be similar for each containment alternative.

3.8 In Situ Treatment Alternatives

Two in situ treatment alternatives have been developed for the purpose of this initial screening activity. These involve two specific technologies that have been extensively researched at the INEEL to evaluate site-specific application requirements:

- In Situ Grouting alternative—This involves applying ISG to stabilize buried waste and contaminated soil in place.

- In Situ Vitrification alternative—This involves applying ISV to treat and stabilize buried waste and contaminated soil in place.

As discussed in Section 2.1, these technologies focus primarily on the in situ treatment of the disposal units within the SDA containing the RFP waste, including Pits 1 through 6, Pits 9 through 12, Trenches 1 though 10, and Pad A. Each alternative includes the following components:

- Using ISTD as a preconditioning step
- Placing a protective cover over the entire SDA
- Restricting site access in perpetuity with institutional controls
- Evaluating effectiveness of remedial action with environmental monitoring.

Each of the alternatives additionally provides for in situ grouting of waste deposited in other areas that contain non-TRU groundwater COCs. These areas include the SVRs and specific disposal locations within the remaining trenches. Both in situ treatment technologies would retrieve waste from Pad A for ex situ treatment and subsequent onsite disposal beneath the cap. For the ISG alternative, Pad A waste retrieval is necessary to stabilize the high nitrate salt content. For the ISV alternative, Pad A waste retrieval is necessary to properly configure waste to facilitate a safe and effective treatment using ISV.

3.8.1 In Situ Grouting Alternative Description

This alternative would treat source materials within the SDA with the ISG technology. Individual elements associated with implementing this alternative are presented in Figure 3-16. As shown, the alternative includes a pretreatment stage using thermally enhanced SVE with ISTD to address high organic areas (see Section 3.3.6) and the retrieval and ex situ treatment of the Pad A waste (see Section 3.3.5).

In situ grouting is a technique developed in the construction industry and recently adapted for environmental use. The process entails injecting a slurry-like mixture of cements, chemical polymers, or petroleum-based waxes into contaminated soil or a waste landfill. Grouts are specially formulated to encapsulate the contaminants, isolating them from the surrounding environment. As used in the environmental industry, the process employs nondisplacement jet grouting, whereby soil and waste debris are mixed with grout-forming materials in the subsurface, creating a large grout monolith (DOE-ID 1999; Loomis et al. 1997b). Grouting is accomplished without displacing contaminants or debris or causing the ground to heave. Overall volume of the waste site remains constant, but density of the site is substantially increased as grout fills void spaces between discreet waste components.

In situ grouting has been approved by regulating agencies and implemented on small-scale sites at Oak Ridge National Laboratory, the Savannah River Site, Brookhaven National Laboratory, and the Acid Pit within the SDA (Armstrong, Arrenholz, and Weidner 2002). Though ISG has not been applied to sites as large or with as many radiological and chemical hazards as the SDA, research has been conducted at the INEEL in an effort to evaluate the efficacy of ISG. Results of past applications at other sites and the INEEL research are promising. An evaluation of the technology and application to the SDA conditions, including a summary of ISG case histories, is provided in the supporting report developed for this analysis (Armstrong, Arrenholz, and Weidner 2002).

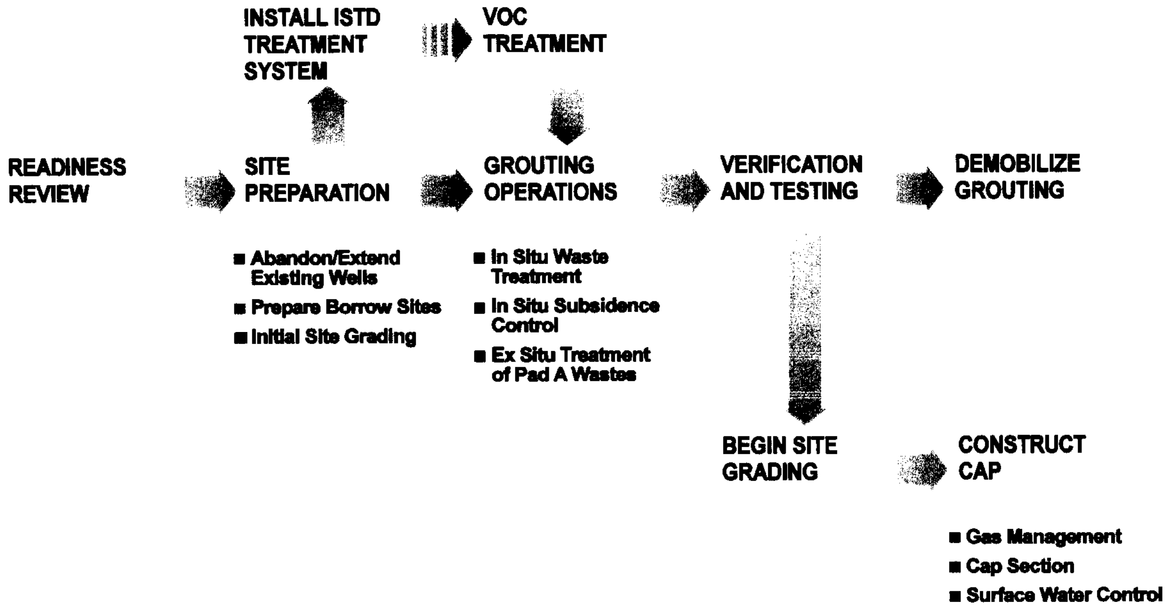

Figure 3-16. In Situ Grouting alternative schematic.

In this alternative, grout would be pumped into the waste zone under high pressure using an injection lance. The injection lance would be inserted into the waste zone using rotary percussion hydraulic hammers, which are commonly used on rock coring drill rigs. To minimize the potential for contamination spread, the lance is direct-driven into waste, so no cuttings or drilling fluids are generated. However, even with this technique small amounts of contamination are expected to be brought to the surface, adhered to the injection lance, or contained in grout returns, which could pose a hazard to workers. Therefore, the grouting rig would be operated inside of a confinement building and workers would be distanced from the equipment during operations. Figure 3-17 offers a conceptual illustration of the grouting operation.

The drill mast, hydraulic head, and injection lance can be mounted on various platforms (e.g., trucks, skids, or tracks). Detailed engineering studies have not been completed to select the best platform(s). Past work at the INEEL used a track-mounted unit, but other platforms offer advantages. For this analysis, the primary deployment platform is a wheeled gantry crane (Armstrong, Arrenholz, and Weidner 2002). The wheeled gantry crane allows easier movement of the rig from hole to hole and distances workers from the equipment while in operation or during moves (Loomis 2001).

In addition to risk posed to workers during operations, there is also risk of surface contamination spread after grouting is completed. If contaminated grout is deposited on the ground surface during operations, it would become exposed to the elements after the temporary confinement building is removed. Wind and weathering could cause contaminants to become airborne, which would pose a risk to nearby facilities. Grouted areas would be covered with a 3-ft layer of soil after operations before moving the confinement building to mitigate potential contamination concerns associated with grout returns.

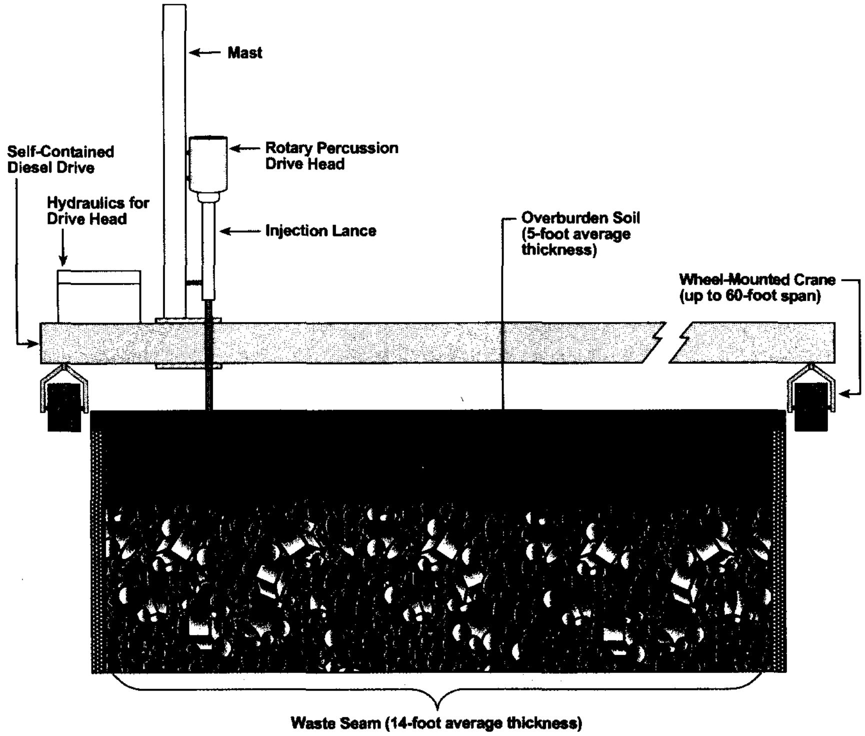

Figure 3-17. Schematic of an in situ grouting operation.

The injection lance would be repeatedly inserted in a tightly spaced pattern. The injection method would produce interlocking columns of grout extending from the underburden soil up through the waste, terminating belowgrade in the overburden. Past work has demonstrated that the interlocking columns cure into a solid monolith with no discernable edges between columns (Armstrong, Arrenholz, and Weidner 2002). Using dense injection spacing also ensures that containers (drums) of waste are punctured by the lance and filled with grout. When injected under high pressure, the cutting action of the grout fractures soil, plastic, wood, and other low strength objects. The cutting action of the jets dislodges particles and small pieces of waste material and mixes them with grout and soil. Large objects remain in place as grout flows under pressure, filling all readily accessible voids between objects (Loomis, Zdinak and Bishop 1997).

When properly designed and applied, ISG produces a durable waste form that resists weathering and degradation over long periods of time. Grout waste forms have been shown to be effective at minimizing infiltration of water and reducing contaminant release to the environment. The supporting report by Armstrong, Arrenholz, and Weidner (2002) provides a discussion of contaminant release. In situ grouting reduces mobility of contaminants by the following mechanisms:

- Reduced permeability—Injecting grout under high pressures into the disposal area fills void space around debris and in the soil matrix. Properly spaced injection points rupture waste containers and fill void spaces inside waste drums and boxes with injected grout. The resultant grout and waste monolith has a very low porosity and low hydraulic conductivity.

- Physical stabilization—Significantly reduced void space in the waste and soil matrix prevents future compaction and subsidence of waste, thereby providing a stable foundation for durable cover systems.

- Encapsulation—Energetic mixing of grout, waste, and soil encases contaminants in a leach-resistant matrix. This minimizes the potential for contaminants to be mobilized by infiltrating water.

- Chemical stabilization—An appropriately selected grout will chemically alter infiltrating water to reduce the solubility potential of contaminants. In addition, certain grouts exhibit an affinity for specific contaminants and can chemically bind contaminants by reaction or adsorption to reduce leachability.

Grouted waste forms are highly durable and will remain physically and chemically stable for long periods of time. Because the grout monolith is constructed 4 to 5 ft bgs, it is protected from mechanical forces (e.g., freeze-thaw cycles). Using selected grouts that are in chemical equilibrium with the site-specific geochemistry also minimizes degrading chemical forces. While some cracking is expected as grout cures, contaminant releases would still be controlled by chemical properties of grout. The grouted waste form would degrade slowly over time. However, because the grout materials are highly insoluble, it is estimated that under the worst conditions, extremely long periods of time would be required for infiltrating water to degrade the waste form (Armstrong, Arrenholz, and Weidner 2002).

Because ISG has only been applied on small scale sites, actual production rates are unavailable. For this evaluation, production rates were estimated based on results of field tests, which are described in more detail in Section 4. The majority of the area that would be treated by grout is in the TRU pits and trenches, which comprises a total of approximately 17 acres. Figure 3-18 presents the estimated operational time for individual waste areas within the SDA. The operational time assumes a single grout rig with a 40-hour work week and does not include pregrouting activities (e.g., design) or postgrouting activities (e.g., capping). As shown, a single rig would require approximately 15 years of operation to accomplish the grout remedial action within the SDA.

3.8.1.1 Organic Pretreatment. As discussed in Section 2, one dominant waste type in the SDA consists of contaminated oil and other hazardous chemicals that were solidified with an absorbent, packaged in drums, and disposed of at the SDA. In anticipation of the need to treat this particular waste stream, some testing has been performed to demonstrate the ability of grout to treat organic waste. In bench and field tests, a number of grout products have been shown to effectively treat oil waste at approximately a 10% waste loading (Armstrong, Arrenholz, and Weidner 2002). As a result, it has been concluded that ISG would effectively treat isolated occurrences of organic oil waste drums across the SDA pits. However, disposal records clearly show that several small areas within the SDA received large shipments of this waste and may still contain concentrations exceeding 10%. Figure 3-9 illustrates several small areas, totaling less than 1 acre, which may contain large caches of drums containing organic oil. Because ISG has not yet been tested for waste at these concentrations, it is assumed that pretreatment would be required.

ISG Planning	
Site	**Implementation Time**
Pits 1-6 & 9-12	11 years
SVRs	0.3 years
Trenches 1-10	1.5 years
Additional trench areas for COCs	0.2 years
Additional foundation stabilization	2 years
TOTALS	**15 years**

Figure 3-18. In situ production.

The ISTD technology would be used to destroy organic oil in these areas. This process would be followed by ISG to stabilize remaining contaminants. ISTD places electric heating elements into waste on approximately 2.4-m (8-ft) centers to heat the waste zone to a temperature sufficient to pyrolize and volatilize most organic material over a several month period. Without this step, grout might not harden and successfully immobilize waste.

3.8.1.2 Pad A Waste. Another problematic waste stream for ISG is nitrate salt. This salt is a dry, granular form that was drummed and disposed of throughout the SDA. As with organic waste, some testing has been done to demonstrate the ability of grouting to effectively treat nitrate salt. In some tests, waste loading as high as 50% nitrate salt has been achieved without deleterious effects (Armstrong, Arrenholz, and Weidner 2002). It is expected that drums of nitrate salt mixed with other waste in the SDA pits will not pose a problem for ISG. However, over 70% of all waste on Pad A, nearly 7,600 m^3 (10,000 yd^3), is evaporator salt consisting of approximately 60% sodium nitrate, 30% potassium nitrate, and 10% other compounds (DOE 1994). Without further testing, it is uncertain ISG would be successful with such high concentrations of nitrates as found on Pad A. Therefore, the assumption for this evaluation is that Pad A waste would be retrieved and its waste streams segregated and stabilized in an ex situ treatment process. The treated material would then be disposed of back onsite beneath the proposed cap.

3.8.2 In Situ Vitrification Alternative Description

The ISV technology has been implemented at a number of waste sites around the world. An evaluation of this technology's applicability to the SDA, including a summary of four recent ISV case histories, is provided in the comprehensive report developed for this analysis (Thomas and Treat 2002). Figure 3-19 shows individual components of ISV for WAG 7 along with the sequence of processing steps in the ISV operation. As shown in Figure 3-19, before the TRU waste units at the SDA are vitrified, they would be pretreated using ISTD to remove most of the water, any other liquids, and VOCs. Pretreating waste using ISTD would be necessary to preclude the potential for a steam explosion that might otherwise breach the approximately 3-m (10-ft) soil cover maintained over the melt during active ISV processing. Pretreatment with ISTD also would be more likely to cause slow venting of acetylene and other flammable gases that may be present in gas cylinders disposed of in the SDA, thereby precluding an explosion or uncontrolled fire in the off-gas hood. A Modified RCRA Subtitle C cap would then be constructed over the site to provide additional protection by limiting infiltration and preventing intrusion of plant roots and animals into soil containing condensed SVOCs. As with the preceding alternatives, long-term monitoring of the site, including groundwater, would be conducted to verify effectiveness.

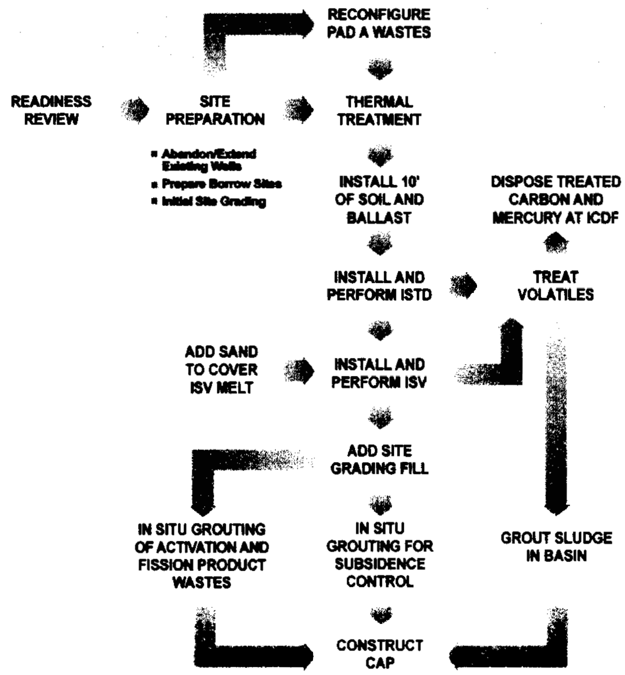

Figure 3-19. In Situ Vitrification alternative schematic.

Heat generated by ISV converts (vitrifies) buried waste and associated soil into a glass-like substance at temperatures ranging from about 1,200 to 1,600°C. Most nonmetallic, inorganic materials (e.g., soil and sludge) will melt and subsequently solidify into a largely amorphous material similar to obsidian. Most of the metallic materials will also melt, but remain as metals, and sink to the bottom of the glassy melt because they are denser than glass. The ISV technology offers several advantages:

- Ability to process a wide range of waste types
- Ability to pyrolyze organic materials, thereby destroying them
- Ability to immobilize waste in a highly leach-resistant and durable form.

Traditional ISV employs an array of four electrodes placed vertically into buried waste and contaminated soil. Electrical current is transferred through the soil between the electrodes, generating heat as a consequence of the soil's resistance to the flow of current. Graphite powder or other electrically conductive materials are placed between the electrodes to provide a starter path for initiating the flow of current. As heated soil and waste melts, electrodes progressively drop through the melt, resulting in the melt growing downward and widening in the process. The progression of a typical ISV melt is presented in Figure 3-20.

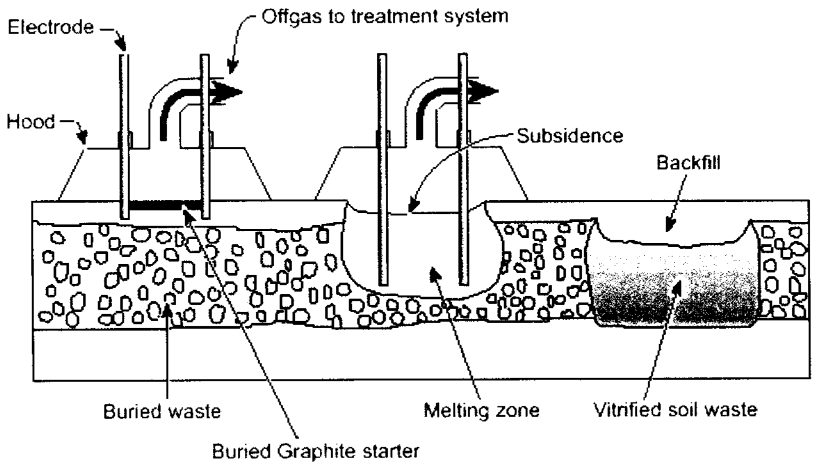

Figure 3-20. In situ vitrification melt progression.

Holding electrodes in place or stopping the flow of current can be used to control melt depths. As size of the melt increases, cooling surface area also increases, until energy lost to cooling equals the amount input by electrodes, thereby stopping further growth of melt. When melt has progressed to a final depth, power is stopped and the melt is allowed to cool. Cooling the melt to ambient ground temperatures requires several years because of insulating properties of soil.

Most organic materials within soil and waste are pyrolyzed or volatilized, then collected and treated in an off-gas treatment system. An off-gas hood covers the entire melt, extending some distance around its edge to control the removal of gases and airborne particles. Off-gases are drawn into the off-gas hood and then treated through a process train consisting of several treatment operations before cleaned gas is discharged to the atmosphere.

Full-scale melts have ranged from 200 to 1,400 tons and generally require approximately 10 to 14 days to complete. The greatest melt depth achieved with the traditional ISV configuration shown in Figure 3-19 was 6.7 m (22 ft). Final melt diameters have ranged up to 13.7 m (45 ft). Generally, when a melt is completed, electrodes are left in the molten glass and sawed off at ground surface. The final melt is smaller than the volume of waste treated as a result of the increased density of glass relative to waste and soil, and removal of gases and void space. Volume of waste is reduced 30 to 70%.

Subsurface planar ISV, a recent advancement of the traditional ISV technology, is being evaluated for the SDA. This modified approach differs from the traditional ISV approach in the method of applying the electrical current and the depth of the soil at which the flow of current is initiated. In subsurface planar ISV, electrical current is transferred only between pairs of electrodes, rather than among all four electrodes, causing two planar-shaped melts to form. As the melts grow downward and spread, they eventually meet and fuse together into a single melt. The starter path for electrical current in the subsurface approach is either installed as a wet or dry material in a deep trench, or injected as a slurry at the desired starting depth. A layer of unmelted soil is maintained at all times over the molten mass, in contrast to the traditional approach in which molten material is exposed at the ground surface.

ISV Planning		
Site	**Melts**	**System Years**
Pit 1	33	2
Pit 2	104	7
Pit 3	56	4
Pit 4	150	11
Pit 5	146	11
Pit 6	74	5
Pit 9	61	4
Pit 10	150	10
Pit 11	33	2
Pit 12	40	3
Pad A	47	3
Trenches 1-10	406	29
TOTALS	**1,300**	**91**

Figure 3-21. ISV production requirements.

Subsurface planar ISV tests have been successfully initiated between 1.8 and 3 m (6 and 10 ft) bgs in cold and hot tests conducted in Richland, Washington, for the INEEL in 1998, and at Los Alamos National Laboratory in 1999 and 2000. Melts progressed downward from these starting depths, reaching a maximum depth of about 7.6 m (25 ft). Subsurface planar ISV offers several primary benefits:

- Lowered temperatures within the off-gas hood because overburden effectively insulates the hood from the melt surface

- Improved melting energy efficiency and increased potential for greater melting depths because insulation over the melt surface conserves more heat for melting

- Enhanced protection of equipment and personnel from molten glass expulsions because overburden provides a protective physical barrier against these events.

A disadvantage of subsurface planar ISV is the likelihood that SVOCs would condense in the overburden soil. These contaminants would otherwise volatilize from the open melt and be collected and processed in the off-gas treatment system.

Waste units at the SDA that would be treated with ISV include Pits 1 through 6, Pits 9 through 12, Trenches 1 through 10, and Pad A. These sites comprise a total area of approximately 17 acres. The areal extent of the vitrified zone would be about 20% larger because ISV melts would extend into adjacent soil to some extent. This especially would be the case for narrow buried waste trenches, where a single line of contiguous ISV melts would vitrify more adjacent soil per unit volume of waste treated than would the numerous adjoining rows of melts used to treat pits. Retrieving and staging Pad A waste in a subsurface pit as required for safe and effective treatment would also increase the total area to be vitrified.

Multiple ISV systems could be operated concurrently. As shown in the ISV plan presented in Figure 3-21, approximately 91 system years would be required to treat the specified waste zones within the SDA. One system year represents the average waste area that can be processed by one ISV system in one year. Thus, six ISV systems would be required to complete ISV operations in 15 years.

3.8.2.1 Pretreatment. Waste would be preconditioned with ISTD before application of ISV. Like ISV, ISTD heats waste but at slower rates and to lower temperatures. Preconditioning waste before ISV is needed to preclude the risk of high-energy melt expulsion events. In addition, pretreatment provides a concentrated off-gas stream that is more amenable to treatment than the highly diluted off-gas stream produced in the ISV process. Concentrated gases are easier to treat because longer residence times can be achieved in equivalent-size unit treatment processes, resulting in improved reactions and physical separations. The process also is much more energy-efficient because dilution air does not have to be heated, cooled, or exhausted.

In a melt expulsion event, molten glass propelled by releasing pressurized gas within the melt is blown into the air. The source of pressurized gas may be an explosion or a rapid conversion of water to steam. The force of expulsion may cause damage to the off-gas hood and contaminated gases to be released to the environment. During ISV, melt expulsion events occur because molten glass is an incompressible fluid that prevents the dissipation of pressurized gas into the void space of surrounding unmelted soil and waste. During ISTD, the release of the gas would occur without the potential for melt expulsion events, because waste contains substantial interconnected porosity and is not molten. The interconnected porosity of unmelted waste and soil allows steam and other gases rapidly released below the ground surface to safely compress into the interconnected void space and then migrate toward the ISTD gas extraction pipes.

The ISV off-gas stream would be more difficult to treat than the ISTD stream because it would be diluted with 100 parts of air to 1 part of gas generated within the waste zone to ensure that concentrations of combustible gases do not rise above their lower flammability limits.

3.8.2.2 Grouting. For this alternative, ISV would not be implemented in the SVRs or the non-TRU trenches. The assumption for this alternative is that ISG would be implemented in these areas as described in Section 3.3.4. Foundation grouting would also be applied in the remaining SDA areas to prevent subsidence of the cap, as discussed in Section 3.3.3.3.

3.8.3 Evaluation of In Situ Treatment Alternatives

The two in situ treatment alternatives are compared against the initial screening criteria of effectiveness, implementability, and cost in the following sections.

3.8.3.1 Effectiveness. The ISV and ISG alternatives, as assembled, are effective in mitigating the long-term risks associated with identified COCs at the SDA. Both alternatives include the Modified RCRA Subtitle C cap system to hydraulically isolate the treated waste, and both would reduce the leachability of the COCs through direct treatment. Fate and transport modeling conducted for each of the alternatives shows that release rates for each COC will be reduced to levels that protect human health and the environment. Results of the modeling are summarized in Section 4.

With the placement of the engineered cap, soil temperature and humidity will be maintained at a virtually constant level within the treated waste zone, and the area freeze/thaw and wet/dry cycles will not affect buried grout and glass monoliths. For ISV, the *Technology Screening Guide to Radioactively Contaminated Sites* (EPA 1996) states "the vitrified mass is very resilient to weathering, which makes it effective for long-term containment of waste." Similarly, grout waste forms, when designed to be compatible with the geochemical environment, will last indefinitely without significant chemical or physical alteration. In the SDA environment, where any infiltrating water will be nearly saturated with minerals, dissolution of grout minerals is expected to occur at an extremely slow rate.

The advantage of ISV is that it pyrolyzes, evaporates, and extracts nearly all organic material within the melt zone, thereby reducing the overall mass of contaminants remaining in the SDA. However, some contaminants would remain in the metal phase that sinks to the base of the glass melt, and others would likely condense in the surrounding soil to some extent. The metal phases at the base of the melts would corrode at a faster rate than glass, thereby increasing the leach-potential of some contaminants. Additional testing may be required to assess the fate of specific mobile contaminants of concern (e.g., C-14 and uranium) that may be largely incorporated in the more corrosion-prone metal phase. An extensive testing program was advocated in the engineering report that accompanies this analysis (Thomas and Treat 2002). Testing could address factors such as the fraction of C-14 and uranium that remains in the metal phase, leachability of the metal phase, and potential for glass melt to act as a barrier that limits contact of the metal phase with water.

Metallic waste forms (e.g., irradiated steels) would be more effectively immobilized in the ISG alternative because of the more basic chemical environment (higher pH) created by the grout. The higher pH environment reduces solubility of most heavy metal species. Grout could not be injected to encapsulate the metallic zone in ISV melts because metals would be in contact with the glassy phase and probably basalt that underlies the waste zone. Thus, with ISV, lead and other hazardous metals may dissolve more readily, because of the neutral chemical environment of glass.

As described in the supporting report (Armstrong, Arrenholz, and Weidner 2002), ISG has been shown to effectively immobilize a wide range of contaminants, including RCRA metals and radioactive isotopes. Testing of commercially available grout has shown that VOCs can also be effectively treated at low concentrations. Specialized grout forms have been developed and demonstrated by DOE to immobilize nitrate waste at up to 50 wt% waste loading. Because not all COCs have available performance data, some uncertainty exists. However, the relatively low permeability of grout, combined with its beneficial chemical properties, indicates that contaminants could be immobilized for a long period of time.

Short-term effectiveness of either ISG or ISV is moderate. Both alternatives have been researched for application at the SDA, and their potential risks to workers, the public, and the environment have been identified. The bases for selecting technologies to form these alternatives included the need to minimize these risks and ensure long-term effectiveness. Short-term risks associated with implementing ISG alone are relatively low. They include high pressures required for grout injection and potential for contaminated grout to spill onto the ground surface. Adding ISTD to the ISG alternative to address uncertainties associated with high concentrations of organic material in waste could diminish the short-term effectiveness of this alternative. Specifically, applying ISTD would increase risks of surface and subsurface fire, explosion, and airborne contamination.

Risks associated with ISV include those described above for ISG and ISTD because these technologies are included as components of the alternative. Additional risks of the ISV alternative include melt expulsion events, thermal and electrical hazards, and risks involving frequent handling of heavy equipment.

Appropriate design features and engineering and administrative controls would be applied in both alternatives to ensure adequate short-term protection to workers, the public, and the environment. However, additional study of both alternatives is necessary to further identify specific design and operating requirements to achieve short-term effectiveness goals.

3.8.3.2 Implementability. Both alternatives are implementable at the SDA. Summaries of case studies and performance data are provided in the supporting reports (Armstrong, Arrenholz, and Weidner 2002; Thomas and Treat 2002). Equipment for both alternatives is either currently available or can be manufactured to satisfy remedial action needs. For ISV, the presence of concentrated levels of fissile materials, irradiated fuel material, gas cylinders, reactive oxidizers, and flammable liquids, and the lack of knowledge of their precise locations within the SDA, complicates implementation of the alternative. Expensive design features and controls would be required to ensure short-term effectiveness.

Though site-specific applications of ISG and ISV at the SDA have been researched in nonradioactive bench-scale and field-scale tests, many issues have not yet been addressed. Both alternatives would require more detailed evaluation of waste generation and disposal records, additional site sampling and analysis, and nonradioactive and radioactive remedial design testing to define specific requirements. For ISV, a method of maintaining at least a 3-m (10-ft) thick soil cover over the melt that avoids bridging and allows for the safe release of gases generated within the melts also must be developed. Risk of unsuccessful development and resolution of safety issues is much higher for the ISV alternative.

It is estimated that up to 700 kW of power will be required to implement the ISV technology with approximately 330 kW required for ISTD. Currently, the Pit 9 substation at the SDA has one line that can provide 15 MW of power. However, for implementation of this alternative, it is assumed that the construction of a project-specific substation will be required.

3.8.3.3 Cost. Table 3-4 summarizes the initial cost estimate and comparative evaluation performed for the two in situ treatment alternatives.

Table 3-4. Total estimated costs for the In Situ Grouting and In Situ Vitrification alternatives.

Cost Element (FY 2002 dollars)	In Situ Grouting ($M)	In Situ Vitrification ($M)
Capital costs	1,073	1,785
Operating and maintenance costs	46	30

As shown, the capital cost for implementing ISV is more than 50% greater than the estimated capital cost of ISG. Capital costs for both alternatives have a number of common elements including constructing the final cover system and implementing ISG in the SVRs and non-TRU trenches. The primary cost differential is associated with technology requirements for treating TRU pits and trenches and the more extensive use of ISTD as a pretreatment for the ISV alternative.

3.9 Retrieval, Treatment, and Disposal Alternative

3.9.1 Alternative Description

The RTD alternative addresses RAOs by retrieving, treating, and disposing of RFP TRU waste. The alternative includes treating retrieved waste, as required to achieve ARARs and facility-specific WAC for either onsite or off-Site disposal. In this alternative, all retrieved TRU waste will be disposed of at the WIPP facility in Carlsbad, New Mexico. All retrieved MLLW will be treated for hazardous constituents and returned to the SDA for disposal in an engineered facility along with any retrieved LLW. A schematic drawing showing individual elements of the alternative is presented in Figure 3-22. As shown, the alternative includes an in situ pretreatment for the high VOC waste and in situ treatment of activation and fission product waste using ISG. This alternative also includes placing a low-permeability cap over the entire SDA to prevent future biotic intrusion into remaining waste or contaminated soil.

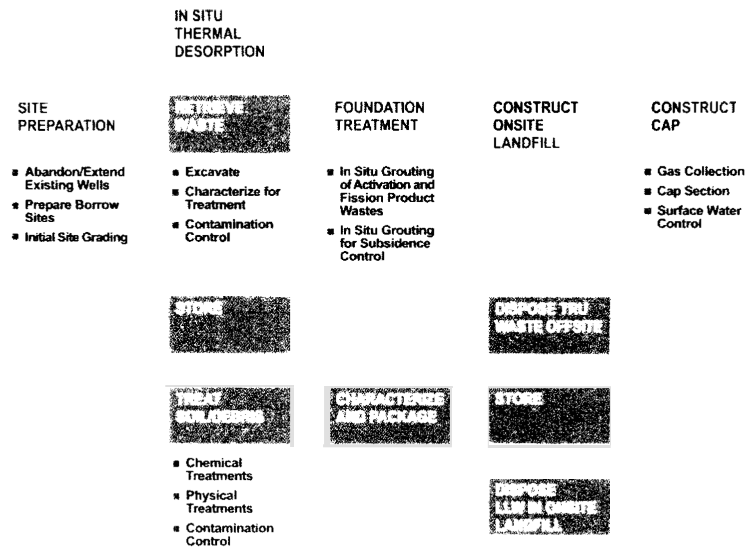

Figure 3-22. Retrieval, Treatment, and Disposal alternative schematic.

As discussed in Section 3.1, retrieval actions will specifically target disposal sites containing the RFP TRU waste in Pits 1 through 6, Pits 9 through 12, Trenches 1 through 10, and Pad A. For this analysis, retrieval requirements were assumed to include waste and soil extending to the first basalt flow. Estimated volume of the SDA soil and waste to be retrieved is based on the available waste inventory. All interstitial soil, 1 ft of the overburden, and 1 ft of underburden soil in each of the disposal units are assumed contaminated above remediation goals. A summary of estimated retrieval volumes is presented in Figures 3-3 and 3-4. For this initial screening evaluation it is assumed that approximately 50% of the RFP waste streams will be classified as TRU waste, with the remainder classified as either LLW or MLLW. This assumption results in these retrieval projections:

- 55,800 m^3 (73,000 yd^3) of TRU waste and soil
- 174,000 m^3 (228,000 yd^3) of MLLW, LLW, and soil.

In addition to the primary remedial action, which involves retrieval, ex situ treatment, and disposal of this waste and soil, it is assumed that implementing this alternative would require the following supplemental remedial actions:

- Activation and fission product treatment—Given the lack of available disposal facilities and concerns regarding retrieving and managing remote-handled waste from SVRs and trenches, activation and fission product waste streams containing COCs in these areas (as shown in Figure 3-5) will be treated in place with the ISG technology.
- Treating VOCs—High organic areas within the SDA (see Figure 3-9) would be treated with ISTD before retrieval to minimize VOC management and contaminant control requirements during retrieval.

- Cap construction and foundation stabilization—This alternative includes backfilling excavated areas to return the site to grade before placing a low-permeability, long-term cover over the SDA. The modified RCRA Subtitle C cover would be placed over the SDA to provide additional protection and to minimize future groundwater impacts resulting from leaching of any remaining residual contamination. Backfill materials will be compacted as required to support the cover system. In addition, any remaining untreated waste units will be stabilized using the ISG technology before constructing the cover as discussed in Section 3.3.3.

The alternative consists of three basic GRAs—retrieval, ex situ treatment, and disposal. Each of these actions is briefly described in following subsections.

3.9.1.1 Retrieval. A number of previous retrieval actions have been conducted for buried waste within the SDA. These include the Early Waste Retrieval project, implemented in 1974, and the Initial Drum Retrieval project, completed in 1978. The Early Waste Retrieval project was implemented to retrieve the oldest buried waste at the SDA (which is in Pits 1 and 2). For both projects, standard earthwork equipment (scrapers and excavators) and manual labor were used to remove overburden soil. Waste containers were removed with vertical lift slings attached to the bucket of a backhoe, and all loose waste and interstitial soil were generally removed by hand or shovel. For the initial drum retrieval, an air-supported weather shield was placed over the work area. All retrieval actions for the EWR were performed inside of an operating area confinement, which was a self-supporting metal building constructed of lightweight metal panels. Exhausted air was filtered through HEPA filters. The primary conclusion from these past retrieval actions is that retrieving buried waste from the SDA is possible. However, to implement full-scale retrieval within the SDA, further development of specific technologies and process options will be required.

For the RTD alternative to be successful, careful consideration must be given to protecting workers, the public, and the environment. Several technologies and controls would be used in order to provide this protection:

- All retrieval activities would be conducted within a double containment structure. A ventilation system would be incorporated into the primary containment structure.

- Excavation sizing, and sorting would be performed by operators wearing personal protective equipment and using manually operated construction equipment with sealed and pressurized cabins.

- Monitoring at the excavation (digface) would be performed to determine external radiation levels; these levels would then be used to determine appropriate measures to protect equipment operators and maintenance personnel.

- Using shoring and soldier piles may require sealing to prevent source release inside the primary containment.

The PERA adopts the assumption that waste retrieval operations can be designed to provide a production rate of 76 m^3 (100 yd^3) per day. This production rate was determined through an evaluation of retrieval equipment, cold tests, previous SDA retrievals, retrieval actions in the United States and Australia, treatment throughputs, storage capacity, and disposal facility rates of waste acceptance. It is assumed that retrieval operations would be conducted 200 working days a year, and that crews would work four 10-hour shifts each week. An estimate of the production requirements for specific SDA disposal units is provided in Figure 3-23.

During retrieval, several types of contamination control would be practiced. Metal curtains would be used to segregate highly contaminated portions of the digface from relatively uncontaminated areas. Foggers, sprays, misters, fixatives, and washes would be used to create a barrier between the work surface and the atmosphere; fix loose, airborne and settled contamination to a surface; and decontaminate personnel, atmosphere, or the environment. For treating and packaging, the entire process would take place in a waste treatment facility specifically designed for proper contamination control. Facility features would include airlocks, multiple contamination control zones, cascading ventilation systems, multiple HEPA filtration on building and process exhaust streams, and continuous monitoring of emissions.

Retrieval Planning	
Site	**Years**
Pit 1	0.5
Pit 2	1.5
Pit 3	0.8
Pit 4	2.1
Pit 5	2.1
Pit 6	1.1
Pit 9	0.9
Pit 10	2.1
Pit 11	0.5
Pit 12	0.6
Pad A	1.4
Trenches 1-10	1.5
TOTALS	**15.1**

Figure 3-23. Retrieval production requirements.

The initial operation at an individual waste unit would involve removing clean overburden soil, which would be stockpiled in an adjacent on-site area. Following retrieval of waste, the waste unit would be backfilled with the stockpiled soil augmented as required with clean soil from an approved off-Site borrow source. Retrieval would then commence at a different pit or trench, and the process would be continued until designated waste was retrieved and the units backfilled.

3.9.1.2 Ex Situ Treatment. Retrieved materials would be treated as necessary to meet health-based standards, regulatory requirements, and the WAC for specific disposal facilities. These treatments would include chemical, physical, and thermal treatment. Some TRU waste would require sizing. All waste and soil would be characterized and assayed to meet transportation requirements and WIPP WAC. Some treatment is expected to be required for the TRU waste fraction. Treatments include solidification of free liquids, removal of prohibited items, and eliminating corrosive, flammable, or reactive hazardous characteristic properties.

Retrieved MLLW and contaminated soil would require treatment before being permanently disposed of. Treatment can include physical treatments (e.g., shredding, sizing, and sorting), thermal treatment (e.g., steam reforming) for removing and destroying hazardous organics, and stabilization to fixate regulated metals. These actions would be performed under a negative pressure in the waste treatment facility, which would be equipped with scrubbers and HEPA filters for off-gas emissions to protect workers and the environment. Characterization of the material would be performed during and following treatment to ensure the treated waste meets the WAC for the disposal site and to determine health and safety requirements (e.g., PPE and air monitoring requirements).

3.9.1.3 Disposal. The only certified and permitted facility for disposal of retrieved TRU waste, including TRU-contaminated soil, is the WIPP. Onsite disposal of TRU waste was not considered implementable because of regulatory issues associated with potential ARARs, which could dictate specific treatment standards and design requirements for an onsite TRU waste disposal facility. Furthermore, a facility used for the disposal of TRU waste would have to be designed to meet the geologic repository performance objectives of 40 CFR 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes."

For the disposal of retrieved LLW and MLLW, which will be treated to satisfy ARARs, the RTD alternative requires constructing an onsite, engineered facility. In accordance with projected ARARs, design elements consistent with the construction standards for a RCRA Subtitle C facility would be required. Specific requirements would include a double membrane subgrade liner with leachate detection and a fine-grained multilayer surface barrier. As discussed in Section 2, the design developed for ICDF landfill would be appropriate for application within the SDA and was identified as the representative technology.

Though construction of a new, engineered facility at the RWMC was identified as the process option for this alternative, available on-Site and off-Site facilities also could be considered during final design for disposal of a portion of the projected waste. The ICDF landfill, which will be located near INTEC, will be ready to accept CERCLA LLW and MLLW in 2003 (DOE-ID 2002). As noted in Section 2, several off-Site facilities are available to receive LLW and MLLW, including Envirocare in Utah and U.S. Ecology in Washington. The Barnwell site in South Carolina is also available, but its east coast location makes it logistically less desirable. Each facility has specific WAC that must be met before disposal.

3.9.2 Evaluation of the Retrieval, Treatment, and Disposal Alternative

3.9.2.1 Effectiveness. Retrieving and disposing of SDA soil and buried waste in accordance with each of the three GRAs would be effective in achieving RAOs and protecting human health and the environment. However, implementing the retrieval action itself has the potential to impact human health and the environment.

Transuranic radioisotopes pose a health risk when inhaled or ingested. In addition, cancer resulting from the ionizing radiation is of concern. Retrieval equipment, vacuums, containment structures, and other standard construction equipment and facilities are proven and reliable in radioactive and hazardous environments. The technologies for waste processing and treatment, while proven, may require modification to improve confinement.

Off-Site disposal also poses a number of issues. Large volumes of contaminated material across the country are directly proportional to projected short-term transportation risk. Preliminary estimates are that over 7,000 truckloads would be required for off-Site disposal of RFP waste (assuming 50% of the RFP waste streams were to be classified as TRU). The likelihood of accidents outside of the INEEL increases with each loaded vehicle traveling to an off-Site destination. However, the shipping containers for transuranic waste have been demonstrated by the Nuclear Regulatory Commission to withstand extreme accident conditions without breaking open or releasing radiation, and it is highly unlikely that radioactivity would be released, even in the event of an accident.

3.9.2.2 Implementability. The implementability of a large-scale retrieval action at the SDA would be difficult because a transuranic waste retrieval project of this magnitude has not yet been performed. Consequently, some actions required to implement alternatives may be the first of their kind and require site-specific designs. Such designs must address and account for a number of health and safety issues to ensure safety of workers and prevent any uncontrolled release of contaminants to the environment. However, most of the technologies—containment structures, material handling facilities, transport facilities, characterization technologies, and ex situ treatment technologies—are implementable at the SDA.

A second key issue regarding implementability of a retrieval action targets availability of necessary equipment and skilled workers. Given the nature of waste and site conditions, equipment required for a retrieval action would most likely have to be modified specifically for this project. Examples of necessary equipment include remote devices, containment structures, ventilation systems, contamination control devices, treatment units, and packaging facilities. Workers required to implement this alternative are available in eastern Idaho, but they would need specific training.

An important implementability concern for off-Site disposal of TRU waste is the magnitude of the transportation requirements. The over 7,000 truckloads projected for the off-Site disposal requirements would have an impact on roads and communities adjacent to the INEEL.

For onsite disposal, implementability issues revolve around regulatory concerns that would dictate specific treatment standards and design requirements for onsite storage.

3.9.2.3 Cost. Costs for a full-scale retrieval action at the SDA are very high compared to those of either the Containment or the In Situ Treatment alternatives discussed previously. Table 3-5 provides a summary of the costs for this alternative.

Table 3-5. Total estimated costs for the Retrieval Treatment, and Disposal alternative.

Cost Element (FY 2002 dollars)	Cost ($M)
Capital costs	6,859
Operating and maintenance costs	30

3.10 Summary of Preliminary Screening Results

A comparative screening summary of each of the alternative's effectiveness, implementability, and cost is provided in Figure 3-24. Those alternatives retained for detailed analysis in Section 4 also are identified.

In accordance with EPA guidance, the No Action alternative, though not protective, is retained for comparative purposes as the base alternative for the detailed evaluations presented in Section 4.

The Limited Action alternative does not achieve the proposed RAOs and therefore has not been retained for detailed analysis. The alternative will only deter human exposure to the identified COCs, depending solely on long-term institutional controls to prevent future access to waste sites and area groundwater. The alternative also does not reduce toxicity, mobility, or volume of site contaminants. Further, the alternative does not prevent or inhibit future migration of contaminants from the source term to the underlying groundwater.

The Surface Barrier alternative was retained for detailed analysis. Constructing the surface barrier does not require extensive intrusive work, and risks resulting from potential worker exposure and environmental releases during implementation are relatively low. In addition, preliminary fate and transport modeling indicates that the cap, with selective application of the ISG technology, would meet the RAOs and provide long-term protection of human health and the environment.

Alternatives	Effectiveness	Implementability	Costs	Retained?
No Action	• Does not mitigate site risks	• Maintenance of existing monitoring programs only	• No capital costs • Long term monitoring costs only	Yes - In accordance with EPA directive
Limited Action	• Prevents direct exposure • Does not treat source • Does not mitigate projected groundwater impacts	• Standard earthwork • Does not require intrusion into the waste • Requires future groundwater use restrictions	• Low capital costs • Long term monitoring and maintenance costs	No - Does not achieve RAOs
Surface Barrier	• Prevents direct exposure • Surface Barrier reduces contaminant mobility and minimizes groundwater impacts • Does not reduce toxicity or volume of source • Activation/fission products in SVRs and trenches stabilized with ISG • VOCs in high organic waste streams destroyed with ISTD	• Short implementation period • Standard earthwork • Minor amount of intrusive work • 5M cy of material required for construction	• Capital costs significantly higher than Limited Action • Long term monitoring and maintenance costs	Yes - Achieves RAOs with lowest capital costs
Full Containment	• Prevents direct exposure • Reduction in contaminant mobility similar to surface barrier • Activation/fission products in SVRs and trenches stabilized with ISG • VOCs in high organic waste streams destroyed with ISTD	• Longer implementation period • Requires major extensive intrusive work • Implementation verification difficult	• Capital costs significantly higher than surface barrier • Similar long term monitoring and maintenance costs	No - Minor degree of additional protectiveness does not offset concerns associated with implementability, short term worker exposure and higher costs
In Situ Grouting	• Prevents direct exposure • Reduces contaminant mobility through treatment • Long term stability of grouted matrix • VOCs in high organic waste streams destroyed with ISTD	• Researched for INEEL specific application • Long implementation period • Requires extensive intrusive work • Requires the implementation of ISTD technology to pretreat high organics areas	• Capital costs higher than Surface Barrier • Long term monitoring and maintenance costs	Yes - Alternative meets RAOs and provides for a further reduction in containment mobility
In Situ Vitrification	• Prevents direct exposure • Reduces contaminant toxicity, mobility, and volume through treatment • Provides a more stable long term matrix • Activation/fission products in SVRs and trenches stabilized with ISG	• Specialized equipment required • Long implementation period • Concerns associated with potential worker exposure and contaminant release during implementation • Requires implementation of ISTD technology to pretreat wastes • Site-specific technology *applications must be proven*	• Capital costs higher than ISG • Long term monitoring and maintenance costs could be reduced	Yes - Alternative meets RAOs and provides for improved stability of waste form
Retrieval/ Treatment/ Disposal	• Prevents long term direct exposure • Highest potential short term exposures • Reduces contaminant toxicity, mobility, and volume through treatment • Removes all TRU wastes from source areas • Activation/fission products *in SVRs and trenches* stabilized with ISG	• Very long implementation period • Requires specialized contamination control/retrieval *equipment* • Regulatory concerns associated with off-site disposal of TRU wastes • Site-specific technology applications must be proven	• Highest capital costs associated with contamination control/retrieval equipment, characterization, and treatmen • Long term monitoring and maintenance costs can be minimized	Yes - Alternative meets RAOs by removing buried TRU waste

Figure 3-24. Initial screening summary.

The Full Containment alternative was not retained for detailed analysis. The incremental increase in long-term protectiveness offered by this alternative was considered to be relatively small and does not appear to warrant the significant projected increase in remedial costs. The increased effectiveness of a horizontal barrier is questionable because permeability of the horizontal barrier would probably be significantly greater than that of the surface barrier. In addition, implementing this full containment alternative will require significant intrusive activities, which will heighten potential worker exposure concerns and increase potential short-term releases of contamination to the environment. Also, a number of implementation concerns are associated with the full containment alternative. Specialized equipment would be required, and verification of the successful implementation of the subsurface horizontal barriers would be difficult. Construction delays could result if the borehole spacing during construction is significantly different from that estimated during design. Estimated cost of the Full Containment alternative is higher than the cost of the Surface Barrier alternative. The Full Containment alternative was not retained for detailed analysis because of increased cost, implementation concerns, and the questionable increase in effectiveness.

Both in situ treatment alternatives were retained for detailed analysis. These alternatives are effective in achieving RAOs and protecting human health and the environment. As discussed previously, both ISG and ISV are established technologies. In addition, the INEEL has conducted a number of previous studies investigating the applicability of ISV and ISG for site-specific applications. Though not all technical issues have been fully resolved, available data indicate that both alternatives would be implementable.

The RTD alternative has been retained for detailed analysis. This alternative addresses specific stakeholder and State of Idaho issues in that it includes removing buried TRU waste from the site. In general, while the RTD alternative offers the highest degree of long-term protectiveness, it is also the most difficult to implement, imposes the highest degree of short-term risk to workers and the environment, and costs the most.

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4. DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of assembled remedial alternatives required by the NCP in 40 CFR 300.430(e)(9). Five alternatives, listed in Table 4-1, were retained for detailed analysis. Each alternative, except No Action, focuses a primary technology (i.e., containment, ISG, ISV, and RTD) on mitigating COCs within the RFP TRU waste contained in Pits 1 through 6 and 9 through 12, Trenches 1 through 10, and Pad A. Assembled alternatives also include supplemental technologies, discussed in Section 3.2 to address other COC-bearing waste streams in the SDA.

Table 4-1. Retained alternatives for Waste Area Group 7.

No.	Alternative Title
1	No action
2	Surface barrier
3	In situ grouting
4	In situ vitrification
5	Retrieval, treatment, and disposal

Alternatives are evaluated in terms of seven of the nine CERCLA (42 USC § 9601 et seq.) criteria defined in EPA guidance (EPA 1988) and presented in Section 4.1. Sections 4.2 through 4.6 provide detailed descriptions and individual analyses of five alternatives. Throughout the analyses, the level of detail provided is conceptual and is offered to facilitate a comparative assessment of the alternatives provided in Section 5.

4.1 Evaluation Criteria

The nine CERCLA criteria for evaluating remedial alternatives listed in Table 4-2 are promulgated under 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan." These criteria address statutory requirements and technical and policy considerations necessary for assessing and selecting remedial alternatives.

The CERCLA criteria fall into three groups: (1) threshold, (2) balancing, and (3) modifying. The first two criteria (i.e., overall protection of human health and the environment, and compliance with ARARs) are threshold criteria that a remedial alternative must meet to be eligible for selection. Alternatives that fail to protect human health and the environment or fail to comply with ARARs (or do not justify a waiver) do not meet statutory requirements for selecting a remedy and are eliminated from further consideration.

The next five criteria are (1) long-term effectiveness and permanence, (2) reduction of toxicity, mobility, or volume through treatment, (3) short-term effectiveness (4) implementability, and (5) cost. These are balancing criteria used to consider significant trade-offs among alternatives. The CERCLA guidance for conducting feasibility studies lists appropriate questions to be answered when evaluating an alternative against the balancing criteria (EPA 1988). These questions are addressed in the detailed analysis presented in this section to provide a consistent basis for evaluating each alternative.

Table 4-2. Comprehensive Environmental Response, Compensation and Liability Act evaluation criteria.

Category	Criteria
Evaluated in this feasibility study	
Threshold	Overall protection of human health and the environment
	Compliance with applicable or relevant and appropriate requirements
Balancing	Long-term effectiveness and permanence
	Reduction of toxicity, mobility, or volume through treatment
	Short-term effectiveness
	Implementability
	Cost
Evaluated in the future record of decision following stakeholder comment on the proposed plan	
Modifying	State acceptance
	Community acceptance

The final two modifying criteria (state and community acceptance) are used in assessing benefits and costs among alternatives that may form the basis of the final selection.

Brief descriptions of the nine criteria are provided in the following subsections. The alternative analysis provided in Sections 4.2 through 4.6 includes assessing the ability of each alternative to satisfy the two threshold and five balancing criteria. The modifying criteria will be evaluated following receipt of stakeholder comments. Analysis of each alternative begins with a description followed by a criterion-by-criterion evaluation. A summary of the screening analysis for each alternative is provided in Appendix C. A detailed presentation of costs is provided in Appendix D.

4.1.1 Threshold Criteria

4.1.1.1 Overall Protection of Human Health and the Environment. The protection evaluation criterion addresses whether an alternative can provide adequate protection of human health and the environment. Protection includes lowering risk to acceptable levels by reducing concentrations or eliminating potential routes for exposure and minimizing exposure threats introduced by actions during remediation. As indicated in EPA guidance (EPA 1988), the protection evaluation criterion overlaps with the criteria for compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness (EPA 1988).

4.1.1.2 Compliance with Applicable or Relevant and Appropriate Requirements. The NCP (40 CFR 300.430[e][9][B]) requires that alternatives ". . .be assessed to determine whether they need to attain applicable or relevant and appropriate requirements under federal environmental laws and state environmental or facility siting laws or provide grounds for invoking one of the waivers under paragraph (f)(1)(ii)(c) of this section." Cleanup of a CERCLA site must meet requirements or standards promulgated by federal laws and more stringent state laws that relate as ARARs (42 USC § 9621[d][2]).

The ARARs apply to both environmental regulations that direct site cleanup and environmental media criteria that protect human health and the environment. These regulations also promulgate protective requirements for natural, historic, and archaeological resources. However, ARARs do not encompass worker protection requirements addressed under the "Occupational Safety and Health

Administration Act" (OSHA) (20 CFR 1910). While Section 300.150, "Worker Health and Safety," of the NCP does require compliance with general OSHA workplace standards, such standards do not fall within the scope of ARARs under CERCLA (42 USC § 9621[d][2]).

Requirements other than CERCLA-driven ARARs also apply to WAG 7. The TSA within WAG 7 is currently subject to the conditions of a RCRA (42 USC § 6901 et seq.) permit and will be operated and closed in accordance with RCRA permit conditions. It is assumed that the TSA will be closed under RCRA clean-closure requirements.

Preliminary ARARs are identified in the discussions for each alternative. Final determination of ARARs will be completed as part of remedy selection and documented in the ROD.

4.1.2 Balancing Criteria

4.1.2.1 Long-Term Effectiveness and Permanence. The NCP (40 CFR 300.430[e][9][C]) requires that alternatives be ". . .assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternatives will prove successful." Following are factors considered in the assessment:

- Magnitude of residual risk—Risk remaining from untreated waste or treatment residuals remaining in the SDA source term after remedial activities are completed. Characteristics of the residual waste are considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

- Adequacy and reliability of controls—These involve controls (e.g., containment systems and institutional controls) used to manage residual risks associated with treatment residuals or untreated waste that remain at the project site, long-term reliability of management controls necessary for continued protection from residuals, and assessment of potential needs for maintaining and replacing technical components of the alternative.

Residual risk estimates were developed for each remedial action to assess the reduction in human health risks. The evaluations consist of source-release and fate and transport simulations to estimate risk from ingesting groundwater only. Models used to develop risk estimates for the ABRA (Holdren et al. 2002) (e.g., DUST-MS, and TETRAD) also were employed to simulate release and subsurface transport of contaminants to the aquifer beneath the SDA subsequent to hypothetical remediation in 2010.

Infiltration rates and amounts of contamination in the SDA after remediation are principal factors affecting risk estimates. Site-specific technology performance data are unavailable to describe release rates from treated and contained SDA waste. Conservative estimates of release rates for the alternatives were developed based on information in scientific literature. Therefore, risk estimates for each alternative may be higher than the actual residual risk from implementing any alternative. The simplifying assumption that remediation will be instantaneous and complete in 2010 also affects results. In addition, simulated migration of postulated contamination in the vadose zone at the time of remediation is affected only by the change in water movement caused by the remedy. Otherwise, no change in mobility is simulated and the same partition coefficient values are applied. Note also that the influence of the OCVZ system was not included in the modeling. Continuing to operate this system could have a significant effect in reducing groundwater risks associated with VOCs as currently presented in the ABRA.

Beginning in 1952, with the start of SDA operations, groundwater risks are estimated for 10,000 years. Analysis of long-term effectiveness presents the highest estimated risks from ingesting groundwater at the point of maximum cumulative risk. Two scenarios were simulated: (1) one that includes contributions from postulated contamination in vadose zone at the time of remediation and (2) one that ignores postulated contamination in the vadose zone at the time of remediation. Simulations without postulated contamination in the vadose zone provide a basis for evaluating and comparing effectiveness of alternatives in controlling the release of contaminants from the source zone after remediation.

Confidence in the groundwater modeling depends on the representativeness of the geochemical, geophysical, surface water, source release, vadose zone transport modeling, and model calibration. These processes are affected by many parameters, some of which can vary by orders of magnitude and may not be accurately represented in the simulations. Because of the many uncertainties and simplifying assumptions for the fate and transport simulations and risk estimates (see Sections 5 and 6 of the ABRA, Holdren et al. 2002), risk results should not be viewed as accurately predicting future groundwater contamination. Rather, results are used to compare relative long-term effectiveness of the alternatives in preventing future groundwater contamination.

4.1.2.2 Reduction in Toxicity, Mobility, and Volume Through Treatment. The NCP (40 CFR 300.430[e][9][D]) addresses the statutory preference for selecting remedial actions that employ treatment technologies that, as their principal element, permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances. Permanent and significant reduction can be achieved through destroying toxic contaminants, reducing total mass, irreversibly reducing contaminant mobility, or reducing total volume of contaminated media. This criterion focuses the evaluation of an alternative on a variety of specific factors:

- Treatment processes used and materials they treat
- Amount of hazardous materials destroyed or treated
- Degree of expected reduction in toxicity, mobility, or volume described as a percentage of reduction
- Degree to which the treatment is irreversible
- Type and quantity of treatment residuals that remain following treatment
- Ability of the alternative to satisfy the statutory preference for treatment as a principal element.

4.1.2.3 Short-Term Effectiveness. The NCP (40 CFR 300.430[e][9][E]) requires evaluations of an alternative's potential effects on human health and the environment during construction and remediation. The feasibility study evaluations address the following factors for each alternative:

- Protecting the community during remedial actions (specifically, addressing any risk that may result from implementing a remedy [e.g., fugitive dust or transportation of hazardous materials])
- Ensuring the health and safety of remediation workers
- Ensuring the reliability of protective measures
- Mitigating environmental impacts that may result from constructing and implementing remedial actions

- Determining amount of time until the RAOs are met.

Short-term environmental impacts are related primarily to the extent of physical disturbance of habitat. In addition, risk may be associated with the potential disturbance of sensitive species resulting from human activity in the area.

Short-term human health impacts are closely related to exposure duration; specifically, the amount of time a person may be exposed to hazards associated with the waste, its treatment, or its removal. The longer the exposure time, the greater the potential risk. This correlation between exposure duration and risk is a factor in categorizing short-term human health impacts posed by an alternative. One category of potential impacts is the risk to remediation and nonremediation workers from mechanical hazards associated with implementing the alternative and from exposure to hazardous substances, including radioactive materials and radiation fields. Also included, but considered separately, are impacts to workers who support remedial activities but are not part of the remediation staff. Such workers may be exposed to materials released during remedial activities (including excavation, waste packaging, and waste processing) or to radiation fields attributed to waste staging. Potential impacts include radiological risks (collective dose equivalent and excess cancer risk) and OSHA-type accident rates.

Another category of impacts is risks to the public. The public could be impacted through releases of hazardous substances from waste handling and processing activities or from off-INEEL waste transportation exposures to radioactive materials. The public also could be impacted by transportation accidents associated with off-INEEL waste disposal.

The short-term human health impacts associated with each alternative have been quantitatively evaluated and are discussed in detail in a technical report (Schofield 2002) prepared to support development of this PERA.

4.1.2.4 Implementability. The NCP (40 CFR 300.430[e][9][F]) requires that assessment of the ease or difficulty of implementing the alternatives consider the following factors:

- Technical feasibility—Technical difficulties in constructing and operating the alternative, the likelihood of technical problems when implementing the technology that might lead to schedule delays, ease of implementing and interfacing additional remedial actions (if necessary), and the ability to monitor effectiveness of the remedy.

- Administrative feasibility—Ability of the alternative to be coordinated with activities of other offices and agencies, and the potential for regulatory constraints to develop (e.g., uncovering buried cultural resources or encountering endangered species).

- Availability of services and materials—Availability of adequate off-INEEL treatment, storage, and disposal (TSD) facilities with sufficient capacity, availability of necessary equipment and specialists and provisions to ensure any necessary additional resources, availability of services and materials, and availability of prospective technologies.

4.1.2.5 Cost. The NCP (40 CFR 300.430[e][9][G]) requires assessment of expenditures for capital, operation, and maintenance costs required to complete each measure. Once these values have been identified and a present worth has been estimated for each alternative, comparative evaluations can be made.

Cost estimates presented in this report are based on preliminary descriptions of the alternative and do not include detailed engineering data. An estimate of this type, in accordance with EPA guidance

(EPA 2000), should be accurate between -30 and +50%. Cost estimates for each alternative include a contingency consisting of both scope and bid preparation considerations. Contingency values applied were alternative-specific, in accordance with EPA guidance (EPA 2000). In addition, the net present worth calculations assume a discount rate of 7%, consistent with current EPA guidelines.

Cost estimates were prepared from current information and are presented in FY 2002 dollars. Actual project costs will depend on final scope and design of the selected remedial action, the schedule of implementation, competitive market conditions, and other variables. However, most of these factors would not affect the relative cost differences between alternatives. Detailed cost estimates for each alternative are provided in Appendix D.

4.1.3 Modifying Criteria

4.1.3.1 State Acceptance. The NCP (40 CFR 300.430[e][9][H]) addresses the technical and administrative issues and concerns a state may have about each alternative. This criterion is addressed following State of Idaho review of the WAG 7 RI/FS and proposed plan.

4.1.3.2 Community Acceptance. The NCP (40 CFR 300.430[e][9][I]) requires that an assessment be conducted of issues and concerns the public may have about each alternative. This criterion is addressed following public review of the WAG 7 proposed plan.

4.2 Alternative 1—No Action

4.2.1 Alternative Description

Guidance specifies preparing and developing a No Action alternative to use as a baseline to compare with other alternatives (40 CFR 300.430[e][6]). Under the No Action alternative, no remedial action would be taken at the WAG 7 site beyond the current site-wide monitoring of environmental media. Buried waste would remain as it is and no future maintenance or institutional controls would be implemented to prevent access to the waste by human or ecological receptors. Costs for this alternative include long-term monitoring of groundwater, soil, air, and other environmental media for 100 years.

No Action Alternative Remediation Strategy

Existing site conditions will remain unchanged. No action would be taken to reduce contaminant mobility, toxicity, or volume.

Key Element:
Long-term monitoring.

A summary of the proposed monitoring program is presented in Table 4-3. This program has been developed to provide an assessment for protectiveness with consideration given to the RAOs and current environmental monitoring practices. As shown in the table, groundwater monitoring involves a staged quarterly, semiannual, and annual program to be conducted through the existing groundwater monitoring network. No upgrades or improvements to groundwater-monitoring are included under this alternative. Similarly, vadose zone monitoring would be conducted with existing lysimeters and vapor ports. In addition, this alternative includes periodic site inspections to identify biotic intrusion problems. A review of monitoring requirements would occur every 5 years to evaluate the effectiveness of the No Action alternative.

4.2.2 Screening Assessment

In the following sections, an assessment is provided of the ability of the No Action alternative to satisfy the two threshold criteria and the five balancing criteria described in Section 4.1.

Table 4-3. Projected monitoring requirements of the No Action alternative.

Media	Assumptions
Groundwater	Sample 16 locations quarterly for 2 years; semiannually for following 3 years; annually for remaining 95 years.
Vadose zone	Annual sampling of lysimeters (37); vapor port (20) sampling quarterly for 5 years and annually for remaining 95 years.
Surface water	Sample two points every 5 years for 100 years.
Air	Sample four existing air monitors annually for 100 years; annual radiological monitoring.
Biological	Animal intrusion monitoring conducted twice during first 5-year period and once every following 5 years for a total of 100 years.

4.2.2.1 Overall Protection of Human Health and the Environment (Threshold Criterion). The No Action alternative would not protect human health and the environment. As identified in the ABRA, existing conditions at the site pose and would continue to pose a risk to human health and the environment through a number of projected pathways, including direct contact and groundwater usage. Only through radioactive decay or other natural processes would risk levels be reduced.

4.2.2.2 Compliance with Applicable or Relevant and Appropriate Requirements (Threshold Criterion). The No Action alternative includes long-term monitoring with no additional remedial actions implemented at the WAG 7 site. The EPA (1991) directive indicates that ARARs are not applicable to a no-action alternative. However, because monitoring would continue under this alternative, compliance with ARARs is addressed by considering chemical-, location-, and action-specific ARARs and TBC requirements. For the No Action alternative, it is assumed that long-term environmental monitoring would be implemented under an existing program without changes to that program. Appendix A presents a comprehensive summary of the potential ARARs that have been identified.

Table 4-4 provides an evaluation summary of the major substantive ARARs for the No Action alternative. Each requirement is identified by (1) type (i.e., chemical-, location-, or action-specific), (2) relevance (i.e., applicable, relevant and appropriate, or TBC), and (3) regulatory source citation. The table also presents a conclusion as to whether the proposed alternative would satisfy a corresponding requirement.

Table 4-4. Summary of the regulatory compliance evaluation for the No Action alternative.

ARAR or TBC	Type	Relevance	Citation	Meets Evaluation?
Radiation protection of the public and the environment	Chemical Action	TBC	DOE Order 5400.5	No
Idaho control of fugitive dust emissions	Chemical Action	AR	IDAPA 58.01.01.650, .651	No
Radioactive waste management	Action	TBC	DOE Order 435.1	No

AR = applicable requirement
ARAR = applicable or relevant and appropriate requirement
TBC = to-be-considered requirement

4.2.2.2.1 Chemical-Specific (Applicable or Relevant and Appropriate Requirements)—As discussed in Section 2, chemical criteria are based on the RAOs established for this PERA including inhibiting ingestion of and direct exposure to COCs in soil and waste and inhibiting migration of COCs to groundwater. The No Action alternative would not meet the RAOs because this alternative does not propose any action to reduce, control, or mitigate exposure from radiological or hazardous contaminants. The alternative would not comply with the Idaho rules for control of fugitive dust emissions (IDAPA 58.01.01.650, .651) that apply to any source of fugitive dust. Because no effort would be made to mitigate or control dust that might occur over time, this alternative might result in noncompliance with this standard. In addition, contaminants would continue to leach from the site at rates that would affect groundwater and pose potential future risks to human health. As discussed in Section 2.2, this analysis focuses on mitigating contaminants in the source term. Technology applications for remediating area groundwater are not directly addressed. Therefore, criteria (e.g., MCLs and the maximum contaminant level goals [MCLGs]) established under the "National Primary Drinking Water Standards" (40 CFR 141) and the groundwater quality standards, as adopted by the "Ground Water Quality Rule" (IDAPA 58.01.11), were not considered as ARARs for OU7-13/14. However, remedial actions at WAG 7 must take into consideration these criteria and address estimated groundwater risks to ensure compliance with the RAOs.

4.2.2.2.2 Location-Specific (Applicable or Relevant and Appropriate Requirements)—Evaluating location-specific ARARs is impossible because the No Action alternative does not propose any action.

4.2.2.2.3 Action-Specific (Applicable or Relevant and Appropriate Requirements)—The No Action alternative does not propose any action to reduce, control, or mitigate exposure from radioactive and hazardous chemical contaminants. Consequently, compliance with action-specific ARARs is not specifically pertinent. A possible exception may be failure of the alternative to fulfill DOE orders that are TBCs (i.e., DOE Order 435.1, "Radioactive Waste Management," and 5400.5, "Radiation Protection of the Public and the Environment.") The DOE Order 435.1 establishes requirements and specific responsibilities for implementing radioactive waste management practices applicable to all DOE radioactive waste. This order specifies that protecting the public and the environment from radiation must comply with the criteria and requirements of DOE Order 5400.5. The No Action alternative would not (1) fulfill TBCs, (2) mitigate possible health risks projected for current workers, potential future residents, and environmental receptors, and (3) achieve specific waste management standards and criteria.

4.2.2.3 Long-Term Effectiveness and Permanence (Balancing Criterion). The No Action alternative does not provide for long-term control of human and ecological exposure to waste within the WAG 7 boundary. As documented in the ABRA, modeling shows that migrating contaminants from the waste to the surface and groundwater will result in unacceptable carcinogenic risk (greater than 1E-04) and noncarcinogenic hazards (combined hazard index greater than 2) to future human receptors. Ecological risks also are unacceptable, with a resulting hazard quotient greater than 10. The magnitude of risk for the No Action alternative is significant to future receptors because exposure to the waste and any resulting contaminated soil would not be inhibited.

4.2.2.4 Reducing Toxicity, Mobility, or Volume Through Treatment (Balancing Criterion). The No Action alternative does not reduce the toxicity, mobility, or volume of contaminants at the site.

4.2.2.5 Short-Term Effectiveness (Balancing Criterion). Because no further remedial actions would be taken, this alternative could be readily implemented without additional risk to the community, workers, or environment. No specialized equipment, personnel, or services would be required to implement the future monitoring program required for the No Action alternative. Further, there would be no short-term adverse impacts to socioeconomic or cultural resources because of remedial actions. Should additional monitoring wells be required in the future in or around WAG 7, any administrative, engineering, and PPE measures could be used to ensure that employees are properly protected.

4.2.2.6 Implementability (Balancing Criterion). Because no further action would be taken under this alternative, no difficulties or uncertainties with construction would arise and no specialized equipment, personnel, or services would be required. All monitoring techniques are technically and administratively implementable and are conducted routinely. However, whether a long-term monitoring program could be enforced and maintained during the full duration of the projected site risks, as identified in the ABRA, is questionable.

4.2.2.7 Cost (Balancing Criterion). Because no capital costs are budgeted, total project costs associated with this No Action alternative primarily involve the long-term environmental monitoring program described previously. As presented in Appendix D, total monitoring and management costs for a period of 100 years are projected to be approximately $38.5 million. The net present value of the No Action alternative is estimated at $9.6 million. The costs include an estimated 20% contingency. A summary of the costs is provided in Table 4-5.

Table 4-5. Estimated costs for the No Action alternative with contingency.

Cost Element	Total Costs ($M)	Net Present Value ($M)
Capital costs	None	None
Operating and maintenance costs		
Fencing and signage	0.3	—
Monitoring	33.7	—
Management	4.5	—
Total alternative costs	**38.5**	**9.6**

4.3 Alternative 2—Surface Barrier

4.3.1 Alternative Description

The Surface Barrier alternative consists of institutional controls, physical barriers, and long-term operation and maintenance. The primary technology associated with this alternative is the long-term multilayer cover system. Layers of the cover would be designed not only to prevent human or ecological receptors from direct contact with the buried waste, but also to stabilize some contaminants in place and minimize migration through leaching, volatilization, or biotic uptake.

In addition to the primary technology, the Surface Barrier alternative includes implementing a number of supplemental

Surface Barrier Alternative Remediation Strategy

Isolation of the buried waste and reduction of contaminant migration through the placement of a long-term, low-permeability cover system.

Key Elements:
(1) In situ grouting at selected disposal sites
(2) In situ thermal treatment in areas with high levels of volatile organic compounds
(3) Pad A retrieval and reconfiguration
(4) Foundation stabilization
(5) Long-term multilayer cover
(6) Physical and administrative land-use restrictions
(7) Long-term monitoring and maintenance.

technologies to ensure compliance with the RAOs. In situ grouting would be applied to the waste disposal areas within the SDA to (1) treat contaminant-specific disposal areas where preliminary modeling indicates that the cap alone may be unable to adequately mitigate future groundwater risks and (2) stabilize the subsurface to prevent future subsidence that could damage the integrity of the cover system. For this alternative, ISG would be used to encapsulate waste within SVRs and specific areas within the trenches that contain C-14, I-129, Nb-94, and Tc-99. Distribution of this waste is depicted in Figure 3-4. Grouting would be extended into remaining pits and trenches as required to stabilize the cap subgrade. This general foundation stabilization step would be similar for all alternatives requiring a capping technology and would be conducted as described in Section 3.3 to ensure long-term stability of the cover system. This alternative also includes retrieving and placing Pad A waste into a more stable configuration within the SDA, as required to minimize potential for future subsidence.

Discussions about the basic elements of this alternative are provided in the following subsections.

4.3.1.1 Preconstruction Activities. These activities would include borrow-source investigations, a safety assessment, and mobilization and setup of equipment, supplies, and personnel. Primarily, borrow-source investigations would involve verifying the quantities of silt loam available at Spreading Areas A and B. Material at Spreading Area B proposed for use in the clay barrier layer would be sampled and tested to verify that it can be placed and compacted to achieve a very low permeability. If the material at Spreading Area B does not meet permeability requirements, other sources would need to be investigated, or additives (e.g., bentonite) considered for construction of the clay barrier layer.

4.3.1.2 Primary Technology—Long-Term Low-Permeability Cap. The multilayer, low-permeability cap covering the entire SDA would be designed in accordance with specifications developed for the ICDF landfill at the INEEL. The cap would consist of a grading fill layer, a gravel gas collection layer, a compacted clay layer, a geomembrane, a capillary barrier, a coarse-fractured basalt biotic barrier, coarse and fine gravel and sand filters, an engineered earth fill layer, a perimeter berm, a riprap armor layer on berm and barrier side slopes, and a vegetated topsoil layer on the surface. Figure 4-1 shows a typical section of the cap construction with the protective berm system. As shown in Figure 4-1, the perimeter berm would extend approximately 100 ft from the toe of the cover system and be designed to protect the waste disposal units during potential flood conditions. Grading fill would be placed over the disposal areas to integrate with the perimeter berm and facilitate lateral drainage of the individual cover layers.

The cap design incorporates continued operation of the OCVZ vapor vacuum extraction system. Concurrent with construction, wells and treatment units supporting the OCVZ system would be extended or relocated. In addition, a gas collection layer would be incorporated into the cap design to passively vent VOC releases from the buried waste.

The cap would be constructed in phases. The first phase would focus on constructing the ICDF barrier within the inactive portions of the SDA while maintaining access to ongoing LLW disposal activities in Pits 17 through 20. During the second construction phase, after closure of LLW disposal pits, the perimeter berm would be completed and the ICDF barrier extended over any remaining areas.

4.3.1.3 Supplemental Technologies. To provide compliance with the RAOs, this alternative would require implementing a number of supplemental technologies within the SDA to address contaminant-specific concerns and provide for long-term stability of the cover system.

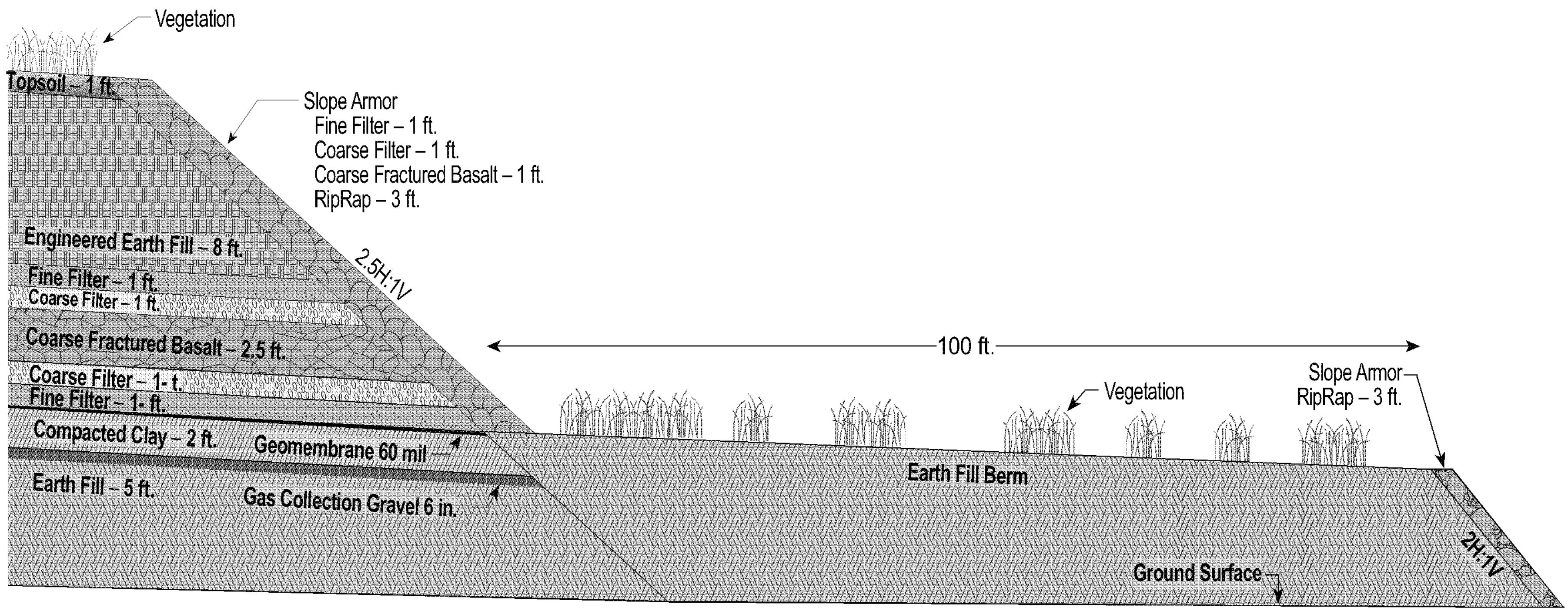

Figure 4-1. Cross-section view of the Surface Barrier alternative.

4.3.1.3.1 In Situ Organic Treatment—The OCVZ treatment system is currently in operation to remove VOCs, including CCl_4, from the vadose zone beneath the SDA, as discussed in Section 3.3.8. Carbon tetrachloride has been detected in area groundwater at concentrations slightly above drinking water standards and was identified in the ABRA as the contaminant posing the most imminent groundwater risk. Estimates of the SDA CCl_4 inventory have been revised upward (Miller and Varvel 2001), and adequacy of the present OCVZ system is currently being evaluated. Preliminary modeling results also have shown that even after putting the low-permeability ICDF cover in place, CCl_4 would continue to leach from the source term at a potentially unacceptable rate.

For these reasons, the Surface Barrier alternative has included implementing the ISTD technology to treat waste zones containing high concentrations of VOCs before constructing the cover system. Disposal records indicate that CCl_4 is contained primarily in the oil waste (Series 743 sludge) received from the RFP. Distribution of this waste is depicted in Figure 3-8. For this alternative, it is projected that the ISTD technology would be applied over the extent of the Series 743 sludge disposals, a total area of approximately 5 acres.

In situ thermal desorption would employ an array of heated stainless steel pipe assemblies inserted in the ground on an 8×8-ft spacing to a depth of approximately 3 ft below the buried waste. Each assembly would include a sealed pipe containing an electrical resistance-heating element, a vented pipe used to extract gases, and thermocouples. Each extraction pipe would be connected to a pipe manifold that would convey gases to an off-gas treatment system. The pipe assemblies would be inserted into the ground using vibratory or hydraulic techniques. A more detailed discussion about implementing ISTD within the SDA is presented in Section 4.5.1.2. Determination of specific pretreatment requirements would be evaluated further during the design phase.

4.3.1.3.2 In Situ Grouting—Disposal units in the SDA would be grouted before construction of the low-permeability cap to (1) encapsulate and immobilize specific COC-bearing waste in situ and (2) stabilize the cover foundation for structural support. A detailed discussion of the implementation of ISG within the SDA is provided in Section 4.4 and in the supporting report (Armstrong, Arrenholz, Weidner 2002).

Activation and fission products, including C-14, I-129, Nb-94, and Tc-99, have been identified in the ABRA as COCs that exceed risk-based thresholds. Preliminary modeling results also indicate that even after putting the low-permeability ICDF cover in place, these mobile COCs would continue to leach from the source term and potentially affect area groundwater at unacceptable concentrations. The activation and fission product waste within the SDA is contained primarily in the SVRs and a number of locations within the LLW trenches (see Figure 3-4). To address the RAOs, this waste would be encapsulated in grout or other media to immobilize contaminants and reduce the infiltration of moisture around the waste. In the trench areas, grout would be injected on approximately 2-ft centers. Such a high density of injection points ensures that waste containers would be intersected and the contents mixed with high-pressure grout. Cementitious grouts have been shown to be effective waste forms for radioactive contaminants (e.g., C-14).

A similar approach would be used in the SVRs. Because the SVRs consist of a series of approximately 650 individual vaults arranged in 21 rows, grout would be injected at each vault rather than on the rigid grid used for pits and trenches. Soil vaults are (1) small, approximately 16-in. diameter, and (2) large, approximately 57-in. diameter, and they are arranged in long lines across a number of areas within the SDA. The grout injection lance likely would be inserted around the perimeter of each vault. Injected grout would surround the waste object(s) and fill any void space in the soil vault. Soil above and below the object(s) also would be grouted. As grouting of soil vaults has not been performed before, some field-testing would be necessary to ensure safe operations.

The pits and remaining areas within the SDA would be grouted for foundation stabilization using the modified grouting program discussed in Section 3.3.3. This grouting technique would fill readily accessible void spaces and minimize future subsidence problems.

4.3.1.3.3 Pad A Waste Preparation—For the Surface Barrier alternative the Pad A waste would be retrieved. Pad A is not in a configuration that could be easily capped and poses a potential subsidence problem following placing of the cover system. The Pad A waste area extends to an average height of 9 m(29.5 ft), and the cover is not stable enough to support heavy equipment. In addition, it is critical that future subsidence be prevented to avoid damage of the surface barrier and minimize future maintenance work. Owing to the unstable nature of the surface of the Pad A waste pile and potential design issues associated with incorporating the pile into the final cover system, waste and soil would be retrieved and reconfigured in a compacted layer within the center of the SDA before plac the final cover.

Pad A primarily contains TRU alpha-emitting radioisotopes with concentrations less than 10 nCi/g and radiation levels less than 200 mR/hour at the container's surface, though two shipments contained TRU waste at concentrations greater than 100 nCi/g (DOE-ID 1998). Containers of waste (i.e., drums and plywood boxes) are stacked and covered with soil. Each stack at Pad A consists of as many as 11 drums or five boxes. Drums are stacked horizontally in staggered layers and boxes are stacked around the periphery of the pad. Retrieving the Pad A waste would require building a containment structure to prevent contaminant releases during retrieval. A discussion of the retrieval process for Pad A is presented in Section 4.6.1.3.

4.3.1.3.4 Land-Use Restrictions—Institutional controls and physical barriers include restricting access by imposing deed restrictions and posting permanent markings and informational notices on the site. Land-use restrictions would further prohibit construction of water-supply wells and the future use of groundwater as a potable source within the immediate vicinity and downgradient of the site area. Physical barriers for this alternative would include a perimeter fence to restrict site access. These measures would prevent possible exposure to humans and ecological receptors.

4.3.1.3.5 Monitoring and Maintenance—The Surface Barrier alternative would require routine maintenance of the protective measures to ensure that features are inspected and repaired as necessary. In particular, maintenance to prevent or repair damage from erosion, burrowing animals, and deep-rooted plants. In addition, the Surface Barrier alternative would include long-term groundwater and air monitoring, conducted as part of the INEEL facility-wide monitoring. This program would be similar to that described for the No Action alternative (see Section 4.2.1), augmented by vegetation monitoring. Monitoring would be conducted annually for 5 years after placing the cover system and every 5 years thereafter. Periodic maintenance would be required to reestablish areas of failed vegetation. The cost estimate is based on performing these activities for 100 years, although maintenance in perpetuity would be required to ensure continued protection of human health and the environment.

4.3.1.4 Estimated Project Schedule. Figure 4-2 details the schedule for the tasks involved in the first phase of construction. The projected schedule shows that, with an approved ROD in 2005, the initial phase of cap construction could be completed by 2016, with an additional 2 years projected to establish the vegetative cover.

Active disposal at the SDA is projected to end by 2020. Then, the second phase of construction would cover the estimated remaining 5 acres. Because of the small size of this area, the cap could be constructed in a 2-year period, followed by an additional 2-year period to establish the vegetative cover.

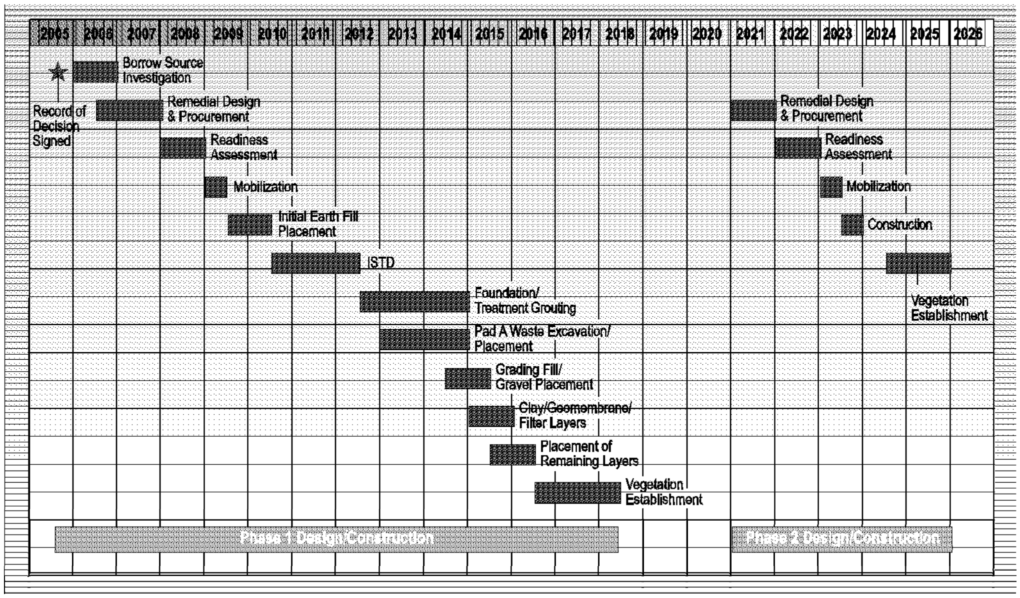

Figure 4-2. Schedule for tasks in the first phase of construction for the Surface Barrier alternative.

4.3.2 Screening Assessment

The following sections present and assess the ability of the Surface Barrier alternative to satisfy the two threshold and five balancing criteria described in Section 4.1.

4.3.2.1 Overall Protection of Human Health and the Environment (Threshold Criterion). This alternative is projected to provide for the long-term protection of human health and the environment. The multilayer, low-permeability cap would control and minimize contaminant migration by reducing surface water infiltration rates, thus impeding further release of contamination to the aquifer. Implementing the ISG technology would effectively stabilize activation and fission products within the SVRs and trenches. Implementing ISTD would provide for treating VOCs within the source term and minimize future requirements for the OCVZ system. In addition, the cap would effectively isolate buried waste, prevent ecological receptor exposures, prevent transport of contaminants by plants and animals, and prevent ingestion of, and direct exposure to COCs located at the waste sites.

4.3.2.2 Compliance with Applicable or Relevant and Appropriate Requirements (Threshold Criterion). The Surface Barrier alternative would cover buried waste at WAG 7 by installing and maintaining a long-term multilayer cover system. Therefore, the key ARARs for this alternative relate to containing buried waste over time. Additional ARARs for this alternative relate to the supplemental technologies required to satisfy the RAOs. Limited grouting also would be completed in the Surface Barrier alternative to encapsulate or stabilize waste in the SVRs and trenches where activation product material is disposed of. Foundation grouting to prevent cap subsidence would be performed for remaining waste disposal sites within the SDA. The ARARs identified for grouting (discussed in Section 4.4.2.3) also would apply to this remedy. The ARARs for ISTD, which would be applied in the high VOC areas, are identified in Section 4.5.2.3. The ARARs related to the retrieval action required for the Pad A waste are presented in Section 4.6.2.3.

The evaluation summary of the key ARARs for the Surface Barrier alternative, including limited ISG, ISTD, and RTD, is presented in Table 4-6. Each requirement is identified by type (i.e., chemical-, location-, or action-specific), relevance (i.e., applicable, relevant and appropriate, or TBC), and regulatory source citation. The table also presents a conclusion as to whether the proposed alternative would satisfy a corresponding requirement. Appendix A presents a comprehensive summary of the potential ARARs identified for the WAG 7 feasibility study.

4.3.2.2.1 Chemical-Specific (Applicable or Relevant and Appropriate Requirements)—As described in this PERA, the Surface Barrier alternative would meet RAOs for direct contact because the protective layers of the surface barrier would prevent exposure to underlying soil and waste by any inadvertent human intruders and ecological receptors.

Table 4-6. Regulatory compliance evaluation summary for the Surface Barrier alternative.

ARAR or TBC	Type	Relevancy[a]	Citation	Meets Evaluation?
Radiation protection of the public and the environment	Chemical Action	TBC	DOE Order 5400.5	Yes
Idaho toxic air pollutants	Chemical	A	IDAPA 58.01.01.585 and .586	Yes
Idaho ambient air quality standards for specific air pollutants	Chemical	A	IDAPA 58.01.01.577	Yes
National emission standards for hazardous air pollutants	Chemical	A	40 CFR 61	Yes
Native American graves protection and repatriation regulations	Location	A	43 CFR 10	Yes—if encountered
Preservation of historic, prehistoric, and archeological data	Location	A	36 CFR 800 and 40 CFR 6.301(b) and (c)	Yes—if encountered
Protection of archaeological resources	Location	A	43 CFR 7	Yes—if encountered
Preservation of historical sites	Location	A	Idaho Statute 67-4601 et seq. and Idaho State Historical Statute 67-4101 et seq.	Yes—if encountered
Compliance with environmental review requirements for floodplains and wetlands	Location	A	10 CFR 1022	Yes
Protection of floodplains	Location	RA	Executive Order 11988; 40 CFR 6.302(b); 40 CFR 6 Appendix A	Yes
Remediation waste management sites located within floodplains	Location	A	40 CFR 264.18(b)	Yes
Location standards for TSD facilities located within floodplains	Location	A	40 CFR 264.1(j)(7)	Yes
Idaho groundwater quality rule	Action	A	IDAPA 58.01.11.006	Yes[b]
Standards for owners and operators of TSD facilities—general groundwater monitoring requirements	Action	A	40 CFR 264.97	Yes[b]
Standards for owners and operators of TSD facilities—location of facilities	Action	A	IDAPA 58.01.05.2 (40 CFR 270.14)	Yes
Standards for owners and operators of TSD facilities—closure and postclosure	Action	RA	IDAPA 58.01.05 (40 CFR 264 Subpart G)	Yes

Table 4-6. (continued).

ARAR or TBC	Type	Relevancy[a]	Citation	Meets Evaluation?
Standards for owners and operators of TSD facilities—landfills	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart N)	Yes[b]
Standards for owners and operators of TSD facilities—air emission standards for process vents	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart AA)	Yes
Standards for owners and operators of TSD facilities—air emission standards for equipment leaks	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart BB)	Yes
Standards for owners and operators of TSD facilities—remediation waste management rules	Action	A	IDAPA 58.01.05 (40 CFR 264.1[j][1] through [13])	Yes
Idaho control of fugitive dust emissions	Action	A	IDAPA 58.01.01.650, .651	Yes
National ambient air quality standards	Action	A	40 CFR 50	Yes
National Pollutant Discharge Elimination System	Action	RA	40 CFR 122.26	Yes
Radioactive waste management	Action	TBC	DOE Order 435.1	Yes

a. A = applicable requirement, RA = relevant and appropriate requirement, TBC = to-be-considered requirement
b. Evaluation criteria met, not including the vadose zone contribution.
ARAR = applicable or relevant and appropriate requirements
CFR = *Code of Federal Regulations*
DOE = U.S. Department of Energy
IDAPA = Idaho Administrative Procedures Act
TSD = treatment, storage, and disposal

Groundwater in the vicinity of WAG 7 comprises the Snake River Plain Aquifer. This sole-source aquifer is a source of potable water. Consequently, though drinking water standards (IDAPA 58.01.11; 40 CFR 141) were not identified as ARARs, remedial actions for WAG 7 must take into consideration these criteria along with site-specific risk-based concentrations to ensure compliance with the RAOs. Depth to the water table is approximately 580 ft. As designed, this alternative would significantly reduce infiltration and limit mobility of COCs from the source, satisfy RAOs that protect groundwater, and comply with applicable state and federal groundwater criteria (e.g., MCLs and MCLGs). This alternative would not address existing contamination in the vadose zone.

The Clean Air Act requires each state to identify areas that have not attained National Ambient Air Quality Standards (NAAQS) for criteria air pollutants. According to the EPA Green Book and the most recent listing designating nonattainment areas for criteria pollutants (EPA 2001), the State of Idaho (including the INEEL and WAG 7) is not located within a designated nonattainment area for any criteria pollutant. Consequently, no current substantive requirements for new sources or modifications to existing air-emission point sources would affect or apply to the Surface Barrier alternative. When constructed, the surface barrier would prevent the emission of radionuclides higher than Idaho standards for the control of air pollution and DOE Order 5400.5.

In addition, the chemical-specific requirements of state and federal air quality standards would be met during both construction and remediation. Idaho state requirements include controlling toxic air pollutants (IDAPA 58.01.01.585 and .586), ambient air quality standards for specific air pollutants (e.g., as particulate matter [IDAPA 58.01.01.577], and emission of fugitive dusts [IDAPA 58.01.01.650]).

Federal requirements include NESHAPs (40 CFR 61) (e.g., radionuclides) and NAAQS (40 CFR 50) (e.g., particulate matter).

4.3.2.2.2 Location-Specific (Applicable or Relevant and Appropriate Requirements)—Studies of the INEEL conclude that all archeological material and data are related to surficial areas and do not meet the criteria for listing under any repatriation or historical site regulations (EG&G 1992). However, if material for the surface barrier is excavated from an off-INEEL borrow area, and if regulated artifacts or sites are encountered, applicable federal and state preservation requirements would be applicable and would be met. These include the following:

- Native American Graves Protection and Repatriation Regulations (43 CFR 10)
- Protection of Historic Properties (36 CFR 800 and 40 CFR 6.301[b])
- Preservation of Historical Sites (Idaho Statute 67-4601 et seq.).

Waste Area Group 7 is not designated as a floodplain, though flooding attributed to unseasonable snowmelts occurred in 1962, 1969, and 1982. Conditions suggest that floodplain protection measures are applicable or relevant and appropriate, as indicated in Table 4-6. Included are requirements for federal agencies to comply with floodplain management (10 CFR 1022), to protect floodplains (40 CFR 6), and to implement protective measures at remediation waste sites (40 CFR 264.1[j][7]) and RCRA-permitted facilities (40 CFR 264.18 [b]). The design of the surface barrier would meet these requirements and would include (1) appropriate engineering controls to prevent washout of any hazardous waste by a 100-year flood event required by RCRA 40 CFR 264.1[j][7] for remediation waste sites or (2) the location standards for TSD facilities required by RCRA (40 CFR 264.18[b]).

4.3.2.2.3 Action-Specific (Applicable or Relevant and Appropriate Requirements)—For RCRA requirements to be applicable to a CERCLA site, materials must be listed or exhibit a characteristic of hazardous waste. Active generation or placement of hazardous waste is not proposed for the Surface Barrier alternative. However, RCRA "General Groundwater Monitoring Requirements" (40 CFR 264.97) that use monitoring wells to detect COCs in the underlying aquifer are applicable to this alternative. Provisions for groundwater monitoring would be included in the alternative.

Furthermore, because the Surface Barrier alternative leaves waste in place, RCRA Subtitle C requirements for closure and postclosure (40 CFR 264 Subpart G) may be relevant and appropriate because the SDA is not a new or existing RCRA-regulated unit. The RCRA requirements for landfills (40 CFR 264 Subpart N) and remediation waste management sites (40 CFR 264.1[j]) are applicable for designing and operating the surface barrier. These requirements are adopted by reference in the State of Idaho "Rules and Standards for Hazardous Waste" (IDAPA 58.01.05). The design, construction, and operation of the surface barrier would meet these substantive state requirements. In addition, the RCRA Subtitle C requirements for air emission standards for process vents (40 CFR 264 Subpart AA) and equipment leaks (40 CFR 264 Subpart BB) may be applicable for some equipment used during ISTD operations, if it is possible that their emissions contain levels of restricted hazardous volatile waste above established thresholds. If applicable, these requirements would be met by using appropriate engineering controls.

Organic vapors that accumulate beneath the surface barrier would be collected, removed, and treated by the OU 7-08 active OCVZ treatment system at the RWMC. The EPA Office of Air Quality Planning and Standards is developing a new maximum achievable control technology (MACT) for the remediation site source category. This MACT, projected to be effective after 2002, would apply to remediation sites that are major sources of organic hazardous air pollutants during remediation activities.

If applicable to CERCLA sites, all vents, remedial material management units, and associated equipment components involved in the remedial activity could require emission controls.

For RCRA LDR treatment standards (40 CFR 268) to apply to waste, the placement of restricted hazardous waste must occur. For the Surface Barrier alternative, the only potential placement activity would be associated with retrieving waste from reconfiguring Pad A. The RCRA generator requirements for hazardous waste determination and management (40 CFR 262.11) would be applicable because potentially hazardous material may be generated during retrieval. Furthermore, applicable requirements would prohibit placing restricted RCRA-hazardous waste in land-based units (e.g., landfills) until it has been treated to standards protective for disposal (40 CFR 268; IDAPA 58.01.05.011). The WAG 7 area will be defined as an area of contamination (AOC). Because it is assumed that the AOC concept would be used when retrieving and handling the Pad A waste, consolidation and movement would occur without triggering RCRA Subtitle C requirements (e.g., LDRs).

Institutional controls are often included with remedies to enhance long-term management protection. These controls supplement engineered remedies (40 CFR 300.430[a][1]). Institutional controls, including security measures, access controls, fencing, and land-use restrictions, are components of the Surface Barrier alternative. These controls would help prevent possible exposure to waste by human intruders and biota. The institutional controls also would meet applicable DOE requirements for residual radioactivity left in place, including the related provisions of DOE Order 5400.5.

Storm water discharge requirements from "National Pollutant Discharge Elimination System" (NPDES) (40 CFR 122.26) would be considered during design and operation of the surface barrier. However, best management practices would be implemented during construction and operation of this alternative for storm water control, road construction, waste management, and other activities that support and relate to the remedy, as appropriate. In addition, DOE requirements (identified as TBCs) for the protection of human health would be met during these remedial activities, including as low as reasonably achievable (ALARA) exposures to radioactivity. Requirements of DOE Order 435.1 would be met. This order specifies that all DOE radioactive waste is to be managed in a manner that protects workers, public health and safety, and the environment.

4.3.2.3 Long-Term Effectiveness and Permanence (Balancing Criterion). The Surface Barrier alternative would (1) reduce risk by inhibiting water infiltration through waste, thereby impeding further release of contamination to the aquifer, (2) prevent ecological intrusion and deter human intrusion into the waste, (3) eliminate risk from direct radiation exposure, and (4) protect the waste from wind and water erosion. The cap would eliminate the potential for spread of contamination on the surface and in the air. Grouting SVRs and trenches would immobilize fission and activation products (e.g., C-14, I-129, Nb-94, and Tc-99). In addition, the alternative includes ISTD in high VOC areas to minimize future CCl_4 releases from the source term and to reduce operational requirements for the OCVZ system. Risk modeling shows this alternative would be effective in reducing contaminant migration and groundwater ingestion risk attributed to COCs in the burial zone to acceptable levels.

Though this alternative would be effective at minimizing future risk, it is assumed that some COCs would be released before remedial action could take place. The amount released to date and current rates of release are not known with certainty. However, the ABRA (Holdren et al. 2002) indicates that the preremediation release might result in groundwater contamination posing a risk greater than 1E-04. Modeling indicates that this risk would peak by 2110 and could extend beyond the boundary of the SDA for a distance of approximately 460 to 600 m (1,500 to 2,000 ft). Therefore, this alternative could require institutional controls that prohibit using groundwater within this buffer zone around the SDA.

In addition to the prohibition on groundwater use within a buffer zone around the SDA, other institutional controls would be required to ensure RAOs are met and maintained. Land-use restrictions would be required to prevent development, excavation, or drilling on and near the SDA. Frequent inspection and maintenance of the surface barrier would be required. The barrier would have to be reconstructed every 500 to 1,000 years. Environmental monitoring would be required to assess the continued effectiveness of Surface Barrier alternative in preventing migration of contaminants to the aquifer.

4.3.2.3.1 Risk Modeling Assumptions—For the Surface Barrier alternative, water was assumed to infiltrate the barrier system at a rate of 0.114 cm/year. In the grouted SVRs and selected trenches, contaminant releases from the grout were conservatively assumed to occur by diffusion from within 2-ft diameter grout columns. These columns would be formed by injecting grout into the waste site to create columnar monoliths (see Section 4.2.5.1). For modeling purposes, the surface available for leaching was assumed to be the outside surface of the 2-ft-diameter columns. This is based on a conservative assumption that the points of contact between columns might be a zone of weakness where cracks could form. Realistically, the surface area available for leaching would probably be much smaller, but few data are available to support an accurate prediction of the extent of cracking that would form in grouted waste over long periods of time.

The DUST-MS model assumed that the infiltrating water would flow through the columnar joints in the grout at volumetric rates equal to the surface area of the treated area multiplied by the infiltration rate. The volume of water contacting the waste in a given time was assumed to dissolve contaminants up to their solubility limits. Concentrations of contaminants released from the source term were input to the TETRAD model to estimate groundwater concentrations and drinking-water risk.

4.3.2.3.2 Magnitude of Residual Risk—The magnitude of residual risk associated with the Surface Barrier alternative is illustrated in Figure 4-3. This figure shows two risk projections: (1) risk associated with postremediation release of contaminants from the SDA source term only, and (2) total risk represented by release of source-term contaminants plus postulated contamination in the vadose zone before the remedial action. The risks represent exposure at the point of maximum groundwater contamination. For results that include the postulated contamination in the vadose zone, this location lies

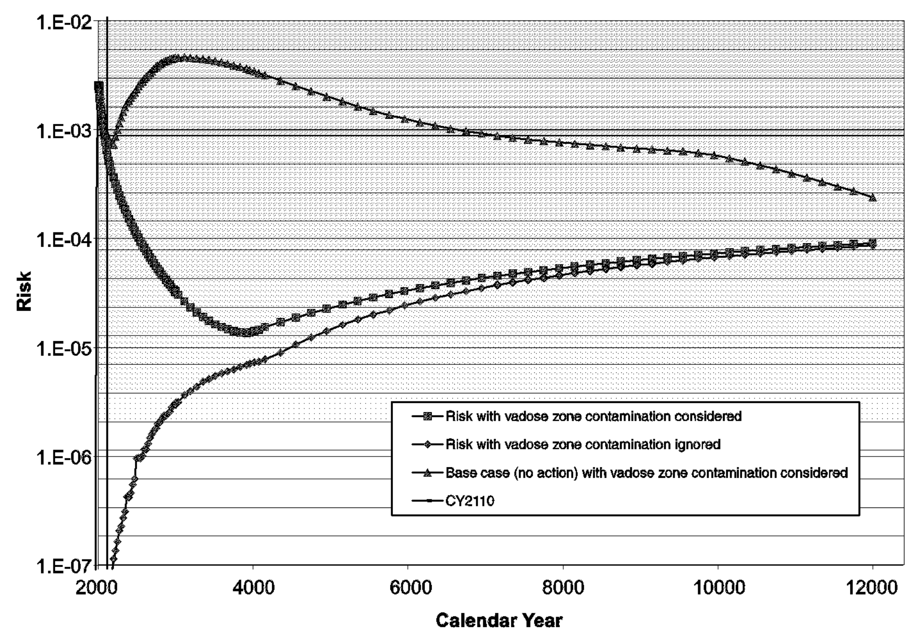

Figure 4-3. Carcinogenic risk for the Surface Barrier alternative.

at the southern edge of the SDA. Modeling shows that near-term risks are dominated by COCs that may already have been released to the vadose zone. However, considerable uncertainty remains because the mass of potential contaminants in the vadose zone and rates of release are not known.

As shown in Figure 4-3, carcinogenic risk associated with postremediation release of contaminants (i.e., preremediation vadose zone contamination neglected) reaches approximately 1E-05 in 2,000 years and then continues to rise at a slower rate, reaching a maximum of approximately 9E-05 in 10,000 years. Carbon-14 accounts for approximately 80% of the risk in 2,000 years. Technetium-99 and I-129 are other significant contributors. After 1,000 years, uranium isotopes dominate risk.

Figure 4-4 shows the residual noncarcinogenic hazard for the Surface Barrier alternative. The risk modeling indicates that the hazard index attributable to postremediation contaminant release under this alternative would be less than 1.0. The simulated hazard index peaks at 0.4 in approximately 2,500 years and then it decreases in subsequent years.

In both the carcinogenic and noncarcinogenic risk curves shown in Figures 4-3 and 4-4, the potential influence on risk levels caused by potential contaminants previously released from the source term to the underlying vadose zone are presented. As shown for the carcinogenic risks, effects of potential contaminants released to the vadose zone before remediation result in cumulative groundwater risk greater than 1E-07 for a zone that extends 460 m (1,500 ft) beyond the SDA boundary.

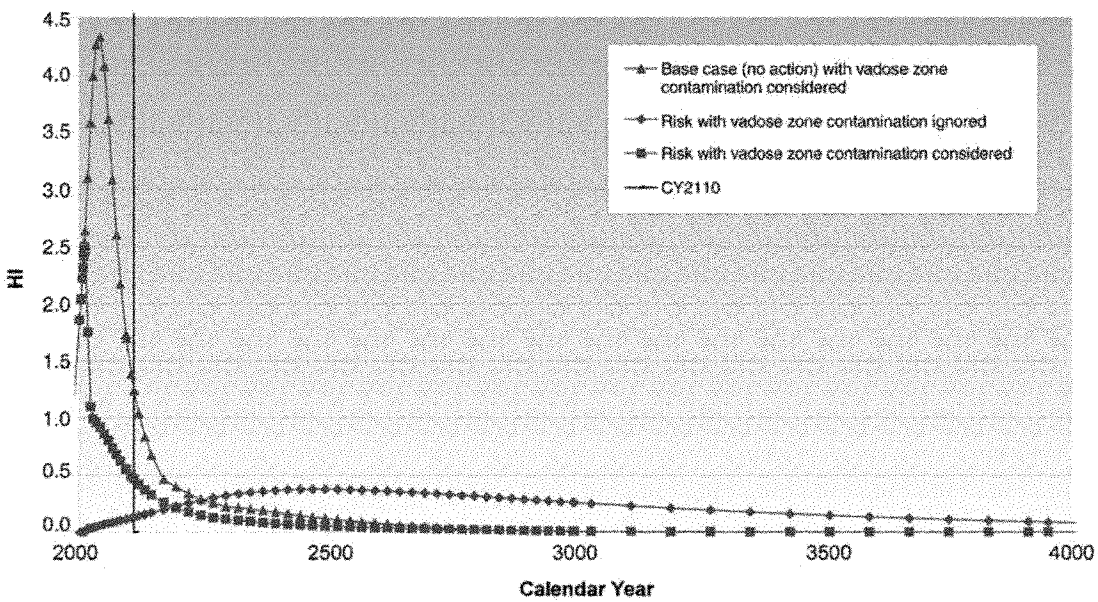

Figure 4-4. Noncarcinogenic hazard for the Surface Barrier alternative.

4.3.2.3.3 Adequacy of Reliability and Controls—Monitoring and maintenance of the surface barrier would be required in perpetuity to assure the effectiveness and permanence of the remedy. High-density polyethylene geomembranes have a limited life. Subsidence of underlying waste caused by consolidation of the waste may cause settlement and compromise the effectiveness of the barrier over time. Regular monitoring (e.g., visual inspections and surface elevation surveys) would be performed to detect compromises in the integrity or effectiveness of the barrier. The barrier would be maintained and repaired as required to achieve the original performance standards. Because of the required life span of the remedy, portions of the barrier would require repair or periodic reconstruction, and the entire barrier would be replaced once every 500 to 1,000 years.

In addition to monitoring, maintenance, and periodic replacement, the long-term reliability and performance of the barrier would be assessed through post—remediation monitoring of groundwater, the vadose zone, air, animals, and surface vegetation.

To ensure protectiveness, active institutional controls would be required to limit land-use activities near the SDA. A prohibition on drilling and using groundwater within a buffer zone around the SDA would have to be enforced. Access controls would have to be implemented and maintained in perpetuity to prevent intrusion into the waste.

4.3.2.3.4 Summary of Long-Term Effectiveness—Fate and transport modeling indicates that the remedial action would control future releases from the source term to the degree that the incremental postremediation peak carcinogenic risk would be less than 1E-04 and the hazard index would be less than 1.0 for the groundwater ingestion pathway. Appropriate institutional control and operation and maintenance programs, plus periodic barrier repair and replacement, would provide adequate and reliable long-term control of the waste. Should the postulated contamination in the vadose zone at the time of remediation cause groundwater contamination to exceed health-based levels in a zone beyond the boundary of the SDA, institutional controls would be required to prevent access to, and use of, any contaminated groundwater. Therefore, the Surface Barrier alternative is an effective and permanent remedy.

4.3.2.4 Reduction in Toxicity, Mobility, or Volume Through Treatment (Balancing Criterion). The contaminant technology does not include treatment or waste removal to reduce the toxicity, mobility, or volume of contaminants. However, placing the surface barrier would inhibit contaminants from migrating and minimize potential exposure and impacts to groundwater. For this alternative, the mobility of the activation and fission products (i.e., C-14, I-129, Nb-94, and Tc-99) in the SVRs and trenches would be reduced by using ISG. Further, implementing ISTD in high organics areas would remove and destroy VOCs, thus reducing the volume of VOCs within the source term.

4.3.2.5 Short-Term Effectiveness (Balancing Criterion). The key components of the Surface Barrier alternative's short-term effectiveness entail the following:

4.3.2.5.1 Protecting the Community During Remedial Actions—This alternative could be readily implemented with minimal risk and impact to the public and INEEL workers, although increased traffic at the INEEL during borrow-material acquisition is anticipated. If borrow material is obtained off the INEEL, increased traffic would affect neighboring communities. Traffic control plans would be developed to minimize the impact and potential increase in transportation risk to the public and the INEEL.

Most materials required for cap construction would be obtainable from borrow sources within the INEEL boundaries, but a source off the INEEL could be required for the cobble material.

4.3.2.5.2 Protecting Workers During Remedial Actions—Using appropriate PPE, engineering controls, and adherence to INEEL health and safety protocols, this alternative could be readily implemented with moderate risk and impact to workers. Remediation workers could potentially be exposed to radionuclides during site-preparation activities (e.g., subsurface stabilization and cap construction). Chemical and radiological hazards from direct ionizing radiation exposure, inhalation exposures, and contact exposures from beta sources would be mitigated through adherence to DOE and INEEL health and safety protocols. Earth-moving equipment modified with positive-pressure ventilation-system cabs and HEPA filters could be used at the INEEL to minimize exposure to radioactively contaminated areas. The barrier material in the lowermost layer(s) would add sufficient shielding throughout the remainder of construction activities.

A report prepared in support of this PERA (Schofield 2002) estimated the risk to workers associated with constructing the surface barrier. The analysis was conducted assuming a potentially worst-case condition in which all RFP waste is classified as TRU waste. The evaluation considered direct external radiation exposure and exposure to mechanical injuries for remediation workers. No risks to the public were projected for this alternative because no off-INEEL transportation of hazardous material is assumed. Estimated risks are listed below:

- Cancer = 1.55
- Injury = 84.7
- Fatality risk = 0.19.

As shown, the evaluation predicts that during implementing the Surface Barrier alternative, one to two workers would develop cancer caused by exposure to hazardous substances, including radioactive material and radiation fields. This evaluation conservatively assumes the same crew would be involved throughout the duration of the project. It is also estimated that approximately 85 injury accidents would occur during implementation of this alternative. The projection for fatality accidents is less than one.

The environmental monitoring component of this alternative would involve currently existing procedures that use engineering, administrative, and PPE measures to ensure worker protection during monitoring activities. In the event that the existing monitoring network was expanded as part of this alternative, engineering, administrative, and PPE measures would be used to protect workers during installation.

In accordance with DOE orders, construction activities would be performed in accordance with the ALARA approach for protection from radiation.

4.3.2.5.3 Environmental Impacts Associated with Construction—Environmental impacts associated with the Surface Barrier alternative include potential particulate emissions resulting from construction activities and increased construction-related traffic. Particulate emissions would be controlled with applicable dust-suppression techniques.

4.3.2.5.4 Time Until Remedial Action Objectives are Achieved—Preliminary project schedules estimate that the surface barrier (Phase I) could be completed within 11 years of an approved ROD. An additional 7 years would be required to complete construction of the surface barrier over the active disposal cells.

4.3.2.6 Implementability (Balancing Criterion). Key components of the Surface Barrier alternative's implementability include elements described in the following subsections.

4.3.2.6.1 Technical Feasibility—Technologies associated with implementing the Surface Barrier alternative are available and have been demonstrated previously at the INEEL and other sites. No known site-specific features would inhibit constructing a cap, and the required construction technology, services, and specialists would be readily available. Construction would involve standard techniques and earthwork equipment. In addition, similar caps have been successfully constructed at other DOE facilities.

Though the ICDF cover design has not yet been implemented at the INEEL, the cap is designed to use natural material readily available near the INEEL.

Major implementability issues associated with this alternative would be (1) the amount of subsidence that could occur without damaging the cover and (2) determining the mitigating measures to be taken before the cover is constructed. Subsidence is a well-documented, annual occurrence at the SDA. For example, a visual inspection of the SDA performed in April 1999 identified 13 subsidences across a number of pits and trenches. Subsidences ranged from 8 to 300 ft long, 4 to 37 ft wide, and 8 in. to 12 ft deep. Average subsidence length was 60 ft, average width was 15 ft, and average depth of the deepest points in a subsidence was 3 ft. However, subsidences as deep as 12 ft have been observed.

Though modern geosynthetics (e.g., low linear polyethylene) have the high tensile strength and flexibility to accommodate substantial settling, long-lived, low-permeability caps generally require a stabilized foundation. Even if the cover material could bridge subsidences, sagging and eventual collapse would be expected over long periods. The low-permeability cap design would require a stable foundation to preserve the integrity of the infiltration-inhibiting layers. The substantial subsidence currently being experienced could reduce the effectiveness of the cap and would be difficult to repair, because of the layered nature of the design. Methods to control subsidence would need to be developed and implemented before constructing the cap, and the actual foundation requirements would have to be developed as part of remedial design. Presently, consideration is given in this PERA for applying a grouting program to stabilize the foundation area within the cap footprint. However, during final design, other methods, such as dynamic compaction and preloading, could be adopted.

Though constructing the surface barrier would involve standard industry practices, the required mitigation of the potential landfill subsidence would complicate implementation of the alternative. The INEEL-developed nonreplacement jet grouting technology has been demonstrated on small scale but not on a large and complex site (e.g., the SDA) (Armstrong, Arrenholz, Weidner 2002).

Retrieving and treating Pad A waste is technically feasible. Waste is assumed to be primarily low-level with a minor amount of TRU. No hazards (e.g., explosives or highly flammable materials) have been identified.

4.3.2.6.2 Administrative Feasibility—Though most actions within this alternative are implemented under CERCLA and thus would not require permits, substantive provision of permits that would otherwise be required are identified as ARARs. Any selected remedial alternative would be required to demonstrate ARAR compliance. Because the Surface Barrier alternative, including ISG, would adequately address identified ARARs, no known administrative barriers would exist to prohibit implementation.

Safety disciplines, including radiation safety, industrial hygiene, and construction safety, are readily available at the INEEL. Regulatory compliance support is available at the INEEL. Any changes to the storm water systems may require some environmental assessment. This issue is not anticipated to adversely affect the administrative implementability of this alternative.

Because of the potentially significant exposure to radiological contaminants, perhaps the most challenging issues with any remedial action taken at the SDA would be demonstrating readiness to conduct safe operations and obtaining administrative approval to commence operations. Activities of the Surface Barrier alternative would involve primarily standard construction work conducted on the surface of the SDA. However, the need to control future subsidence would generate some level of radiological and nuclear material hazard. The process of safety analysis, design, and operational readiness for systems and techniques to control subsidence would be complex. However, the safety analysis and design work already completed for ISG at the site, along with past technology performance tests, would likely reduce the requirements for any postROD safety analysis.

The Surface Barrier alternative would be administratively feasible for WAG 7. Long-term monitoring activities, cover-maintenance activities, and 5-year site reviews would require long-term coordination; however, these activities would not present significant administrative difficulties.

4.3.2.6.3 Availability of Services and Materials—Services and materials required to implement the Surface Barrier alternative include mechanical hauling and grading, constructing a grout batch plant, hauling grout materials, in situ nonreplacement jet grouting of the subsurface, hauling and placing materials to construct a multilayered cover, installing storm flow diversions, constructing fences and other access controls, and site restoration including grading and reseeding.

All earthwork under this alternative would involve using readily available standard construction equipment, trades, and materials. Soil and rock could be borrowed or quarried from regional sources. Services and infrastructure for construction activities are readily available in the local region, and services and materials for the jet grouting are available nationally from a number of commercial vendors.

Preliminary assessments indicate that suitable materials are available from borrow areas on and off the INEEL. However, this project would require extensive excavation within the designated areas. For example, approximately 3.5 million yd^3 of silt loam materials would be required to complete construction of the cover. Assuming this was retrieved from a single pit with an average extraction depth of 20 ft, it is projected that the pit surface would cover approximately 100 acres.

4.3.2.7 Cost (Balancing Criterion). The net present value of the Surface Barrier alternative is estimated at $616.1 million, which includes $609.4 million for capital and $6.7 million for operating and maintenance (O&M). The primary capital costs are associated with the surface barrier construction. The primary O&M costs are associated with the environmental monitoring conducted during the 100-year period. Table 4-7 provides a summary of both the total project costs and the net present-value estimates. The costs include an estimated average 33% contingency.

Table 4-7. Estimated costs for the Surface Barrier alternative with contingency.

Cost Element	Total Costs ($M)	Net Present Value ($M)
Capital costs		
In situ grouting and foundation grouting	246.5	—
Surface barrier	154.2	—
Volatile organic compound treatment using ISTD	104.3	—
Pad A retrieval and reconfiguration	163.0	—
Testing	13.0	—
Management, design, and reporting	78.9	—
Total capital costs	795.0	609.4
Operating and maintenance costs		
Monitoring and surveillance	31.5	—
Cover maintenance	9.0	—

Table 4-7. (continued).

Cost Element	Total Costs ($M)	Net Present Value ($M)
Fencing and signage	0.3	—
Management	4.9	—
Total operating and maintenance costs	45.7	6.7
Total cost for alternative	**841.6**	**616.1**

ISTD = in situ thermal desorption

4.4 Alternative 3—In Situ Grouting

4.4.1 Alternative Description

> **In Situ Grouting Alternative Remediation Strategy**
>
> Stabilizing buried waste through in situ grouting. Future exposure to the stabilized waste would be prevented through implementing administrative and physical land-use restrictions including placement of a low-permeability or biotic-barrier cover system.
>
> **Key Elements:**
> (1) In situ grouting of buried waste
> (2) Retrieval and ex situ stabilization of Pad A waste
> (3) Pretreatment of high organic areas using in situ thermal desorption
> (4) Placement of low-permeability cover system
> (5) Physical and administrative land-use restrictions
> (6) Long-term monitoring and maintenance.

This alternative would rely on ISG as the primary technology to treat the COC-bearing waste streams within the SDA. The technology would be applied to RFP TRU waste in Pits 1 through 6 and 9 through 12, and Trenches 1 through 10. Other waste sites, including the SVRs and other locations at which elevated levels of C-14 and other COCs are found, also would be treated with ISG to immobilize COCs. Any remaining untreated disposal areas would be grouted in place, as necessary, to ensure a stable foundation for a protective, low-permeability cap that would cover the entire SDA.

The ISG technology would encapsulate waste and associated contaminants in a stable monolith designed and implemented to reduce contaminant migration from the site to acceptable levels. Grouted waste material would be further isolated from potential future human or ecological receptors through construction of a low-permeability biotic barrier cover system. Other supplemental technologies would include using ISTD as a pretreatment for high organic waste streams within the SDA to facilitate successful application of ISG. In addition, because of high nitrate content in Pad A waste, this alternative would include retrieval and ex situ treatment to ensure compliance with the RAOs.

Components of this alternative are described in following subsections. Grouting technology and applications are discussed in detail by Armstrong, Arrenholz, and Weidner (2002).

4.4.1.1 Primary Technology—In Situ Grouting. The term *in situ grouting* is used broadly to describe various techniques that apply stabilizing agents to the waste site. The process entails injecting a slurry-like mixture of cements, chemical polymers, or petroleum-based waxes into contaminated soil or waste landfill. Grouts are specially formulated to encapsulate contaminants, isolating them from the surrounding environment. As used in the environmental industry, the process is described as nondisplacement jet grouting whereby soil and waste debris are mixed subsurface, forming a large grout monolith (DOE-ID 1999; Loomis, Zdinak, and Bishop 1997). Grouting is accomplished without displacing contaminants or debris or ground heaving. Overall site volume remains constant, but the site density is increased substantially.

Grout is typically pumped into the waste zone under pressure using an injection lance. Injection lances are direct-pushed into the waste zone using rotary percussion action, which minimizes potential for surface contamination. The injection method produces interlocking columns of grout extending from the underburden soil up through the waste, terminating subsurface in the overburden. Interlocking columns cure into a solid monolith with no discernable edges between columns. Containers of waste are filled from the inside with grout. When injected under high pressure, the cutting action of the jets fractures low-strength objects and thoroughly mixes waste particles with the grout. Large objects remain in place as the grout flows under pressure into voids around the objects. All readily accessible voids are filled (Loomis, Zdinak, and Bishop 1997).

Based on results of past field trials at the INEEL, high-pressure injection grouting would be well-suited for ISG of the SDA. The low porosity of soil and presence of containerized waste requires injection of grout at relatively high pressures and at very dense spacing. That spacing would allow every waste drum to be physically pierced by the injection lance to ensure drum contents are treated (Loomis, Zdinak, and Bishop 1997). For the purpose of this PERA, it is assumed that rotary-point injection would be used for the pits and trenches where intimate mixing of waste and grout is desired.

Though numerous individual grout formulations are commercially available (many of them applicable to the SDA), several representative grouts are presented for purposes of this PERA evaluation. The primary grout type is ASTM Portland cement, which has the most performance data available and is readily available and relatively inexpensive. The secondary grout type represents more complex formulations that cure into very dense products analogous to hematite or other naturally occurring minerals. The commercially available grout (e.g., Gment-12) is a cementitious grout containing blast-furnace slag. Because of recent testing, commercial grout is a strong candidate for application at the SDA (Loomis et al. 2002). Other commercially available products (e.g., TECT, which was used in the past to stabilize low-level radioactive and mercury-contaminated soil at the SDA [Loomis et al. 1998]) also would be thoroughly evaluated during the remedial design phase. The actual selection of grouts would include parameters (e.g., COCs, remediation goals, costs, and compatibility with the injection equipment). The specific formulations would require careful evaluation and testing during the remedial design to optimize grouts for each different type of waste. This evaluation assumes that the grout (Gment-12) would be applied universally across the SDA.

The basic grout injection techniques and equipment have been repeatedly demonstrated, as discussed in Section 2. Using a direct-push injection lance and system of high-pressure pumps has been shown to be effective and implementable (Armstrong, Arrenholz, Weidner 2002). Though some safety analysis and testing has been performed, the question of how best to control potential surface contamination is still outstanding and would need to be resolved during the remedial design should this alternative be selected.

In situ grouting would be conducted under a radiological confinement building and that workers would be remotely located during grout injection. The structure would be a modular steel building erected in linear sections to allow the ISG system to progress down a long row inside the structure. The structure would be maintained under negative pressure and ventilated through a HEPA filter system. The structure would be continually disassembled and moved as the ISG operation progressed across the SDA. Because preliminary analyses indicated that the potential for airborne contamination is very low, it is not anticipated that the building would become highly contaminated. A robust system of radiation monitors inside the structure would be used to verify that contamination is maintained at acceptable levels. Because contaminated material could reach the surface of the overburden during implementation, the ground surface would be covered with approximately 2 ft of soil after operations cease, but before the building is moved, to ensure that no contamination would be left exposed on the ground surface. Worker-risk issues are discussed further in Section 4.4.2.6, as well as in the supporting report (Armstrong, Arrenholz, Weidner 2002).

Past ISG work typically used trucks or small tractors to move the grouting apparatus from hole to hole. However, for an area as large as the SDA, an alternative deployment system would be more practical. In the large pit areas where thousands of injections would be required on 2-ft centers, a crane system would be recommended for maneuvering the injection lance (Loomis 2001). Instead of being fastened to a truck bed or small tractor, the mast and hydraulic head would be mounted on the crane's transverse beam. The crane would be operated remotely to incrementally position the injection lance over each hole. Pumps would be located remotely and no personnel would be required near the injection area during operations. To improve implementability, a wheel-mounted crane would be used. Tire-mounted cranes are available with self-contained diesel drives that would facilitate moving the grouting system across the SDA. Using tire-mounted cranes also eliminates the need for supporting rails. Tire-mounted gantry cranes are commercially available with suitable load capacity and spans up to 60 ft.

Some uncertainty is associated with using a wheel-mounted crane because the apparatus has not been used previously at the SDA. Some engineering and testing would be required during remedial design to ensure a suitable system is obtained. However, ISG would be implementable regardless of the platform used to mount the injection equipment. For purposes of the evaluation, the crane system is the primary deployment platform.

A number of steps would be required for implementing an in situ technology (e.g., ISG) within the SDA. Figure 4-5 provides a conceptual process diagram that overviews implementation of this technology. The key tasks identified in the figure are discussed below.

4.4.1.1.1 Safety Analysis and Remedial Design—The initial step of all remedial alternatives would entail a thorough engineering design and analysis of hazards. This evaluation assumes, based on the *Operable Unit 7-13/14 Preliminary Safety Analysis Report for In Situ Grouting at the Subsurface Disposal Area* (Peatross 2001), that the ISG operation would be classified as a low-hazard radiological operation. To ensure safety of workers, the remedial design would require that engineering and administrative controls be developed, tested, and demonstrated to be effective.

Engineering aspects of remedial design would draw heavily on existing equipment and techniques. However, using a wheel-mounted crane would require additional design engineering to mount the drill mast and hydraulic head to the crane. The crane and drill injection system would be fabricated to specification by commercial vendors. Lights and camera systems also would be fabricated, installed, and tested. All intrusive alternatives would be field-tested before operations began to determine that the system, as delivered, meets all requirements.

While numerous grouts are commercially available, site- and equipment-specific formulation testing would be required. Application at the SDA would be complicated by the presence of a wide variety of waste types. Several areas in the SDA may have extremely high concentrations of problematic waste types that would require developing and testing specialized grouts.

4.4.1.1.2 Infrastructure—The SDA is contained within the RWMC, a 200-acre facility where radiological and hazardous materials are routinely handled, stored, characterized, and shipped. Radiation engineering, maintenance, utilities, and other support services are available at the RWMC. Power, water, roads, transportation, and cafeterias also are available nearby.

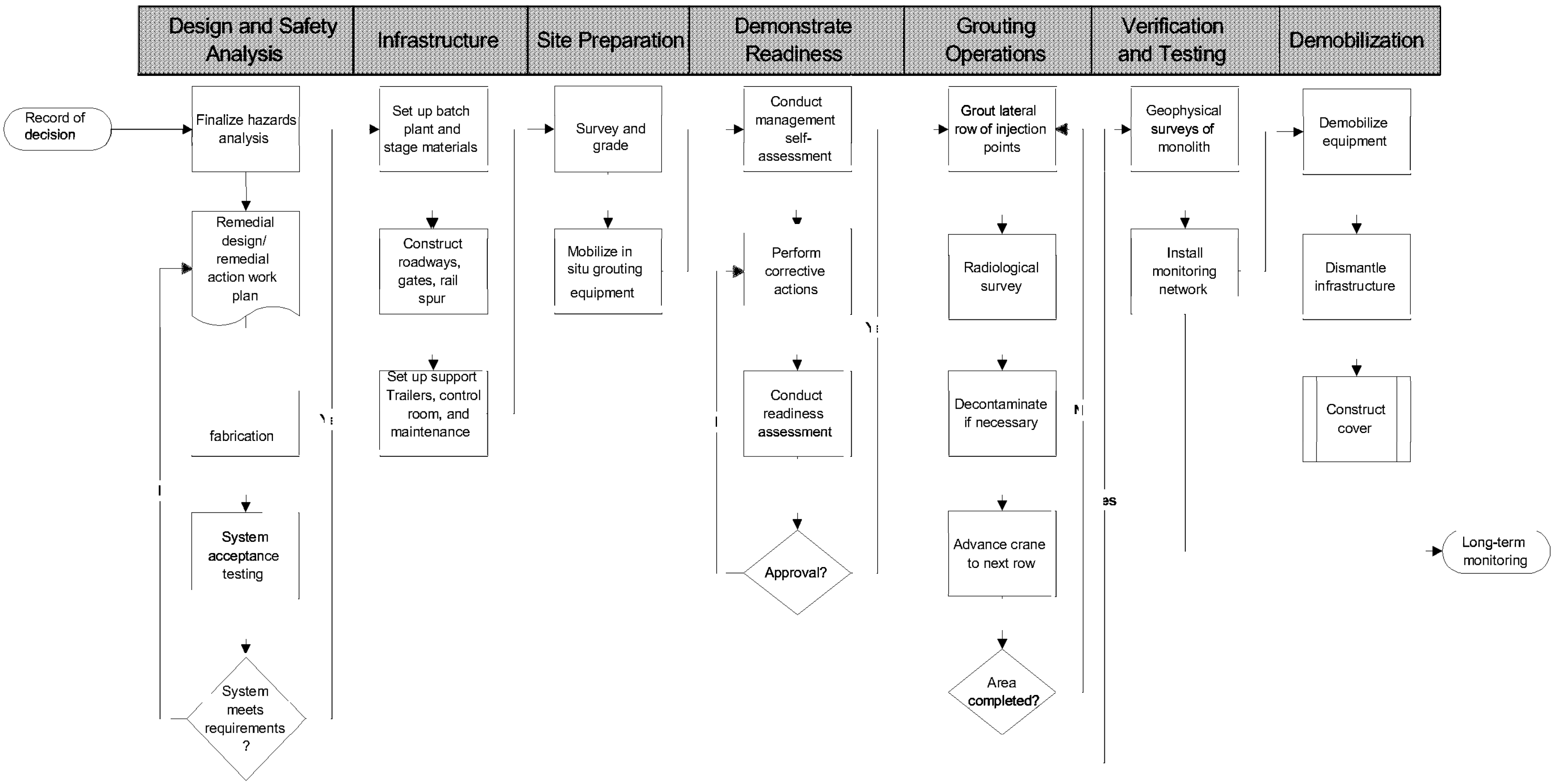

Figure 4-5. Conceptual process flow for the In Situ Grouting alternative.

However, to support ISG operations, some facility modifications would be required. A grout batch plant would be constructed near the SDA. Previously, cement batch plants have been located adjacent to the SDA. Several locations immediately adjacent to the SDA are suitable for this purpose and have power and water available nearby. Materials to formulate the grout would be shipped from vendors by rail car. An active rail spur runs to the RWMC. Trailers similar to those currently used at the RWMC would be installed in the SDA to support operational controls, radiation controls, and personnel facilities. Pump housing also would be installed to contain the high-pressure pumps and feed systems. The pump house would be designed to interface with the grout delivery trucks. Temporary electrical lines would be run aboveground to provide power to the ISG operational areas.

4.4.1.1.3 Site Preparation**—**Minimal site preparation would be required for ISG. The SDA is relatively level and well-graded. However, areas with drainage ditches, roads, and miscellaneous equipment would require some grading and fill to ensure level terrain to operate the crane system.

Areas to be grouted would be surveyed and engineering drawings made. A suite of geophysical surveys would be conducted to determine pretreatment conditions of the waste zones. High-resolution electromagnetic and sonic techniques have been used at the SDA to discern waste edges and other subsurface features. In addition, geophysical probes using active and passive neutron and gamma surveys would be deployed to help discern activity levels of the waste to be grouted. Recent active logging of Pit 9 (OU 7-10) has shown the relative difference in moisture content between soil and waste can be useful in mapping the geometry of the waste zone. Survey data would be correlated with disposal records to validate the dimensions of the areas to be grouted. The final step of site preparation would be to mobilize the grouting equipment to the ISG operational area.

4.4.1.1.4 Demonstrate Readiness**—**Though the ISG operation likely would be classified as a low-hazard, nonnuclear operation, worker safety is paramount. A rigorous process of safety reviews, identification of deficiencies, and corrective actions would be performed before starting operations.

4.4.1.1.5 Grouting Operations**—**Grouting operations would commence with positioning the injection crane system over the first grout area. It is envisioned that the injection lance would be moved in short increments laterally across the span of the crane and that the crane would be incrementally advanced forward across long strips of ground. Actual positioning, spacing, and sequencing of drilling would be optimized during remedial design. This evaluation assumes that grout would be injected on a triangular pitch grid at approximately 20-in. centers to ensure every buried waste container would be grouted on the inside.

The grout would be mixed at the batch plant adjacent to the SDA and delivered by truck to the ISG operational area. The grout truck would be received at the pump house and the grout fed into the high-pressure positive displacement pumps. A system of high-pressure lines would deliver grout to the injection lance.

The injection lance would be driven with rotary percussion action into the soil and waste to a depth of 20 ft or until refusal. Refusal would be defined in remedial design, based on rate of advancement to avoid exceeding operating limits of the equipment. Refusal likely would occur at varying depths because elevation of basalt bedrock varies widely. In addition, large objects (e.g., steel debris) would cause refusal. If the operator concludes that refusal was caused by an impenetrable object, the injection pattern would be modified to inject around the object to encase its perimeter. Once the maximum depth has been reached, the drill stem rotation and high-pressure displacement pump would be started. Grout would be pumped down the center of the injection lance and out two jet nozzles at the tip. The injection lance would be rotated and retraced at a predetermined rate proven to ensure good grout placement. Most of the grout on the drill stem would be scrubbed off when the stem is retracted through the overburden. Grouting would be stopped at the waste and overburden interface. The objective would be to avoid unnecessarily grouting the overburden or forcing grout to the surface.

After each hole is completed, the injection lance would be fully retracted and the lance assembly surveyed remotely for radiological contamination. High-volume air monitors mounted on the crane near the injection lance also would be used to detect any airborne contamination. If contamination were detected, the equipment would be decontaminated. The injection lance would be moved laterally one increment and the injection process would be repeated. After all points under the span of the crane are grouted, the crane would be walked forward an increment and the process repeated.

After a section has been grouted, operations would be suspended temporarily to allow for placing a soil cover over the grouted areas. A 3-ft thick cover of soil over all grout returns, spills, and drips would help maintain a clean environment inside the containment structure and would prevent possible erosion and resuspension of contaminants after the building has been removed.

In the SVRs, a modified approach would be used. Because the SVRs comprise a series of individual vaults (i.e., unlined holes augured into the soil), grout would be injected at each vault position rather than on a rigid grid such as that defined for pits and trenches. Approximately 650 individual soil vaults are arranged in long lines and spread across a number of areas within the SDA. Soil vaults are small, with a diameter of approximately 16 in.; and large, with a diameter of approximately 57 in. The injection lance would be inserted on the perimeter of each vault making two injections for each small vault and four injections for each large vault. The purpose of grouting would be to encapsulate waste by filling void spaces in the soil vault surrounding the waste. Soil above and below the waste also would be grouted. Because grouting soil vaults has not been performed before, some field testing would be recommended to ensure safe operation in SVR areas.

4.4.1.1.6 Verification and Testing—Following injection of grout, posttreatment geophysical surveys would be conducted to verify the extent of the grout monolith. High contrast in moisture content and density would be used as indicators of the vertical and horizontal extent of the monolith. Operational data, including pressures and volumes of grout injected over each area, would be evaluated to verify the thoroughness of each grouting campaign. Additionally, a network of monitoring probes would be installed throughout the monolith before curing to collect moisture and vapor samples and to monitor temperature, reduction, and pH conditions.

4.4.1.1.7 Demobilization—After each grouting campaign, equipment and trailers would be demobilized and decontaminated as necessary. As each portion of the SDA was grouted, cap construction would commence, which would include foundation grouting in the untreated areas.

4.4.1.2 Supplemental Technologies. To provide compliance with the RAOs, the ISG alternative would require implementation of a number of supplemental technologies within the SDA to address contaminant-specific concerns and provide for the long-term stability of the cover system.

4.4.1.2.1 Organic Pretreatment—The areas that contain oil waste in very high concentrations (Series 743 sludge) may not be effectively grouted with cementitious grouts. Series 743 organic sludge originating from the RFP contains high oil content (averaging 37 gal/drum) and a greasy-like consistency (Clements 1982). In previous tests with simulated waste, researchers have had difficulty in grouting oil-based waste (Loomis and Thompson 1995). More recent testing has demonstrated success in grouting waste streams with 10 to 12% oil using a wide range of grout types.

For the ISG alternative, the ISTD technology would be applied in areas within the SDA containing high concentration of Series 743 organic sludge. Because of previous analysis (Miller and Varvel 2001) of the distribution of this waste stream as depicted in Figure 3-8, it is estimated that a total area less than 1 acre in size would have these high concentrations and require pretreatment. These areas are located primarily in Pit 4, with smaller distributions in Pits 6, 9, and 10.

A detailed discussion about implementing ISTD within the SDA is in Section 4.5.1.2. Determination of specific pretreatment requirements would be further evaluated during the design phase.

4.4.1.2.2 Pad A Treatment—Drums of nitrate salt (Series 745 sludge) stacked on Pad A may preclude using in situ treatment options. A number of grouts are available (e.g., silica- or hydrocarbon-based grouts), which conceptually would provide effective treatment for nitrate salt. However, the available performance data about application of ISG to pure salt waste are limited. Because waste loading could be extremely high (approaching 100 wt%) in areas of pure salt waste, ISG would not be as effective as an ex situ stabilization process. Therefore, this evaluation assumes that the waste from Pad A would be retrieved and stabilized in an ex situ treatment system. Waste would be retrieved from Pad A and segregated based on treatment process. This evaluation assumes that all of the Pad A waste would need to be processed. The retrieval process for Pad A is discussed in Section 4.6.1.3.

Waste streams present in Pad A would be stabilized with an ex situ treatment. Presently, specific information about the waste streams disposed at Pad A is unavailable. However, in general it is known that the waste was composed primarily of nitrate salt, depleted uranium, and sewage sludge (Becker et al. 1998). Though the Pad A site could be grouted in situ, effectiveness is highly uncertain without a more detailed understanding of types and concentrations of the waste.

The specific stabilization process would need to be determined after a thorough evaluation of waste types, but it is envisioned that the granular nitrate and oxidized uranium chips would be mixed with stabilizing agents in a pug mill. The *Mixed Waste Salt Encapsulation Using Polysiloxane—Final Report* (Loomis, Miller, and Prewett 1997) states that DOE-Complex salt waste (e.g., Pad A nitrate salt) was suitable for grout stabilization. The resultant grouted waste form passed the toxicity characteristic leaching procedure and U.S. Department of Transportation oxidizer testing. Based on these tests, it is assumed that nitrate salt would be conducive to ex situ treatment. However, small amounts of waste in Pad A exceed 100 nCi/g TRU, and other waste may be determined to carry additional RCRA-listed waste codes (e.g., F001). This waste would be evaluated on a case-by-case basis and might necessitate additional disposal requirements. Waste that exceeds 100 nCi/g TRU likely would be disposed of at WIPP. NonTRU waste requiring a Subtitle C constructed landfill for disposal (i.e., listed waste) may be sent to the ICDF or other commercial TSD facility. Debris waste, if requiring treatment, likely would be macroencapsulated in polyethylene. Both stabilization and macroencapsulation processes are used at commercial mixed waste disposal facilities. Some study may be required to define operational parameters (e.g., proper melt indices) to ensure that cracking or spalling of the treated waste form would not occur. Following stabilization and macroencapsulation, the Pad A waste would be placed back into a pit in the SDA and would be covered by the modified RCRA Subtitle C cap.

A majority of the waste in Pad A includes nitrate salt, which currently are assumed to carry characteristic EPA waste codes (i.e., D001). Detailed analyses of all Pad A waste types have not been performed at this stage; therefore, other code applications are unknown. Further characterization would occur upon waste retrieval. If the waste types were characteristic only (as suspected with the nitrate salt), then the characteristic codes might be removed through treatment. Underlying hazardous constituents (UHCs) and corresponding universal treatment standards (40 CFR 268.48) also would be evaluated before redisposal. For this evaluation, it is assumed that a Subtitle C landfill would not be required.

4.4.1.2.3 Surface Barrier—Following completion of ISG, a modified RCRA Subtitle C cap would be constructed to limit infiltration of water, further reduce contaminant mobility, and inhibit future access to the stabilized waste. The modified RCRA Subtitle C cap would be composed of eight layers of material with a combined minimum thickness of 1.7 m (5.6 ft). The modified RCRA Subtitle Cap is designed to provide containment and hydrologic protection for a performance period of 500 years. Before construction of the cap, untreated waste areas would be grouted to stabilize the foundation and minimize future subsidence-related maintenance requirements.

Construction of the barrier would involve placing a site-grading fill within the SDA to eliminate any depressions and facilitate positive perimeter drainage. Site-grading fill would be followed by layers of sand mixed with gravel, and cobbles. The perimeter of the barrier would be sloped at 3:1 and armored with riprap to prevent its erosion. A perimeter berm system also would be constructed to maintain any floodwaters at least 100 ft from the toe of the cover to minimize moisture movement into the stabilized waste zones.

The alternative assumes that the OCVZ system would continue to operate. Concurrently with construction, wells supporting the OCVZ system would either be extended or relocated, as necessary. The cover design also includes a gas collection layer to passively vent VOC releases from buried waste.

4.4.1.2.4 Monitoring and Maintenance—This alternative involves performing routine maintenance to address potential issues (e.g., burrowing animals and erosion). Groundwater, vadose-zone, and air monitoring activities conducted as part of this alternative would facilitate identification of contaminant migration or other changes in site conditions that may warrant future remedial actions. Table 4-8 identifies the alternative's monitoring activities, which would be conducted in concert with the scheduled operations and maintenance activities of the INEEL-wide program.

Table 4-8. Projected monitoring requirements for the In Situ Grouting alternative.

Media	Sampling Strategy
Groundwater	Sample 16 locations quarterly for 2 years; semiannually for the following 3 years; annually for the remaining 95 years.
Vadose zone	Sample lysimeters (37) and vapor port (20) quarterly for 5 years and annually for the remaining 95 years.
Air	Sample four existing air monitors annually for 100 years.
Surface water	Sample two points every 5 years for 100 years.
Biological	Conduct animal intrusion inspection during vegetation monitoring.
Vegetation	Conduct annual inspections for 5 years; every fifth year for the next 20 years.

4.4.1.3 Estimated Schedule. The entire ISG alternative is estimated to be complete within 12 years from ROD signature. Figure 4-6 graphically illustrates the task schedule for the ISG alternative.

As shown, the remedial design and procurement phase, including grout-formulation testing, procurement and fabrication, and acceptance testing of the equipment is estimated to require 3 years. Upgrading the necessary infrastructure would be done concurrently during this time. Operations to treat the pit areas, SVRs, and trenches containing TRU and C-14 sources would be completed in approximately 5 years if operations were suspended a quarter of the year (during winter months) and three grout rigs were operated simultaneously. Pad A waste would be retrieved and treated concurrently with the grouting operation. Cap construction also would be concurrent with the grouting operation, with completion approximately 1 year after treatment operations are finished.

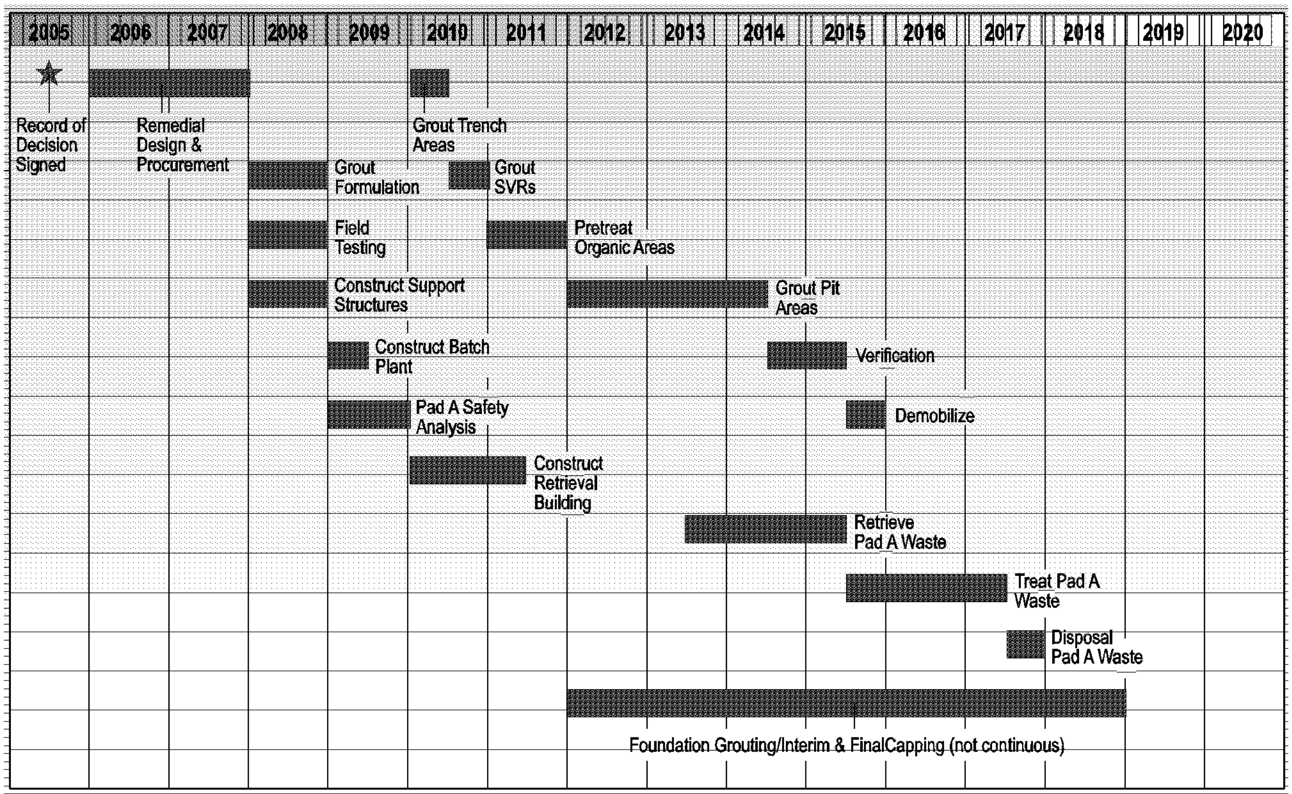

Figure 4-6. Schedule for the In Situ Grouting alternative.

4.4.2 Screening Assessment

In the following sections, an assessment is provided of the ISG alternative's ability to satisfy the two threshold criteria and the five balancing criteria described in Section 4.1.

4.4.2.1 Overall Protection of Human Health and the Environment (Threshold Criterion). The ISG alternative would protect human health and the environment. It is projected that the alternative would be implemented by 2019 and would achieve all of the RAOs. Because contaminants would remain at the site, monitoring would be a required element of the alternative.

4.4.2.2 Compliance with Applicable or Relevant and Appropriate Requirements (Threshold Criterion). The ISG alternative is designed to stabilize and contain buried waste through injection of a stabilizing grout and installation of a surface barrier. In addition, waste in Pad A would be retrieved and stabilized in an ex situ treatment system. The key ARARs for this alternative, therefore, relate to containing buried waste over time and identifying and managing RCRA hazardous waste. Under CERCLA, ARAR compliance is addressed by considering chemical-, location-, and action-specific ARARs (and TBCs) independently. Appendix A presents a comprehensive summary of potential ARARs that have been identified for the WAG 7 feasibility study. The evaluation summary of the key ARARs for the ISG alternative is presented in Table 4-9. Each requirement is identified by its type (i.e., chemical-, location-, or action-specific), its relevance (i.e., applicable, relevant and appropriate, or TBC), and the regulatory source citation. The table also presents a conclusion as to whether the proposed alternative would meet a corresponding requirement. Detailed discussions of significant requirements are presented below.

Table 4-9. Regulatory compliance evaluation summary for the In Situ Grouting alternative.

ARAR or TBC	Type	Relevancy[a]	Citation	Meets Evaluation?
Idaho groundwater quality rule	Chemical	A	IDAPA 58.01.11.200	Yes[b]
National primary drinking water standards	Chemical	RA	40 CFR 141 MCLs and MCLGs	Yes[b]
Radiation protection of the public and the environment	Chemical Action	TBC	DOE Order 5400.5	Yes
Idaho toxic air pollutants	Chemical	A	IDAPA 58.01.01.585 and .586	Yes
Idaho ambient air quality standards for specific air pollutants	Chemical	A	IDAPA 58.01.01.577	Yes
National emission standards for hazardous air pollutants	Chemical	A	40 CFR 61	Yes
Native American graves protection and repatriation regulations	Location	A	43 CFR 10	Yes—if encountered
Preservation of historic, prehistoric, and archeological data	Location	A	36 CFR 800 and 40 FR 6.301(b) and (c)	Yes—if encountered
Protection of archaeological resources	Location	A	43 CFR 7	Yes—if encountered
Preservation of historical sites	Location	A	Idaho Statute 67-4601 et seq. and Idaho State Historical Statute 67-4101 et seq.	Yes—if encountered
Compliance with environmental review requirements for floodplains and wetlands	Location	A	10 CFR 1022	Yes
Protection of floodplains	Location	RA	Executive Order 11988; 40 CFR 6.302(b); 40 CFR 6 Appendix A	Yes
Remediation waste management sites located within floodplains	Location	A	40 CFR 264.18(b)	Yes
Location standards for TSD facilities located within floodplains	Location	A	40 CFR 264.1(j)(7)	Yes
Idaho groundwater quality rule	Action	A	IDAPA 58.01.11.006	Yes[b]
Standards for owners and operators of TSD facilities—general groundwater monitoring requirements	Action	A	40 CFR 264.97	Yes[b]
National ambient air quality standards	Action	A	40 CFR 50	Yes
Idaho control of fugitive dust emissions	Action	A	IDAPA 58.01.01.650 and .651	Yes
Idaho fuel burning equipment—particulate matter	Action	A	IDAPA 58.01.01.675 through 681	Yes
Idaho particulate matter—process equipment emission limitations on or after July 2, 2000	Action	A	IDAPA 58.01.01.710	Yes
Identification and listing of hazardous waste	Action	A	40 CFR 261	Yes

Table 4-9. (continued).

ARAR or TBC	Type	Relevancy[a]	Citation	Meets Evaluation?
Hazardous waste determination	Action	A	IDAPA 58.01.05.006 (40 CFR 262.11)	Yes
Standards for owners and operators of TSD facilities—closure and postclosure requirements	Action	RA	IDAPA 58.01.05 (40 CFR 264 Subpart G)	Yes
Standards for owners and operators of TSD facilities—landfills	Action	RA	IDAPA 58.01.05 (40 CFR 264 Subpart N)	Yes
Standards for owners and operators of TSD facilities—use and management of containers	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart I)	Yes
Standards for owners and operators of TSD facilities—tank systems	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart J)	Yes
Standards for owners and operators of TSD facilities—surface impoundment	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart K)	Yes
Standards for owners and operators of TSD facilities—air emission standards for process vents	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart AA)	Yes
Standards for owners and operators of TSD facilities—equipment leaks	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart BB)	Yes
Standards for owners and operators of TSD facilities—tanks, surface impoundments, and containers	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart CC)	Yes
Standards for owners and operators of TSD facilities—containment buildings	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart DD)	Yes
Standards for owners and operators of TSD facilities—remediation waste management rules	Action	A	IDAPA 58.01.05 (40 CFR 264.1[j] [1] through [13])	Yes
LDRs	Action	A	IDAPA 58.01.05.011 (40 CFR 268)	Yes
National pollutant discharge elimination system	Action	RA	40 CFR 122.26	Yes
Radioactive waste management	Action	TBC	Order DOE 435.1	Yes

a. A = applicable requirement, RA = relevant and appropriate requirement, TBC = to-be-considered requirement
b. Evaluation criteria met not including the potential vadose zone contribution.
ARAR = applicable or relevant and appropriate requirements
CFR = *Code of Federal Regulations*
DOE = U.S. Department of Energy
IDAPA = Idaho Administrative Procedures Act
TSD = treatment, storage, and disposal

4.4.2.3 Chemical-Specific (Applicable or Relevant and Appropriate Requirements). The ISG alternative would meet RAOs for direct contact because the stabilized waste and its overlying low-permeability barrier cover system would prevent human and ecological receptors from direct exposure. This alternative also would reduce mobility of COCs and reduce infiltration. Not including contaminants presently in the vadose zone, the ISG alternative would inhibit COC migration from buried waste to underlying groundwater. Application of this alternative would meet the RAOs and related PRGs identified for groundwater (IDAPA 58.01.11; 40 CFR 141) if the potential vadose zone contribution is excluded.

The chemical-specific requirements of state and federal air quality standards would be met during both construction and remediation action implementation. Idaho state requirements include controlling toxic air pollutants (IDAPA 58.01.01.585 and .586), ambient air quality standards for specific air pollutants (e.g., particulate matter [IDAPA 58.01.01.577]), and emission of fugitive dusts (IDAPA 58.01.01.650). Federal requirements include NESHAPs (e.g., radionuclides) (40 CFR 61) and NAAQS (e.g., particulate matter) (40 CFR 50).

4.4.2.4 Location-Specific (Applicable or Relevant and Appropriate Requirements).

Location-specific ARARs for the ISG alternative are the same as those for the Surface Barrier alternative (see Section 4.2.4.2).

4.4.2.5 Action-Specific (Applicable or Relevant and Appropriate Requirements).

Because the ISG alternative leaves waste in place, RCRA Subtitle C requirements for closure and postclosure (40 CFR 264 Subpart G) and landfills (40 CFR 264 Subpart N), as adopted by reference in the State of Idaho's Rules and Standards for Hazardous Waste (IDAPA 58.01.05), may be relevant and appropriate because the SDA is not a new or existing RCRA-regulated unit. Design and operation of the surface barrier would meet the RCRA substantive requirements for a top liner. The RCRA Subtitle C requirements for air emission standards for process vents (40 CFR 264 Subpart AA) and equipment leaks (40 CFR 264 Subpart BB) may be applicable for some equipment used during in situ thermal desorption operations, if emissions contain levels of restricted hazardous volatile waste above established thresholds. If applicable, these requirements would be met by using appropriate engineering controls. In addition, RCRA Subtitle C requirements for air emission standards for tanks, surface impoundments, and containers (40 CFR 264 Subpart CC) and treatment of hazardous waste using containers, tanks, surface impoundments, and waste piles (40 CFR 264 Subparts I, J, K, and L) may be applicable to Pad A waste if hazardous waste is encountered and treated onsite. RCRA general groundwater monitoring requirements (40 CFR 264.97) that use monitoring wells to detect COCs in the underlying aquifer are applicable to the ISG alternative. Provisions for groundwater monitoring are included in this alternative.

Furthermore, substantive RCRA generator requirements for hazardous waste identification and management (40 CFR Parts 261 and 262) would be applicable to this alternative if hazardous waste were generated during these activities. Also, the substantive portions of 40 CFR 268, including applicable LDRs and requirements for generators that treat hazardous waste, would apply to activities at Pad A if hazardous waste were treated onsite before disposal. Special rules for treating characteristic hazardous waste (40 CFR 268.9) would apply, if stored nitrate salt identified as an oxidizer (D001) is treated.

Implementing institutional controls (e.g., security and access) identified for this alternative would prevent possible exposure to waste by human intruders and biota. The controls would also meet applicable DOE requirements for residual radioactivity left in place, including related provisions of DOE Order No. 5400.5.

Construction and remediation would meet state and federal air quality standards requirements. Idaho state requirements include controlling toxic air pollutants (IDAPA 58.01.01.585 and .586), ambient air quality standards for specific air pollutants (e.g., particulate matter [IDAPA 58.01.01.577]), emission of fugitive dusts (IDAPA 58.01.01.650), particulate matter emission standards for fuel burning equipment (IDAPA 58.01.01.675 through 681), and process equipment emission limitations (IDAPA 58.01.01.710). Federal requirements include NESHAPs (e.g., radionuclides) 40 CFR 61 and NAAQS (e.g., particulate matter) 40 CFR 50. These requirements would be met by using appropriate engineering controls. Organic vapors that may accumulate beneath the biotic barrier following remediation would be collected, removed, and treated by the active OCVZ treatment system (OU 7-08) and the designed passive gas collection layer operating in the modified RCRA Subtitle C cap. The EPA Office of Air Quality Planning and Standards is developing a new MACT for the remediation site source category. This MACT, projected to be effective after 2002, would apply to remediation sites that are major sources of organic hazardous air pollutants during site remediation activities. If applicable to CERCLA sites, all vents, remedial material management units, and associated equipment components involved in the remedial activity could require emission controls.

As required, NPDES storm water discharge protective measures and best management practices would be implemented for storm water controls, road building, waste management, and other related remedial activities as appropriate. Applicable DOE TBC requirements for protection of human health also would be met during remedial activities.

Requirements of DOE Order 435.1, which specifies that all DOE radioactive waste is to be managed in a manner protective of worker and public health and safety and the environment, would be met.

4.4.2.6 Long-Term Effectiveness and Permanence (Balancing Criterion). The ISG waste form would be physically and chemically stable over geologic time. The most significant mechanism causing grout degradation is dissolution of grout materials by slowly infiltrating water. However, as discussed in the supporting report, grout waste forms are chemically compatible with the natural SDA environment. Recent grout testing has demonstrated that dissolution of grout materials, even in saturated conditions, would occur only at extremely low rates (Armstrong, Arrenholz, Weidner 2002).

If ISTD is performed, VOCs in treated areas would be permanently removed and destroyed. This would eliminate future risk associated with COCs (e.g., CCl_4, methylene chloride, and tetrachloroethylene). The surface barrier would further reduce risk by inhibiting infiltration of water through the grouted waste, thereby impeding further release of contamination to the aquifer.

Though this alternative would be effective at minimizing future risk, some COCs presumably would have been released before remediation could take place. The amount that has been released to date and current rates of release are not known with certainty. However, conservative estimates are that the preremediation release may result in groundwater contamination posing a risk above 1E-04. Modeling indicates that this risk would peak by 2110 and could extend beyond the boundary of the SDA for a distance of approximately 1,500 to 2,000 ft. Therefore, this alternative could require institutional controls that prohibit using groundwater within this buffer zone.

In addition to prohibiting groundwater use within the buffer zone around the SDA, other institutional controls would be required to ensure RAOs are met and maintained. Land-use restrictions would be required to prevent development, excavation, or drilling on and near the SDA. Frequent inspection and maintenance of the surface barrier would be required. In addition, the barrier would have to be reconstructed every 500 years. Groundwater monitoring would be required to ensure contamination does not exceed acceptable levels beyond the institutional control boundary.

Assuming contamination in the vadose zone is ignored, long-term (10,000-year) modeling performed for this alternative provides an indication of effectiveness of the ISG technology and surface barrier in preventing migration of COCs remaining in the burial zone of the SDA. Simulations indicate that this alternative would effectively reduce contaminant migration and control groundwater ingestion risk from COCs in the burial zone to acceptable levels.

4.4.2.6.1 Risk Modeling Assumptions—Water was assumed to infiltrate the modified RCRA Subtitle C Barrier at a rate of 0.114 cm/year. Contaminant releases from the grout were conservatively assumed to occur by diffusion from within 2-ft-diameter grout columns. These columns would be formed by injecting grout into the waste site to create interlocking columnar monoliths. This is based on a conservative assumption that the points of contact between columns may be a zone of weakness where cracks can form. For modeling purposes, the surface available for leaching was assumed to be the outside surface of the 2-ft-diameter columns. Realistically, surface area available for leaching is would be much lower, but few applicable data are available to develop accurate prediction of cracking in grouted waste over long periods.

The DUST-MS model assumed that infiltrating water flows through the columnar joints in the grout at volumetric rates equal to the surface area of the treated region multiplied by the infiltration rate. The volumes of water contacting the waste in a given period were assumed to dissolve the contaminants released in the same period, up to their solubility limits. Modeling limitations precluded chemical alteration of infiltrating water as it passes through the grouted waste in the simulations. As a result, release rates in the model might be biased high. The concentrations of contaminants released from the source term were input to the TETRAD model to estimate groundwater concentrations and drinking water risk.

4.4.2.6.2 Magnitude of Residual Risk—The magnitude of residual risk associated with this alternative is illustrated in Figure 4-7. This figure shows the cumulative carcinogenic risk over time caused by ingestion of groundwater impacted by release of residual contaminants in grouted TRU pits and trenches and grouted SVRs.

The figure presents two risk projections: (1) risk associated with postremediation release from the residual source term in the SDA only, and (2) total risk represented by release of residual source-term contaminants plus postulated contamination in the vadose zone before application of ISG in the SDA. The risks represent exposure at the point of maximum groundwater contamination; for results that include potential COCs in the vadose zone, this location lies at the southern edge of the SDA. Modeling results show that the near-term risks are dominated by COCs that may have been released before the remedial action. However, considerable uncertainty is in the assumptions used in the risk modeling, because the mass of potential COCs in the vadose zone and the rates of release from the SDA are unknown.

As shown in the figure, carcinogenic risk associated only with postremediation release of contaminants reaches approximately 4E-06 in 2,000 years and then decreases to approximately 2E-07 in 10,000 years. Carbon-14 accounts for approximately 80% of the risk in 1,000 years. Technetium-99 and I-129 are other significant contributors. After 1,000 years, uranium isotopes dominate risk.

The residual hazard index for this alternative is assumed less than 1.0. As stated previously, risk modeling indicates that the hazard index attributable to postremediation contaminant release under the Surface Barrier alternative would be less than 1.0. It is assumed that, given the treatment provided by ISG, the residual hazard index for the ISG alternative would be lower than that for the Surface Barrier alternative.

In the carcinogenic risk curve shown in Figure 4-7, the potential influence on risk levels caused by contaminants previously released from the source term to the underlying vadose zone are presented. Model results show that contaminants released to the vadose zone before remediation result in cumulative risks in groundwater greater than the 1E-04 levels for a zone that extends 1,500 ft beyond the SDA boundary.

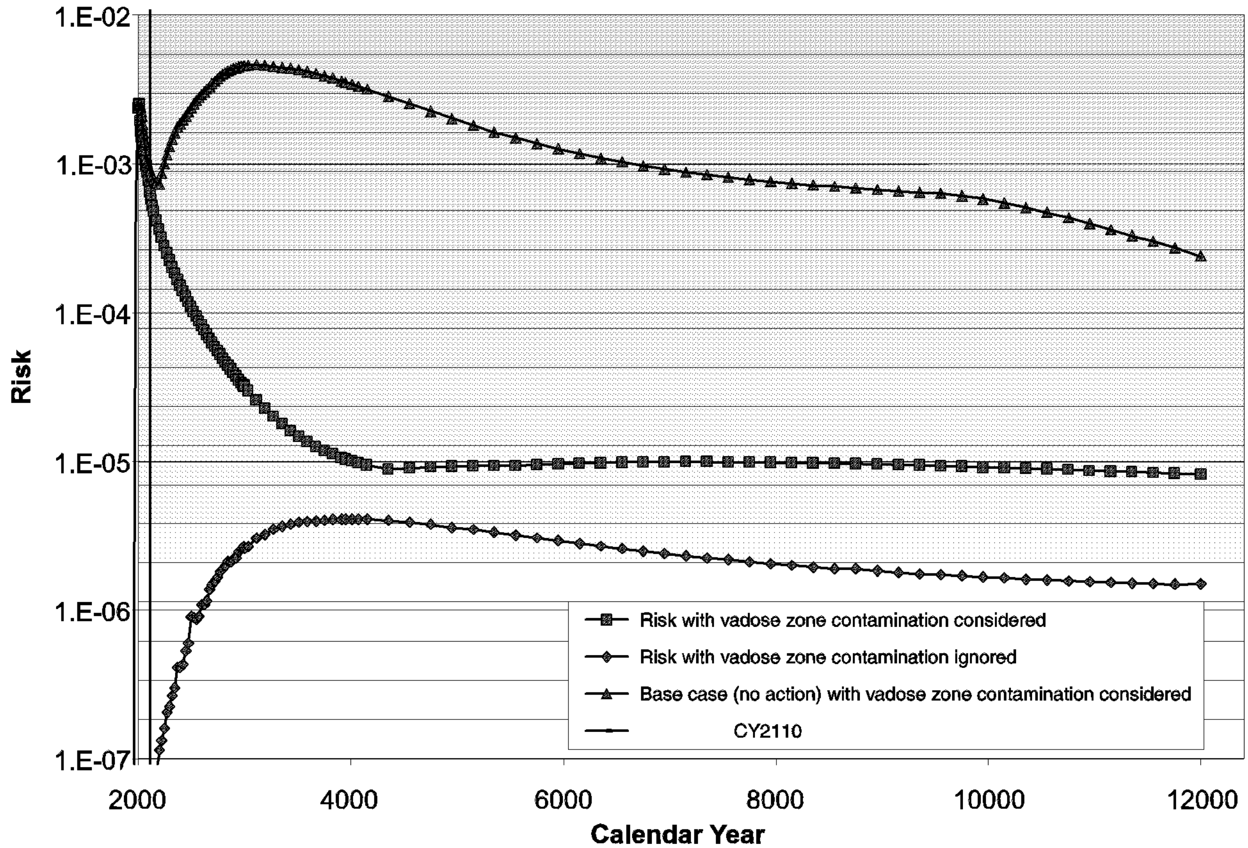

Figure 4-7. Residual groundwater risk for the In Situ Grouting alternative.

4.4.2.6.3 Adequacy of Reliability and Controls—Monitoring the treated waste and maintaining the barrier would be required in perpetuity to ensure effectiveness and permanence of the remedy. Regular monitoring (e.g., visual inspections and surface-elevation surveys) would be performed to detect compromises in the barrier's integrity or effectiveness. The barrier would be maintained and repaired as required to achieve original performance standards. Because of the required life span of the remedy, portions of the barrier likely would need to be repaired or reconstructed periodically and the entire barrier likely would need to be replaced once every 500 years.

Long-term reliability and performance of the ISG remedy would be assessed through monitoring of groundwater, the vadose zone, air, fauna, and surface vegetation. In addition, a network of monitoring probes would be installed throughout the monolith before the grout cures, to collect moisture and vapor samples and monitor temperature, redox, and pH conditions over time.

To ensure protectiveness, active institutional controls would be required to limit land-use activities near the SDA. A prohibition on drilling and using groundwater within a buffer zone around the SDA would have to be enforced. Access controls would have to be implemented and maintained in perpetuity to prevent intrusion into the waste.

4.4.2.6.4 Summary of Long-Term Effectiveness—Fate and transport modeling indicates that the postremediation peak carcinogenic risk would be less than 1E-04 and the hazard index would be less than 1.0 for the groundwater ingestion pathway, when postulated contamination in the vadose zone is not included. The grout monolith would be chemically and physically stable over geologic time. Appropriate institutional controls and operation and maintenance programs, plus periodic barrier repair and replacement, would provide additional long-term control for the stabilized waste. Should the potential COCs in the vadose zone at the time of remediation cause groundwater contamination to exceed health-based levels in a zone beyond the SDA boundary, institutional controls would be required to prevent access to, and use of, any contaminated groundwater. Therefore, the ISG alternative is an effective and permanent remedy.

4.4.2.7 Reducing Toxicity, Mobility, or Volume Through Treatment (Balancing Criterion). This alternative would encapsulate all waste sites contributing to the potential risk to human health and the environment with ISG technology. Pretreating some high-organic areas may be required to ensure adequate grouting. Because all waste is encapsulated in the grout mixture rather than destroyed or reduced, contaminants present in the encapsulated form would be immobilized significantly but would remain onsite.

4.4.2.8 Short-Term Effectiveness (Balancing Criterion). Components of the ISG alternative's short-term effectiveness entail the following:

4.4.2.8.1 Protecting the Community During Remedial Actions—The ISG alternative could be readily implemented with minimal risk and impact to the public and INEEL workers. Increased traffic on the INEEL during borrow-material acquisition is anticipated. And if borrow material is obtained from sources off the INEEL, increased traffic would affect communities near the INEEL. Therefore, traffic control plans would be developed to minimize the impact and potential increase in transportation risk to communities both the on and off the INEEL.

4.4.2.8.2 Protecting Workers During Remedial Action—This alternative could be implemented with moderate risk and impact to remediation workers. As with all alternatives that disturb buried waste, the potential exists for worker exposure to direct ionizing radiation and other chemical hazards. Because the ISG technique involves repeatedly inserting steel lances into the waste and injecting grout under high pressures, contamination potentially could be brought to the surface, adhered to the injection equipment or imbedded in grout returns. Past ISG work at the INEEL has experienced minor to large amounts of grout returns (wet grout forced to the surface during injection operations) (Armstrong, Arrenholz, Weidner 2002).

The OU 7-13/14 Preliminary Safety Analysis predicts that the potential amount of contamination brought to the surface would be minimal (Peatross 2001). Furthermore, because of the encapsulating properties of grout, the contamination would not become easily airborne. Based on results of the analysis, unmitigated hazards would not exceed dose evaluation guidelines established in DOE-ID Order 420.D, "Requirements and Guidance for Safety Analysis." The ISG operation would not be classified as a nuclear operation in accordance with DOE Standard (STD) DOE-STD-1027-92 "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Report." Using the process established in DOE Standard DOE-STD-5502-94, "Hazard Baseline Documentation," and DOE-ID Order 420.D, the ISG operation would be classified as a low radiological hazard.

Because of these analyses, ISG is not subject to many of the difficult controls and processes associated with nuclear operations as some other remedial alternatives. Worker safety aspects of ISG would be governed under an extensive health and safety plan prepared in accordance with 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response," and 20 CFR 1926.65, "Safety and Health Regulations for Construction." The health and safety plan would include a detailed hazards analysis and identify engineering and administrative controls to ensure protection of workers.

The ISG operation would be conducted inside a negative-pressure radiological confinement building. In addition, using a wheeled gantry crane platform would allow workers to remain outside the building during grouting operations. The confinement building and remote operations would be implemented to provide a defense in depth approach to worker safety.

The confinement building structure would be maintained under negative pressure and ventilated through a HEPA filter system. The structure would be continually disassembled and moved as the ISG operation progresses across the SDA. The OU 7-13/14 Preliminary Safety Analysis (Peatross 2001) predicted that the potential for airborne contamination is very low, so it is anticipated that the building would not become highly contaminated. A robust system of radiation monitors inside the structure would be used to verify that contamination is maintained at acceptable levels. Workers would enter the building periodically to monitor contamination levels or to repair equipment but would not be allowed inside during operations when the potential for surface contamination is highest.

Though worker risks in terms of evaluation guidelines are relatively low, the practical issue of controlling the spread of radioactive contaminants during and after the grouting operation remains. Some form of surface contamination control would be required to prevent spread of surface contamination across the SDA and neighboring facilities.

Previous INEEL tests on simulated waste have used concrete or steel platforms, referred to as thrust blocks, to cover the ground and contain grout returns. A flexible plastic bag or shroud, referred to as a drill-string enclosure, also has been tested to encase the drill string itself in an effort to minimize the potential for contamination spread. While the system of thrust blocks and drill-string enclosure may be a viable approach, a number of operational problems have precluded a successful demonstration.

Another approach that has been suggested has been to cover postoperational grout returns with a 3-ft layer of soil. The soil would preclude erosion and possible airborne suspension of contaminants in the interim period before construction of the cap. Because of results of the OU 7-13/14 Preliminary Safety Analysis, and considering the protection offered by remote operations and a confinement building, the simpler contamination-control approach may be preferred. Because the contamination-control techniques have not yet been designed and demonstrated, some uncertainties would need to be resolved during the remedial design.

In addition to the radiological and chemical hazards posed by the waste, the heavy equipment used during implementation of the ISG alternative (e.g., drill rigs, cranes, high pressure pumps, batch plant equipment, trucks, and loaders) pose significant industrial hazards. During the remedial design and subsequent readiness activities, remediation workers would need to ensure that all systems are properly designed and meet the appropriate engineering specifications and standards. Operations would need to be conducted in a planned and controlled manner with adequate procedures and trained crews to ensure the safety of workers.

Retrieving and treating Pad A waste presents additional hazards. Retrieving low-level radiological waste presents inherent risks to workers, but the risk is substantially less than that posed by retrieval of waste from TRU areas. Notably, several drums were retrieved previously from Pad A for experimental purposes (early 1990s) without using a radiological confinement building. A thorough hazard analysis is needed to determine worker risk posed by the Pad A operation and to establish requirements for confinement systems and other safety systems.

The report prepared in support of this PERA (Schofield 2002) estimated the risk to workers associated with implementing this alternative. The evaluation considered direct external radiation exposure and exposure to mechanical injuries for remediation workers. No risks to the public were projected for this alternative because no off-INEEL transportation of hazardous materials would occur. Engineering controls during implementation would preclude the release of particulate radioactive materials. Risk results of that evaluation are these:

- Cancer = 1.07
- Injury = 74.5
- Fatality = 0.17.

As shown, the evaluation predicts that during implementation, one person would develop cancer because of exposure to hazardous substances, including radioactive material and radiation fields. Approximately 75 injury accidents would occur during implementation, and the projection for fatality accidents is less than one.

4.4.2.8.3 Environmental Impacts Associated with Construction—Environmental impacts associated with the ISG alternative include potential particulate emissions resulting from construction activities and increased construction-related traffic. Particulate emissions would be controlled with applicable dust suppression techniques, as necessary, to ensure that exposure to off-INEEL receptors does not exceed either 25 mrem/year total effective dose equivalent from all exposure pathways or the 10 mrem/year total effective dose equivalent through the air pathway (in accordance with DOE Manual 435.1-1, "Radioactive Waste Management Manual").

4.4.2.8.4 Time Until Remedial Action Objectives Are Achieved—Preliminary project schedules project that the ISG alternative could be fully completed within 12 years of an approved ROD. The alternative would meet all RAOs, but ultimate effectiveness of the ISG alternative would not be confirmed until the cap is constructed, operated, and monitored for some time.

4.4.2.9 Implementability (Balancing Criterion). This alternative is implementable. In situ grouting has been widely tested as either CERCLA treatability studies or small remedial actions. Information provided by past testing demonstrates that ISG is an effective technology with applications for the SDA (Armstrong, Arrenholz, Weidner 2002). However, ISG has not yet been implemented at the scale that would be required for OU 7-13/14. As with all intrusive alternatives for the SDA, significant technical risks are associated with treating the buried waste. Estimates of production rates and costs for this alternative have significant uncertainty because buried waste sites as large and complex as the SDA have not been treated before with this technology.

4.4.2.9.1 Technical Feasibility—Results of past field trials at the INEEL and other DOE sites show that injection grouting is clearly implementable at the SDA. The actual deployment system used to inject the grout would need to be evaluated during remedial design and optimized for specific waste streams. However, for this evaluation it is clear that rotary point injection would be technically feasible for use in pits and trenches where intimate mixing of waste and grout is desired.

The necessary equipment is commercially available and commonly used. The primary components of the ISG system (i.e., batch plants, cranes, drill rigs, and positive displacement pumps) are all commonly used and reliable. Though some equipment modifications would be necessary, no further development or testing (other than acceptance testing) is envisioned.

Treating the SDA with ISG would require hundreds of thousands of individual injections. The sheer number of injections required is challenging and the heterogeneous nature of the subsurface treatment zone would complicate operations. However, considering past field trials, and assuming that a crane-mounted system would be used, the time estimated for treating the SDA is reasonable.

Treating the SDA would require a large volume of grout, more than 200,000 yd^3. However, producing the grout is technically feasible. A single, moderately sized batch plant can produce 500 yd^3 each day, more than enough to support the injection operations.

Retrieving and treating Pad A waste is technically feasible. The waste is primarily low-level with a few drums of TRU waste. No hazards (e.g., explosives or highly flammable materials) have been identified. Stabilization and macroencapsulation processes are used commercially to treat radioactively contaminated waste. Again, specific constituents of the waste would need to be evaluated and stabilizing agents tested to ensure applicable requirements are met, but the process is technically feasible.

Technical difficulties with the ISG process encountered during past field tests included excessive grout returns, inadequate permeation with low-pressure systems, and clogging of injection nozzles. Those difficulties have been largely resolved through subsequent design and testing (Armstrong, Arrenholz, Weidner 2002). However, several waste streams may pose potential problems for implementing ISG and must be considered in this evaluation and addressed in detail during remedial design. The ISG technology is relatively robust and this evaluation assumes that ISG could be applied effectively to most waste streams found in the SDA. However, ISG performance for several waste types, depending on concentration and aerial extent, is unknown. These waste types include:

- Organic oil—Series 743 organic sludge originating from the RFP has high oil content (averaging 37 gal/drum) and a grease-like consistency (Clements 1982). In previous tests with simulated oil waste streams, researchers have had difficulty grouting oil-based waste streams (Loomis and Thompson 1995). However, more recent bench-scale testing indicates that waste streams with 10 to 12 wt% oil could be effectively treated with a wide range of grout types. Waste with significantly higher organic loadings could be effectively treated using specialized grouts, such as blast furnace slag grouts, hydrocarbon-based grouts, or other grouts. Areas in the SDA with intermittent or scattered drums of organic oil waste should are not problem areas because the oily mixture would be encapsulated on all sides by competent grout. However, grout performance data are not readily available for areas with many oil drums. Pretreatment by ISTD would be required before ISG could be applied to areas with high numbers of Series 743 sludge drums. Previous analysis of the distribution of Series 743 sludge (Miller and Varvel 2001) estimated that a total area of less than 1 acre may have such high concentrations. These areas are located in Pits 4, 6, 9, and 10.

- Nitrate salt—745 Series nitrate sludge waste is comprised primarily of dried sodium nitrate and potassium nitrate salt that originated from evaporation ponds at RFP. High concentrations of salt compounds interfere with the curing of many cementitious grouts. However, recent bench tests have demonstrated that waste loadings up to 12-wt% nitrate have no effect on the grout leach resistance (Armstrong, Arrenholz, Weidner 2002). Furthermore, past work demonstrated that, with certain grout formulations, competent waste forms could be achieved with waste loadings approaching 50-wt% nitrate salt. Research also found many grouts that failed when mixed with high concentrations of nitrate salt. The researchers recommended that results not be extrapolated from one waste to another, but tests on actual waste should be used to select a grout formulation (Loomis, Miller and Prewett 1997; Spence et al. 1999).

  As with the oil-based sludge drums, intermittent nitrate waste drums would not significantly affect the performance of the ISG monolith. However, areas with high densities of nitrate drums with waste loadings exceeding 50 wt% could preclude effective curing of cementitious grouts. Areas with nitrate salt waste in concentrations exceeding 50 wt% would be identified as interference areas that could not be effectively grouted without further development and testing of grout formulations. A paraffin- or polyethylene-based grout would be effective, but performance data specific to nitrate salt have not been developed. Pad A, with its high concentration of nitrates, would be retrieved and the waste stabilized in an ex situ treatment system to ensure performance standards are met.

- Large objects—Jet injection grouting relies on advancing an injection lance through the waste with rotary-percussion action. SDA waste includes construction debris (e.g., concrete, steel, and pipes) and large objects (e.g., trucks, tanks, reactor-vessel pieces). Intersecting such objects would prevent fully advancing the injection lance and prevent grouting at that spot. If drill refusal is an isolated event, the offending object may be sufficiently encased with grout through adjacent holes. However, an area may become impossible to grout successfully if a large cache of steel or other such debris is encountered. Presently, maps of large-object areas are unavailable, so it is difficult to predict to what extent drill refusal would be a problem. Many of the COCs are associated with drummed waste (sludge) that, as demonstrated by recent probing, is easily penetrated. Areas containing large caches of demolition debris, vehicles, or other large objects could pose a challenge for drilling and may preclude grouting of those areas.

4.4.2.9.2 Administrative Feasibility—Though the actions under the ISG alternative are implemented under CERCLA and do not require permits, the substantive provisions of permits that would otherwise be required are considered to be ARARs. Any selected remedial alternative would be required to demonstrate ARAR compliance. Because the ISG alternative would adequately address identified ARARs, no known administrative barriers would exist to prohibit implementation.

Safety disciplines (e.g., radiation safety, industrial hygiene, and construction safety) are readily available at the INEEL. Regulatory compliance support, including permitting required for construction activities, also is available. Changes to the storm water or Big Lost River systems may require assessing wetlands and associated environmental receptors or habitats, but this issue is not anticipated to adversely affect the administrative implementability of this alternative. Previous implementations of ISG at the INEEL and other DOE sites did not encounter any administrative barriers.

Though this alternative's activities do not expose buried waste or provide a way to bring any substantial contamination to the surface, the act of puncturing through and pressure-grouting waste would generate some level of radiological and nuclear material hazard. The process of safety analysis, design, and operational readiness for systems and techniques to treat the waste would be difficult. However, preliminary safety analysis and design work completed for ISG, coupled with the success of past technology performance tests, show that these issues could be adequately mitigated with proper design and operations. While long-term monitoring activities, cover maintenance, and 5-year site reviews would require long-term coordination, these activities would not present significant administrative difficulties.

4.4.2.9.3 Availability of Services and Materials—Services and materials required include mechanical hauling and grading, construction of a grout batch plant, hauling grout materials, in situ nonreplacement jet grouting of the subsurface, hauling and placing materials to construct a multilayered cover, installing storm flow diversions, constructing fences and other access controls, and site restoration including grading and reseeding.

All earthwork under this alternative would involve using readily available standard construction equipment, trades, and materials. Soil and rock could be borrowed or quarried if needed from regional sources. Services and infrastructure for construction activities are readily available in the local region, and services and materials for the jet grouting are available from a number of commercial vendors. At least two vendors have provided ISG services to the INEEL in the past.

A number of commercial firms specializing in formulating and producing many types of grout are available. While some specific, experimental grout types may not available on a large scale, all of the candidate grouts tested and proposed for this application are thought to be available on a production scale. The multiple vendors have extensive experience formulating specific grouts with additives to suit individual remediation goals and deployment mechanisms. For example, additives have been shown to reduce leachability of heavy metals to below instrument detection limits. Other additives increase set time and reduce viscosity to facilitate handling and injecting grout into the waste seam. Many grouts could be readily mixed onsite in a batch plant similar to the cement batch plants commonly found near large construction sites. Raw materials could be brought in readily by truck or rail and staged onsite.

4.4.2.10 Cost (Balancing Criterion). The net present value of the ISG alternative is estimated at $823 million, as shown in Table 4-10. The net present value estimate includes $815 million for capital and $8 million for O&M costs. Primary capital costs are associated with the primary waste sites. The primary O&M costs are associated with environmental monitoring and cap maintenance. The costs include an estimated average 33% contingency.

Table 4-10. Total estimated costs for the In Situ Grouting alternative with contingency.

Activity	Total Costs ($M)	Net Present Value ($M)
Capital costs		
Surface barrier	70.9	—
In situ grouting and foundation grouting	576.2	—
Volatile organic contaminant treatment using ISTD	52.2	—
Pad A retrieval and reconfiguration	201.9	—
Testing	23.7	—
Management, design, and reporting	147.7	—
Total capital costs	1,072.6	814.5
Operating and maintenance		
Monitoring and surveillance	31.5	—
Cover maintenance	9.0	—
Fencing and signage	0.3	—
Management	4.9	—
Total operating and maintenance costs	45.7	8.1
Total	**1,118.3**	**822.6**

ISTD = in situ thermal desorption

A cost evaluation has been performed to show the sensitivity of the total capital cost for the ISG alternative when production rates are varied. Figure 4-8 shows the projected cost increase if grouting time were increased from 4 minutes per grout hole. As shown, if grouting production rates were to slow from 4 minutes per grout hole to 8 minutes per hole, the total project costs estimates would increase from approximately $1.1 to $1.4 million. While the costs increase in a nearly linear fashion, they do not double when the ISG production rate doubles. This demonstrates that while production rates are a significant cost factor for the ISG alternative, other substantial costs could be incurred independent of production rate.

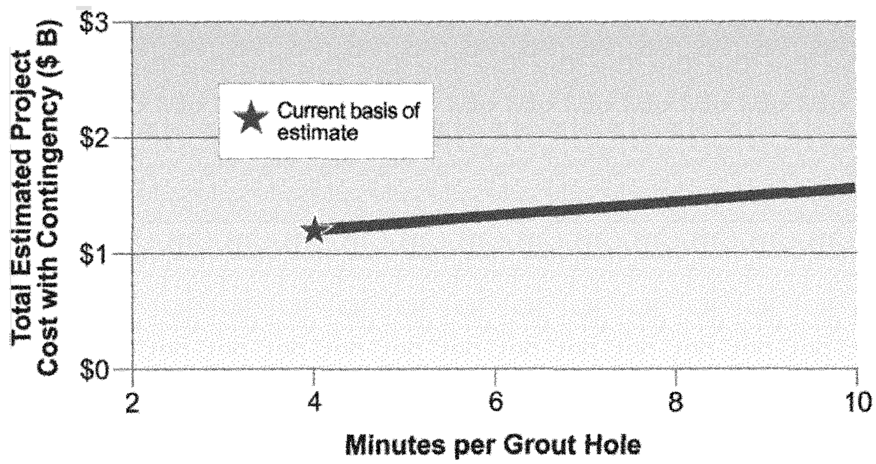

Figure 4-8. Sensitivity analysis for In Situ Grouting alternative production rates and total capital costs.

4.5 Alternative 4—In Situ Vitrification

4.5.1 Alternative Description

This alternative relies on in situ vitrification (ISV) as the primary technology to treat the COC-bearing waste streams within the SDA. The technology would be applied to the TRU Pits 1 through 6 and 9 through 12, and the TRU Trenches 1 through 10. Waste on Pad A would be reconfigured and treated with ISV. To minimize potential occurrence of melt expulsion event during ISV processing, ISTD would be used in the waste areas as a pretreatment. Vitrified waste materials would then be further isolated from potential future human or ecological receptors through construction of a low-permeability biotic barrier cover system.

In Situ Vitrification Alternative Remediation Strategy

Stabilizing and treating buried waste with in situ vitrification (ISV) and selective in situ grouting. Contaminants would either be destroyed or immobilized in glass-like monoliths (and grout monoliths) reducing migration to adjacent media to acceptable levels. Future exposure to the stabilized waste would be prevented through implementing administrative and physical land-use restrictions and would include placement of a low-permeability and biotic barrier cover system.

Key Elements:

(1) In situ vitrification with in situ thermal desorption pretreatment
(2) Reconfiguration of the Pad A waste for ISV treatment
(3) Selective in situ grouting of buried waste
(4) Foundation grouting
(5) Placement of low-permeability cover system
(6) Physical and administrative land-use restrictions
(7) Long-term monitoring and maintenance.

The ISV technology would remove and destroy organic constituents of waste and encapsulate most inorganic constituents within a durable, glass-like monolith. This stable waste form would reduce the potential for migration of identified COCs to adjacent media. The exceptions are C-14, I-129, Nb-94, and Tc-99 in activated metal, which are not likely to be incorporated into the melt, but instead would remain in association with the metal that would pool at the base of the melt (Thomas and Treat 2002). The activated metal waste streams containing C-14, I-129, Nb-94, and Tc-99 are located primarily in the SVRs and in isolated areas in the non-TRU trenches. Because the activated metal is remote-handled with very high gamma radiation, significant safety issues are associated with retrieving this waste. Furthermore, there would be no disposal option for this waste if it was retrieved. Therefore, to ensure compliance with the RAOs, in situ encapsulation using ISG technology would be performed.

4.5.1.1 Primary Technology—In Situ Vitrification. The ISV components of the alternative, summarized in following subsections, include readiness activities, treatment, capping, access restrictions, and long-term monitoring and maintenance. ISV treatment activities in this alternative include moving the waste on Pad A to a new adjacent pit while adding more soil to ensure a mixture suitable for vitrification, placing a layer of soil over the areas to be vitrified to meet the 10-ft cover objective, preconditioning the waste using ISTD, vitrifying the waste using ISV, treating off-gases generated during ISTD and ISV processing, and treating secondary waste produced during off-gas processing.

4.5.1.1.1 Readiness Activities—Readiness activities include further site characterization and analysis of waste generation and disposal records, testing, design, construction, permitting, authorization-basis analysis, and operational readiness reviews.

Further characterization and analysis of records are needed to better establish bounding conditions for safe and effective operations at individual ISV melt settings. A preliminary review of data indicates that the potential exists for excessive levels of combustible and alkaline materials and perhaps inadequate soil at some melt settings. The potential for encountering spent fuel and high radiation sources also exists. These issues need improved bases for planning tests and developing the authorization basis and design for safe operations.

A significant level of nonradioactive and radioactive testing would be required in this alternative. This alternative would employ ISV and ISTD in unproven applications. Unique conditions for these technologies include high concentrations of potentially respirable plutonium powders in some waste containers and the possible presence of spent fuel, high-gamma-radiation sources, and gas cylinders. In addition, it is imperative that large melt expulsion events be precluded because of severe burn hazards and inhalation risks created when airborne plutonium powder escapes a gas containment system under pressure. Including ISTD in the alternative and maintaining a minimum of 10 ft of soil cover over the molten glass at all times have potential to preclude melt expulsion events. Testing under bounding conditions would be required to prove that these features would ensure safety and effectiveness. Tests of ISV and ISTD off-gas and secondary waste treatment systems also would be required to support the design of systems capable of meeting safe operating limits and complying with regulatory permit conditions.

4.5.1.1.2 Restaging Pad A Waste in Adjacent Pit—Waste on Pad A consists largely of closely spaced drums stacked 11-high and wooden waste boxes on an asphalt pad installed at grade. The drums cover an area of approximately 33,000 ft^2. Soil covers the stacked drums and is bermed around the site at about a 4:1 slope. The amount of interstitial soil between drums is deemed insufficient to ensure effective vitrification, especially in consideration of the large fraction of high-alkali waste placed in some areas on Pad A. Therefore, the waste would be restaged with an equal volume of soil in a 150 × 240 × 25-ft-deep pit constructed adjacent to Pad A. Contaminated overburden, underburden, and berm soil would be used as the source of soil added to the waste. The waste and soil mixture would fill the pit to within 5 ft of the top. A 5-ft layer of clean soil would be placed on top of the waste and soil mixture before the building was decontaminated and removed.

The restaging building would encompass the entire Pad A and the new disposal pit. A central wall would divide the building into two nearly equal areas. The plan dimensions of the building would be approximately 300 × 300 ft. The height of the building would be approximately 35 ft abovegrade in the Pad A area and 20 ft abovegrade in the new pit area. In the Pad A and new pit area, remotely operated bridge cranes equipped with clam shovels would be used to move the waste and soil to the pit. Transfer carts would be used to move waste in bins from the Pad A area to the pit area. The building would be constructed to Seismic Category II requirements, ensuring seismic stability while restaging activities are conducted. Water fogs would be employed to minimize airborne particulates. The building would be maintained under a negative pressure of about –4 in. water gauge to ensure containment of airborne contamination. Air in the building would be exhausted through HEPA filters and a stack after heating the air to above dew point temperature. Two 100% blowers would provide for exhausting the facility. A separate diesel-powered blower would provide ventilation in the event of loss of line power.

4.5.1.1.3 Addition of Soil to Protect Against Melt Expulsion Events—A large release of pressurized steam or other gas beneath the glass pool can cause a melt expulsion event. Soil would be added to the top of the designated pits and trenches to meet the objective of a minimum of 10 ft of soil over zones undergoing vitrification. The soil cover would provide a barrier to prevent expulsion of molten glass. Approximately 5 ft of soil covers the waste sites at present. A total of 12 ft of soil would be needed to allow for safely emplacing ISV starter path material between electrodes at a depth of 10 ft. This would ensure a 2-ft buffer of clean soil above the waste level at startup. As the melt grows and deepens, additional soil would be added to fill the hole created by subsidence, resulting in a soil cover of about 17 ft at completion of the melt.

The soil cover also must support the heavy equipment used during ISV, including 20-yd^3 dump trucks, boom cranes, and ISV off-gas hoods weighing more than 50 tons. Local soil contains sufficient clay to render the soil unsuitable for road use under rainy conditions. Thus, the upper 3 ft of soil would consist of a suitable road ballast material, compacted to meet vehicle load-bearing requirements. A 4-ft soil layer emplaced below the ballast would provide the remaining soil height to satisfy the minimum 10-ft cover requirement at startup.

The soil and ballast cover would be flat and extend 20 ft beyond footprints of the trenches and pits. These features would ensure a suitable surface for centering the ISV off-gas hoods over edges of the waste zone to be vitrified and then sealing the hoods to the ground. The cover would span the entire area that contains the designated trenches because the spacing between trenches averages only about 20 ft. Some contiguous pits also would be combined under the same soil and ballast cover to facilitate moving ISTD and ISV equipment. Specific groupings of pits and trenches under the same soil and ballast cover would include (1) all designated trenches and Pits 1 and 2, (2) Pit 3, (3) Pits 4, 6, 10, 11, and 12, (4) Pit 5, (5) Pit 9, and (6) the reconfigured Pad A waste. The soil and ballast cover placed on each of the waste-site groupings would be encircled by bermed soil with side slopes of 3:1. The berms would be 7 ft high and their bases would extend 21 ft beyond the edge of the cover. The total quantity of soil that would be used in the cover and berms is approximately 250,000 yd^3. The total quantity of ballast that would be used in the covers is approximately 170,000 yd^3. The soil and ballast would cover a total area of about 32 acres, not including the area covered by the berms.

4.5.1.1.4 Preconditioning the Waste Using In Situ Thermal Desorption—The ISTD technology would be used to precondition the waste and at least 2 ft of the soil underburden, before the ISV application. Like ISV, ISTD heats the waste, but at slower rates and to lower temperatures. Waste and underburden would need to be preconditioned to preclude risk of melt expulsion events during ISV and provide a concentrated off-gas stream that is more amenable to treatment than the diluted ISV off-gas stream. Waste would be heated to a level sufficient to dry out the soil and waste sludge, vaporize volatile materials, and safely breach most remaining sealed containers by the internal pressure generated by the heated contents. The underburden would be heated to remove interstitial water as well as water perched on the underlying basalt.

Release of steam and other gases during ISTD would take place without incurring melt expulsion events because unmelted waste at ISTD operating temperatures contains substantial interconnected porosity. This allows any steam and other gases rapidly released belowground to compress safely into the interconnected void space in the waste zone and then migrate toward gas extraction pipes. Melt expulsion events have occurred during past ISV operations because molten glass is an incompressible, impermeable fluid that prevents dissipation of pressurized gas into void spaces in the surrounding unmelted waste and soil. Gases released within molten glass are buoyant, and thus are released at the glass surface, sometimes with forces sufficient to cause melt expulsion events. The maximum temperature reached during ISTD (800°C [1,472°F]) is well below the temperature at which soil and steel melt. The minimum temperature that would be reached (360°C [680°F]) is the temperature at which metallic mercury boils. Other major components of the waste are sodium nitrate and potassium nitrate, which decompose at 380° and 400°C (680° and 752°F), respectively, and could be destroyed largely during ISTD. Gas cylinders also should be safely breached because they are constructed with gas vent plugs designed to slowly relieve pressure at approximately 200°C (392°F).

The ISTD would employ an array of heated stainless steel pipe assemblies inserted into the ground on an 8 × 8-ft spacing to a depth of approximately 3 ft below the buried waste. Each assembly would include a sealed pipe that contains an electrical resistance-heating element, a vented pipe used to extract gases, and thermocouples. Each extraction pipe would be connected to a pipe manifold that conveys the gases to an off-gas treatment system. Because the height of the waste zone averages about 9 ft, and because a 12-ft-thick layer of soil would cover the waste, the average pipe assembly would be inserted to a depth of 24 ft.

The assemblies would be inserted into the ground with either vibratory or hydraulic techniques. The INEEL has demonstrated the effectiveness of the vibratory technique in penetrating the waste zone with rods and beams to mechanically breach sealed containers. However, the method of inserting pipes in previous applications of ISTD was to drill oversized holes into the ground and simply lower pipes into the holes. The advantage of this approach is that steam and other vapors can pass into the space between the waste and a pipe assembly and then freely enter the gas-extraction pipe. Driving the pipes into the ground as required in the SDA application could cause the gas-extraction holes to become caked with soil, thereby reducing the rate at which heating and extraction could occur. Therefore, a method of sealing the extraction holes with a material that can be melted out is being developed. This method should allow the extraction pipes to be inserted using vibratory or hydraulic techniques while ensuring acceptable heating and extraction rates. A method of filtering gas-entrained plutonium and cesium-137 (Cs-137) powders within the extraction pipes also would be needed to ensure worker safety. An internal sand filter may be an effective option.

The ISTD process occurs at a rate that is largely a function of spacing the heating pipes. Heat is transferred from the heating elements to the pipes and then to the waste at a nominal rate of 350 W per linear foot of heated pipe. Six ISTD systems would be used, each paired with an ISV system. Figure 4-9 shows a plan view of a paired ISTD and ISV system.

Four larger systems would be used when processing pits, and two smaller systems would be used when processing trenches. With the 8 × 8-ft spacing of the pipe assemblies, heating would occur over about a 90-day period. This is in contrast to the 18-day period estimated to complete an ISV cycle. Thus, each ISTD system must cover an area approximately five times larger than the area being vitrified to match the ISV processing rate. In pits where the largest glass melts would be created, 100 pipe assemblies would be employed in each ISTD system. The smallest melts would be created when vitrifying trenches; these would require about 60 assemblies per ISTD system.

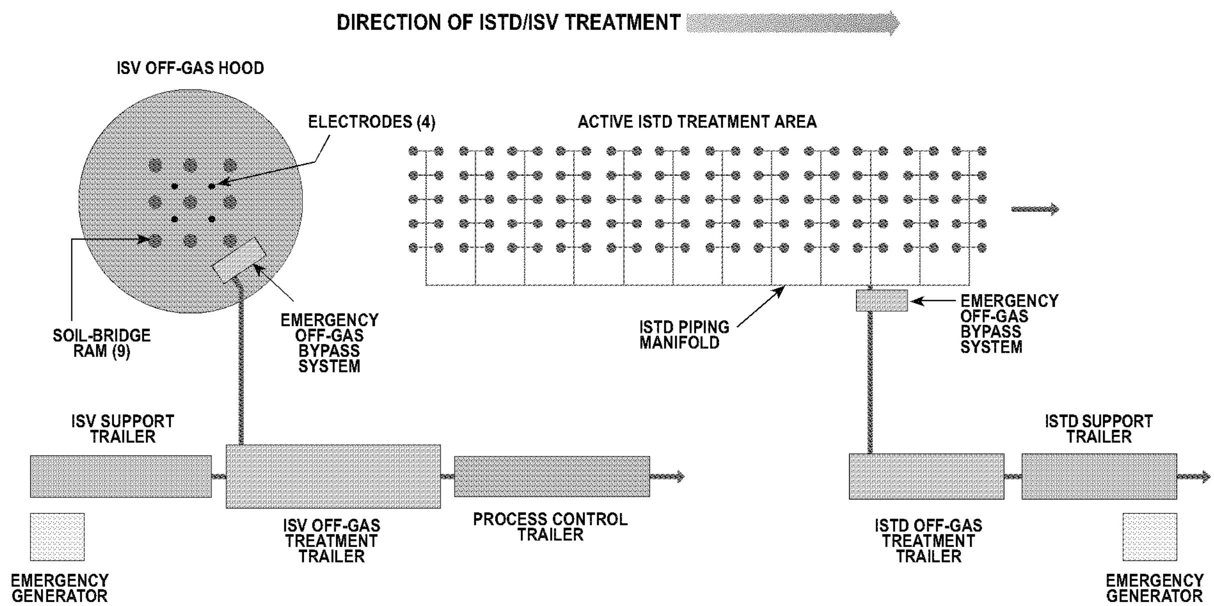

Figure 4-9. Plan view of paired in situ thermal desorption and in situ vitrification system.

Each of the larger ISTD systems would require about 330 kW of power. The smaller systems would require about 160 kW. Additional power would be required for off-gas processing. About 15 MW of installed power capability would be necessary to support all ISTD and ISV power needs in this alternative. Power would be distributed to the combined ISTD and ISV systems through power grid that would allow each paired ISTD and ISV system to draw a maximum of about 4 kW during nonroutine operations when high off-gas cooling demands are encountered. One power line at the OU 7-10 substation can currently provide 15 MW of power. However, for costing purposes for this alternative, it is assumed that an additional substation would need to be constructed to provide for long-term project-specific demands.

Each ISTD system would be operated as a single system or divided into five subsystems, each covering somewhat more than the area of a single melt. When a subsystem reaches its heating-temperature objectives, the pipe manifold that collects off-gases would be isolated from the rest of the off-gas manifold by closing valves. The 12 or 20 extraction pipes in the subsystem would be crimped closed; the manifold section would be disconnected and transported to the front of the advancing ISTD system and reconnected after gas purging at that location. ISTD processing at a given melt setting would be completed about a month ahead of the time at which ISV would begin. This approach would allow sufficient room for both ISV and ISTD operations while allowing both operations to be monitored and controlled from a single control trailer.

4.5.1.1.5 In Situ Vitrification—To raise the temperature of the ISTD-treated waste further (to approximately 1,500°C) to convert it to a glassy monolith, ISV would be used. The ISV application would complete the pyrolysis and decomposition of the waste constituents initiated by ISTD, then vitrify the waste and associated soil. Figures 4-10 and 4-11 depict application of planar ISV technology to pits.

The ISV process would heat soil and waste in the designated pits and trenches by passing current through the materials using four 12-in.-diameter graphite electrodes inserted into the ground. The amount of heat generated during ISV processing is a function of the electrical resistance of the soil and the current passed between electrodes. In situ vitrification is a much faster process than ISTD, which relies on conduction of heat outward into the waste from internally heated pipes. The insulating characteristics of soil and most waste materials limit the rate of heat transfer by conduction.

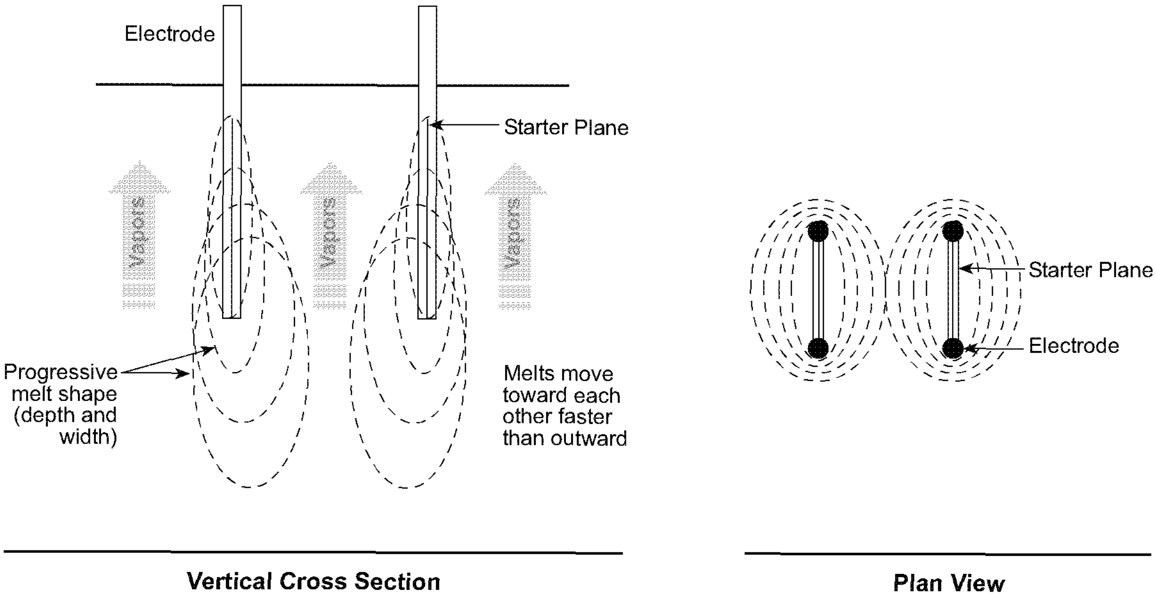

Figure 4-10. Cross-sectional and plan views of planar in situ vitrification melt progression (graphic adapted from LANL 2000).

As shown in Figure 4-11, electrodes used to vitrify pit waste would be installed in a square array on roughly 11-ft spacing. This configuration would create generally circular melts averaging about 35 ft in diameter. The shape of the melts in the trenches would be engineered to minimize melting into adjacent uncontaminated soil.

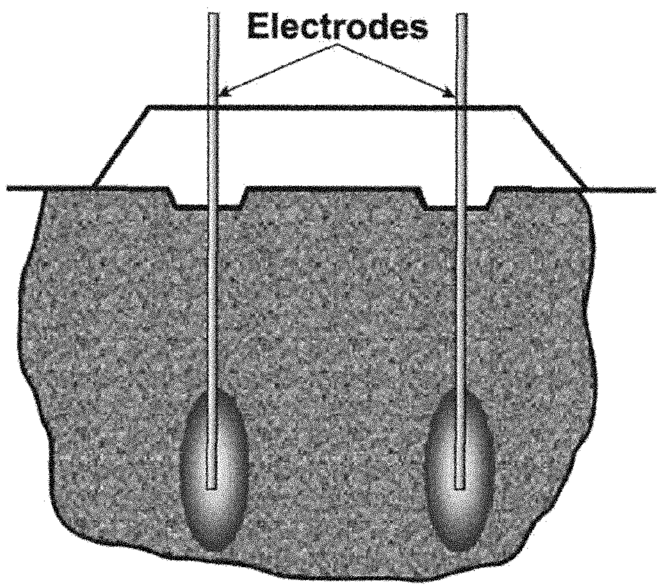

Figure 4-11. Subsurface planar in situ vitrification (graphic from LANL 2000).

Electrodes used to vitrify trench waste would be installed 11 ft apart in a line. This configuration would create oblong-shaped melts averaging approximately 35-ft long × 15-ft wide. Electrical current passed between pairs of electrodes would create generally planar melts (hence, the term planar ISV).

In the pit melting application, the planes would melt together and create circular-shaped melts. In the trench melting application, four electrodes would be installed along a line at points spaced 11 ft apart. Power would be supplied to each end electrode and the closest central electrode, causing two planar melts to form along the line. Power subsequently would be applied between the two central electrodes, causing the two planar melts to grow together into a longer planar melt.

When voltage is first applied to the electrodes in the ISV process, a flow of electrical current is established through an electrically conductive, buried starter path containing powdered graphite and glass frit. The resultant discharge of joule heat in the starter path raises starter-path temperatures to as high as 2,000°C. This temperature is well above the temperature required to melt soil (1,100 to 1,400°C). As the starter path melts, soil immediately adjacent to the starter path begins to melt and mix with the molten frit. These events increase both the electrical resistance of the molten frit and the amount of energy dissipated at a given amperage level (Buelt et al. 1987).

The starter path would be created using a backhoe to excavate trenches 2-ft wide × 10-ft deep (i.e., 2 ft above the buried waste level). A 1-ft-deep layer of the starter path material would be placed in each trench, followed by four 2-ft-diameter × 10-ft-long steel tubes inserted vertically on 11-ft centers. The trenches would then be backfilled with the excavated soil. The tubes would provide holes for guiding the electrodes to the desired starting elevation. If necessary, approximately 6 in. of electrically conductive grease would be added to the base of each tube to ensure adequate electrode-to-starter path conductivity.

When powered, the electrodes gradually would sink through the molten soil into the waste zone under their own weight, or, alternately, they would periodically be held at a selected depth using mechanical guides to help achieve greater melt widths. Thermocouples embedded in the waste at 30 and 35-ft-diameter locations would provide the capability to monitor the progression of the melt. The thermocouples would be connected electronically to a control trailer, where process operators could observe the waste temperatures in real time. The thermocouples would indicate progressively increasing temperatures as the melt grows, until burning out at approximately 1,400°C.

As the size of a melt increases, the surface area of the molten mass in contact with unmelted soil and waste also would increase until the amount of energy lost to cooling equals the amount added by joule heating. At this point, the melt would stop growing. The process would be engineered with sufficient capacity to ensure that desired melt parameters were achieved in the SDA application.

The volume of an ISV melt is usually much less than that of the original waste and soil. Densification of the waste and soil occurs because the glass usually contains few voids, and because the oxidation and pyrolysis that occur during melting largely eliminate organic materials. A volume reduction of 30 to 70% is typical. A 60% volume reduction would be expected in the designated pits and trenches at the SDA, resulting in melts averaging about 6 ft in height. The average depth of the base of a completed melt below the soil-cover surface would be about 24 ft.

On average, each melt setting would consume approximately 100,000 kWh, given an estimated power consumption rate of 300 kWh/ton of glass produced. The estimated time to provide power to a melt is 8 days, requiring delivery of 700 kW of power to the pit electrodes and 350 kW to the trench electrodes. The surface areas of the melts would overlap each other by 15%, and the melts would overlap into the soil that bounds the trenches and pits by an average of 6 ft, to ensure effective vitrification of contaminated areas. A total of 1,300 melts would be required over a 15-year operating period, necessitating four pit-ISV systems and two trench-ISV systems operating on an 18-day melt-to-melt cycle at a 70% total operating efficiency.

Gases produced at each ISV setting would be vented to a 70-ft-diameter off-gas hood centered over each melt zone. A pressure of about -1.3 cm or -0.5 in. water gauge would be maintained in the hood at all times using blowers to ensure containment of contaminants. About 99% of the total flow to the off-gas system would be air to ensure that the concentrations of flammable constituents of the off-gas would remain well below the lower flammability limit of the constituents. The hood would be substantially more robust than hoods used in earlier ISV applications. It would resist the highly corrosive effects of melt off-gases and effectively contain respirable TRU contaminants that may be emitted. High concentrations of hydrochloric acid in the off-gases suggests that construction using an expensive alloy (e.g., Hastalloy) may be required to ensure long life. The hood would be free-standing, circular in its plan dimensions, and capped with a rounded dome. Stress risers would be minimized in the design to enhance long life.

The heavy weight of this hood would require a tractor to move the hood to the next melt location. The free-standing hood would be hydraulically jacked 1 ft off the ground using an external frame and then driven 32 ft to the next melt setting, where it would be lowered to the ground. A boom crane with a minimum 60-ft reach and 5-ton capacity would be used to raise and move a hopper of dry sand around the boundary of the hood. An operator would direct the flow of sand from the hopper through a hose around the circumference of the hood to ensure that an adequate hood-to-ground seal is made.

The hood would be equipped with remote grapples to accept new electrode segments at the four electrode positions located near the center of the hood. The grapples would also screw the segments onto the electrodes and then lower the electrodes into the tube guides installed over the starter paths. The crane would lift and transfer 12 to 16 electrode segments to the grapple positions during each 8-day ISV power-on cycle. The crane used to seal the hood to the ground also would be used to lift electrode segments and perform several other functions including moving the ISTD pipe manifold. Thus, a crane would be dedicated to each of the six ISTD and ISV systems.

Additional hood equipment would include nine hydraulic rams capable of breaking down bridges of soil that may form over the melts as the waste undergoes volume reduction during melting. This step would ensure that the 10-ft protective soil cover would be maintained and not breached during a cave-in. The top of each ram would be equipped with a cyclone and star valve to aid in the receipt and delivery of washed, dry sand to the hood through a center-line hole in the ram. Washing the sand would be necessary to minimize the dust load on the off-gas treatment system and to minimize generation of secondary waste. Dry sand would be pneumatically delivered from a 20-yd^3 hopper truck each day to the cyclones and fed down the hollow core of the rams into the enclosed space of the hood. The addition of sand to the hood would compensate for the average 10 ft of subsidence expected during vitrification and provide insurance that the waste area would not become exposed to air. Exposure of the hot, dry waste to air could increase the risk of an underground fire. Adding sand to the melt area on a daily basis also would rejuvenate its filtering effect, helping to limit the upward migration of contaminants. This also would provide additional protection against a melt expulsion event.

Approximately 7 ft of sand would be added to the subsidence zone, leaving 3 ft to be filled with road ballast after the hood would be moved to the next location. Before the electrodes are powered, sand would be added through the center ram to establish a cone of sand 15 ft in diameter at its base. The flow of sand down the surface of the cone would result in filling the annular space between the electrodes and the electrode insertion tubes, thereby ensuring that a 10-ft cover of soil would be established in all areas before the electrodes are powered. Operating the rams would tend to flatten out the level of sand under the hood.

Approximately 300,000 yd^3 of sand would be delivered and placed to seal hoods to the ground and compensate for subsidence. Approximately 100,000 yd^3 of ballast would be delivered and placed to restore the load-bearing capability of the site to support future traffic. Approximately five 20-yd^3 truckloads of sand and ballast would be delivered each day to the six locations undergoing ISV.

4.5.1.1.6 Treating Off-Gases Generated During In Situ Thermal Desorption and In Situ Vitrification—Separate off-gas treatment systems would be used to treat off-gases generated by the paired ISTD and ISV systems for the following reasons:

- Off-gases generated by the ISTD system would be highly concentrated in flammable species, including hydrogen and carbon monoxide. This gas stream must not be mixed with air except when achieving controlled combustion. In contrast, the off-gases generated by the ISV system would be diluted with 100 parts of air to 1 part of melt gas in the off-gas hood, specifically to preclude the possibility of combustion or an explosion.

- Off-gases generated by the ISTD system would contain most of several volatile species that may not be as effectively treated in the highly diluted ISV off-gas stream. These species include volatile organic carbon compounds that escape pyrolysis, acidic halogens (notably hydrochloric acid) created during the hydrolysis of CCl_4 and other halogenated hydrocarbons, nitrogen oxides created during the dissociation and reaction of sodium and potassium nitrates, and mercury vapors.

- Off-gases generated by the ISTD system would be produced continuously, whereas off-gases generated by the ISV system would essentially cease several days after curtailing power to the electrodes.

Both off-gas systems would be subject to considerable variability in concentrations of off-gas streams because of high variability in compositions of buried waste. The five times larger area covered by the thermal desorption system and the leap-frog strategy of moving ISTD off-gas manifolds forward rather than thermally desorbing the same area all at once would dampen much of the gas variability in the ISTD process. Concentrations of semivolatile materials entering the ISV off-gas system would vary, but the sand layer maintained over the melt may be very effective in condensing semivolatile materials and filtering smoke and dust particles. Effective condensation of fission products having high gamma energies from spent fuel and radiation sources (especially Cs-137) and the filtration of TRU-contaminated particles would be critical to ensuring worker protection.

Additional definition of the compositions of buried waste within specific 1,000-ft^2 zones of the trenches and pits would be required to establish bounding conditions necessary for designing the off-gas systems and performing hazard analyses. (The average area of a pit melt is about 1,000 ft^2.) The limited analysis used as the basis for this PERA shows that the off-gas systems must protect against environmental releases of mercury, TRU-contaminated particles, acid gases (in particular nitrogen oxides, carbon monoxide, and hydrochloric acid), and volatile organic carbon compounds. Volatile and semivolatile radionuclides, (e.g., chlorine-36, Cs-137, I-129, and tritium), may be (1) present below levels of concern, (2) effectively condensed in the sand cover, or (3) effectively removed in the treatment train designed for the chemical COCs. Additional testing and analyses of the potential concentrations of these radionuclides in the off-gases would be necessary to determine if special removal processes must be incorporated into the off-gas systems.

The conceptual ISTD off-gas system would include traps to condense and collect elemental mercury as the off-gas exits the gas extraction pipes. Other trap locations also may be needed in the off-gas collection manifold to minimize corrosive damage to piping. The gas would then pass through a roughing filter and a metal HEPA filter designed to stop further entrainment of any TRU-contaminated particles that may be present. After filtration, the still-hot gases would be chilled to about 20°C (68°F) to condense and collect both water and mercury in a wet scrubber or demister. Elemental mercury would be collected in traps and condensed water would be passed through two activated carbon filters in series to remove organics and mercury in the +2 valance state. Feasibility of the wet carbon adsorption step would require further evaluation after bounding conditions for 1,000-ft^2 zones are established and off-gas treatment flow sheets are developed.

Water after adsorption would be neutralized with sodium hydroxide or lime and evaporated to a salt concentration of about 3 molar using primarily waste heat generated by the off-gas system. The concentrated salt solution would be transported in 1,000-gal tanker trucks to a Secondary Waste Treatment Facility (described in the following subsection) for further processing. One tanker truck would be transported every 5 days to the Secondary Waste Treatment Facility. Approximately 200,000 gal of 19-molar sodium hydroxide would be needed in ISTD and ISV off-gas neutralization processes over the 15-year period of operation. Two 5,000-gal steel tanks would be needed—one a heated tank for receipt of the 19-molar sodium hydroxide, and one for preparing dilute neutralization feed. Both tanks would be installed in a lined, bermed basin for protection of workers and the environment in the event of a leak.

Scrubbed but still-acidic off-gases would then be treated in a thermal oxidation unit using natural gas as the source of heat (when required) and controlled-air feed as the source of oxygen. Approximately 1 MW of natural gas would be used for thermal oxidation, evaporation, and other heating purposes. Thermal oxidation would effectively oxidize carbon monoxide and almost all of the volatile and semivolatile organic carbon materials. The presence of significant concentrations of certain acid gases (e.g., sulfur oxides) may prevent using catalysts, thereby requiring high-temperature oxidation and an increased cooling demand for subsequent gas treatment.

Resulting gas would be cooled and then passed through either a dry acid scrubber or a dry carbon adsorber, depending on whether the concentration of mercury would be high enough to contaminate the lime-based acid scrubbing medium. If so, two activated carbon adsorbers first would be used in series to remove mercury in the +2 valance and residual organic carbon. Removing mercury in the +2 valance state likely would be optimized in the presence of hydrochloric acid vapors. The acidic gases would then be passed through two bag houses or static lime-based dry scrubbers in series to remove acid halogens and sulfuric acid before being drawn into a blower. The blower would impel the gas forward to a selective catalyzed reactor (SCR) where anhydrous ammonia would be injected to chemically reduce the nitrogen oxides to nitrogen gas. A tanker truck would deliver ammonia to each of the six systems every few weeks. Approximately 200,000 gal of anhydrous ammonia would be consumed over the 15-year processing period. The fully treated gases would be discharged to the atmosphere through a stack. This conceptual off-gas treatment system would be included as part of the overall process-flow diagram for the ISV alternative shown in Figure 4-12.

The ISTD off-gas system would include two identical treatment trains, both designed for 100% capacity at approximately 100 ft^3/minute. Adsorber vessels would be mounted on skids. Both trains would operate simultaneously but one in standby mode to ensure readiness in case the other fails. Both trains would be installed in a single off-gas-processing trailer. The off-gas treatment process would be controlled from the same trailer used to control the thermal desorption, ISV, and ISV off-gas treatment processes. Two diesel generators designed to withstand the design-basis earthquake would provide emergency power to blowers in the event of loss of line power to ensure continued ventilation of the off-gas system.

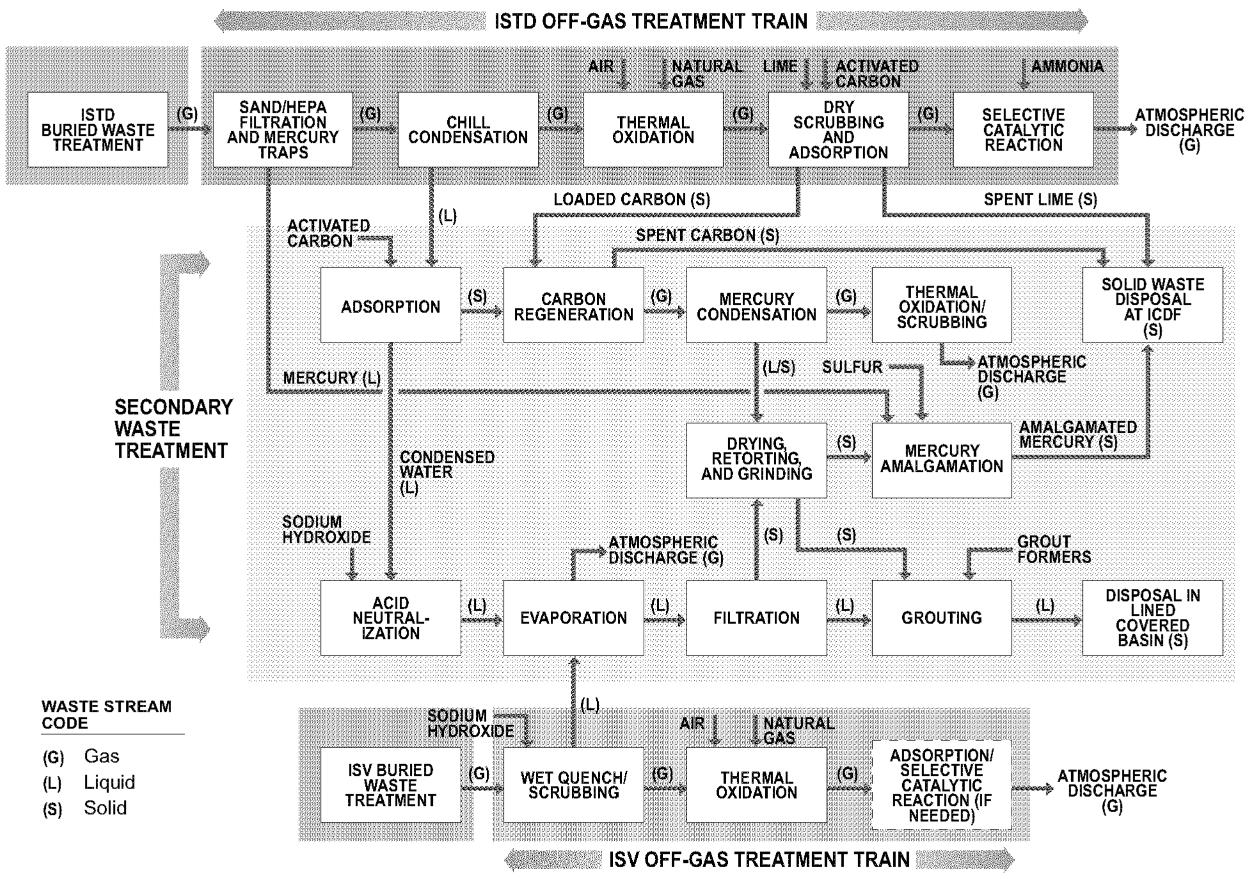

Figure 4-12. Process flow diagram for in situ vitrification.

The ISV off-gas system would be similar to the ISTD system, but would be nearly 100 times the capacity of the ISTD system to accommodate the dilution air added at the hood. The off-gas treatment train would begin with a roughing filter and HEPA filter, followed by a quencher and wet scrubber with a mercury trap and solids filter. Water recirculated through the scrubber would be neutralized with sodium hydroxide or lime to scrub acids from the off-gases. The scrub solution would be evaporated using primarily waste heat and then trucked to the Secondary Waste Treatment Facility for further processing. The scrubbed off-gases would be passed through banks of activated carbon adsorbers to remove trace organics and mercury. The fully treated gas would be drawn through two 100%-capacity blowers and discharged to the atmosphere through a stack. Like the ISTD system, the ISV system would include two identical off-gas treatment trains that would fit onto a single trailer (with the exception of the adsorber vessels).

Redundant ventilation systems provided for each ISV system are necessary to effectively contain airborne contaminants. Each redundant off-gas treatment train would be capable of drawing and treating about 3,000 ft^3/minute of gas. As a necessary precaution, an emergency backup ventilation system powered with the emergency diesel generators would automatically be activated during a large earthquake that might sever the duct connections between the hoods and off-gas trailers. A seismically qualified damper on the hood would be automatically opened to start emergency ventilation. Hood gases would be drawn by an emergency blower through a bank of metal HEPA filters and then discharged to the atmosphere from a short stack. The same system would be used in other emergencies and when moving the hoods. Similar but much smaller emergency systems would be employed in each of the ISTD systems to prevent explosion.

4.5.1.1.7 Secondary Waste Treatment—Secondary waste generated during ISTD and ISV operations would include flasks of elemental mercury; vessels containing saturated activated carbon and spent acid sorber materials; concentrated, neutralized scrubber solutions; and failed equipment. Failed equipment would include spent roughing filters and HEPA filters, and corroded or plugged pipes and off-gas processing vessels. Failed equipment potentially contaminated with TRU materials would be treated and disposed of by placing it on top of one of the trenches purposely not covered with soil and road ballast. The failed equipment would be covered with soil and ballast, and then vitrified with the waste beneath it. A small fraction of the failed equipment, particularly the filters, may be classified as TRU waste. Requirements for disposal of failed equipment would need to be specified in the ROD if this alternative were selected for implementation. Most of the remaining secondary waste would be classified as either LLW or MLLW.

The concentrated acid scrubber solutions would be transported from the ISTD and ISV off-gas systems in 1,000-gal batches and pumped into an agitated 10,000-gal steel tank. The solution would then be filtered or centrifuged to remove sludge, which would likely contain mercury and other heavy metals requiring treatment. The sludge would be dried and retorted to drive off mercury, which would be condensed and further treated. The filtered scrubber solution would be collected in one of two other 10,000-gal tanks in preparation for grouting, which would immobilize the solution and heavy metals it may contain.

Grouting would be accomplished on an 8,000-gal waste batch basis once every 40 days. A dry grout blend consisting of Portland cement and slurry-suspending clay would be mixed in a ratio of about 10 lb of blend per gal of waste solution. Volume of the resulting grout slurry would be about 50% greater than volume of the solution. The grout slurry would be pumped approximately 300 ft to a basin where it would flow to a low point and harden. The basin would be approximately 200 ft^2 at the surface, double-lined with polyethylene, and covered with floating polyethylene. It would be designed to contain about 2 million gal of grout. Dry grout blend material would be purchased premixed from a vendor, transported in 20-yd^3 hopper trucks, and unloaded using pneumatics into a 50-yd^3 grout-feed silo. Approximately 6,000 tons of dry blend material would be required over the 15-year operating period. Treatment and disposal requirements for the grout basin should be specified in the ROD if this alternative were selected for implementation.

Saturated activated carbon would be regenerated under elevated temperatures and chemically reducing conditions. This step would enable its reuse about 10 times by removing adsorbed mercury and organic compounds. The estimated quantity of spent activated carbon disposed of is 1,000 55-gal drums. Spent carbon would be disposed of at the ICDF. Organic materials desorbed from the carbon would be destroyed in the vapor form in a small thermal oxidation unit. Desorbed mercury would be reduced, condensed, and then amalgamated along with mercury collected in flasks during ISTD and ISV processing and with mercury condensed during retorting scrubber sludge.

Mercury amalgamation would occur by combining and mixing the mercury with elemental sulfur or proprietary chemicals at ambient temperature, then vigorously agitating the mixture to create the amalgam. Some scrubber sludge that resists retorting would be ground to a fine powder and amalgamated as well. Approximately 100 tons of sulfur would be needed in the amalgamation process. The estimated total quantity of amalgamated waste produced is 2,000 5-gal containers. Amalgamated waste would be disposed of at the ICDF.

Spent acid sorber material would be disposed of directly in its processing vessels at the ICDF. Approximately 500 500-gal vessels of spent acid sorber material would be disposed. A similar volume of waste would be produced if bag houses were used for dry acid scrubbing.

The Secondary Waste Disposal Facility would be a metal-frame building that provides approximately 10,000 ft^2 of floor space. The building would have about 20 ft of headroom and would also house a small laboratory for analyzing secondary waste and treated products, in addition to the secondary waste treatment processes previously described. A maintenance and storage building would be located nearby, as would an office trailer with a lunchroom, and another trailer with a change room.

4.5.1.2 Supplemental Technologies. To provide compliance with the RAOs, this alternative requires implementing a number of supplemental technologies within the SDA to address contaminant-specific concerns and provide for long-term stability of the cover system.

4.5.1.2.1 Grouting—The ISV technology would adequately treat identified COCs, with the exception of C-14, I-129, Nb-94, and Tc-99 associated with activated metal waste. These contaminants might not be incorporated in the melt, and would remain with metal that would pool at the base of the melt (Thomas and Treat 2002). The metal would leach at a higher rate than glass, thereby releasing the C-14, I-129, Nb-94, and Tc-99 and adversely affecting the quality of the underlying groundwater. The general distribution of the activated and fission product waste within the SDA is depicted in Section 2. As shown, the activated and fission product waste containing C-14, I-129, Nb-94, and Tc-99 are located primarily within the SVRs and isolated areas within the remaining low-level waste trenches. To address this issue, this alternative requires that the ISG technology be applied to these areas to immobilize C-14, I-129, Nb-94, and Tc-99.

Implementing ISG in these areas would follow the implementation presented previously for the ISG alternative in Section 4.4, and addressed in the accompanying technical report (Armstrong, Arrenholz, Weidner 2002).

4.5.1.2.2 Capping—To isolate treated waste and inhibit any future biotic intrusions, a low-permeability cap would be constructed over the entire SDA to limit infiltration of water and further reduce the mobility of waste. The proposed multilayer cap isa modified RCRA Subtitle C Cap, described previously for the ISG alternative. The cap consists of eight layers, including topsoil, sand filter, gravel filter, lateral drainage layer, asphalt, and a base course over grading fill. Before the cap is placed, subsurface stabilization with grout would be conducted to ensure foundation stability in nonvitrified areas and to minimize future subsidence-related maintenance requirements. These activities would be conducted when vitrification has been completed. Grading fill initially would be placed over the SDA where required to reduce surface undulations and crown the site before cap construction.

4.5.1.2.3 Access Restrictions—The land-use restrictions identified for this alternative would be similar to those discussed for the ISG alternative and primarily would involve controlling future access and developing the immediate site area.

4.5.1.2.4 Monitoring and Long-Term Maintenance—Groundwater, vadose-zone, and air-monitoring activities would be conducted as described for the ISG alternative. A review of the monitoring requirements, operations and maintenance activities, and trends in monitoring data would occur every 5 years to evaluate the effectiveness of the remedial action. Routine maintenance would be performed to repair monitoring wells and correct damage done by burrowing animals and erosion. For costing purposes, these activities are assumed to occur for 100 years. Because of the nature of the remedial actions associated with this alternative, it is assumed for costing purposes that monitoring requirements could be reduced after the initial 5-year review. The projected reduction would include 50% of the groundwater and lysimeter monitoring and elimination of the vapor port monitoring.

4.5.1.3 ***Estimated Project Schedule.*** Figure 4-13 shows the anticipated project schedule for implementing this alternative. Assuming a ROD signature date of 2005, the projected remedial activities would require approximately 24 years to implement, with completion in the year 2029.

As shown in Figure 4-13, it is projected that following completion of the ROD in 2005, approximately 8 years would be required for design and procurement, testing, and construction and testing of equipment. The ISTD and ISV waste treatment would begin in 2014.

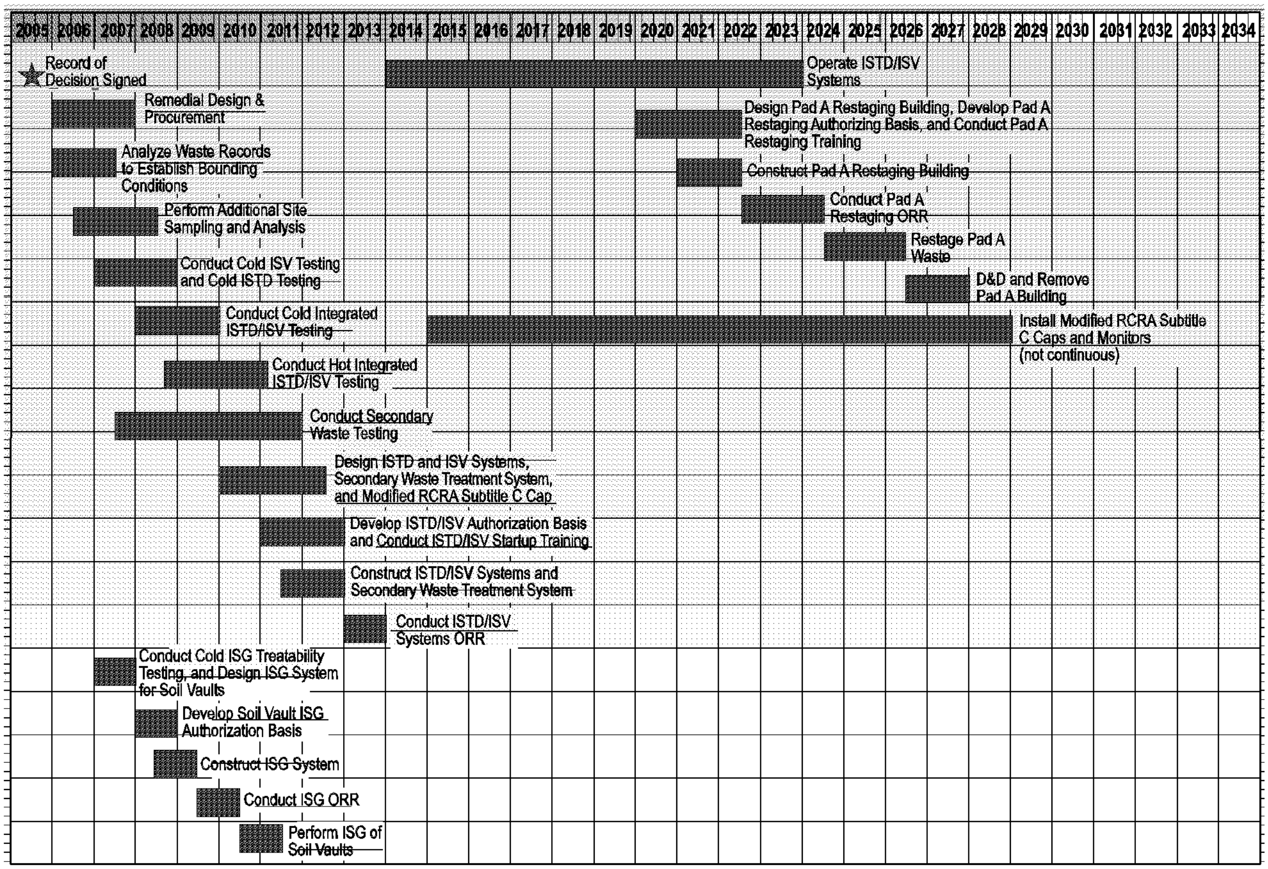

Figure 4-13. Schedule for the In Situ Vitrification alternative.

4.5.2 Screening Assessment

In the following sections, an assessment is provided of the ability of the In Situ Vitrification alternative to satisfy the two threshold criteria and the five balancing criteria described in Section 4.1.

4.5.2.1 ***Overall Protection of Human Health and the Environment (Threshold Criterion).*** The ISV alternative would be protective of human health and the environment and achieve the RAOs. Additionally, implementation of the alternative would reduce risks to an acceptable level. Preliminary schedules show that the alternative would be fully implemented by 2029, approximately 9 years following closure of the active pits. Because contaminants would remain at the site, monitoring would be continued through the 100-year institutional control period.

4.5.2.2 Compliance with Applicable or Relevant and Appropriate Requirements (Threshold Criterion).

4.5.2.2 Compliance with Applicable or Relevant and Appropriate Requirements (Threshold Criterion). This alternative involves the solidification of buried waste by the process of ISV and the construction of a low-permeability surface cover system. This alternative also involves treating selected areas with grout and restaging Pad A waste into a new pit to facilitate ISV of this waste. The key ARARs for the ISV alternative relate to containing buried waste over time. Under CERCLA, ARAR compliance would be addressed by considering chemical-, location-, and action-specific ARARs (and TBCs) independently. Appendix A presents a comprehensive summary of the potential ARARs that have been identified for this PERA. Table 4-11 provides the evaluation summary of the key ARARs for the ISV alternative.

Each requirement is identified by type (i.e., chemical-, location-, or action-specific), relevance (i.e., applicable, relevant and appropriate, or TBC), and regulatory source citation. The table also offers a conclusion as to whether the proposed alternative would meet a corresponding requirement. Detailed discussions of the significant requirements listed are presented in the following sections.

Table 4-11. Regulatory compliance evaluation summary for the In Situ Vitrification alternative.

ARAR or TBC	Type	Relevancy[a]	Citation	Meets Evaluation?
Radiation protection of the public and the environment	Chemical Action	TBC	DOE Order 5400.5	Yes
Idaho toxic air pollutants	Chemical	A	IDAPA 58.01.01.585 and .586	Yes
Idaho ambient air quality standards for specific air pollutants	Chemical	A	IDAPA 58.01.01.577	Yes
National emission standards for hazardous air pollutants	Chemical	A	40 CFR 61	Yes
Native American graves protection and repatriation regulations	Location	A	43 CFR 10	Yes—if encountered
Preservation of historic, prehistoric, and archeological data	Location	A	36 CFR 800 and 40 CFR 6.301(b) and (c)	Yes—if encountered
Protection of archaeological resources	Location	A	43 CFR 7	Yes—if encountered
Preservation of historical sites	Location	A	Idaho Statute 67-4601 et seq. and Idaho State Historical Statute 67-4101 et seq.	Yes—if encountered
Compliance with environmental review requirements for floodplains and wetlands	Location	A	10 CFR 1022	Yes
Protection of floodplains	Location	RA	Executive Order 11988; 40 CFR 6.302(b); 40 CFR 6 Appendix A	Yes
Remediation waste management sites located within floodplains	Location	A	40 CFR 264.18(b)	Yes
Location standards for TSD facilities located within floodplains	Location	A	40 CFR 264.1(j)(7)	Yes
Idaho groundwater quality rule	Action	A	IDAPA 58.01.11.006	Yes[b]

Table 4-11. (continued).

ARAR or TBC	Type	Relevancy[a]	Citation	Meets Evaluation?
Standards for owners and operators of TSD facilities—general groundwater monitoring requirements	Action	A	40 CFR 264.97	Yes[b]
National ambient air quality standards	Action	A	40 CFR 50	Yes
Idaho control of fugitive dust emissions	Action	A	IDAPA 58.01.01.650 and .651	Yes
Idaho fuel burning equipment—particulate matter	Action	A	IDAPA 58.01.01.675 through .681	Yes
Idaho particulate matter—process equipment emission limitations on or after July 2, 2000	Action	A	IDAPA 58.01.01.710	Yes
Standards for owners and operators of TSD facilities –closure and postclosure requirements	Action	RA	IDAPA 58.01.05 (40 CFR 264 Subpart G)	Yes
Standards for owners and operators of TSD facilities –landfills	Action	RA	IDAPA 58.01.05 (40 CFR 264 Subpart N)	Yes
Standards for owners and operators of TSD facilities—requirements for incinerators	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart O)	Yes
Standards for owners and operators of TSD facilities—remediation waste management rules	Action	A	IDAPA 58.01.05 (40 CFR 264.1[j][1] through [13])	Yes
Standards for owners and operators of TSD facilities—air emission standards for process vents	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart AA)	Yes
Standards for owners and operators of TSD facilities—air emission standards for equipment leaks	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart BB)	Yes
Land disposal restrictions	Action	A	IDAPA 58.01.05.011 (40 CFR 268)	Yes
Standards for hazardous air pollutants for source categories—waste combustors	Action	A	40 CFR 63 Subpart EEE	Yes
National Pollutant Discharge Elimination System	Action	RA	40 CFR 122.26	Yes
Radioactive waste management	Action	TBC	DOE Order 435.1	Yes

a. A = applicable requirement, RA = relevant and appropriate requirement, TBC = to-be-considered requirement
b. Evaluation criteria met not including the vadose zone contribution.
ARAR = applicable or relevant and appropriate requirements
CFR = *Code of Federal Regulations*
DOE = U.S. Department of Energy
IDAPA = Idaho Administrative Procedures Act
TSD = treatment, storage, and disposal

4.5.2.3 Chemical-Specific (Applicable or Relevant and Appropriate Requirements). The ISV alternative would meet RAOs for direct contact because the solidified, buried waste, and its overlying surface barrier would prevent human and ecological receptors from direct exposure. This alternative would also reduce or prevent mobility of COCs and reduce infiltration. Not including the contaminants presently in the vadose zone, the ISV alternative would inhibit COC migration from buried waste to underlying groundwater and meet the RAOs identified for groundwater.

Chemical-specific requirements of state and federal air quality standards would be met during construction and remediation. Idaho state requirements include controlling toxic air pollutants (IDAPA 58.01.01.585 and .586), ambient air quality standards for specific air pollutants such as particulate matter (IDAPA 58.01.01.577), and emission of fugitive dusts (IDAPA 58.01.01.650). Federal requirements include NESHAPs (e.g., radionuclides) (40 CFR 61) and NAAQS (e.g., particulate matter) (40 CFR 50).

4.5.2.4 Location-Specific (Applicable or Relevant and Appropriate Requirements). The location-specific ARARs for the ISV alternative are the same as those for the Surface Barrier alternative (see Section 4.2.4.2).

4.5.2.5 Action-Specific (Applicable or Relevant and Appropriate Requirements). The substantive portions of NESHAPs for hazardous waste combustors (40 CFR 63 Subpart EEE) are applicable for emission control of the ISV system if the system is defined as an incinerator in accordance with 40 CFR 260.10. The NESHAP establishes the MACT emission standards for constituents and destruction and removal efficiencies as well as RCRA requirements for incinerators (40 CFR 264 Subpart O), including design and operation. These requirements would be met through appropriate engineering controls.

Because ISV would leave waste in place, RCRA Subtitle C requirements for closure, postclosure, and landfills also may be relevant and appropriate because the SDA is not a new or existing RCRA-regulated unit (40 CFR 264 Subparts G and N, as adopted by reference in the State of Idaho "Rules and Standards for Hazardous Waste" [IDAPA 58.01.05]). Design and operation of the surface barrier would meet the RCRA substantive requirements for a top liner. In addition, the RCRA Subtitle C requirements for air emission standards for process vents (40 CFR 264 Subpart AA) and equipment leaks (40 CFR 264 Subpart BB) may be applicable for some equipment used during ISV and ISTD operations (e.g., if emission levels of restricted hazardous volatile waste are above established thresholds). If applicable, these requirements would be met by using appropriate engineering controls. In addition, RCRA general groundwater-monitoring requirements (40 CFR 264.97) using monitoring wells to detect the presence of COCs in the underlying aquifer would be applicable to the ISV alternative. Provisions for groundwater monitoring are included in this alternative.

Any organic vapors that may have accumulated beneath the biotic barrier following remediation would be collected, removed, and treated by the active OCVZ treatment system (OU 7-08) and the designed passive gas-collection layer operating in the modified RCRA Subtitle C cap. The EPA Office of Air Quality Planning and Standards is developing a new MACT for the remediation site source category. This MACT, projected to be effective after 2002, would apply to remediation sites that are major sources of organic hazardous air pollutants. If applicable to CERCLA sites, all vents, remedial material management units, and associated equipment components involved in the remedial activity could require emission controls. These requirements would be followed.

Vitrification of Pad A waste would require restaging the waste into a new deep pit. It is assumed that DOE would use the AOC concept described in *Management of Remediation Waste Under RCRA* (EPA 1998), and as allowed under CERCLA, to permit moving waste, including the hazardous waste associated with Pad A, without violating RCRA treatment, storage, and disposal requirements. The applicability of RCRA Subtitle C to move and consolidate previously disposed waste or contaminated media depends on whether these activities occur in the same AOC. Because the deep pit is proposed for construction next to Pad A, it is assumed that the transfer would occur within the same AOC.

Institutional controls are often included in remedies to enhance long-term management protection. These controls supplement engineered remedies (40 CFR 300.430[a][1]). Institutional controls including security measures, access controls, fencing, and land-use restrictions are components of this alternative. These controls would help prevent possible exposure to waste by human intruders and biota. The controls would also meet applicable DOE requirements for residual radioactivity left in place, including the related provisions of DOE Order No. 5400.5.

As required, NPDES storm water discharge protections and best management practices would be implemented for storm water controls, road building, waste management, and other related remedial activities as appropriate. Applicable DOE TBC requirements for protection of human health would be met during remedial activities.

Requirements of DOE Order 435.1 would be met. This order specifies that all DOE radioactive waste is to be managed in a manner that is protective of worker and public health and safety and the environment.

4.5.2.6 Long-Term Effectiveness and Permanence (Balancing Criterion). Implementation of this alternative would provide for reliable long-term protection. Applying ISV to waste in the TRU pits and trenches would produce a stable, leach-resistant waste form. The VOC constituents would be destroyed through the ISV treatment process or pretreatment by ISTD, wherever it is applied. Most inorganic constituents, including most radionuclides, would be encapsulated in a glass-like matrix. Some SVOCs (i.e., VOCs with low boiling points, and volatile radionuclides and metals [e.g., cadmium, Cs-137, lead, and mercury])would evaporate and condense on adjacent soil. In this event, these constituents may not be immobilized in the glass-phase of the final waste form. However, with construction of the surface barrier, any contamination that condenses on the overburden soil would be effectively isolated and contained, preventing human and ecological exposure.

Salt known to be present in the waste may also melt and migrate away from the melt zone well before the melting temperature of the soil is reached. Molten salt can wick into pores of the soil and may entrain other alkalis (e.g., Cs-137 and dissolved heavy metals) as they migrate. Therefore, a salt zone, if created, may have higher potential for leaching any entrained COCs than the more stable glass-like matrix. ISV testing would be required to determine if a salt zone would be formed, to identify the types and amounts of COCs that would partition into this phase, and to assess the long-term durability of a salt phase. Grouting the SVRs and trenches with high concentrations of the fission and activation products C-14, I-129, Nb-94, and Tc-99, which are in metallic form, immobilizes these contaminants and minimizes potential for migration.

Though this alternative would be effective at minimizing future risk, it is assumed that some COCs would have been released before remedial action could take place. The amount released to date and current release rates are not known with certainty. However, conservative estimates indicate that preremediation release may result in groundwater contamination posing a risk greater than 1E-04. Modeling indicates that this risk would peak by 2110 and would extend beyond the boundary of the SDA for a distance of approximately 460 to 600 m (1,500 to 2,000 ft). Therefore, this alternative could require institutional controls that prohibit using groundwater within this buffer zone.

The key components of the ISV alternative's long-term effectiveness and permanence include residual risk, the reliability of the treated waste system over the long term, and the effectiveness of controls.

4.5.2.6.1 Risk Modeling Assumptions**—**Simulations show groundwater ingestion risks where the highest concentrations occur in the model. Releases of COCs from vitrified waste were assumed to occur by corroding the surface of vitrified HLW glass. The rate used was 1E-05 gm/cm^2-d, which is based on results from an ISV demonstration at the INEEL in 1990 (Callow 1991); this value is equivalent to the established corrosion rate for vitrified HLW. The demonstration was a reliable indication of long-term durability at the time the test was performed, but it is now believed the vapor hydration test should also be performed to estimate long-term durability of vitrified radioactive waste (McGrail 2000). Therefore, significant uncertainty exists in assigning a corrosion rate to vitrified waste in the SDA. Though the corrosion rate is expected to be much lower than indicated by results from the demonstration, data to improve predictions of the long-term durability of vitrified SDA waste and soil are not available.

Releases from melted metal occur by corroding the surface of metal, which is assumed to have the same surface area as untreated waste metals. Using unchanged waste geometry coupled with a metal corrosion rate of 2.2E-04 mm/year (the expected rate of corrosion of stainless steel in a weak salt brine) (Adler-Flitton, Nagata, and Norby 2001) is a very conservative assumption. Realistically, the surface area available for corrosion would be greatly reduced and a large portion would be protected from corrosion by the vitrified matrix above the metal phase. However, data are not presently available to refine these modeling assumptions. Other factors, such as impurities in the metal, also could modify the effective corrosion rate.

For types of waste treated by ISG, contaminant releases from the grout were conservatively assumed to occur by diffusion from within 2-ft-diameter grout columns. These columns would be formed by the injection of grout into the waste to create interlocking columnar monoliths (see Section 4.2.5.1). For modeling purposes, the surface available for leaching was assumed to be the outside surface of the 2-ft-diameter columns. This is based on a conservative assumption that the points of contact between columns may be a zone of weakness where cracks could form. In reality, the surface area available for leaching would be much lower, but few applicable data are available to support improved predictions for grouted waste over long periods.

Certain COCs with carcinogenic risks greater than 1E-06 and unacceptable noncarcinogenic hazards (hazard indexes greater than 1.0) are assumed to be destroyed or partially removed by treatment in this alternative. These COCs include nitrates and all VOCs, including CCl_4, methylene chloride, and tetrachloroethylene. Nitrates and VOCs were assumed fully removed at the TRU pits and trenches during the application of ISTD and ISV.

Water was assumed to infiltrate the modified RCRA Subtitle C Barrier at a rate of 0.114 cm/year. Using the DUST-MS model, the infiltrating water was assumed to flow through the columnar joints in the grout and around the glass monolith at volumetric rates equal to the surface area of the waste sites times the infiltration rate. The volumes of water contacting treated waste in a given period were assumed to dissolve contaminants released in the same period, up to their solubility limits in water. Because of modeling limitations, the chemical alteration of infiltrating water as it passes through the grouted and vitrified waste could not be represented; hence, rates of release modeled may be higher or lower than would be expected. The concentrations of contaminants released from the source term were input to the TETRAD model for estimating groundwater concentrations and drinking-water risk. In addition, the cap and its integral biotic barrier were assumed effective in preventing the intrusion of plant roots into the soil above the melt where SVOCs would have condensed. Testing and further analysis would be necessary to quantify the amounts of condensed SVOCs and their potential impact to risk through the groundwater pathway.

4.5.2.6.2 Magnitude of Residual Risk—The magnitude of residual risk associated with the ISV alternative is illustrated in Figure 4-13. This figure shows the cumulative carcinogenic risk over time caused by ingestion of groundwater impacted by release of residual contaminants in the vitrified TRU pits and trenches and grouted SVRs. The figure provides two risk projections: (1) risk associated with postremediation release from the residual source term in the SDA only, and (2) total risk represented by release of residual source-term contaminants plus postulated contamination in the vadose zone before the application of ISV in the SDA. The risks represent exposure at the point of maximum groundwater contamination; the simulated location associated with potential COCs in the vadose zone lies at the southern edge of the SDA. Modeling results are that the near-term risks are dominated by contamination that may have been released to the vadose zone before ISV. However, high uncertainty exists in assumptions used in the risk modeling, as the mass of COCs in the vadose zone and the rates of release from the SDA are unknown.

As shown in the figure, carcinogenic risk associated only with postremediation release of residual SDA contaminants would reach approximately 4E-06 in 2,000 years and then stabilize between approximately 2E-06 and 5E-06 in 2,000 to 10,000. Carbon-14 accounts for approximately 80% of the risk 2,000 years. Technetium-99 and I-129 are other significant contributors. After 2,000 years, uranium isotopes dominate risk.

In the carcinogenic risk curve shown in Figure 4-14, the potential influence on risk levels because of contaminants previously released from the source term to the underlying vadose zone are presented.

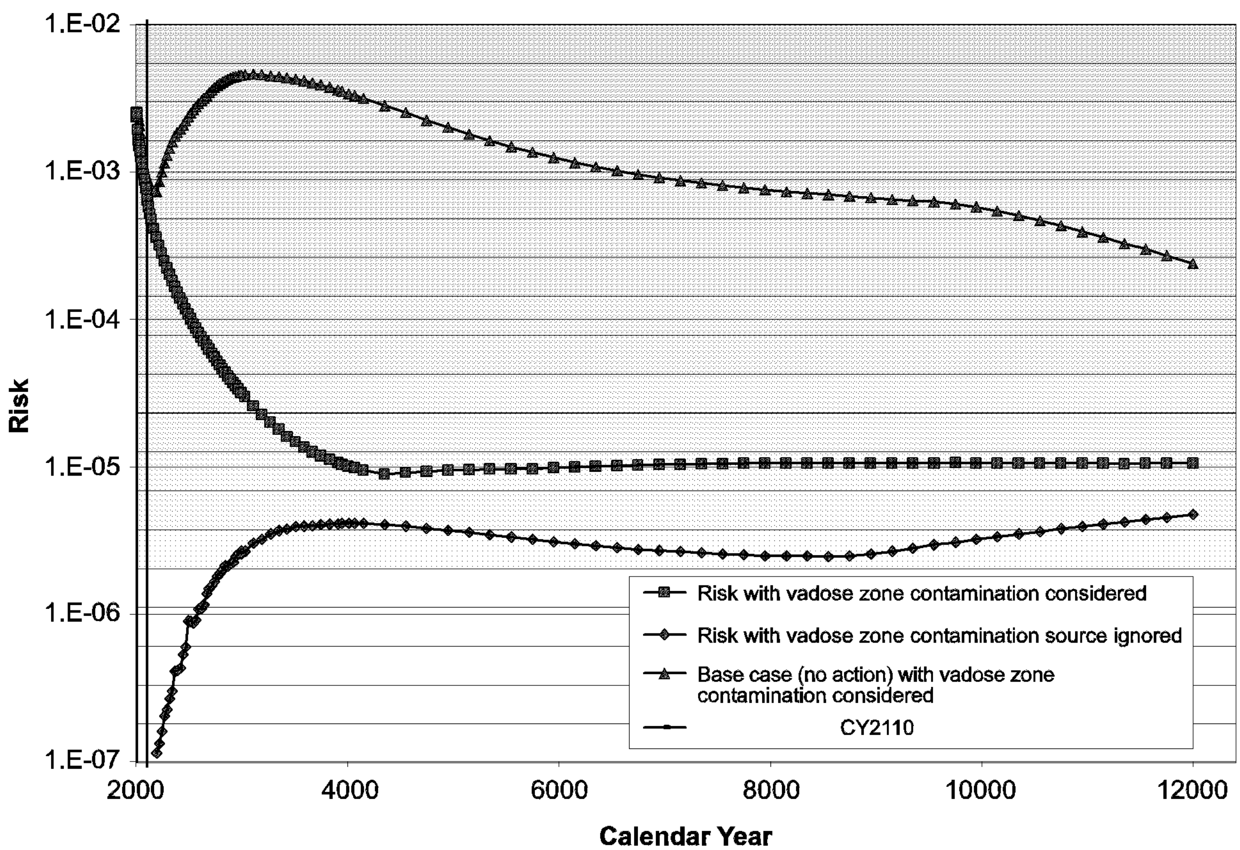

Figure 4-14. Carcinogenic risk for the In Situ Vitrification alternative.

Model results indicate that contaminants released to the vadose zone before implementing the remedial action may pose cumulative groundwater risk higher than 1E-04 for a zone that extends 1,500 ft beyond the SDA boundary. The residential hazard index for the ISV alternative is assumed less than 1.0. As stated previously, risk modeling indicates that the hazard index attributable to postremediation contaminant release under the Surface Barrier alternative would be less than 1.0. With treatment provided by ISV, the residual hazard index for the ISV alternative would be lower than that for the Surface Barrier alternative.

4.5.2.6.3 Adequacy of Reliability and Controls—The ISV and ISG waste forms would be physically and chemically stable over geologic time. Little or no long-term operational requirements for the treated waste forms are envisioned other than monitoring.

In addition to the physical chemical stability of the glass monolith and grouted matrix, the multilayered barrier would provide additional protection of human health and the environment by reducing infiltration and inhibiting biotic intrusion from the surface. The barrier also would minimize precipitation that reaches the glass and grouted waste forms, thereby further reducing leaching of the waste.

Monitoring treated waste and maintaining the barrier would be required in perpetuity to ensure effectiveness and permanence of the remedy. Regular monitoring (e.g., visual inspections, surface-elevation surveys) would be performed to detect compromises in the integrity or effectiveness of the barrier. The barrier would be maintained and repaired as required to achieve the original performance standards. Because of the required life span of the remedy, it is assumed that portions of the barrier would need to be repaired or reconstructed periodically and that the entire barrier would need to be replaced once every 500 years.

The long-term reliability and performance of the ISV and ISG treatment would be assessed through monitoring of groundwater, the vadose zone, air, fauna, and surface vegetation. In addition, a network of monitoring probes would be installed throughout the grout monolith before the grout cures, to collect moisture and vapor samples and monitor temperature, redox, and pH conditions over time.

To ensure protectiveness, active institutional controls would be required to limit land use near the SDA. A prohibition on drilling and using groundwater within a buffer zone around the SDA would be necessary. Access controls would be implemented and maintained in perpetuity to prevent intrusion into the waste.

4.5.2.6.4 Summary of Long-Term Effectiveness—Fate and transport modeling indicates that the postremediation peak carcinogenic risk would be less than 1E-04 and the hazard index would be less than 1.0 for the groundwater ingestion pathway, when the postulated contamination in the vadose zone is not included. The ISV and grout monoliths would be chemically and physically stable over geologic time. Appropriate institutional controls and operation and maintenance programs, plus periodic barrier repair and replacement, would provide additional long-term control for the vitrified and stabilized waste. Should the potential COCs in the vadose zone at the time of remediation cause groundwater contamination to exceed health-based levels in a zone beyond the boundary of the SDA, institutional controls would be required to prevent access to, and use of, any contaminated groundwater. Therefore, the ISV alternative could be an effective and permanent remedy.

4.5.2.7 Reduction in Toxicity, Mobility, or Volume Through Treatment (Balancing Criterion). As indicated, selected waste sites contributing to the potential risk to human health and the environment would be treated in place with ISV. Organic waste contaminants at the ISV sites would be destroyed or their masses reduced significantly. Most inorganic contaminants would be immobilized in glass, but some would be concentrated in the less leach-resistant metal zone at the base of glass melts. ISG applied to other selected waste sites would be effective in treating specific COCs (e.g., C-14). Off-gas treatment would be required in the ISV application to destroy or capture and treat volatile and airborne contaminants. The captured and treated off-gas contaminants would meet requirements for disposal at the INEEL. Further discussion on the quality and durability of the vitrified waste form is presented by Thomas and Treat (2002).

4.5.2.8 Short-Term Effectiveness (Balancing Criterion). Key components of the ISV alternative's short-term effectiveness entail protecting the public, workers, and environment as it is implemented.

4.5.2.8.1 Protecting the Community During Remedial Actions—Significant uncertainties exist about implementation of ISV at the SDA. However, advancements in ISV technology and results from cold testing would allow appropriate engineering and administrative controls to be developed to ensure safe implementation. At a minimum, traffic within the INEEL during the acquisition of borrow material would increase. If borrow material was obtained from off-INEEL sources, increased traffic would affect communities on and off of the INEEL. Traffic control plans to minimize the increase in transportation risk to both the on- and off-INEEL communities would be .

4.5.2.8.2 Protecting Workers During Remedial Actions—Remediation workers could be exposed to radionuclides in the surface soil during placing of the 10-ft-thick soil cover to protect against melt expulsion events. Conversely, the 1- to 2-m (3- to 6-ft) overburden soil present over the SDA makes significant exposure unlikely. If a release of contamination to the environment were to occur during ISTD or ISV, PPE and vehicles modified with positive-pressure ventilation system cabs and HEPA filters could be used to minimize exposure to residual radioactive contamination. Equipment modified for use in radioactively contaminated environments is available at the INEEL from previous remedial actions.

Other risks to workers would result from routine physical hazards, such as moving heavy equipment, including cranes, trucks, off-gas hoods, trailers, electrodes, and piping manifolds, during construction and operations. The risk of melt expulsion events, thermal hazards, and electrical hazards also would be elements of the ISV alternative. Including ISTD as a pretreatment and placing additional overburden soil would mitigate melt expulsion events. Training and using PPE would reduce thermal and electrical risks. Potential exposure to VOCs and other off-gas components would be limited through using hoods and off-gas treatment systems. Additionally, an explosion involving nitrate salt and reducing agents present in some of the waste streams is a potential chemical and physical hazard associated with ISV. Mitigation would be achieved by placing at least 3 m (10 ft) of overburden over the area to be vitrified.

A report prepared in support of this PERA (Schofield 2002) estimated risks to workers who are implementing this alternative. The evaluation considered direct external radiation exposure and exposure to mechanical injuries for remediation workers. No risks to the public were projected for this alternative because no off-INEEL transportation of hazardous materials would occur. Engineering controls during implementation would preclude the release of particulate radioactive materials. Estimated risks are:

- Cancer = 10.5
- Injury = 278.0
- Fatality = 0.62.

The evaluation predicts that during implementation of the ISV alternative, approximately 10 people would develop cancer because of exposure to hazardous substances, including radioactive material and radiation fields. Approximately 278 injury accidents with less than one fatality are estimated to occur during implementation.

Short-term risks were also quantified for off-normal occurrences (accidents) during implementation of the remedial action (Schofield 2002). These risks are portrayed in terms of the effects on a maximally exposed individual. The worst-case unmitigated accident scenario established for the ISV alternative was a melt expulsion event scenario. For this event, the unmitigated dose was reported at 37,000 rem, 50-year committed effective dose equivalent. However, for the subsurface planar ISV approach, as described in this report, the mitigating controls would reduce the maximally exposed individual exposure by a minimum of 1/10,000 or 3.7 rem, 50-year committed effective dose equivalent. The estimated lifetime cancer risk for the potential receptor is 2.33E-03.

Criticality is not an issue with respect to implementing ISV in the SDA for several reasons, but primarily because fissile isotopes would be dispersed (rather than concentrated) throughout the vitrified mass (Thomas and Treat 2002).

Occupational exposures would be kept ALARA and below the limits set forth in 10 CFR 835.202, "Occupational Dose Limits for General Employees." Radiological occupational exposures also would be kept ALARA and below the limits set forth in 10 CFR 835.202 of less than 5 rem/year.

The environmental monitoring component of this alternative is based on existing procedures that incorporate engineering, administrative, and PPE measures to ensure worker protection during monitoring activities.

4.5.2.8.3 Environmental Impacts Associated with Construction—Appropriate engineering and administrative controls would be developed to ensure safe implementation with minimal risk to the environment. Other environmental impacts include potential particulate emissions associated with construction activities and increased construction-related traffic. Particulate emissions would be controlled using dust-suppression techniques to ensure that exposure to off-INEEL receptors does not exceed 25 mrem/year total effective dose equivalent from all exposure pathways and does not exceed 10 mrem/year total effective dose equivalent through the air pathway in accordance with DOE Manual 435.1-1.

4.5.2.8.4 Time Until Remedial Action Objectives Are Achieved—Preliminary schedules project that the alternative could be completed within 24 years of an approved ROD. The ISV alternative would satisfy all RAOs, with the ultimate effectiveness of this alternative verified after the cap is constructed, operated, and monitored for some time.

4.5.2.9 Implementability (Balancing Criterion). Key components of the ISV alternative's implementability are technical and administrative feasibility and availability of services and materials.

4.5.2.9.1 Technical Feasibility—The ISV process, in particular the Subsurface Planar approach, is capable of processing selected SDA waste and producing a high quality glass waste form that is resistant to leaching over geologic time periods. The average size and depth of the waste appears amenable to applying subsurface planar ISV. The composition of the INEEL soil, the soil-to-waste ratio, and temperature and size of the melt appear to favor formation of a high-quality waste form.

However, certain waste conditions, including sealed, buried drums, large voids, and large metal forms have the potential to impede ISV processing. Remedial designers may require additional pretreatment beyond that planned or may exclude certain areas to avoid processing problems. In the past, these problems have included fires in the off-gas hood, explosions, and other violent melt expulsion events. Five of the 100 full-scale melts experienced at least one of these events while melting, resulting in damage to the equipment and termination of the project. The engineering study developed in support of the PERA describes the problems in detail and contains descriptions of two of the projects in which melt expulsion events occurred (Thomas and Treat 2002).

The wide range of hazardous constituents, and the uncertainty of their concentration and distribution, also presents a challenge for the design of the off-gas treatment system. The list of contaminants present at the SDA is extensive and complex, ranging from heavy metals and radionuclides to VOCs. Volatile and semivolatile metals, particulates, and products of pyrolysis of organics would be generated from an ISV melt. Examples of hazardous off-gas components include chloroform, I-129, benzene, cadmium, methylene chloride, tritium, nitrous oxides, and mercury. The technical feasibility of treating such constituents would depend on regulatory limits and the emission quantities and rates of emission derived from a more complete characterization of the waste streams.

While the ISV technology has been applied successfully in more than 100 melts over a period of about 10 years, the majority of the applications have been implemented at chemically contaminated soil sites. The technology has never been applied at a site where the amount of radiological material posed such a significant hazard as at the SDA. The presence of combustible, liquid, and reactive materials further complicates applying ISV at the SDA. Currently, it is unclear what measures would be required to adequately protect workers during ISV processing. Though a detailed safety analysis has not been completed, the potential for melt expulsion events and underground fires to expose workers to thermal, chemical, and radiological hazards remains despite mitigative features included in the alternative. The subsurface approach of planar ISV melting would significantly improve safety operations, but additional testing would be needed before requirements could be established for systems, structures, and components important to safety. Until these requirements have been defined, complications of this alternative are difficult to fully assess.

The implementability is rated low at this point because of the unresolved uncertainties about the potential for melt expulsion event, underground fires, and off-gas treatment. While researchers believe that new designs, in particular the subsurface planar ISV, would effectively mitigate many hazards traditionally experienced with ISV, the technology has not been sufficiently demonstrated on the variety and type of waste found in the SDA. Extensive analysis, design, and testing would be required before implementing ISV at the SDA.

4.5.2.9.2 Administrative Feasibility—Though most actions under this alternative would be implemented under CERCLA and would not require permits, substantive provisions of permits that would otherwise be required are considered ARARs. Any selected remedial alternative would be required to demonstrate ARAR compliance. The IDEQ and EPA would determine whether the selected remedy adequately addresses ARARs and would achieve ARAR compliance. Requirements for off-gas treatment would be stringent and may pose an implementation difficulty. Because the waste is not fully characterized, it may be difficult to design and permit an off-gas system to ensure air quality standards are not violated.

Safety disciplines, including radiation safety, industrial hygiene, and construction safety, are readily available at the INEEL. Regulatory compliance supports, including permitting required for construction activities, are also available. Though any changes to the storm water or Big Lost River systems may require assessing wetlands and associated environmental receptors or habitats, this issue is not anticipated to adversely affect the administrative implementability of this alternative.

Activities associated with the ISV treatment pose numerous nuclear hazards. According to DOE policy, all hazards need to be clearly identified and mitigated before the start of any nuclear operation. The approval process for any nuclear treatment or processing facility is inherently difficult and the uncertainties associated with ISV would further complicate the administrative approval.

4.5.2.9.3 Availability of Services and Materials—Currently, one commercial vendor is available to provide subsurface planar ISV services. Some equipment and services used in previous ISV remediation would be available, but given the potential consequence of an inadvertent radiological release, the equipment and systems, including the hood and off-gas treatment system, would be identified as safety-significant systems in accordance with DOE orders. That requires engineers to conservatively estimate the consequences to workers and the public that could result from normal operations and certain accident scenarios. In the case of ISV processing at the SDA, the preliminary conclusions are that the risks to workers would be significant enough to require specialized equipment. Determining safety risk would require designing and fabricating new equipment not readily available from the commercial ISV provider. The difficult design, manufacturing, and testing requirements associated with safety-significant systems structures and components substantially lower the implementability of this alternative.

One power line at the OU 7-10 substation can provide 15 MW of power. This alternative incorporates construction of an additional substation to meet project-specific power demands.

4.5.2.10 Cost (Balancing Criterion). The net present value of the ISV alternative is estimated at $1,197 million, as shown in Table 4-12. The net present value for capital is estimated at $1,193 million, and O&M costs are estimated at $4 million. The primary capital costs are associated with the vitrification application.

Table 4-12. Total estimated costs for the in situ vitrification alternative with contingency.

Cost Element	Total Costs ($M)	Net Present Value ($M)
Capital costs		
In situ vitrification and ISTD treatment	991.8	—
Surface barrier	70.9	—
In situ grouting and foundation grouting	191.7	—
Pad A retrieval and treatment	163.0	—
Testing	109.2	—
Management, design, and reporting	258.5	—
Total capital costs	1,785.1	1,193.3
Operating and maintenance		
Monitoring and surveillance	16.7	—
Cover maintenance	9.0	—
Fencing and signage	0.3	—
Management	4.2	—
Total operating and maintenance costs	30.2	4.1
Total	**1,815.3**	**1,197.3**

ISTD = in situ thermal desorption

A cost evaluation has been performed to show the sensitivity of the total costs for the ISV alternative when melt production rates are varied. Figure 4-15 shows the projected cost increase if the power-on time for each melt were increased from 8 days.

As illustrated, if ISV melt production rates slow from a power-on time per melt of 8 days to 16 days and the schedule for completing the alternative established for the 8-day power-on cycle is retained for the 16-day power-on cycle, total costs would be estimated to increase from $1.8 to $2.6 billion. While the costs increase in a nearly linear fashion, costs do not double when the power-on melt time is doubled. This demonstrates that, while production rates are a significant cost factor for the ISV alternative, other substantial costs could be incurred independent of the production rate.

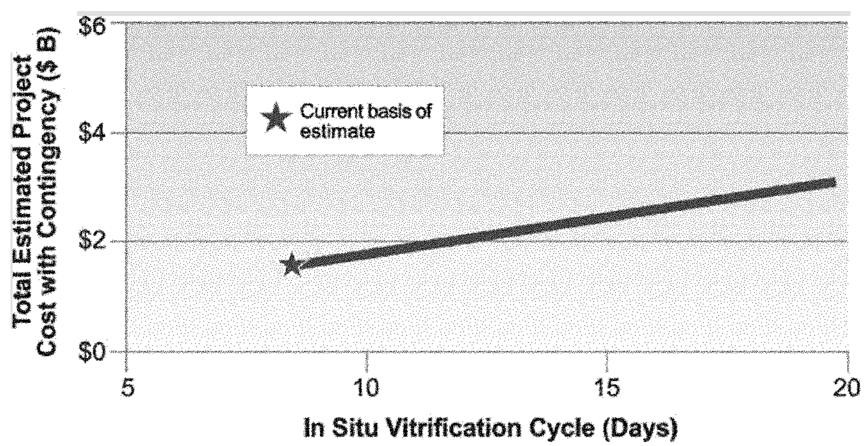

Figure 4-15. Sensitivity analysis comparing in situ vitrification production rates and total cost.

4.6 Alternative 5—Retrieval, Treatment, and Disposal

4.6.1 Alternative Description

The RTD alternative involves retrieval, ex situ treatment, and disposal of onsite buried waste within the SDA. Scope of this alternative is similar to that of in situ treatment alternatives, in that the primary RTD technologies focus on remediating the RFP waste in Pits 1 through 6 and Pits 9 through 12, Trenches 1 through 10, and Pad A. The basic premise of this alternative is that TRU waste and soil would be retrieved from these disposal units, characterized, treated as required to meet WAC, packaged, and then transported to WIPP for final disposal. All other retrieved materials, including LLW and MLLW, would be treated onsite to meet regulatory and risk-based requirements, then placed in an onsite, engineered disposal facility.

A summary of the detailed process required to implement the RTD alternative from signing of the ROD through site closure is presented in Figure 4-16. Bulleted items identify technical components of the process.

Retrieval, Treatment, and Disposal Alternative Remediation Strategy

Retrieval and ex situ treatment of buried waste materials. Retrieved TRU waste would be transported off-Site to the Waste Isolation Pilot Plant (WIPP) for disposal. All other retrieved waste would be treated on-Site to meet risk-based and regulatory standards and then disposed of at the Idaho National Engineering and Environmental laboratory (INEEL) in an engineered long-term facility.

Key Elements:

(1) Waste retrieval
(2) Ex situ treatment
(3) Transuranic waste disposal at WIPP
(4) Low-level waste and mixed low-level waste disposal at INEEL landfill
(5) Selective in situ grouting at designated waste sites
(6) In situ thermal desorption in areas of high volatile organic compounds
(7) Installation of cap
(8) Institutional controls
(9) Long-term monitoring and maintenance

As shown in Figure 4-16, the RTD alternative also includes the in situ remediation of the activation and fission product waste within the SVRs and the LLW trenches using the ISG technology. Applying ISG technologies in these areas is also a common remediation component of the Surface Barrier, ISG, and ISV alternatives. A second common supplemental technology is using the ISTD technology in the high VOC waste streams to minimize material-handling requirements during retrieval. Following remediation, excavated waste sites would be backfilled and systematically capped with a low-permeability, modified RCRA Subtitle C cap. Ancillary facilities and programs would be established to maintain the cover and to facilitate long-term monitoring of the area.

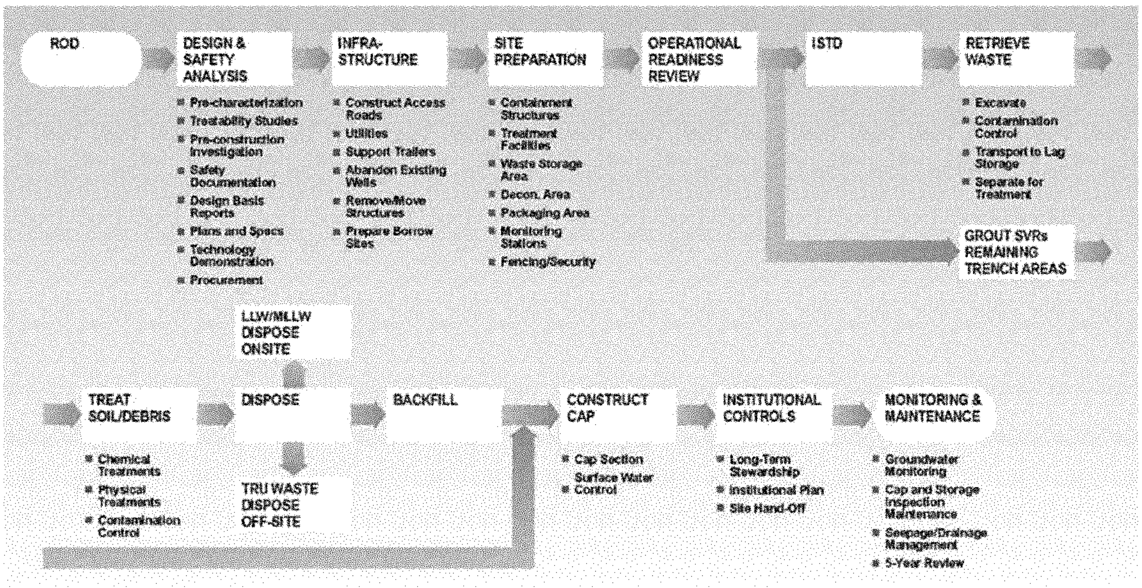

Figure 4-16. Process summary of the Retrieval, Treatment, and Disposal alternative.

Implementing the elements of the RTD alternative is relatively complex. The basic elements are outlined in Figure 4-17 and individually discussed in the following subsections.

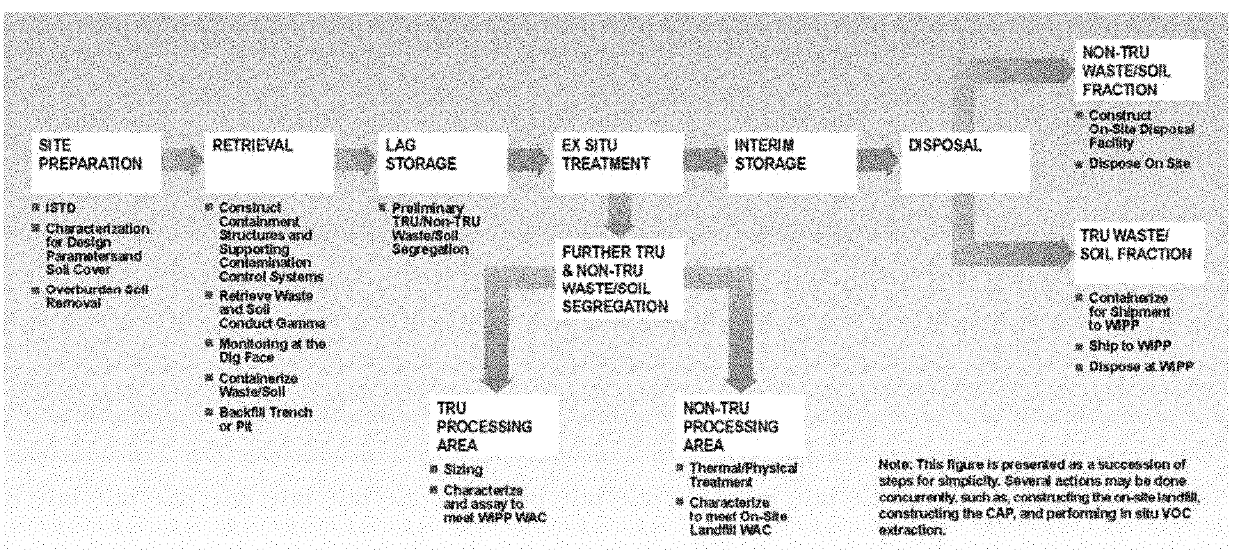

Figure 4-17. Retrieval, ex situ treatment, and disposal actions.

4.6.1.1 Site Preparation. Much preparation would be needed before retrieval begins. This would include establishing contamination control zones and construction lay-down areas, constructing perimeter fencing, obtaining utilities, installing monitoring devices, and constructing access roads. Three additional tasks required for site preparation include characterizing existing soil cover, constructing support structures, and removing clean overburden soil.

4.6.1.1.1 Soil Cover Characterization—Characterization would be performed with probing techniques similar to those recently used at the INEEL during the OU 7-10 Stage I Project and would be used to determine soil cover (overburden soil) thickness and general chemical and radiological concentrations and properties. The data would be used to determine the amount of clean soil that could be initially stripped and stockpiled onsite before containment construction. Stockpiled soil would be reused as clean backfill in the retrieval areas. Probes would be installed in the soil cover and radiological concentrations and cover thickness determined. Soil samples also would be collected from the casing or by hand auger or geoprobe methods for subsequent laboratory analyses.

4.6.1.1.2 Construction of Retrieval Support System—Constructing support buildings for the retrieval would be the next preparatory step. Proposed buildings would contain treatment facilities, lag storage, administrative space, a decontamination area, and an equipment maintenance and storage area. General locations of these facilities are shown on Figure 4-18. The AOC would be established for the project to encompass all areas associated with the retrieval action.

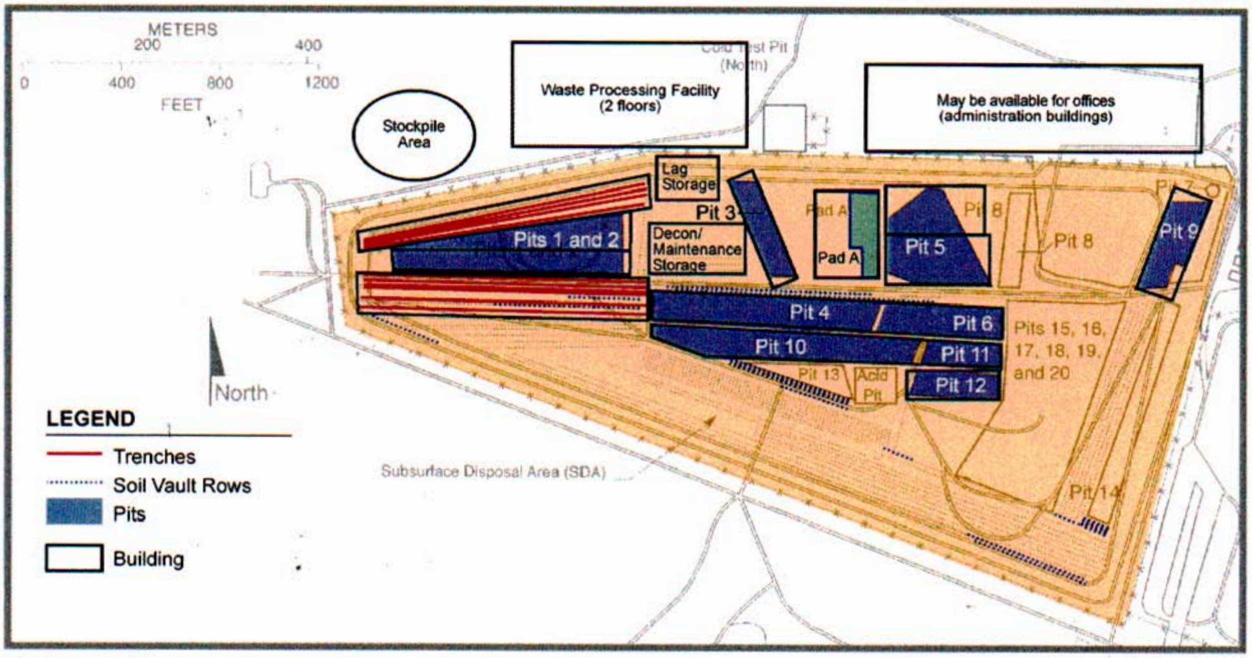

Figure 4-18. Layout graphic for the retrieval action site.

All buildings would be designed and constructed in accordance with the International Building Code and Performance Category 2 standards for wind, seismic, and flood design requirements. Heating, lighting, and ventilation systems are required for all structures. Additional design details would include the following:

- Administrative buildings that would contain personnel required for project management, engineering, project controls, and other management and administrative activities. The 10,000-ft^2

administrative building area(s) would provide office space, meeting rooms, shift worker lockers with change rooms and showers, radiological control offices, and lunch rooms.

- Equipment maintenance and storage buildings that would provide approximately 10,000 ft^2 of space to house necessary equipment such as fire trucks, forklifts, trucks, spare waste bins, PPE, and other necessary equipment and supplies. The building would have separate space for performing maintenance on various pieces of equipment required for retrieval, transport, and treatment activities.

- Decontamination building that would be used for equipment decontamination. The 5,000-ft^2 building would contain several separate decontamination areas and two large doors to allow moving equipment into the building.

- Lag storage building that would be used to initially separate TRU and non-TRU waste and soil and provide temporary storage for these materials before shipment to the treatment facility. The 70,000-ft^2 building has been sized for operation of nondestructive assay (NDA) equipment along with sufficient space to store 16 weeks of retrieved waste and soil. The structure would have a reinforced concrete floor with a ceiling height of 15 ft and two large doors to accommodate waste entry and exit. Materials would be transported within the facility using forklifts.

- Treatment facility that would be separated into TRU and non-TRU processing areas. The building would be a two-story facility, approximately 44 ft high. The facility would be designed as a Category 2 nuclear facility and include pressure process areas, airlocks, multiple contamination control zones, cascading ventilation systems, multiple HEPA filtration on building and process exhaust streams, and continuing monitoring of emissions. Exhaust systems would consist of the following components: quencher, venturi scrubber, packed bed scrubber, demister, reheater, catalytic oxidation, parallel HEPA filters, carbon filters, and parallel off-gas fans. In addition to waste treatment components, the 130,000-ft^2 facility would accommodate remote container-opening and waste-sorting equipment, which would include gloveboxes, large and small manipulators, and sizing equipment.

A secondary storage building would be constructed adjacent to the waste treatment facility to provide storage space for waste shipments before transportation to WIPP. The 75,000-ft^2 structure would be sized to provide approximately 225 days of storage, assuming waste drums would be stacked three high.

4.6.1.1.3 Overburden Soil Removal—Initial excavation activities at the site would involve removing clean overburden soil. Soil would be excavated from proposed retrieval areas in stages with a bulldozer or other excavation equipment. Because the soil is assumed to be clean, this activity could occur in the open atmosphere before constructing containment structures. Clean soil would be stockpiled, further characterized through sample collection and laboratory analysis, and used as backfill. A common stockpile area would be defined (located outside of the AOC if necessary) and used for the duration of the project. Stockpile management would include run-off and wind control. For costing purposes, it is projected that an average of 5 ft of overburden soil could be removed as clean material. Removing this overburden would generally leave a thin layer of soil (1 ft) over the waste matrix; however, a thicker cover might be left over some areas, particularly if high-radiation levels are encountered or radiation exposure reduction is desired.

During design or after the characterization effort, the decision might be made to excavate the overburden inside of containment. In this case, the overburden would be left in place until the time of waste excavation.

4.6.1.2 Primary Technology—Retrieval. The following sections discuss primary elements required for retrieval actions. These include containment structures and equipment, the process to retrieve buried material, monitoring used at the digface, and waste containerization.

4.6.1.2.1 Containment Structures and Curtain Confinement—A double-walled structure erected over a pit or trench area would serve as primary and secondary containment to isolate the retrieval action and enclose the laydown, decontamination, and equipment storage areas. The identified retrieval process requires that 12 separate containment structures be constructed. The width of each structure would be restricted to 200-ft or less to facilitate designing and operating an internal crane system. Locations of pits and trenches would make it possible for one building to contain more than one pit or trench. Proposed groupings of pits or trenches per building are shown on Figure 4-18. Pits that have a span greater than approximately 200 ft (e.g., Pits 1, 2, and 5) would require using H-piles to construct the perimeter wall within the disposal units. H-piles would be driven into underlying basalt to provide support. The common wall would be shared by both containment structures. As retrieval progresses into the subgrade in these areas, lagging would be placed and sealed between the H-piles to prevent contamination exposure. Assuming that containment structures would be built to Hazard Category 2 safety standards, each structure would be required to meet certain seismic, flood, and wind restrictions. Modular structures could be moved to some extent as retrieval progresses to minimize capital costs during construction.

4.6.1.2.2 Pit Excavation Approach—An operator in the cab of an excavator would retrieve waste from the pits by benching down and then removing it from an at-grade position, as shown on Figure 4-19. A conventional excavator with the above modifications was chosen for this PERA over a remote excavator for various reasons. The hermetically sealed excavator would allow operators better visibility of the digface, which would promote precise digging and sorting and better control of waste. In turn, this precision and control would decrease the amount of equipment breakdowns, significantly increase overall production rates, and help maintain a safer environment. However, developments to remote excavators are improving the reliability and efficiency of such equipment. Therefore, it is expected that an appropriate, cost-effective, remote excavator would be available for use at the time planned for excavation.

As shown in Figure 4-19, contamination control at the digface would consist of a series of moveable flame-retardant plastic or metal curtains (similar to those used in the INEEL TSA to protect against leaking boxes). These curtains would provide for contamination control and confinement and would be sealed as well as possible, but are not expected to serve as containment. A gantry crane would be used not only to hold and move curtains within the containment structure, but also would be equipped to apply water, foams, foggers and support lifters, detectors, metal curtains, and other equipment. The curtain confinement also would incorporate a ventilation system. The system would apply negative pressure to the digface and direct the airflow to HEPA filters and a thermal treatment system to control contamination and prevent it from entering the large primary and secondary containment structure.

A system to apply a water vapor mist to fully saturate air exhausted from the retrieval zone would be constructed to control airborne contamination. A recycle system also would be constructed for condensate collected in the system before treating the air exhaust. Air treatment would employ a thermal oxidation unit, acid scrubber, demisters, heaters, and banks of HEPA filters in two parallel systems to provide redundancy in the event one system failed. The combination of the thermal oxidation unit and the acid scrubber would effectively treat any organic compounds that might be encountered during excavation. Remaining elements of the treatment system would be used to keep all other particulate matter from exiting the curtain confinement.

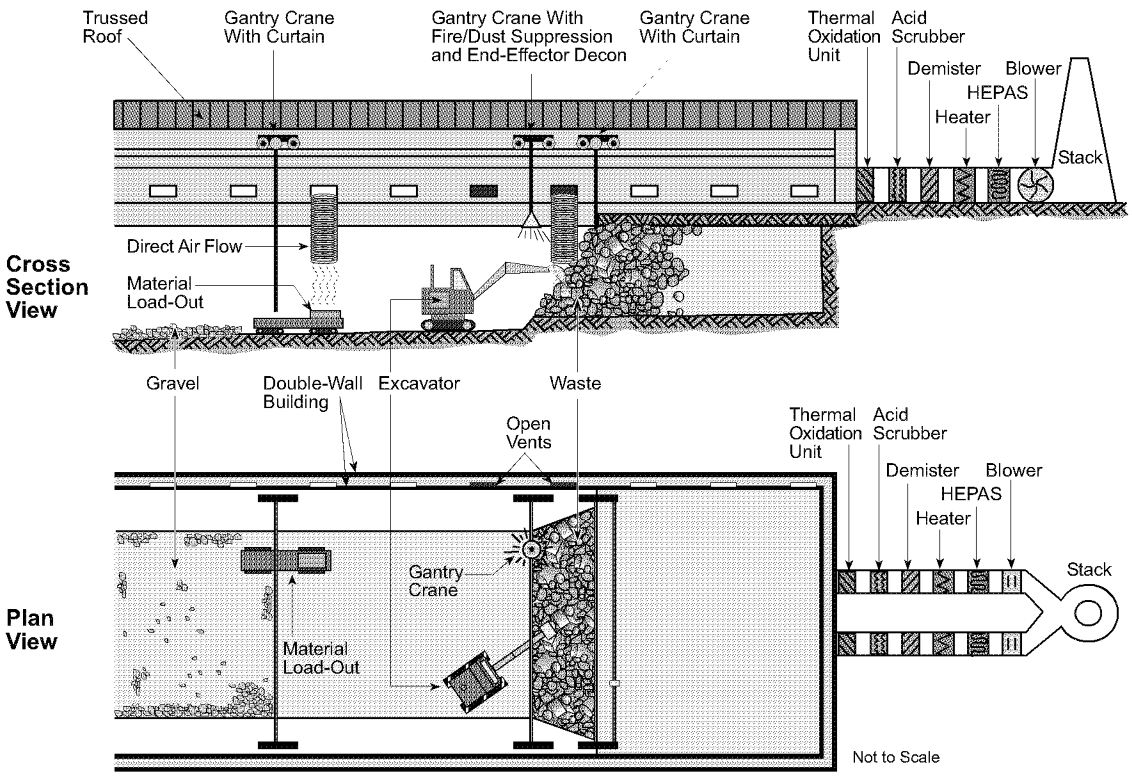

Figure 4-19. Excavation concept for pits.

An air lock system, similar to those used in nuclear facilities, would be used to facilitate moving drums and waste, each in bins, out of the curtain confinement. An airlock system with water, misters, foggers, venting, and other means of control also would provide entry and protection for personnel.

The at-grade position shown in Figure 4-19 offers more advantages than an abovegrade position. Working from an at-grade position provides better visibility of the work area. This would further increase production rates and offer operators more time to plan the retrieval, thus increasing production rates (Valentich 1993). In addition, handling large objects from an at-grade position decreases the risk of the pit collapsing or the excavator overturning, and personnel can access waste as necessary to collect samples for nonroutine circumstances. To further decrease risk of a pit collapsing, sidewalls of the excavation would be sloped in accordance with OSHA regulations, or sheet piles would be used to meet safety standards.

A modified, manually operated excavator would retrieve buried waste and soil. Modifications would include a hermetically sealed cabin (sealed and positive pressure) equipped with a complete supplied-air system that would circulate air to the cabin and the engine compartment. Shielding would be required on the equipment to protect workers from radiation. In addition, the excavator would have air supply tanks attached to the inside of the cabin with an emergency escape pack in the cab. Operators would wear PPE with a facemask and supplied air and move into the cab through a control area that has a clean path to the equipment. Contamination control would be available in the event of an emergency where the operator had to leave the excavator while inside the containment structure. Refueling or maintaining the excavator would be conducted at stations inside the curtain confinement zone specifically designed for these operations.

Proposed safety measures would provide operators with multiple levels of protection. Technologies such as these have proven reliable in various hazardous and contaminated environments.

Personnel-operated heavy equipment with sealed and pressurized cabins modified with either supplied air or filtered air has been used successfully at many sites, including Maralinga and Calvert City. Shielded excavators have been proven at sites like Hanford in the 100N Reactor Area.

As the digface progresses, the excavator would carefully pick at the digface with a small bucket equipped with a thumb for grasping pieces of waste that do not fit into the bucket (or other end-effectors), then the excavator would place waste and potentially clean overburden into soil bags or waste bins (lined with poly-sacks). Metal curtains held by the gantry crane would be moved in approximately 30-ft increments as the digface progresses to provide continuous contamination control. Overhead support systems also would be advanced with the retrieval equipment. In addition, the walls and ceiling would be painted and sidewalls fogged and sprayed with a fixative as curtains are moved to ensure contamination is fixed in place. This type of operation has been demonstrated and is proven in nuclear applications (Sykes 2002). Fire-suppression systems, water misters, painting and fixative systems, and other contamination control devices (e.g., fogging system) would be hung from a gantry crane for use inside the curtain confinement zone.

As waste is removed, operators would attempt to keep contents of each bin as homogeneous as practical (presorting), while simultaneously trying to minimize actions that might contaminate clean soil surrounding the waste zone. For example, operators would try to keep metals in one bin and potentially clean overburden, sideburden, and underburden (1 ft between cleanburden and waste) in another bin. In addition, various end-effectors and precise digging and extracting would maximize the amount of segregation that could be achieved at the digface and within the curtain confinement zone. This process would simplify segregation required at the waste processing facility and facilitate waste processing in campaigns based on selected waste types. Waste that would require cutting or sizing to fit in the bins would be temporarily set aside for handling by another piece of equipment. This technique was found useful at Hanford (Sykes 2002) and may increase production rates. Intact drums and containers would be extracted using appropriate end-effectors available to the excavator in the curtain confinement zone.

Some items would not be treatable with the selected sizer or cutter located in the storage area (as would be the case for large tanks, trucks, reactor vessels, and heavy machinery). Those items would be removed from the digface and relocated to a nearby, out-of-the-way location until the appropriate disposition could be identified. High-level waste, Class C waste, or other materials not amenable to treatment or onsite disposal would be temporarily left in place until appropriate disposition was determined.

4.6.1.2.3 Trench Excavation Approach—The excavation approach for trenches would be similar to that described for pits, as illustrated in Figure 4-20. Containment structures, curtain confinements, and supporting equipment would be the same as described for the pits. However, because several trenches are aligned approximately 8 ft from each other, containment structures could be built over multiple trenches and worked as one waste site. Excavation would systematically remove waste, but leave clean soil between trenches. The waste face would be advanced approximately 15 ft, and then clean soil between trenches would be removed and used as backfill in the excavated area behind the equipment. Because waste containers in trenches are likely more intact than in pits, various end-effectors would be available to remove material from the digface in a precise manner and keep containers intact. Properly using end-effectors would mean carefully extracting intact containers for direct placement into bins.

4.6.1.2.4 Pad A Excavation Approach—The Pad A excavation would employ a slightly different approach than that used for pits and trenches, because the area is aboveground with relatively intact drums and deteriorated boxes. As shown in Figure 4-21, the entire excavation area would be enclosed in a double containment building.

The building would incorporate similar contamination control measures and a similar filtration system to the ones used for the pits and trenches. However, the Pad A containment structure would be much larger than the structures used for the pit and trench excavations to accommodate the abovegrade location of the Pad A waste and impacted soil. Records indicate that Pad A contains only a minor amount of TRU material and therefore would not require the same protective measures needed in the pits and trenches. Conversely, other radiological contaminants must be considered in the Pad A retrieval design. Equipment would include standard excavation equipment (e.g., a backhoe and front-end loader). In addition, it is projected that curtains would not be used to isolate the digface within the secondary containment structure.

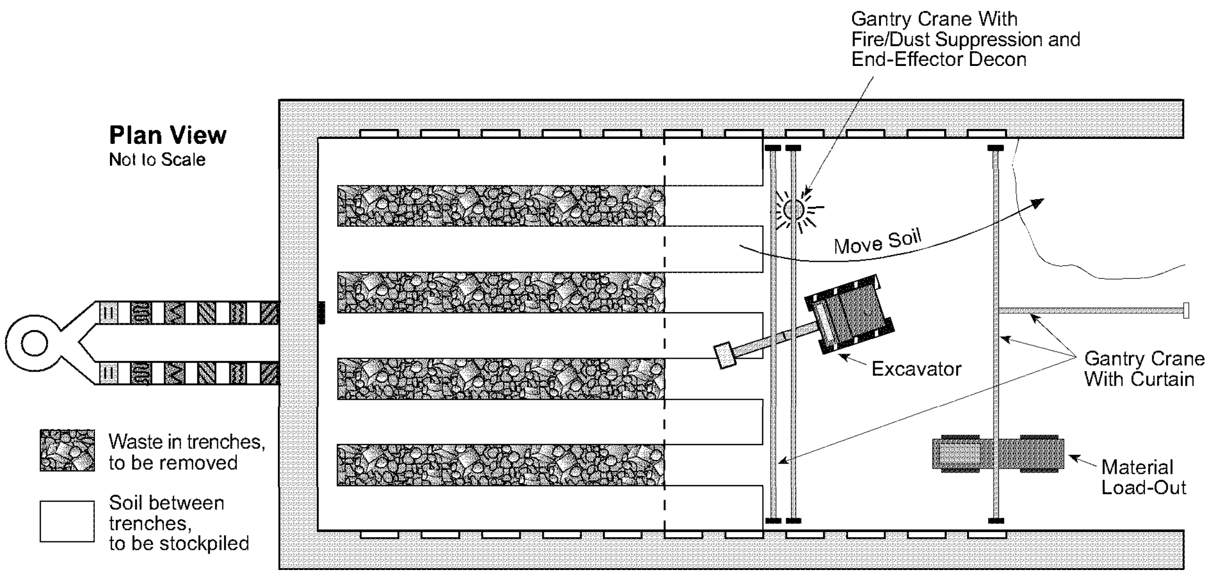

Figure 4-20. Excavation concept for trenches.

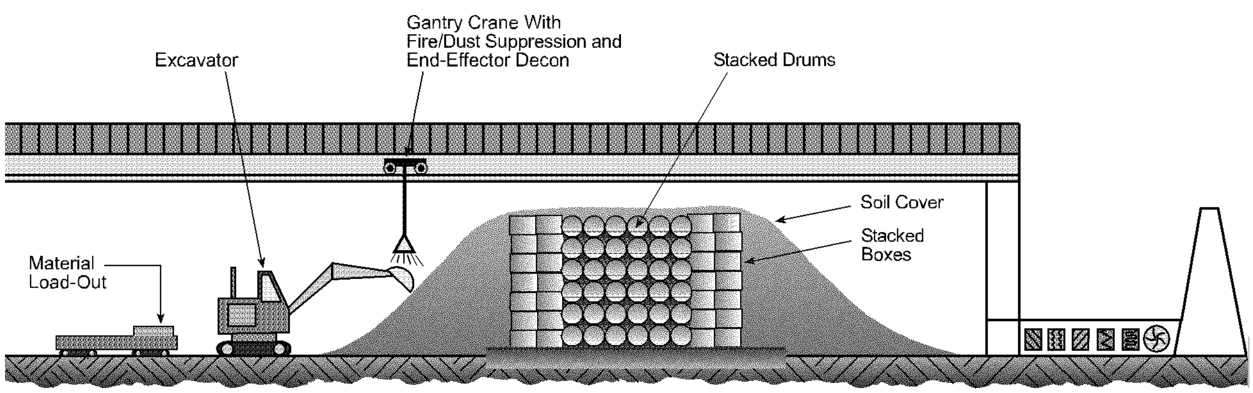

Figure 4-21. Excavation concept for Pad A.

4.6.1.2.5 Production Rates—Retrieval actions could be designed to maintain a production rate of 76 m^3 (100 yd^3) per day. This projected production rate was based on evaluating retrieval equipment, cold tests, previous SDA retrievals, retrieval actions in the United States and Australia, treatment throughputs, storage capacity, and disposal facility rates of waste acceptance. Retrieval operations would be conducted 200 working days a year for this alternative, and crews would work four 10-hour shifts each week. Various factors could impact this production rate. Factors that would decrease production include the availability of only one piece of equipment for digging, sizing, and sorting material and the occurrence of unexpected conditions (e.g., unknown materials, equipment breakdown, and poor weather) (Sykes 2002). Factors that would increase production include using larger bucket sizes, the ready availability of end-effectors for changing operations, operating more than one retrieval operation in parallel, and the availability of a second piece of equipment for sizing and sorting (Sykes 2002).

4.6.1.2.6 Monitoring at the Dig Face—Monitoring at the digface would include gamma-radiation, health and safety, criticality, simple chemical testing to identify reactive and ignitable materials, and visual monitoring to determine digging strategies and to protect workers and the environment. Prior characterization results, available shipping records, and being observant during excavation should result in safe and productive retrieval. Therefore, the only characterization that would be performed at the digface would be for protection from gamma radiation and VOCs and simple chemical screening. This would require a gamma detector and VOC monitor near the digface to detect excessive radiation and VOC concentrations. Such measurements would help determine the level of shielding to safely handle waste containers. Visual monitoring by equipment operators and remote cameras during excavation and would be performed to identify fires, chemical compatibility issues (e.g., nitrate salts with organic material), anomalous material, and criticality issues. Samples of waste or soil would only be collected at the digface as a result of event-driven situations (i.e., visual occurrence of a chemical reaction or other unusual behavior that would be nonroutine). The excavator bucket and gantry crane would be equipped to collect this sample.

4.6.1.2.7 Containerization or Lag Storage—Waste and soil in the retrieval area would be placed into bins by the excavator or sizer (front-end loader). Bins would be located within mobile airlocks fitted and sealed to a rectangular hole at the base of the curtain. The airlock or bin would be positioned near the digface for ease of access and to minimize spreading loose material. The airlock would be equipped with a waste-addition hopper and an integral ventilation system that would minimize the potential for dust contamination outside of bins when they are filled. As filled bins are withdrawn from the airlock, lids would be placed on and clamped to the top. Surfaces of bins would be manually swabbed and checked for contamination. If present, contamination would be manually removed and surfaces would be painted, if necessary, to fix contaminants in place. Water used for decontamination would be collected and recycled through the system.

Decontaminated bins would be removed from the airlock and sent to lag storage where they would await further segregation before treatment. Temporary transportation routes would be within the AOC and surfaced with gravel or paved as needed.

In the lag storage area would be an initial counting of bins (or other containers) for the sole purpose of separating TRU from non-TRU waste streams. Once inside the processing facility, waste would undergo a more precise segregation. One of the most cost-effective and safest ways to make this determination would be to use NDA techniques rather than opening containers to collect samples.

4.6.1.3 Primary Technology—Ex Situ Treatment. All retrieved waste and soil would be transferred from lag storage to the waste processing facility for treatment. The processing facility would be designed and constructed as a Category 2 nuclear facility, and would include negative pressure process areas, airlocks, multiple contamination control zones, cascading ventilation systems, HEPA filtration and thermal-oxidation and acid-scrubbing units on building and process exhaust streams, and continuous monitoring of emissions. Proposed treatment steps for retrieved soil and waste are schematically portrayed in Figure 4-22. The treatment facility would be divided into separate areas for TRU and non-TRU waste. The following subsections describe shared treatment facility components as well as those used for separate treatment areas.

4.6.1.3.1 Treatment Facility Overview—The waste processing facility would have a common area with the remainder of the space divided into two major process areas, one for the TRU waste and the other for non-TRU. These areas are two completely separate, independent facilities with each having its own process equipment, ventilation systems, and contamination control zones. The common area would provide for the following functions: initial presorting, TRU and non-TRU waste separation, utilities, control rooms, data processing, and administration.

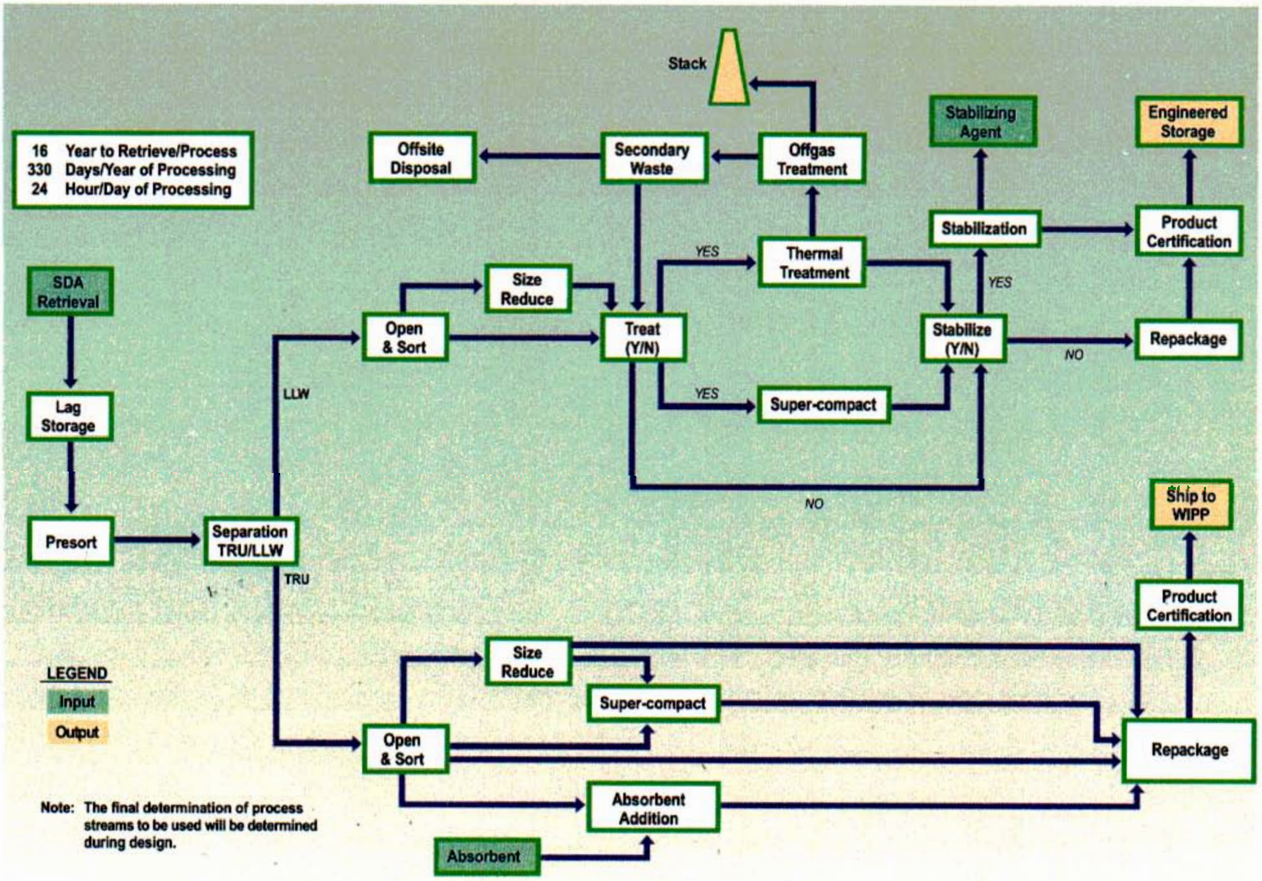

Figure 4-22. Process flow diagram for ex situ treatment.

Remotely operated equipment would be used to perform all processing of exposed waste. Manipulators, conveyors, and gloveboxes would be employed as necessary. Though provisions would be made for manned bubble suit entry into processing cells, this option would be employed only for nonroutine operations and maintenance. In some non-TRU processing areas, personnel using lesser protection may be allowed entry if the surface and airborne contamination levels are sufficiently low.

Cost estimates are based on the processing facility operating 330 days/year on a 24 hour/day, 7-days/week. One month is allowed annually for scheduled maintenance. A 75% availability factor has been applied (i.e., the system is down 25% of the time) to account for unexpected problems in any of the process lines. On this processing schedule, the facility would process approximately 46 m^3 (60 yd^3) per day, but would operate more days annually than the retrieval operations. The lag storage area would be designed to accommodate sufficient waste from retrieval operations, yet provide sufficient storage space for treatment facility downtime.

The actual containers and overpacks used to transport waste would be designed to optimize the retrieval and processing operations. Waste would be transported to the processing facility in 4 × 4 × 7-ft bins that have been overpacked in 5 × 6 × 8-ft containers. Using a 90% loading factor, approximately 16 overpacks with their inner boxes or bins of waste would arrive at the facility daily.

As discussed in Section 2, the exact split of the TRU versus non-TRU components of the RFP waste stream is uncertain. Assuming 50% of RFP waste is TRU, estimated quantities of waste and soil to be retrieved and the required processing rates are shown in Table 4-13.

Table 4-13. Volumes of waste and soil.

	Transuranic[a] Waste	Transuranic[a] Soil	Transuranic[a] Total	Non-transuranic[b] Waste	Non-transuranic[b] Soil	Non-transuranic[b] Total	Total Waste Plus Soil
Volume (yd^3/year)	2,400	2,200	4,600	4,200	10,000	14,200	18,800
Design (lb/hour)	500	1,000	1,500	900	4,500	5,400	6,900
Total volume (yd^3)	37,900	35,500	73,400	66,600	160,200	226,800	300,200

a. Transuranic waste estimate based on 50% of Rocky Flats Plant waste stream.
b. Low-level waste.

Safety issues in processing include fire prevention and suppression, prevention and mitigation of explosion hazards, contamination control, radiation shielding (a minor issue with this waste), and normal industrial hazards. The facility would be designed, constructed, and operated in accordance with all applicable regulations, codes, and standards. Criticality control is not anticipated to be a concern in this facility, but would be investigated further in the design phase of the project. Information gained during the OU 7-10 Glovebox Excavator Method Project would be used to reassess this issue during the project design phase.

4.6.1.3.2 Resorting and Transuranic and Nontransuranic Separation—Waste would arrive from the lag storage area in sealed waste overpacks containing boxes of waste and soil that were filled at the retrieval site. In the lag storage area, initial TRU and non-TRU separation would occur. Because of the volume of waste being shipped to the processing facility, multiple parallel process lines, each with its own loading dock, would be required.

Two options exist for transferring waste into the waste processing facility. In the first option, overpacks would pass directly through an airlock and into a presorting cell. At this location, lids would be remotely removed from waste overpacks and bins containing waste removed from the overpacks onto a presort table. Empty bins would be placed back in the overpack with lids reattached. The overpack would then move to a decontamination cell where the exterior surface of the overpack would be decontaminated. After a final survey, the overpack would pass back out through another airlock to a receiving truck, which would return bins and overpacks to the retrieval site for reuse. During final design, a transfer system patterned after the double lid, bagless transfer system used for 55-gal drum containers could be considered. In this option, the waste overpack would be mated to a transfer port and the lid would be removed. Remotely operated equipment would be used to transfer the bin containing waste to the presort table. After the bin has been emptied, it would be returned to the overpack. The lid would be reattached to the overpack, disconnected from the mating port, and returned to the retrieval site by truck.

For either method, waste would be transferred from the bin to the presort cell. Waste in the presort cell would be put into a condition that allowed it to be assayed and subsequently divided into TRU and non-TRU waste fractions. Presort processes could include an additional separation of soil from larger waste materials, opening selected drums or other containers to accommodate specific assay equipment requirements, and limited sizing. The degree of size reduction necessary to allow for accurate assay would be determined during design.

From the presort cell, waste would pass into the separation or assay cell where assay equipment would further separate waste and soil into two streams. Radioassay equipment would include segmented gate conveyor systems for soil and smaller waste sizes that could be placed on conveyors approximately 2-in. deep. This system is capable of assaying at a 100-nCi/g level at a rate of 22 tons/hour and diverting waste into two streams. Material containing concentrations greater than 100 nCi/g TRU would be sent to the TRU processing area of the facility. Material containing less than 100 nCi/g would be sent to the non-TRU processing area. The large-size waste would be placed in a favorable configuration for counting and then assayed with equipment similar to the box and drum counters currently being used in other DOE facilities.

4.6.1.3.3 Transuranic Processing Area—The TRU processing area would have a configuration similar to the AMWTP, including similar process lines and equipment. In this area, the TRU fraction of waste would be sized, treated, characterized, and packaged to meet transportation requirements and the WIPP WAC (DOE-WIPP 2002). Compared to the treatment for non-TRU waste, minimal treatment would be required for the TRU waste. Waste and soil sent to the TRU processing area would arrive in various physical and chemical forms and would first enter opening and sorting cells. In the cells, waste and soil would be removed from their containers (note that most retrieved drums and boxes are expected to be in a state of deterioration), visually inspected, sampled for chemical composition as necessary, and sorted for downstream processing. The intent of the inspection process is to identify and remove or treat prohibited items including liquids, pyrophoric materials, explosives, pressurized cylinders, material requiring neutralization, and flammable materials.

When necessary, real-time radiography would be used to provide information to assist in the opening of any intact waste containers that might contain prohibited items. Prohibited items detectable by real-time radiography include liquid waste and gas cylinders. Downstream processing would include adding absorbents for any free liquids, chemically neutralizing acids and caustics, and super compacting selected waste to reduce waste volume. To meet the WIPP WAC, necessary size reduction would be performed to allow efficient repackaging of waste in 55-gal drums or standard waste boxes, which provide an internal volume of 66.3 ft^3.

4.6.1.3.4 Nontransuranic Processing Area—In the non-TRU processing area, non-TRU waste and soil fraction would be processed, characterized, and packaged to meet the WAC for disposal in an onsite engineered disposal facility designed in accordance with the RCRA Subtitle C standards. Waste and soil to be retrieved are known to contain RCRA-regulated hazardous chemical contaminants, which must be treated to meet regulatory standards and address risk before disposal. These treatments would include chemical, physical, and thermal processes for removing hazardous organics and stabilizing regulated metals and radionuclides.

Much like waste sent to TRU processing, waste and soil sent to the non-TRU processing area would first enter an opening and sorting cell. There, it would be segregated into additional streams for processing. Waste would be screened to separate soil and smaller debris from larger pieces of waste. Some size reduction and drying might be required at that point to reduce soil clumps. The larger fraction would be separated by remote equipment into categories based on their ability to be shredded into smaller fractions. The degree of separation and sizing required would be a function of the final selection of thermal treatment equipment used. Large industrial shredders would be employed to reduce the size of the material as necessary.

Selecting technologies for ex situ treatment of remediation waste has been the subject of a number of previous studies at the INEEL. Currently, an evaluation is being conducted to select treatment technologies for the AWMTP facility, which is located adjacent to the TSA. A thermal treatment technology would be used to address the organic constituents within the waste stream. During a recent DOE assessment of treatment technologies (DOE 2000), steam reforming was identified as a most promising technology and a potentially viable alternative to incineration.

The U.S. Army Program Management for Assembled Chemicals Weapons Assessment is testing a continuous steam treater to destroy chemical munitions. The U.S. Army has performed two major pilot-scale test programs on the continuous steam treater and has had contractors develop the design basis and preliminary equipment specifications for full-scale operations. This technology has been reviewed by the National Research Council and the A. D. Little Company (i.e., U.S. Army's chief technical evaluator in the program). The continuous steam treater heats waste to drive off volatile and hazardous compounds. This is accomplished by blanketing waste with superheated steam that acts as a carrier gas and by heating the vessel wall with induction coils. To maximize processing rates, waste must be in a form that allows steam to reach all of the organic material as rapidly as possible. Processing steps include shredding of waste and, if needed, a carrier (e.g., carbon or lime) is used to ensure uniformity of solid flow within the unit. In the first stage, a horizontal chamber similar to a stainless steel shell would be used that incorporates an internal, slowly rotating auger. The continuous steam treater shell would have external inductive heating and 538°C (1,000°F) superheated steam inside. Superheated steam would pass through the continuous steam treater shell countercurrent to the waste feed flow.; Steam enters near where treated waste discharges and exits near the waste feed input. Inside the shell, the rotating, multibladed auger shaft rotates in a trough running the length of the shell to agitate, rotate, and move waste. Treated waste exits the shell through a rotary discharge airlock. Superheated steam, which acts as a carrier gas, now contains volatilized gases and exits the shell. Subsequent gas cleanup steps would include filters, scrubbers to remove corrosive acid gases, and HEPA filters, followed by reheat and catalytic oxidation to remove residual organics. Oxidation of carbon monoxide and hydrogen to carbon dioxide and water also would occur. Early removal of corrosive compounds (e.g., acidic compounds) should reduce metallurgical concerns about materials of construction. State-of-the-art filtration would limit particulate discharges to within acceptable limits. Finally, in-line catalytic destruction of pollutants (e.g., carbon monoxide and hydrogen) would ensure compliance with emission limitations while recovering inherent heat energy by generating needed process steam and power.

The proposed thermal treatment operation processing of the non-TRU waste and soil would result in a char-type residue. This residue would be stabilized in either a Portland cement grout or sulfur polymer cement. Both agents are effective for stabilizing and would meet applicable LDRs for waste disposal of ash and soil containing RCRA-regulated metals and radionuclides. The exact formulation and quantities of agent to be used would be determined during the project design phase. Stabilized waste would be placed in 55-gal drums. Larger, oversized waste would be placed in specially designed containers. Then containers would be moved to an engineered storage facility.

Secondary waste generated from non-TRU treatment would include scrubber blowdown solution, filters, and waste generated during routine operations and maintenance activities. The scrubber solution would be evaporated and resulting salts and residue would be stabilized as a solid and sent to the engineered storage facility with the other processed non-TRU waste. All other material would be processed through the facility with the exception of carbon filters containing low-vapor-point metals that might continue to be recycled through the process. These filters would be packaged to meet the engineered disposal facility WAC and sent to this facility.

Because of the wide dispersal of RCRA-regulated organic material disposed of in the SDA, all of the non-TRU waste and soil would be thermally processed. For a 16-year processing campaign, the design rate of the thermal treatment unit is estimated at approximately 5,000 to 6,000 lb/hour. A rotary treatment unit configured for this size is not unreasonable. Rotary kiln pyrolysis systems have been built and are being operated in Europe. These are used for municipal solid waste gasification offering capacities four to five times greater than 8,000 to 10,000 lb/hour. Depending on future and more detailed investigations, two or more rotary treatment units may be included to provide adequate spare capacity.

4.6.1.4 Primary Technology—Disposal. Waste and soil processed through the treatment facility would be characterized and designated for either off- or on-INEEL disposal. All processed materials would be taken from the treatment facility to an interim storage facility to await disposal. Transuranic materials designated for WIPP disposal would be temporarily stored in the enclosed structure adjacent to the treatment facility as described in Section 4.6.1.1. Treated MLLW and LLW designated for onsite disposal would be temporarily placed in a lined interim storage area constructed within the AOC and in accordance with federal and state requirements. The interim storage facility would separate waste by container type, weight, and known waste characteristics. The facility would be large enough to store containers for at least a year to await characterization results and to meet WAC. Discussions pertaining to off- and on-INEEL disposal of waste and soil are presented in following subsections.

4.6.1.4.1 Off-INEEL Disposal—Waste that meets the WIPP WAC (DOE-WIPP 2002) would be disposed of at WIPP, near Carlsbad, New Mexico, as shown in Figure 4-23. The WIPP facility is the only site certified for the disposal of TRU and mixed TRU waste and has a current design capacity of 175,000 m^3 (230,000 yd^3), which is expected to be filled by 2034. It is estimated that approximately 135,000 m^3 (175,000 yd^3) of RFP waste would be retrieved when implementing this alternative. As discussed previously in this text, the percentage of the RFP waste stream that would be classified as TRU is uncertain, but is projected to be on the order of 50%. Through sizing and compaction, the waste volume could be reduced by 25 to 33%. Even so, the projected volume of TRU waste and soil may represent 30% or more of the current WIPP design capacity and it is uncertain if it could be accommodated without approval to increase the disposal capacity. To increase the capacity at WIPP, the U.S. Congress would have to amend the WIPP Land Withdrawal Act of 1992 (Public Law 102-579). If WIPP is the only option for TRU disposal and its capacity is not expanded, load management techniques must be employed during retrieval, treatment, and packaging to reduce the volume of material destined for the facility.

The WIPP facility is exempt from federal LDRs in accordance with the WIPP Land Withdrawal Act Amendment of 1996 (U.S. Senate 1996). Before TRU waste could be shipped to WIPP, waste certification authority and transportation authority must be obtained from the U.S. Department of Energy Carlsbad Field Office, which includes extensive reviews and audits to verify the waste-generation site complies with all WIPP requirements. Transuranic waste would be certified by meeting the requirements specified in the WIPP WAC (DOE-WIPP 2002) and the "WIPP Hazardous Waste Permit" (New Mexico Environment Department 2002). To ship TRU waste to WIPP, requirements of the *TRUPACT-II Authorized Methods for Payload Control (TRAMPAC)* (DOE 2002) would have to be met.

Quality assurance activities must conform to the U.S. Department of Energy Carlsbad Field Office Quality Assurance Program Document (QAPD) (DOE 1999).

The following documents must be prepared by the INEEL for certification:

- Transuranic waste certification plan—documents how the INEEL complies with each requirement of the WIPP WAC

Figure 4-23. Route from the Idaho National Engineering and Environmental Laboratory to the Waste Isolation Pilot Plant.

- Certification quality assurance (QA) plan—documents how compliance with each quality requirement in the WIPP WAC is assessed by the INEEL

- Waste characterization QA project plan—explains in detail procedures and methods used for waste characterization

- Site-specific TRAMPAC—describes in detail how the INEEL complies with Appendix 1.3.7 of the Transuranic Package Transporter Model 2 (TRUPACT-II) safety analysis report for packaging as reflected in the WIPP WAC

- Packaging QA plan—describes the WAG 7 QA program for TRU waste packaging

- Sampling plan—supports the site-specific QA project plan and defines how waste containers are chosen for sampling on a waste-stream basis.

The time required to implement an acceptable program and grant certification authority depends on the complexity of the program being implemented, funding for site activities, and scope of certification audits. Complex programs may require several years to completely implement. To date, the INEEL has received certification for the RFP TRU waste stored in the TSA. Stored waste is expected to be similar to the material that would be excavated from the TRU pits and trenches.

Waste designated for WIPP disposal would undergo characterization and assay in the TRU processing area. Characterization during waste processing would include visual examination of the retrieved waste material and sampling and analysis of soil and waste for hazardous constituents and radionuclides. After waste is packaged into drums, each drum would be assayed to determine the isotopic ratios and quantities, and headspace gas samples would be collected and analyzed for VOCs and flammable gases.

Only one type of U.S. Nuclear Regulatory Commission-approved container is designed to carry contact-handled TRU radioactive waste to WIPP, the TRUPACT-II (DOE-NTP 2000). This container, shown in Figure 4-24, is composed of a protective stainless steel skin, a layer of insulation and foam, and an inner and outer containment vessel. The TRUPACT-II container is designed to carry 14 of the 55-gal drums, two standard waste boxes, or one 10-drum overpack (DOE-WIPP 2002). The TRU waste and soil would be packaged in 55-gal drums for this alternative. However, other larger containers may be approved at a later time that could lower costs.

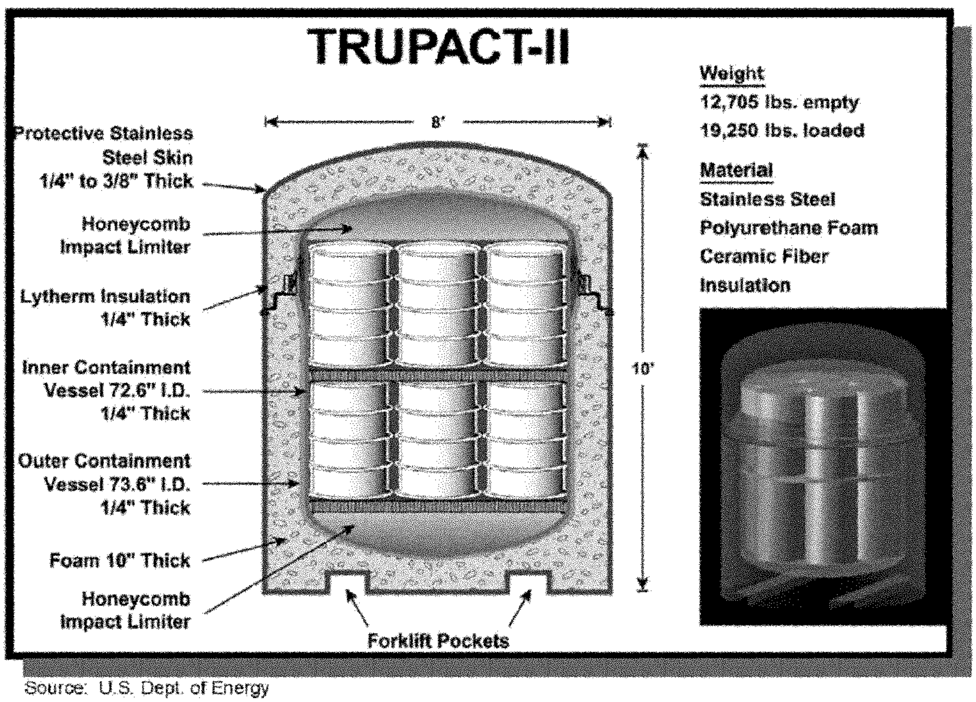

Figure 4-24. Packing configuration of the Transuranic Package Transporter Model 2.

4.6.1.4.2 Onsite Disposal—Non-TRU waste and soil processed through the treatment facility would be placed in an engineered disposal facility constructed within the SDA. The major components of the facility would include disposal cells (landfill) and evaporation ponds. Numerous steps involved in planning and designing this type of disposal facility include the following:

- Studies and assessments of site-specific geotechnical, seismic, subsurface consolidation, and slope stability
- Studies and estimates of landfill compaction and subsidence
- Evaluations of the long-term performance of proposed bottom lining and final cover systems, including test pad construction and evaluation
- Analysis and design of leachate collection, treatment, and disposal systems
- Analysis of various human and ecological risks and methods of control
- Preparation of detailed plans, specifications, and estimates, and a construction QA plan
- Preparation of plans and procedures for waste evaluation, WAC, tracking, treatment, and placement
- Preparation of a staff training plan, a storm water pollution prevention plan, a health and safety plan, an operations and management plan, an environmental monitoring plan, and a closure plan.

The onsite disposal facility would be planned, designed, constructed, operated, and closed in accordance with requirements identified for the proposed ICDF landfill. To minimize excavation requirements and minimize the footprint of contamination to the extent possible, the facility would be located where multiple pits had previously been excavated. The facility would be constructed within the AOC to allow flexibility in consolidating and remediating waste without triggering LDRs and other regulatory requirements. The projected location of the facility is shown in Figure 4-25.

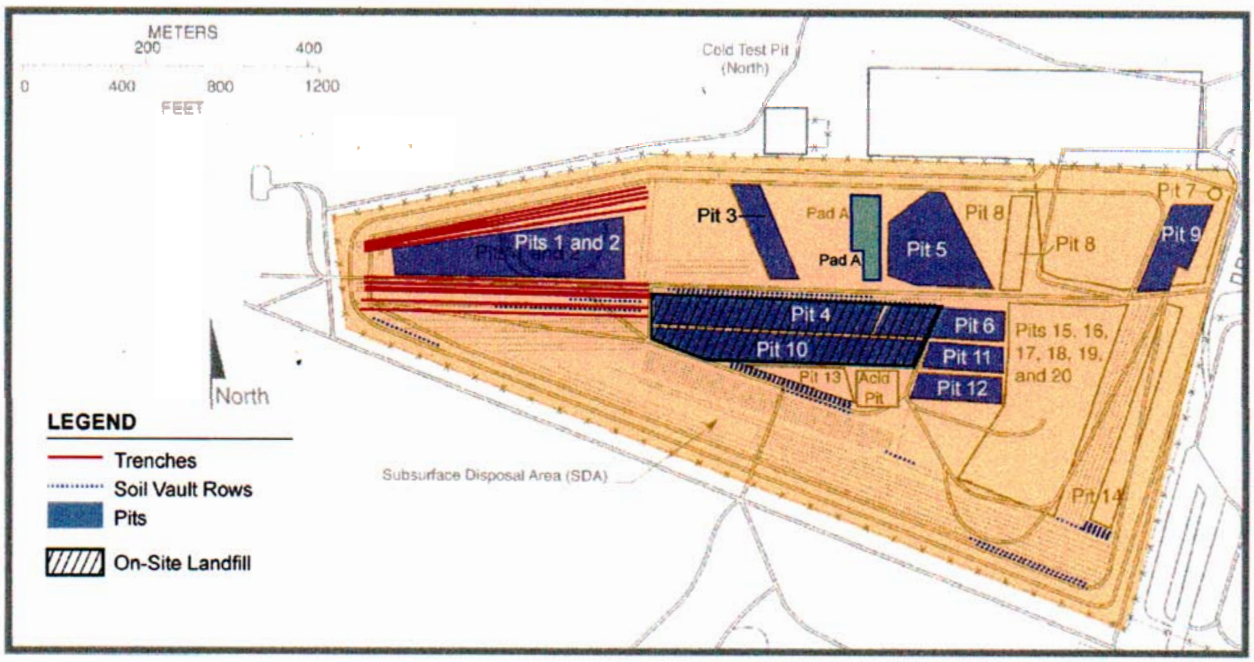

Figure 4-25. Proposed onsite location for a landfill within the area of contamination.

Capacity of this facility would depend on (1) quantity of retrieved waste classified as non-TRU and requiring onsite disposal, (2) increase in waste volume resulting from treatment, and (3) volume of cover soil used during facility operations. An estimated 175,848 m^3 (230,000 yd^3) of retrieved waste and soil would require onsite disposal. This volume of waste is assumed to increase by a factor of 1.2 to account for waste treatment. The resulting estimated disposal capacity required would be approximately 210,253 m^3 (275,000 yd^3).

Construction of the disposal facility would require excavating and shaping the landfill subgrade, installing lining and leachate collection systems, and constructing systems for leachate transmission, storage, and treatment. The leachate collection, transmission, treatment, and disposal system would consist of perforated collection piping on the bottom of the landfill, a leachate collection sump and evaporation pond outside of the landfill, and transmission piping to the sump and pond. An estimated 1,200 ft of perforated 12-in. pipe and 500 ft of nonperforated 12-in. pipe are estimated for the disposal facility. A 20-ft deep leachate collection sump would be constructed adjacent to the facility, with a pumping system for transmission of leachate to the evaporation ponds. Evaporation ponds would need to be sized appropriately for this facility. The alternative includes construction of two ponds with approximate surface dimensions of 200 × 350 ft and an average depth of 8 ft.

Waste entering the disposal facility would be controlled on the basis of source, physical form, and concentration levels in accordance with the established WAC. A uniform and consistent waste acceptance process would be implemented to include planning and waste certification. Developing chemical and radiological acceptance criteria for the landfill would include calculations to determine concentrations in the onsite engineered landfill leachate that protective the evaporation pond liner system and human health and the environment.

It is projected that the majority of materials disposed of would be treated and stabilized with cement. Stabilized waste would be delivered to the site primarily in 55-gal drums, 4 × 4 × 4 ft boxes, or 4 × 4 × 7 ft boxes. Some bulk disposal of contaminated soil and other waste might be allowed in the facility, if such material meets the WAC. The disposal facility also would accept material from the evaporation ponds, which would contain residues from evaporation of leachate and liquid residuals from treatment systems of the non-TRU processing area (e.g., evaporated salts from the scrubbed solution). Materials from the evaporation ponds would be assessed for compliance with the WAC and disposed of in bulk or treated and disposed of as necessary.

Waste would be placed in 5- to 10-ft lifts. Large, bulky materials or containers would be placed carefully in the disposal area to minimize the potential for damage to the bottom or sideslope lining systems. Clean soil would be used periodically to cover waste or stabilize containers as they are placed in the disposal area. Waste treatment and disposal would continue for 16 years concurrent with treatment operations, at which time the disposal facility would be closed. A description of the cap layers and potential borrow sources is provided in the description of the Surface Barrier alternative.

Closure also would involve decommissioning one of the evaporation ponds, a process that would include removing lining materials and filling the pond to grade with earth fill. The remaining pond would remain operational, as required, to collect and evaporate any leachate that accumulates in the disposal area after closure. Accumulated materials in this pond would be disposed of at another facility on the INEEL or at an off-INEEL facility. If monitoring of the remaining pond suggests that additional leachate is not being generated, then the pond would be decommissioned as described above.

4.6.1.5 Supplemental Technologies. To comply with the RAOs, this alternative requires implementing a number of supplemental technologies within the SDA to address contaminant-specific concerns and ensure long-term stability of the cover system.

4.6.1.5.1 In Situ Thermal Desorption**—**For this alternative, the ISTD technology would be used in some of the pits with elevated organic concentrations to remove VOCs from the waste and soil. Because of cost, health, and safety advantages, the majority of VOCs within the SDA would be removed before retrieval. Pretreatment would minimize requirements for ex situ treatment, emissions control, and worker protection. In situ thermal desorption would be applied in areas within the SDA containing high concentration of drums containing Series 743 organic sludge. Previous analysis (Miller and Varvel 2001) of the distribution of this waste stream, as depicted in Figure 3-8, estimates that a total area of less than 1 acre would have these high concentrations and require pretreatment. These areas are located in Pits 4, 6, 9, and 10.

A detailed discussion about implementing ISTD technology within the SDA is presented in Section 4.5.1.2. Specific pretreatment requirements would be determined further during the design phase.

4.6.1.5.2 Grouting**—**To comply with the RAOs, this alternative also would include applying ISG in the SVRs and in areas within the LLW trenches containing activation- and fission-product waste. Waste in these areas consists primarily of remote-handled materials, for which no off-INEEL disposal facilities currently exist. Implementing the ISG technology in these areas would be the same as described previously for the ISG alternative in Section 4.4 and addressed in the accompanying technical report (Armstrong, Arrenholz, Weidner 2002).

4.6.1.5.3 Backfilling and Cap Construction**—**Before excavated wastes sites are backfilled, characterization samples would be collected to verify that remedial action objectives were achieved and to document chemical and radionuclide concentrations left in place. As retrieval progresses, excavated areas would be systematically backfilled with clean fill. This could be done relatively soon after excavation, or after an entire site pit or trench was retrieved. Backfill would be compacted and the area prepared for cap construction. Before the cap is placed, subsurface stabilization using ISG would be conducted in unexcavated areas as necessary to minimize future subsidence-related maintenance.

This alternative requires placement of a low-permeability cap over the entire SDA to protect the site for the long-term. A modified RCRA Subtitle C cover, as described previously for the in situ treatment alternatives, is included in the RTD alternative. Constructing the final landfill cover would be conducted concurrently with retrieval activities. The final design would address required transition of the modified RCRA Subtitle C cover with thicker ICDF cover proposed for the centrally located onsite disposal facility. The transition must be designed to minimize future maintenance requirements.

4.6.1.5.4 Long-Term Monitoring and Maintenance**—**With stabilized waste remaining onsite, a long-term monitoring and maintenance program would be required to verify protectiveness of the remediation. Cost estimates for the RTD alternative include 100 years of monitoring and maintenance with reviews conducted every 5 years in accordance with CERCLA guidance. Initial monitoring requirements for groundwater, vadose zone, surface water, and air would be conducted as described for the in situ treatment alternatives. As with the ISV alternative, the monitoring program is reduced following the initial 5-year review in the cost estimates. The projected reduction would include 50% of the groundwater and lysimeter monitoring and elimination of the vapor port monitoring.

4.6.1.6 Schedule. The projected schedule of remedial activities for this alternative is presented in Figure 4-26. As shown, this alternative would require an estimated 30 years to complete. If the ROD were signed in the year 2005, then remediation would be complete in 2035. This would include an initial 6-year design (i.e., conceptual, preliminary, and final design) and comprehensive safety analysis effort. Design of the project would be phased for the ISTD and retrieval; it is not a continuous 6-year effort. The extended duration would be necessary to perform ISTD and obtain predesign characterization data. Characterization for soil cover removal and ISTD would be completed during this timeframe. After a year of subcontractor procurements, approximately 2-1/2 years would be needed to mobilize to the site and set up necessary facilities. Soil cover removal, followed by containment and infrastructure construction, would require another 2-1/2 years. The operational readiness review would commence at this point before retrieving waste. Waste retrieval (and concurrent backfilling and capping) and treatment would take place over a 16-year period. Final decontamination and decommissioning of the facilities would occur at the end of the project and the final cap would be installed over the backfilled areas.

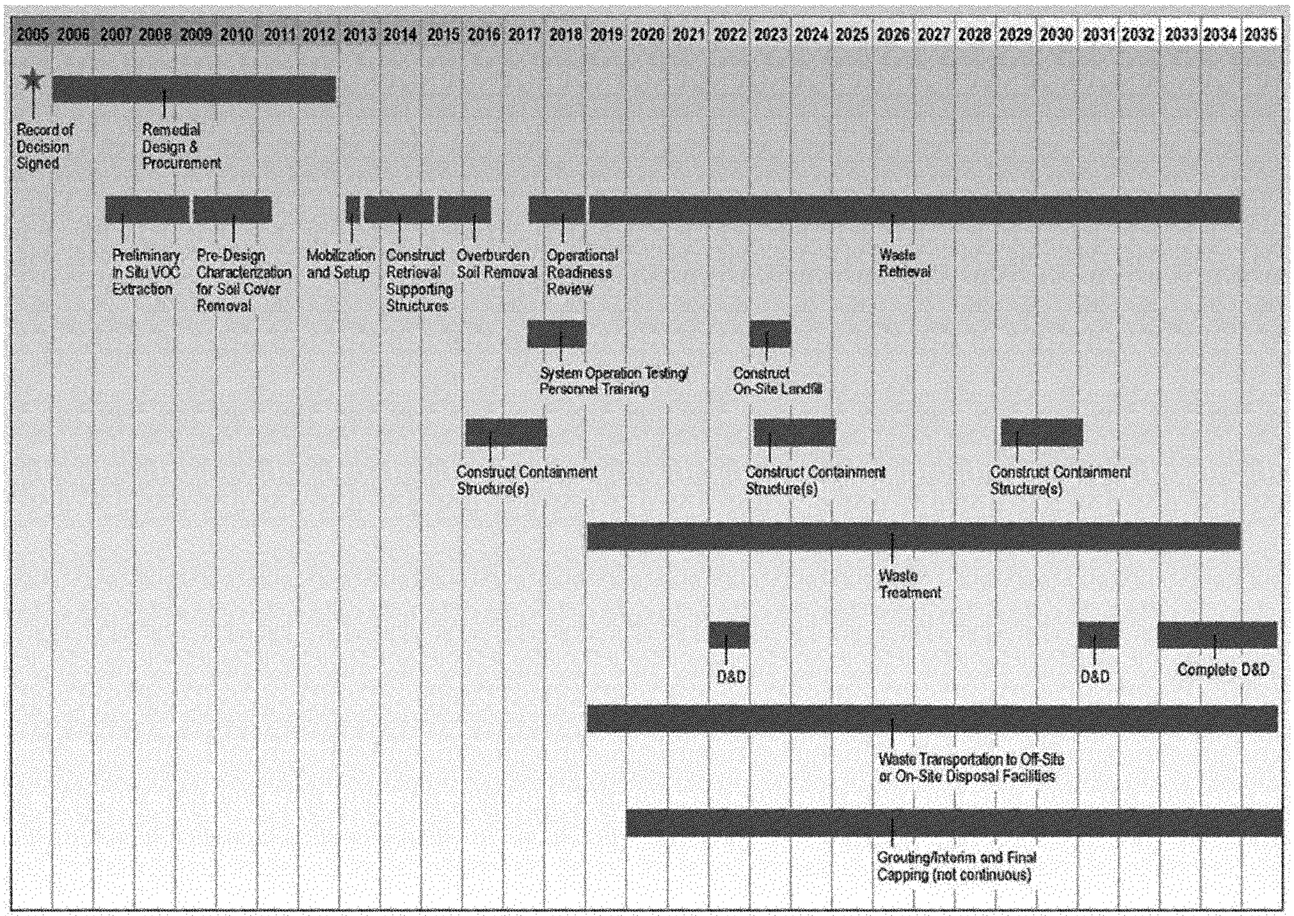

Figure 4-26. Schedule for the Retrieval, Treatment, and Disposal alternative.

As with any construction schedule prepared at this stage of the process, a high degree of uncertainty applies to this schedule. The RTD process flow is complex and requires integration and close coordination of a number of operations. Because of the potential variability in the waste stream and rigorous worker and environmental protection measures required, project delays to address site-specific issues should be anticipated.

4.6.2 Screening Assessment

The following sections provide an assessment of the ability of the RTD alternative to satisfy the two threshold and five balancing criteria described in Section 4.1.

4.6.2.1 Overall Protection of Human Health and the Environment (Threshold Criterion). The RTD alternative is projected to protect human health and the environment and achieve project RAOs. For this alternative TRU waste would be retrieved and transported to an approved off-INEEL facility (i.e., WIPP) for permanent disposal. All LLW and MLLW in the TRU pits and trenches would be retrieved and treated in accordance with remediation goals and regulatory standards and placed back onsite in a secure, long-term disposal facility. Any remaining COC-bearing waste streams would be treated in place using ISG. The entire SDA would be covered with a long-term, low-permeability surface barrier designed to minimize future surface water infiltration and to inhibit human and biotic intrusions in remaining waste. Long-term future monitoring also would be conducted to evaluate effectiveness of the alternative.

Uncertainties exist as to whether human health and the environment could be protected adequately during RTD and shipping actions. Information gathered from a review of retrieval technologies (Sykes 2002) led to the conclusion that technologies exist to provide overall protection.

Implementing this alternative does not minimize the threat of exposure in the short-term (during remediation) because it adds a potential exposure route (i.e., radiation exposure to workers). Equipment operators, radiation control technicians, health and safety personnel, truck drivers, maintenance workers, and other personnel could be exposed to radiation and other hazards while implementing this alternative. However, the RTD alternative would minimize the long-term threat of potential exposure to human health and the environment at the SDA. These issues are discussed further in the following sections.

4.6.2.2 Compliance with Applicable or Relevant and Appropriate Requirements (Threshold Criterion). The RTD alternative involves the RTD of waste (both on and off of the INEEL) from the SDA. Under CERCLA, ARAR compliance is addressed by considering chemical-, location-, and action-specific ARARs and TBCs independently. Appendix A presents a broad summary of the potential ARARs and TBCs that have been identified. An evaluation summary of ARAR and TBC compliance for the RTD alternative is presented in Table 4-14. A discussion about some of these key requirements follows the table.

Table 4-14. Regulatory compliance evaluation summary for the Retrieval, Treatment, and Disposal alternative.

ARAR or TBC	Type	Relevancy[a]	Citation	Meets Evaluation?
Radiation protection of the public and the environment	Chemical Action	TBC	DOE Order 5400.5	Yes
Idaho toxic air pollutants	Chemical	A	IDAPA 58.01.01.585 and .586	Yes
Idaho ambient air quality standards for specific air pollutants	Chemical	A	IDAPA 58.01.01.577	Yes
National emission standards for hazardous air pollutants	Chemical	A	40 CFR 61	Yes
Native American graves protection and repatriation regulations	Location	A	43 CFR 10	Yes—if encountered
Preservation of historic, prehistoric, and archeological data	Location	A	36 CFR 800 and 40 CFR 6.301(b) and (c)	Yes—if encountered
Protection of archaeological resources	Location	A	43 CFR 7	Yes—if encountered
Preservation of historical sites	Location	A	Idaho Statute 67-4601 et seq. and Idaho State Historical Statute 67-4101 et seq.	Yes—if encountered
Compliance with environmental review requirements for floodplains and wetlands	Location	A	10 CFR 1022	Yes

Table 4-14. (continued).

ARAR or TBC	Type	Relevancy[a]	Citation	Meets Evaluation?
Protection of floodplains	Location	RA	Executive Order 11988; 40 CFR 6.302(b); 40 CFR 6 Appendix A	Yes
Remediation waste management sites located within floodplains	Location	RA	40 CFR 264.18(b)	Yes
Location standards for TSD facilities located within floodplains	Location	A	40 CFR 264.1(j)(7)	Yes
Idaho groundwater quality rule	Action	A	IDAPA 58.01.11.006	Yes[b]
Interim status standards for owners and operators of TSD facilities—groundwater monitoring	Action	A	40 CFR 265 Subpart F	Yes[b]
National ambient air quality standards	Action	A	40 CFR 50	Yes
Idaho control of fugitive dust emissions	Action	A	IDAPA 58.01.01.650, .651	Yes
Idaho fuel burning equipment—particulate matter	Action	A	IDAPA 58.01.01.675 through 681	Yes
Idaho particulate matter—process equipment emission limitations on or after July 2, 2000	Action	A	IDAPA 58.01.01.710	Yes
Standards for NESHAPs for source categories—waste combustors	Action	A	40 CFR 63 Subpart EEE	Yes
Polychlorinated biphenyls—storage and disposal	Action	A	40 CFR 761 Subpart D	Yes
Identification and listing of hazardous waste	Action	A	40 CFR 261	Yes
Standards for owners and operators of TSD facilities—landfill closure and postclosure requirements	Action	A	IDAPA 58.01.05 (40 CFR 264 Subparts G and N)	Yes
Standards for owners and operators of TSD facilities—use and management of containers	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart I)	Yes
Standards for owners and operators of TSD facilities—tank systems	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart J)	Yes
Standards for owners and operators of TSD facilities—surface impoundment	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart K)	Yes
Standards for owners and operators of TSD facilities—incinerators	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart O)	Yes
Standards for owners and operators of TSD facilities—miscellaneous units	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart X)	Yes

Table 4-14. (continued).

ARAR or TBC	Type	Relevancy[a]	Citation	Meets Evaluation?
Standards for owners and operators of TSD facilities—air emission standards for process vents	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart AA)	Yes
Standards for owners and operators of TSD facilities—equipment leaks	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart BB)	Yes
Standards for owners and operators of TSD facilities—tanks, surface impoundments, and containers	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart CC)	Yes
Standards for owners and operators of TSD facilities—containment buildings	Action	A	IDAPA 58.01.05 (40 CFR 264 Subpart DD)	Yes
Standards for owners and operators of TSD facilities—remediation waste management rules	Action	A	IDAPA 58.01.05 (40 CFR 264.1[j][1] through [13])	Yes
Hazardous waste determination	Action	A	IDAPA 58.01.05. 006 (40 CFR 262.11)	Yes
Land disposal restrictions	Action	A	IDAPA 58.01.05.011 (40 CFR 268)	Yes
National Pollutant Discharge Elimination System	Action	RA	40 CFR 122.26	Yes
Radioactive waste management	Action	TBC	DOE Order 435.1	Yes

a. A = applicable requirement, RA = relevant and appropriate requirement, TBC = to-be-considered requirement
b. Evaluation criteria met not including the vadose zone contribution.
ARAR = applicable or relevant and appropriate requirements
CFR = *Code of Federal Regulations*
DOE = U.S. Department of Energy
IDAPA = Idaho Administrative Procedures Act
NESHAPs = National Emission Standards for Hazardous Air Pollutants
TSD = treatment, storage, and disposal

4.6.2.3 Chemical-Specific (Applicable or Relevant and Appropriate Requirements). As with the Surface Barrier, ISG, and ISV alternatives, the RTD alternative would meet the RAOs for direct contact because the surface barrier (cap) would prevent human and ecological receptors from direct exposure to soil and waste after excavation is complete. In addition, implementing the RTD alternative would satisfy groundwater RAOs because (1) the combination of waste treatment and disposal would reduce waste volume and toxicity and (2) a surface cover or barrier would reduce surface water infiltration. (Note that contributions to risk from postulated contamination previously released to the vadose zone are not addressed.)

Chemical-specific requirements of state and federal air quality standards would be met during construction and during remedial action implementation. State of Idaho requirements include those for toxic air pollutants (IDAPA 58.01.01.585 and .586), ambient air quality standards for specific air pollutants (e.g., particulate matter) (IDAPA 58.01.01.577), and emission of fugitive dusts (IDAPA 58.01.01.650). Federal requirements include NESHAPs (e.g., radionuclides) (40 CFR 61) and NAAQS (e.g., particulate matter) (40 CFR 50).

4.6.2.4 Location-Specific (Applicable or Relevant and Appropriate Requirements).

Location-specific ARARs for this alternative are the same as those for the Surface Barrier alternative.

4.6.2.5 Action-Specific (Applicable or Relevant and Appropriate Requirements).

Because this alternative leaves some waste in a new landfill, RCRA Subtitle C requirements for closure and postclosure (40 CFR 264 Subpart G) and landfills (40 CFR 264 Subpart N), as adopted by reference in the State of Idaho "Rules and Standards for Hazardous Waste" (IDAPA 58.01.05), are applicable. In addition, the substantive RCRA Subtitle C TSD requirements would be applicable depending on the treatment process selected. These TSD requirements include the following:

- Use and management of containers (Subpart I)
- Tank systems (Subpart J)
- Incinerators (Subpart O)
- Miscellaneous units (Subpart X)
- Air emission standards for process vents (Subpart AA)
- Equipment leaks (Subpart BB)
- Tanks, surface impoundments, and containers (Subpart CC).

The NESHAPs for hazardous waste combusters (40 CFR 63 Subpart EEE) also may be applicable to ISTD operations. These requirements would be met by using appropriate engineering controls.

In addition, RCRA groundwater monitoring standards (40 CFR 265 Subpart F) for using monitoring wells to detect the presence of COCs in the underlying aquifer are applicable to the RTD alternative, and provisions for groundwater monitoring are included in the RTD alternative.

The RCRA generator requirements for hazardous waste determination and management (40 CFR 262.11) would be applicable because potentially hazardous materials might be generated during RTD. Furthermore, RCRA requirements about disposal of hazardous waste in landfills also would be applicable (40 CFR 268 and IDAPA 58.01.05.011); however, a CERCLA waiver may be needed for onsite waste disposal. The WAG 7 area would be identified as an AOC. Because it is assumed that the AOC concept would be used when implementing the RTD alternative, waste consolidation and movement could occur without triggering RCRA Subtitle C requirements (e.g., LDRs). In addition, LDRs are not applicable for TRU waste shipped to WIPP because the Land Withdrawal Act Amendment of 1996 (U.S. Senate 1996) exempts WIPP from LDRs.

Because PCBs were disposed of in the SDA before 1978, any PCB waste retrieved would be subject to either the PCB spill cleanup policy or the self-implementing cleanup of PCB remediation waste. Both cleanup policies use risk-based approaches; consequently, it is believed that protective remedies implemented to prevent exposure to radioactive constituents also would be protective of any PCBs present. Disposal of this waste would depend on its concentration. Polychlorinated biphenyls in concentrations of 50 ppm or greater must be disposed of by incineration or in a chemical landfill, or by an alternate disposal method approved by EPA. Storage and disposal of any retrieved PCB waste would meet the applicable requirements of 40 CFR 761.61 and DOE guidance (DOE-EH 1999). Currently, WIPP is pursuing authorization to accept nonliquid PCB waste in concentrations greater than 50 ppm. It is assumed for this alternative that, at the time RTD is implemented, WIPP would be authorized to accept any nonliquid TRU waste with PCBs from the SDA.

Construction aspects of remediation would meet applicable requirements of state and federal air quality standards. State of Idaho requirements include controlling the following:

- Toxic air pollutants (IDAPA 58.01.01.585 and .586)
- Ambient air quality for specific air pollutants (e.g., particulate matter) (IDAPA 58.01.01.577)
- Emission of fugitive dusts (IDAPA 58.01.01.650)
- Particulate matter emission for fuel-burning equipment (IDAPA 58.01.01.675 through 681)
- Process equipment emissions (IDAPA 58.01.01.710).

Federal requirements include NESHAPs (e.g., radionuclides) (40 CFR 61) and NAAQSs (e.g., particulate matter) (40 CFR 50). These requirements would be met through appropriate engineering controls.

Organic vapors that accumulate beneath the barrier would be collected, removed, and treated by the active OCVZ treatment system (OU 7-08) and the designed passive gas collection layer within the proposed cover. The EPA Office of Air Quality Planning and Standards is developing a new MACT for the remediation site source category. This MACT, projected to be in effect after 2002, would apply to remediation sites that are a major source of organic hazardous air pollutants during site remediation activities. If applicable to CERCLA sites, all vents, remedial material management units, and associated equipment components involved in remediation could require emission controls. These requirements would be followed.

Institutional controls are often added to remedies to enhance long-term management protection and supplement engineered remedies (40 CFR 300.430[a][1]). Institutional controls of the RTD alternative would include security measures, access controls, fencing, and land use restrictions. These controls would help prevent possible exposure to waste by human intruders and biota. Controls also would meet applicable DOE requirements for residual radioactivity left in place, including the related provisions of DOE Order 5400.5.

As required, NPDES storm water discharge protection measures and best management practices would be implemented for controlling storm water, road building, waste management, and other related remedial activities as appropriate. Applicable DOE TBC requirements for protecting human health would be met during remedial activities.

All DOE radioactive waste would be managed so as to protect worker and public health and safety and the environment in accordance with DOE Order 435.1requirements.

4.6.2.6 Long-Term Effectiveness and Permanence (Balancing Criterion). The RTD alternative would provide long-term effectiveness and permanence, including the following actions:

- Removal of TRU waste and contaminated soil from the SDA and transport off-INEEL to a secure repository for permanent disposal

- Grouting-in-place of soil vault rows and trenches with high concentrations of fission and activation products to minimize further migration of these COCs
- Retrieval, treatment, and placement other LLW and MLLW containing identified COCs in an onsite engineered landfill
- Placement of a final protective barrier would be placed over all waste remaining onsite.

These actions would inhibit exposure of humans, plants, and animals to contaminants and would minimize contaminant migration to the groundwater. Because waste would remain at the SDA, long-term operation and maintenance activities, access controls, land use restrictions, and monitoring would be required as long as waste presented a hazard.

Although this alternative would effectively minimize future risk, it is projected that some COCs have already been released. The amount released to-date and current rates of release are not known with certainty. However, conservative estimates indicate that the preremediation release might result in groundwater contamination posing a risk greater than 1E-04. Modeling shows that this risk would peak by the year 2110 and would extend beyond the boundary of the SDA. Therefore, this alternative includes institutional controls that would prohibit using groundwater within this buffer zone. This zone could extend 1,500 to 2,000 ft from the SDA boundary.

In addition to prohibiting groundwater use within the buffer zone around the SDA, other institutional controls would be required to ensure RAOs are met and maintained. Land use restrictions would be required to prevent development, excavation, or drilling on and near the SDA. Frequent inspection and maintenance of the surface barrier would be required. The barrier would require periodic reconstruction every 500 years. Groundwater monitoring would be required to verify contamination does not exceed unacceptable levels beyond the institutional control boundary.

Long-term (10,000-year) modeling, in which any postulated contamination in the vadose zone is ignored, provides an indication of effectiveness of the RTD alternative in preventing migration of COCs remaining in the SDA burial zone. These results show this alternative would be effective in reducing contaminant migration and controlling groundwater ingestion risk from COCs in the burial zone at acceptable levels.

4.6.2.6.1 Risk Modeling Assumptions—Simulations show groundwater ingestion risks where the highest concentrations occur in the model. For the RTD alternative, all waste and associated COCs in the TRU pits and trenches were removed. Treatment and disposal of LLW and MLLW in a secure landfill was assumed to be effective in preventing release of contamination and hence, the model did not include any contribution from this disposed of waste. For the final surface barrier of this alternative, water was assumed to infiltrate at a rate of 0.114 cm/year.

For the grouted waste containing activation and fission products, contaminant releases from the grout were conservatively assumed to occur by diffusion from within 2-ft-diameter grout columns. These columns would be formed by injecting grout into the waste site on 2-ft centers to create columnar monoliths. For modeling purposes, the surface available for leaching was assumed to be the outside surface of the 2-ft-diameter columns. This is based on a conservative assumption that the points of contact between columns where cracks can form may be a zone of weakness. However, the surface area available for leaching is expected to be much lower, and limited data are available to accurately predict the extent of cracking that would form in the grouted waste over long periods of time.

The DUST-MS model assumed that infiltrating water would flow through columnar joints in the grout at volumetric rates equal to the surface area of the treated area multiplied by the infiltration rate. Volumes of water contacting waste in a given timeframe were assumed to dissolve the contaminants released in the same timeframe, up to their solubility limits in water. Concentrations of contaminants released from the source term were input to the TETRAD model for estimating groundwater concentrations and drinking water risk.

4.6.2.7 Magnitude of Residual Risk (Balancing Criterion). Figure 4-27 shows the cumulative carcinogenic risk over time caused by ingesting groundwater contaminated from grouted activated and fission product waste.

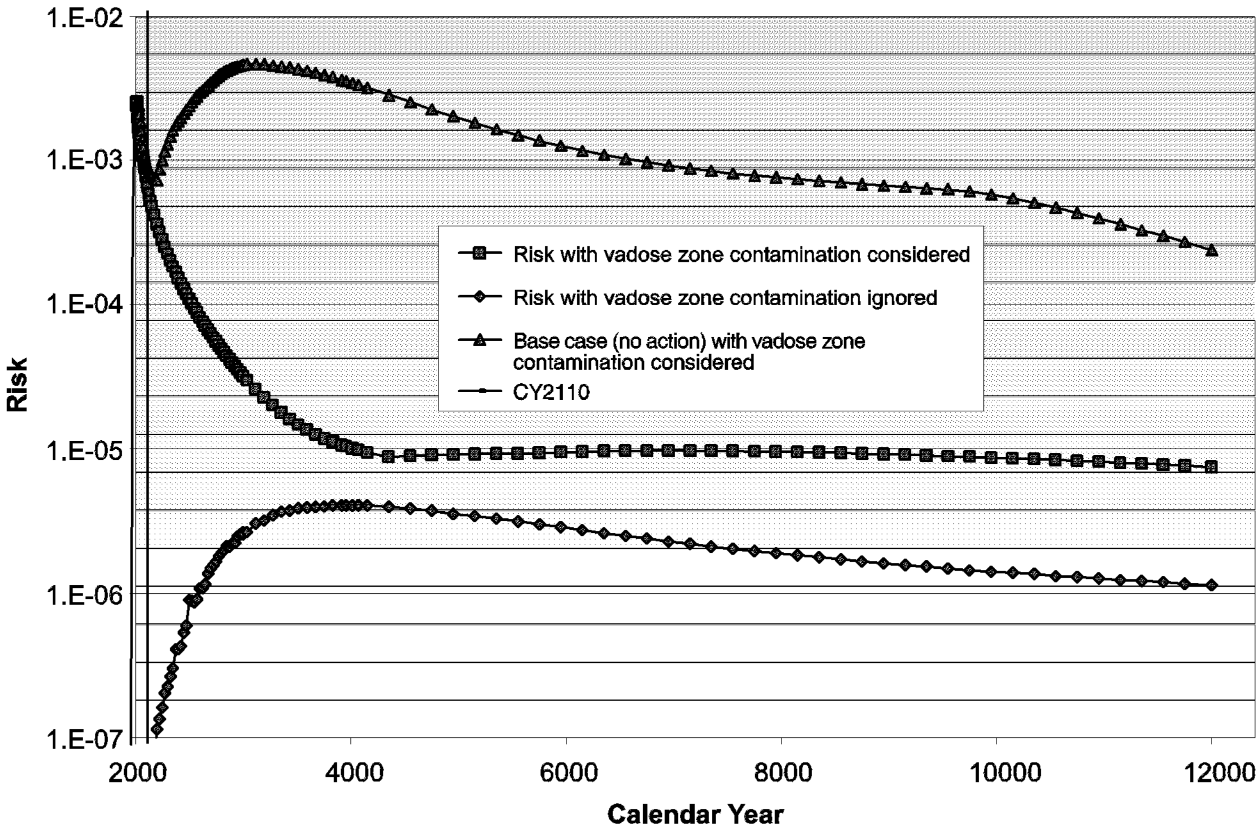

Figure 4-27. Carcinogenic risk for the Retrieval, Treatment, and Disposal alternative.

Figure 4-27 shows two risk projections: (1) risk associated with postremediation release of contaminants from the SDA source term only and (2) total risk represented by release of source-term contaminants, plus postulated contamination present in the vadose zone before installing a containment barrier over the SDA. As shown, carcinogenic risk associated with postremediation release of contaminants from remaining onsite waste would reach approximately 6E-06 in 2,000 years, then would progressively decrease to approximately 1E-06 in 10,000 years.

The residual hazard index for this alternative is assumed to be less than 1.0. The risk modeling indicates that the hazard index attributable to postremediation contaminant release under the Surface Barrier alternative would be less than 1.0. With treatment provided by ISG, the residual hazard index for the RTD alternative would be lower than that for the Surface Barrier alternative.

4.6.2.7.1 Adequacy and Reliability of Controls—Monitoring of remaining SDA waste, including treated waste buried in the engineered landfill and areas treated by ISG, would be required in perpetuity to ensure the effectiveness and permanence of the remedy. Regular monitoring (e.g., visual inspections and surface elevation surveys) would be performed to detect compromises in integrity or effectiveness of the barrier. The barrier would be maintained and repaired as required to achieve original performance standards. Because of the required life span of the remedy, portions of the barrier would require periodic repair or reconstruction, and that the entire barrier would be replaced every 500 years.

The long-term reliability and performance of the ISG remedy implemented for the activation and fission-product waste would be assessed through monitoring. A network of monitoring probes would be installed throughout the monolith before grout cures to collect moisture and vapor samples and monitor temperature, redox, and pH conditions over time.

To ensure protectiveness, active institutional controls would be required to limit land use activities in the vicinity of the SDA. A prohibition on drilling and using groundwater within a buffer zone around the SDA would have to be enforced. Access controls would have to be implemented and maintained in perpetuity to prevent intrusion into the waste.

4.6.2.7.2 Summary of Long-Term Effectiveness—Fate and transport modeling indicates that postremediation peak carcinogenic risk would be less than 1E-04 and the hazard index would be less than 1.0 for the groundwater ingestion pathway, if the postulated contamination in the vadose zone is not included. Retrieval and disposal of TRU waste and soil to an off-INEEL repository, coupled with treatment and disposal of the remaining waste in an engineered storage facility, would eliminate risk from exposure and minimize contaminant migration. The grout monoliths for activation and fission product waste would be chemically and physically stable over geologic time. Appropriate institutional controls, operation and maintenance programs, and periodic barrier repair and replacement would provide additional long-term control for the buried and stabilized waste.

4.6.2.8 Reduction in Toxicity, Mobility, or Volume Through Treatment (Balancing Criterion). As indicated, all waste sites contributing to the potential risk to human health and the environment would be retrieved and either disposed of off of the INEEL or treated and disposed of onsite. The TRU pits and trenches would be retrieved and disposed of off of the INEEL, with no appreciable treatment conducted other than sorting and repackaging. Retrieved MLLW and soil would be treated for hazardous components and disposed of onsite. Reductions in contaminant mass, toxicity, or volume would depend on hazardous components found. Treatment would destroy organic constituents and immobilize inorganic constituents of waste and impacted soil.

Grouting the SVRs and trench areas containing activation- and fission-product waste would reduce mobility of activation- and fission-product COCs in these areas. Further, constructing a low-permeability surface barrier throughout the entire SDA would minimize mobility of any contaminants remaining after remediation.

4.6.2.9 Short-Term Effectiveness (Balancing Criterion). Of all the alternatives, RTD would pose the greatest risk to the public and workers. Primarily, this would be caused by the retrieval process; subsequent onsite transportation, handling, and treatment processes; and transportation of TRU waste off of the INEEL for disposal at WIPP. The key components evaluated to determine whether the RTD alternative meets the balancing criterion would be (1) protection of the community during remediation, (2) protection of the remedial workers during remediation, (3) environmental impacts associated with construction, and (4) time until RAOs are met. The following subsections describe the performance of the RTD alternative for this criterion.

4.6.2.9.1 Protection of the Community During Remedial Actions—The RTD alternative is likely to pose increased risk and impact to the off-INEEL community because of increased traffic. Increased traffic would be anticipated during all phases of the project, and traffic control plans would be developed to minimize the impact and potential increase in transportation risk to the public and onsite workers. Using appropriate engineering controls and adhering to INEEL health and safety protocols would reduce the hazards. Shipping TRU waste off of the INEEL for disposal at WIPP would increase risk to the communities through which waste passes, although these risks would be mitigated by using engineered waste containers and proven waste transportation controls and processes.

4.6.2.9.2 Protection of the Remedial Workers During Remedial Actions—Potential implementation difficulties associated with the RTD alternative could increase risk to remediation workers. However, appropriate PPE, engineering controls, and adherence to INEEL health and safety protocols would reduce the hazards. Remediation workers may be exposed to radionuclides and VOCs while retrieving waste from selected pits and trenches. Earth-moving equipment, modified with positive-pressure ventilation-system cabs and HEPA filters, could be used to prevent exposure to radioactively contaminated airborne hazards. In addition, shielding equipment by placing lead lining on exterior surfaces of equipment would prevent worker exposure to ambient radiation hazards. Other risks to workers include physical hazards (e.g., earth-moving equipment, excavators, and other construction-related activities that could cause physical harm).

Hazards to the public and workers would be mitigated by construction of a containment structure around the area to be excavated, which would minimize potential release of contaminants. A negative pressure ventilation system would be installed in the containment structures to ensure that contaminants would not escape. To better capture contaminants from the source of generation, a laminar airflow hood or shroud could be used at or near the digface. During retrieval of selected TRU pits and trenches at the SDA, a system equipped with an aggressive means of contamination control would be applied at the digface to keep the generation of dust to a minimum. In a highly contaminated area, containment at the digface would consist of an engineered structure that would support ventilation systems and permit remote excavators, cranes, and vacuums to perform the operations. Another protective technology could consist of a system that provides different foams, soil fixatives, water- and dust-suppressant misters, in situ soil stabilization, jet-grouting cement of subsurface barrier walls (to allow vertical excavation), and vacuum systems (INEEL 1997). All characterization of waste and supporting treatment and packaging would be performed with stringent engineering controls and PPE to ensure worker safety. Continuous monitoring of operations and employees would occur throughout the duration of the project to ensure exposure to workers is ALARA.

Implementing ALARA concepts during waste retrieval operations would reduce worker exposures. In accordance with DOE orders, activities would be performed using the ALARA approach to protection from radiation. Training of personnel who use retrieval equipment, along with engineering controls and PPE, would be required throughout the project to ensure safety of workers on the project. Implementing appropriate health and safety measures would further minimize these risks.

Potential vehicle-related impacts include both physical accidents and inhalation of vehicle emissions, fugitive dust, and other particulate material generated during the transportation process. The likelihood of accidents outside of the INEEL increases with each loaded vehicle traveling to an off-INEEL destination, and it is estimated that approximately 7,400 truckloads would be required to transport the TRU waste to WIPP. However, the shipping containers for TRU waste have been demonstrated by the U.S. Nuclear Regulatory Commission to withstand extreme accident conditions without breaking open or releasing radiation. Therefore, it is highly unlikely that a release of radioactivity would occur even in the event of an accident.

Latent cancer risks from radiation exposure and the injury and fatality risks from physical hazards calculated for this alternative are summarized in Table 4-15 (Schofield 2002).

The risks associated with onsite activities were estimated based on a potential worst-case condition in which all RFP waste is classified as TRU waste. As shown, this evaluation predicts that during implementation of onsite RTD operations, approximately 62 onsite workers would develop cancer caused by exposure to hazardous substances, including radioactive material and radiation fields. The calculation projected that approximately 2,530 injury-related accidents and six fatalities would occur.

Table 4-15. Total cancers, mechanical injuries, and fatalities for the Retrieval, Treatment, and Disposal alternative.

Risks Associated with Onsite Activities	Number of Occurrences	Risks Associated with Off-INEEL Activities	Number of Occurrences
Cancer	62.30	Cancer	0.9
Injury	2,530.00	Occupational fatality	0.7
Fatality	5.67	Public fatality	2.7

INEEL = Idaho National Engineering and Environmental Laboratory

The risks associated with off-INEEL transportation activities presented in Schofield (2002) were scaled to account for 7,400 truckloads. During the off-INEEL transportation of the TRU waste to WIPP, approximately four deaths resulting from traffic-related accidents are projected for drivers and the public.

Short-term risks also were quantified for an off-normal occurrence (accident) during remediation (Schofield 2002). These risks are portrayed in terms of the effects on a maximally exposed individual. The worst-case unmitigated accident scenario established for the RTD alternative was for a worker exposed to a high concentration of airborne radiological activity. For this event, it was assumed that a heavy equipment operator inadvertently uncovered a large pocket of highly contaminated soil resulting in the resuspension of large amounts of contaminated particulate matter. The soil pocket is assumed to contain 6.5E+03 Ci of Pu-239 (approximately 10% of the reported SDA inventory). On hearing the air monitor alarm, the operator, who would be wearing an air-supplied hood, would take 3 minutes to exit the primary containment area. The lifetime cancer risk for operators is estimated to be 3.12E-02. It is assumed for this scenario that the ventilation system would be effective in retaining the particulate matter and that receptors outside the primary containment structure would not be exposed.

This alternative also includes an environmental monitoring component that would require controls for the health and safety of personnel. Procedures are currently in place that use engineering and administrative controls and PPE to ensure worker protection during monitoring activities. In the event that the existing monitoring network is expanded as part of this alternative, engineering, administrative, and PPE measures would be used to adequately protect workers during installation. Through past waste retrievals, the INEEL has demonstrated the ability to use engineering and administrative controls for worker protection (Sykes 2002).

4.6.2.9.3 Environmental Impacts Associated with Construction—Environmental impacts associated with the RTD alternative include landscape modifications and particulate emissions associated with retrieval activities and increased construction-related traffic. The surrounding landscape would be disturbed by equipment and vehicles moving in and around the site. Particulate emissions would be controlled with dust-suppression techniques as necessary to ensure that the rate of exposure to off-INEEL receptors would not exceed either the 25 mrem/year for total effective dose equivalent from all exposure pathways, or the 10 mrem/year for total effective dose equivalent through the air pathway, in accordance with DOE Manual 435.1-1. Radiological occupational exposures would be kept ALARA and below the limits set forth in 10 CFR 835.202 and "Radiation Protection—INEEL Radiological Control Manual" (PRD-183) of less than 2 rem/year for each worker.

After all waste has been processed, the processing facility would undergo a D&D&D phase. All LLW and MLLW associated with the D&D&D would be disposed of at the engineered storage facility. Any TRU waste associated with the D&D&D would be disposed of at WIPP. All process buildings would be removed and the site restored.

4.6.2.9.4 Time Until Remedial Action Objectives Are Met—The RTD alternative is projected to require the longest time to implement. In addition, many factors could affect time required to implement, design, construct, and operate the RTD alternative. These factors involve documenting and approving the activity in a timely fashion, available capacity at WIPP to dispose of the retrieved TRU waste, and actual production rates achieved during excavation and treatment. Several retrieval actions could be undertaken simultaneously to meet more aggressive schedules. Conversely, if several remediation projects were undertaken simultaneously, other technology components would be affected because several treatment and storage facilities would have to be constructed and operated. A more aggressive schedule also would increase frequency of shipments to WIPP, and the shipping schedule would have to be modified to handle the load.

4.6.2.10 Implementability (Balancing Criterion). Implementing a large-scale retrieval action at the SDA would be complex because a project of this magnitude has not been attempted before. Evaluations have been performed on retrieval technologies and the most recent excavation experience has been reviewed to determine construction and operation issues associated with this type of project. Many issues arise when evaluating the feasibility of implementing various technologies. Major issues that affect technical feasibility of the alternative are discussed below and are organized to progress through the various components of RTD to identify those with proven implementability, as well as those parts of the alternative where implementation may be difficult. In addition, technical feasibility is discussed by evaluating similarities between other retrieval projects for similar waste and the applicability of these projects to the RTD alternative. In addition, administrative feasibility and availability of needed services and materials is presented to assess the overall implementability.

4.6.2.10.1 Implementability of Preretrieval Activities—Removing soil cover at the SDA with a bulldozer, stockpiling material for characterization, and then using the soil as backfill would be feasible. Characterizing the topsoil layer before removal would aid in determining its disposition. Some areas may not be removed if (1) the material is not clean (e.g., such material would be retrieved with waste as contaminated soil), or (2) the material is providing shielding from the radioactive waste in that location. Removing soil cover should not lead to schedule delays.

In situ thermal desorption would be performed before waste retrieval to remove more than 80% of the VOCs in the waste. Initial VOC extraction could be done before soil cover removal, depending on design requirements. The ISTD systems could be constructed and operated in most locations, although a few isolated locations might not be amenable to VOC extraction (e.g., areas with low VOC content or areas with a lot of oversized debris). Extracting the VOCs before excavation is projected to be more advantageous than addressing health and safety and waste issues associated with high VOC content during excavation, and subsequently in the off-gas during RTD.

4.6.2.10.2 Implementability of Retrieval Activities—Double containment is projected to be necessary for those actions that could potentially involve source release. The primary and secondary containment structure selected for this alternative would provide this containment. Most of the pits are small enough that one containment building could cover the entire pit. Several pits are too large (larger than the average span of a 200-ft building) and two buildings would be necessary. This means that structural support for the buildings (e.g., H-piles, shoring, or soldier piles) would be placed through the waste to anchor the building to bedrock. For the trenches, the containment structure would be constructed in a similar manner with no unique construction or operation issues. Therefore, several trenches could be housed within one containment building because trenches are adjacent to each other and fairly narrow. Other waste-disposal locations (e.g., SVRs located near or between trenches to be retrieved) could be identified before construction and would be left in place. Metal curtains hung from the gantry crane could be constructed, but sealing the curtains and maintaining negative pressure and proper airflow are implementation issues to be resolved during design. Using the curtain as a barrier to confine the excavation, but not as an airseal or containment, is feasible.

Contamination controls needed for decontamination, fixation, dust suppression, and source control are available (e.g., foggers, misters, fine sprays, and strippable coatings) and are anticipated to be attainable to construct or operate. Minor contamination issues within confinement and containment could be mitigated and controlled.

The source control ventilation system attached to the containment structure and used within the confinement at the digface would use a hose system to draw air and airborne particles downward to the floor of the excavation for collection. Details of this system would be developed during the design phase and the optimum system configuration would be obtained.

Manned and modified standard equipment is the most implementable option for the retrieval equipment, although it is anticipated that effective remote equipment would be available for consideration during design. Cranes were viewed as less versatile than excavators because supports needed to construct and operate cranes would make them more difficult to move to a new site. However, constructing and operating the crane for contamination control and fire suppression were deemed straightforward and would be used to complement the standard excavator.

One of the greatest control risks would be the maintenance personnel who routinely enter the contaminated work areas to work on the retrieval equipment (Sykes 2002). Provisions must be in place to allow retrieval equipment to be driven into a controlled maintenance area adjacent to the work area so a more protected environment could be established. Entrance into the contaminated work area for retrieval equipment maintenance should be limited to nonroutine activities to control risk.

A front-end loader and a backhoe for sizing and sorting would be needed within confinement curtains to (1) clean sidewalls of the excavation, (2) move material within the confinement, and (3) cut, size, and sort the material for placement into waste bins. Recent experience at Hanford showed that two pieces of dedicated equipment could be operated within the containment area to increase production rates and facilitate digging, sizing, and sorting actions. The evaluation considers construction of hermetically sealed equipment for this type of operation and operating this equipment in the SDA environment as feasible. Having an operator using PPE in the cabs of the equipment (with supplied air if deemed necessary) is a proven type of operation regarded as feasible. Equipment would require standard maintenance and would be replaced several times during the project lifetime. Many end-effectors (e.g., different-size buckets, some with claws, some toothless; cutters; and grapplers) would be located adjacent to the working digface and are readily available and proven. Previous experience indicates that metal bands wrapped around containers would catch on the equipment (as has occurred during previous retrievals and the cold test [Sykes 2002]) and would have to be cut loose. A second piece of equipment at the working digface would make this a relatively easy operation.

The technique of benching down the excavation and forming a working face in a pit is feasible because waste is relatively compact in clay-type material. Photographs of buried waste during retrieval at many of the pits (EG&G 1978; Thompson 1972) show that the material is relatively compact, so extreme sloughing should not occur. If the equipment breaks down, manned entry into maintenance areas is deemed feasible with the availability of contamination controls and airlock systems. However, redundant systems need to be employed to ensure continual operation. Significant lost time could occur if unknown or unanticipated conditions were encountered, as was the case for the operation at the Hanford 618-B-4 Project. The primary lesson learned from the Hanford Project was that unexpected quantities or types of anomalous waste materials unearthed resulted in schedule delays and the suspension of operations (Sykes 2002). Establishing a second concurrent retrieval action would alleviate this concern, but the treatment system, lag storage area, and many other systems would have to be sized accordingly.

For the trenches, constructing and operating the necessary technologies to retrieve, treat, and dispose of the buried waste is technically feasible. Operational issues needing to be resolved during design are (1) methods for handling the large volume of clean and contaminated soil between the trenches, (2) SVRs that are between the trenches, and (3) isolated waste disposal locations present in the containment (if any are found). Shoring the sidewalls and maintaining structural integrity of the waste would be implementable.

Keeping the retrieval operation contamination-free would prove difficult. During previous retrieval actions at the SDA, the nature of the waste complicated the retrieval and slowed digging operations. The discovery of many seriously damaged barrels necessitated hand digging and lifting. It was recognized that the main problem inherent in mass techniques is the difficulty in achieving contamination control in areas where cardboard cartons and wooden boxes are buried and interspersed with barrels (Sykes 2002). To maintain control of contamination spread, material may be laid down or sprayed on the excavation floor and in dedicated maintenance areas so that equipment driven over the area would not resuspend the contamination. Spills that occur at the digface could be handled with standard equipment and operations. The design effort would determine appropriate trigger points and action levels for spills and reportable quantities for SDA waste retrieval.

Monitoring at the digface for the RTD alternative includes only health and safety monitoring (e.g., visual, gamma, VOC, and fire monitoring and simple chemical testing). Characterization for waste treatment would not be performed at the digface. Gamma detection monitoring also could be used for waste segregation to increase precision of retrieval, but this is a secondary benefit of the equipment. No special equipment would be used for characterization except under nonroutine conditions when a sample could be collected from the excavator bucket. This monitoring program is technically feasible and easy to construct and operate. The observational approach, along with shipping records and previous remediation experience, would be used to keep the operation simple.

Backfilling the sites would be technically feasible and operation and construction issues would be minor. Similarly, packaging waste and soil would be technically feasible and materials would be readily available. However, packaging material must be compatible with waste disposal and characterization requirements. Screening each waste bin to determine the TRU or non-TRU nature of the material would employ NDA. Supersacks used for soil also are not amenable to current TRU NDA because of their large size and the heterogeneity of the soil. This package option also requires further development to determine and demonstrate an implementable approach.

4.6.2.10.3 Implementability of Treatment Activities—Constructing and operating the waste processing facility would be technically feasible. Handling TRU-contaminated materials has been done routinely and safely at Rocky Flats Plant (the source of most of the SDA waste) for many years. The AMWTP being constructed adjacent to the SDA is scheduled to begin processing TRU waste from the TSA in 2003,. Steam reforming is sufficiently understood, has been proven, and would be implementable. The reliability of steam reforming is high compared to other large thermal processing systems. The necessary off-gas equipment also would be similar and implementable. Sufficient technical expertise currently exists to successfully design and construct this facility.

Because using thermal treatment for processing radioactive waste on this large scale has not been done before, development effort (including large-scale testing) would be required before making a final commitment to this technology. Development efforts would concentrate on (1) performance of drum-treatment units, (2) steam-reforming chemistry for the waste to be processed, (3) off-gas treatment including catalytic oxidation, waste feed and discharge systems, and (4) containment issues (e.g., kiln seals if a kiln system were selected).

4.6.2.10.4 Implementability of Onsite and Off-INEEL Disposal Activities**—**For onsite disposal, implementability issues revolve around regulatory concerns that would dictate specific treatment standards or design requirements for the onsite storage facility. However, some RCRA hazardous waste has been buried in the SDA. Similar waste disposed of in the TSA included 25 listed and characteristic waste codes, including D and F codes. Excavating RCRA waste in the SDA could trigger RCRA Subtitle C requirements (e.g., LDRs) requirements, which would potentially dictate performance- or technology-based treatment standards. However, because WAG 7 would be identified as an AOC, the CERCLA process allows moving and consolidating waste within the AOC without triggering LDRs. Pretreatment requirements for TRU waste would not be affected because shipments to WIPP are exempt from LDRs.

For off-INEEL disposal, current capacity of WIPP may pose an issue for this alternative. If the additional TRU waste generated from implementing the RTD alternative exceeds available capacity at WIPP, then another amendment to the WIPP Land Withdrawal Act Amendment of 1996 to expand the capacity at WIPP would be required or an alternative disposal option would have to become available. Current estimates of the total volume of material to be disposed of at WIPP from the RTD alternative represents about 35% of the current capacity of WIPP.

Another implementability consideration is the magnitude of transportation requirements to WIPP and associated environmental concerns. To transport the currently projected volume of TRU waste, more than 7,400 truckloads to WIPP would be needed to complete the project. This would have some impact on roads and communities adjacent to the INEEL and is similar to the number of TRU waste shipments planned from Hanford.

4.6.2.10.5 Technical Feasibility**—**An evaluation of case studies of past retrieval operations and the remedial design recently completed for OU 7-10 supports the conclusion that manually operated retrieval of most types of buried waste would be technically feasible. A list of historic retrieval operations involving mixed radioactive buried waste is presented in Table 4-16.

A careful analysis of the retrieval work performed indicates that the success of all the actions depended on the type and condition of the waste encountered. In previous INEEL projects, otherwise successful retrieval campaigns were thwarted in certain areas when severely deteriorated containers and high levels of airborne contamination were encountered. These past demonstrations lead to the conclusion that drummed waste streams could be retrieved if airborne contamination is adequately controlled to protect remediation workers.

The Glovebox Excavator Method retrieval system, currently under construction at Pit 9 (OU 7-10 Stage II), consists of a fabric weather enclosure structure, steel retrieval confinement structure, excavator, ventilation system, and other supporting equipment. Excavation will commence in 2003, and will clearly demonstrate the technical feasibility of limited retrieval in the SDA. Overburden will be removed to a specified depth, then the excavator arm contained within the retrieval confinement structure will excavate a semicircular swath of waste zone material. The retrieved waste zone material will be placed in a transfer cart by the excavator bucket. One transfer cart will be located at the entrance to each of the three material-packaging gloveboxes. The transfer carts will transport waste zone material inside the gloveboxes where the material will be inspected, segregated where necessary, and sampled. Each of the three gloveboxes will be equipped with three drum bagout stations for packaging the material into 55- and 85-gal drums. The *Technical and Functional Requirements for the Operable Unit 7-10 Glovebox Excavator Method Project* (INEEL 2002) sets the technical baseline for the project.

Table 4-16. Summary of retrievals performed by the U.S. Department of Energy.

Retrieval Description	Year
RFP Trench 1 Burial Ground	1998
Hanford 300 Area 618-4 Burial Ground	1998
Los Alamos Area P Material Disposal Area Technical Area 16	1997
Sandia Radioactive Waste Landfill ER Site 1 and Chemical Disposal Pits ER Site 3	1996
Maralinga	1996
Calvert City	1980s
INEEL SDA Initial Drum Removal Project	1974
INEEL SDA Early Waste Retrieval Project	1974
INEEL SDA solid radioactive waste retrieval test	1972

ER = environmental restoration
INEEL = Idaho National Engineering and Environmental Laboratory
RFP = Rocky Flats Plant
SDA = Subsurface Disposal Area

Table 4-17 provides a summary of technical elements required for the RTD alternative. The level of development is presented for each technology. As shown, many of the technologies required for the RTD alternative have reached advanced stages of development and are commonly used in industry. However, some technologies would require additional development.

Table 4-17. Summary of Retrieval, Treatment, and Disposal alternative remedial elements and levels of development.

Remedial Elements	Level of Development[a]
Remove overburden soil with dozer	5
Characterize overburden soil	5
Perform in situ VOC extraction of buried TRU waste	2
Construct containment structures	5
Construct and operate gantry cranes	5
Apply contamination controls	2 through 5, depending on type used
Construct and operate hermetically sealed equipment	4
Construct and operate airlocks in containment	4
Monitor gamma radiation and VOCs at digface	5
Use the observational approach for excavation	5

Table 4-17. (continued).

Remedial Elements	Level of Development[a]
Perform thermal treatment for non-TRU waste	5
Perform TRU treatment	3
Construct and use waste bins for waste and soil	5
Construct and use NDA to separate TRU in 55-gal drums	5
Construct and use NDA to separate TRU in bins or supersacks	4
Construct and operate onsite landfill	5
Dispose of TRU at WIPP	5

a. Key
1 = Based on theoretical concepts and engineering judgments.
2 = Concept is similar to, but not the same as, other demonstrated applications.
3 = Concept has worked at smaller scale.
4 = Concept is demonstrated in a few applications.
5 = Concept is a common industry practice or has been demonstrated many times.

NDA = nondestructive assay
TRU = transuranic
VOC = volatile organic compound
WIPP = Waste Isolation Pilot Plant

4.6.2.10.6 Administrative Feasibility—Though actions would be implemented under CERCLA for OU 7-13/14 that would not require permits, substantive provision of permits that would otherwise be required are considered to be ARARs. Because the RTD alternative would adequately address identified ARARs, no known administrative barriers exist to prohibit implementation.

For the RTD alternative, potential administrative feasibility issues would revolve around regulatory concerns, which would dictate specific treatment standards and design requirements for the onsite disposal facility. For example, a considerable amount of hazardous waste buried in the SDA might be similar to waste currently stored in the TSA. For the TSA waste, at least 25 listed and characteristic waste codes are identified. Excavating hazardous waste from the SDA could trigger additional substantive requirements that would potentially dictate performance- or technology-based treatment standards.

One challenging issue with any remedial action taken at the SDA would be demonstrating readiness to conduct safe operations and obtaining administrative approval to commence operations because of the nuclear hazards. The RTD alternative activities would expose the buried waste and pose a risk for contamination. The process of safety analysis, design, and demonstration of operational readiness for systems and techniques to remove and treat the waste would be complex. However, based on the safety analysis and design work completed for OU 7-10, these issues would be adequately mitigated with proper design and operations for identified SDA waste streams.

4.6.2.10.7 Availability of Services and Materials—Equipment and structures required for a retrieval action would have to be built specially for this project because of the nature of the waste and site conditions. Examples include remote equipment, containment structures, ventilation systems, contamination control devices, treatment units, storage facilities, monitoring devices, and packaging facilities. In addition, workers required to implement this alternative would have to be specifically trained.

Availability of sufficient capacity at WIPP could be an issue, and the additional TRU waste generated from the RTD alternative could exceed the available capacity by approximately 25,000 m^3 (32,700 yd^3) assuming current waste projections for all the TRU waste generators are accurate. However, additional capacity could be made available if the U.S. Congress amends the WIPP Land Withdrawal Act Amendment of 1996.

4.6.2.10.8 Implementability Summary for Retrieval Alternative—Overall, the RTD alternative is technically feasible and implementable. In summary, the primary technologies that might require further development include thermal treatment as applied to the SDA waste and its off-gas system, TRU analysis, fogging systems, and remote operations to support treatment. Thermal treatments described in previous sections are reasonably demonstrated technologies for a wide range of contaminants including PCBs, pentachlorophenols, chlorinated rubbers, wood, debris, and soil.

If personnel are not allowed to operate retrieval equipment within the dig-face area because of safety, administrative, or other concerns, then using remote technologies would be required. In this event, additional design and development work might be needed to demonstrate the applicability of remote technologies for the SDA waste conditions. (Note that significant improvements are being made to remotely operated excavation equipment by commercial vendors.) Work would be focused on retrieving, sizing, and sorting technologies and developing remote system designs that would achieve acceptable production rates.

4.6.2.11 Cost (Balancing Criterion). The net present value of the RTD alternative is estimated at $3,780 million, which includes capital costs of $3,776 million and O&M costs of $3 million. Table 4-18 summarizes costs for the RTD alternative.

The primary capital costs are associated with waste retrieval and treatment applications at primary waste sites. The primary O&M costs are associated with the environmental monitoring program. Costs include an estimated average 40% contingency. Factors that are addressed with assumptions in PERA cost estimates include the following:

- Production rate
- Remote versus manned equipment
- Characterization requirements at digface, treatment facility, and for disposal
- Hazard classification (Category 1, 2, 3, or radiological)
- Treatment requirements for disposal
- Availability of disposal capacity at WIPP
- Characterization costs for WIPP disposal
- Number of unknown conditions that could cause shutdown or redesign.

Table 4-18. Total estimated costs for the Retrieval, Treatment and Disposal alternative with contingency.

Cost Element	Total Costs ($M)	Net Present Value ($M)
Capital costs		
Waste and soil RTD	5,771.0	—
In situ grouting treatment	191.7	—
Surface barrier	83.6	—
Volatile organic compound treatment using ISTD	52.2	—
Testing	133.2	—
Management, design, and reporting	627.2	—
Total capital costs	6,858.9	3,776.4
Operating and maintenance		
Monitoring and surveillance	16.7	—
Cover maintenance	9.0	—
Fencing and signage	0.3	—
Management	4.2	—
Total operating and maintenance costs	30.2	3.4
Total	**6,889.1**	**3,779.7**

ISTD = in situ thermal desorption
RTD = retrieval, treatment, and disposal

One of the most sensitive elements in the cost estimate is the operational production rate for retrieval. As discussed previously, a retrieval rate of 76 m^3 (100 yd^3) per shift was used to estimate the overall retrieval schedule. However, because of the complex nature of the waste stream, project delays, or slower actual production, risks could be realized. In addition, if the decision were made to remotely retrieve the waste using a robotic versus the operator-in-cab method, then the production rate would be greatly affected (e.g., possibly decreased by a factor of two [Sykes 2002]).

A cost evaluation has been performed to show the sensitivity of the total capital costs for the RTD alternative when production rates are varied. Figure 4-28 shows the projected cost increase if the waste retrieval rate was decreased from 100 yd^3 per day. As shown, if retrieval production rates slowed from 76 m^3 (100 yd^3) per day to 38 m^3 (50 yd^3) per day, the total capital costs would increase from approximately $6.9 to $8.9 billion.

Costs for waste transportation and disposal at WIPP are not included in the cost estimate. These costs are covered by other DOE budgets.

Past retrieval actions at other DOE complexes have run into unknown conditions and have shut down, reevaluated the situation, redesigned the alternative, and may (or may not) have commenced remediation (Sykes 2002). This type of situation could possibly occur at the SDA, and such an occurrence could greatly increase the cost of this alternative. For this PERA, it is assumed that these costs would be included in the established contingency budget.

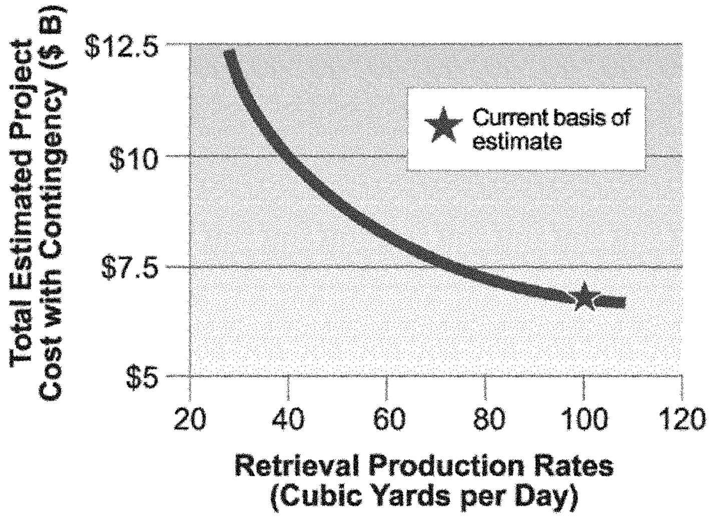

Figure 4-28. Sensitivity analysis for Retrieval, Treatment, and Disposal alternative production rates and total projected costs.

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5. COMPARATIVE ANALYSIS AND RECOMMENDATIONS

This section presents a comparative analysis of the assembled alternatives presented in Section 4 and recommendations for future evaluations to support developing the WAG 7 feasibility study.

5.1 Comparative Analysis of Remedial Alternatives

Following sections provide comparative discussions while briefly assessing advantages and disadvantages of each alternative with respect to the CERCLA screening criteria. A summary of the assessment is provided in Figure 5-1. More details of the comparative screening evaluation are in Appendix C.

5.1.1 Overall Protection of Human Health and the Environment

All assembled alternatives (with the exception of the No Action alternative) would achieve the RAOs. The alternatives would effectively control or eliminate potential exposure pathways, reduce future contaminant releases from the source term, and protect human and ecological receptors. However, all alternatives would leave waste in place within the SDA. Therefore, long-term protectiveness for each alternative depends on the basic premise that DOE or another federal agency would retain control of the site in perpetuity.

In evaluating overall protectiveness, long-term risks and short-term impacts resulting from remediation are considered. As discussed, all action alternatives can satisfy RAOs and provide long-term protectiveness. However, potential short-term impacts could be substantially different. In general, both the Surface Barrier and the ISG alternatives have the shortest implementation period and would have comparably lower potential impacts on both workers and adjacent communities. The Surface Barrier alternative is essentially a standard earthwork operation requiring the least intrusive work. The ISG technology has been extensively researched at the INEEL to provide an approach that minimizes risks to workers and the environment. The two remaining alternatives, ISV and RTD, could have significantly higher short-term impacts in comparison. The ISV concerns involve variability and uncertainty in the nature of buried waste, potential impacts due to emissions from the ISTD and ISV process, and potential melt expulsion events during ISV. Though design measures could be implemented to minimize these potential impacts, additional onsite design testing would be required to adequately address these issues. The RTD alternative requires significant intrusive work that could result in the greatest impacts on workers and the environment. In addition, the RTD alternative includes a significant off-Site transportation component for TRU waste disposal at WIPP. This would result in increased traffic loading and associated impacts within the adjacent communities.

As presented in the previous sections of this PERA, fate and transport modeling indicates that all action alternatives would reduce contaminant migration to groundwater to within acceptable concentrations. However, modeling also indicates potentially significant influences on groundwater quality from contaminants that may have been previously released from the source term to the underlying vadose zone. Impact from this postulated contamination in the vadose zone, in terms of risk to potential future receptors, is presented in Figure 5-2.

	Alternatives				
Criteria	No Action	Surface Barrier	In Situ Grouting	In Situ Vitrification	Retrieval/ Treatment/ Disposal
Overall protection of human health and the environment	• Does not address RAOs • Does not provide for the overall protection of human health and the environment	• Addresses RAOs • Immobilizes and isolates COC bearing wastes through capping • Destroys organic COCs in high concentration waste streams using ISTD • Immobilizes activation/fission product COCs using ISG	• Addresses RAOs • Immobilizes COC bearing wastes using ISG • Destroys organic COCs in high concentration waste streams using ISTD	• Addresses RAOs • Immobilizes and destroys wastes using ISTD/ISV • Immobilizes activation/fission product COCs using ISG	• Addresses RAOs • Removes TRU wastes from site • Non TRU COC bearing waste streams will be retrieved, treated and placed in on-site engineered landfill. • Immobilizes remaining COC wastes using ISG
Compliance with ARARs	• Not compliant	• Potentially compliant	• Potentially compliant	• Potentially compliant	• Potentially compliant
Long term protectiveness and permanence	• Does not provide for long term protectiveness	• Provides long term protectiveness • Long term maintenance required to insure protectiveness	• Provides long term protectiveness • Potentially permanent solution • Long term maintenance required to insure protectiveness	• Provides long term protectiveness • Potentially permanent solution • Long term maintenance required to insure protectiveness	• Provides long term protectiveness • Permanently removes risks associated with TRU wastes • Long term maintenance required to insure protectiveness
Reduction of toxicity mobility and volume through treatment	• Does not reduce source toxicity, mobility, or volume	• ISG treatment reduces contaminant mobility in SVRs and trenches. • ISTD treatment reduces organic COC volumes in high concentration waste streams.	• Reduces contaminant mobility in all COC bearing wastes	• Reduces contaminant mobility, toxicity and volume in all COC bearing wastes	• Removes TRU wastes • Ex situ treatment will reduce toxicity, mobility, and volume of retrieved non-TRU wastes from pits, trenches, and Pad A. • ISG treatment reduces contaminant mobility in SVRs and trenches.
Short term effectiveness	• Lowest worker risk	• Minimal intrusive work requirements	• Contamination control for ISG researched for INEEL specific application	• Contamination control for ISV has not been proven. • Higher potential worker risk	• Extensive intrusive work requirements • Highest risks to workers and off-site communities
Implement-ability	• Easily implemented	• Primary technology (surface barrier) consists of standard earthwork operation.	• Primary technology (ISG) has been researched for SDA specific application.	• Primary technology (ISV) requires specialized equipment.	• Requires complex interaction of remedial activities and technologies with site-specific designs
Costs	Total Cost **$ 38.5M** Net Present Value **$ 9.6M**	Total Cost **$841.6M** Net Present Value **$616.1M**	Total Cost **$1,118M** Net Present Value **$ 822.6M**	Total Cost **$1,815.3M** Net Present Value **$1,197.3M**	Total Cost **$6,889.1M** Net Present Value **$3,779.7M**

Figure 5-1. Comparative analysis of alternatives.

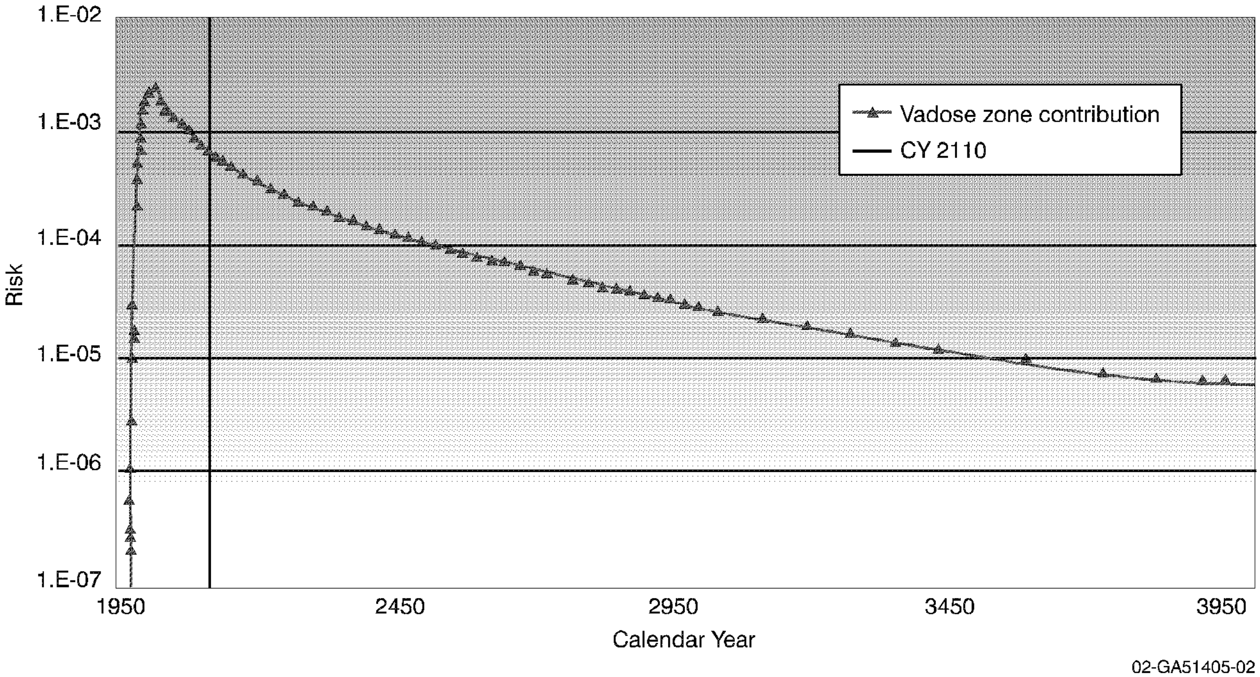

Figure 5-2. Groundwater risk for a hypothetical future residential scenario resulting from postulated contamination in the vadose zone.

Results of the analysis indicate that, regardless of the alternative selected (including RTD), future adverse impacts on the groundwater near the SDA could be realized. As shown in the figure, contaminants within the vadose zone are projected to result in carcinogenic risk exceeding 1E-04 in the underlying groundwater extending for approximately the next 500 years. However, several issues must be considered in interpreting Figure 5-2:

- The plot shows maximum cumulative groundwater ingestion risk associated with postulated contamination in the vadose zone. The simulated receptor location for this maximum risk is generally at the southeast corner of the SDA, where maximum contaminant concentrations are predicted to occur. The region of the aquifer where the maximum estimated risk occurs is not readily accessible to the public because of its location within controlled boundaries of the INEEL. Modeled risk estimates at the INEEL boundary do not exceed 1E-06.

- Peak risk within the INEEL boundary, occurring in approximately 2010, is attributable primarily to C-14, I-129, and Tc-99. Substantial uncertainties are associated with estimated risks and, as discussed in the ABRA, detected concentrations in the environment do not validate the magnitude or timing of the maximum risks. Detected concentrations in the environment are much smaller than simulated concentrations, indicating that the models are not well calibrated. However, C-14, I-129, and Tc-99 have been detected in the environment, and some increasing trends in the monitoring data may be developing. Therefore, the potential vadose zone contamination indicated by the modeling may be developing, but not as quickly as is predicted in the simulations.

- If contaminant release is slower than assumed in the model, risk would spread out over time. Compared to the modeling results, the peak could occur later in time and could take longer to diminish. The magnitude of the peak risk could be less than the currently predicted peak, but could still exceed threshold levels because of the substantial mass of these contaminants in the SDA.

- The magnitude of the potential vadose zone contamination will be affected by the timing of remedial actions. If actions to substantially reduce release of C-14, I-129, and Tc-99 are implemented within the next few years, future impacts to area groundwater could be greatly reduced.

5.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

Compliance with ARARs is addressed by evaluating chemical-, action-, and location-specific factors. A summary of potential ARARs and TBCs is presented in Appendix A. A listing of ARARs, TBCs, and potential compliance issues for each alternative is provided in their respective subsections.

The PERA does not address remediating area groundwater. Therefore, contaminant-specific groundwater standards, such as federal and state drinking water standards, were not identified as ARARs for OU 7-13/14. All action alternatives reduce future releases from the source term to levels that comply with these standards, but do not address potential influences from contaminants that may have already been released to the vadose zone. Fate and transport modeling indicates potentially significant influences on groundwater quality from postulated contamination in the vadose zone.

The INEEL Site Composite Cover used for the Surface Barrier alternative or the Modified RCRA Subtitle C Cap used for the ISG, ISV, and RTD alternatives would effectively isolate waste and contaminated soil and provide compliance with contaminant-specific ARARs associated with air quality and dust emissions from the site.

All action alternatives can be designed to be compliant with the identified location-and action-specific ARARs and TBCs. The location-specific ARARs are essentially identical for all alternatives. To implement any alternative, appropriate study and mitigation measures would be conducted for developing borrow areas. The same would be done for any infringement on areas adjacent to the SDA to address the potential presence of archaeological and historical artifacts. It is assumed that all action-specific ARARs would be met by using appropriate engineering controls.

All action alternatives can achieve the RAOs and provide long-term protection of human health and the environment. Each alternative includes a protective cap with long-term maintenance to preclude biotic intrusion into buried waste and to minimize release of contaminants remaining in the source term. In addition, all alternatives would reduce future contaminant release such that concentrations in the aquifer will not exceed a hazard quotient of 2 or carcinogenic risk greater than 1E-04). Potential impacts of postulated contamination in the vadose zone are not addressed. The relative influence of each alternative on carcinogenic risk associated with groundwater quality is depicted on Figure 5-3.

As shown in the figure, the highest degree of groundwater protectiveness is provided by the ISG, ISV, and RTD alternatives. For these alternatives, groundwater risks associated with future releases from the source term would not exceed 1E-05 anywhere in the aquifer. The Surface Barrier alternative would result in steadily increasing carcinogenic risk levels over time, as contaminants slowly leach from the source term, approaching a 1E-04 level in year 12000. The No Action alternative yields cumulative carcinogenic risk in excess of 1E-03.

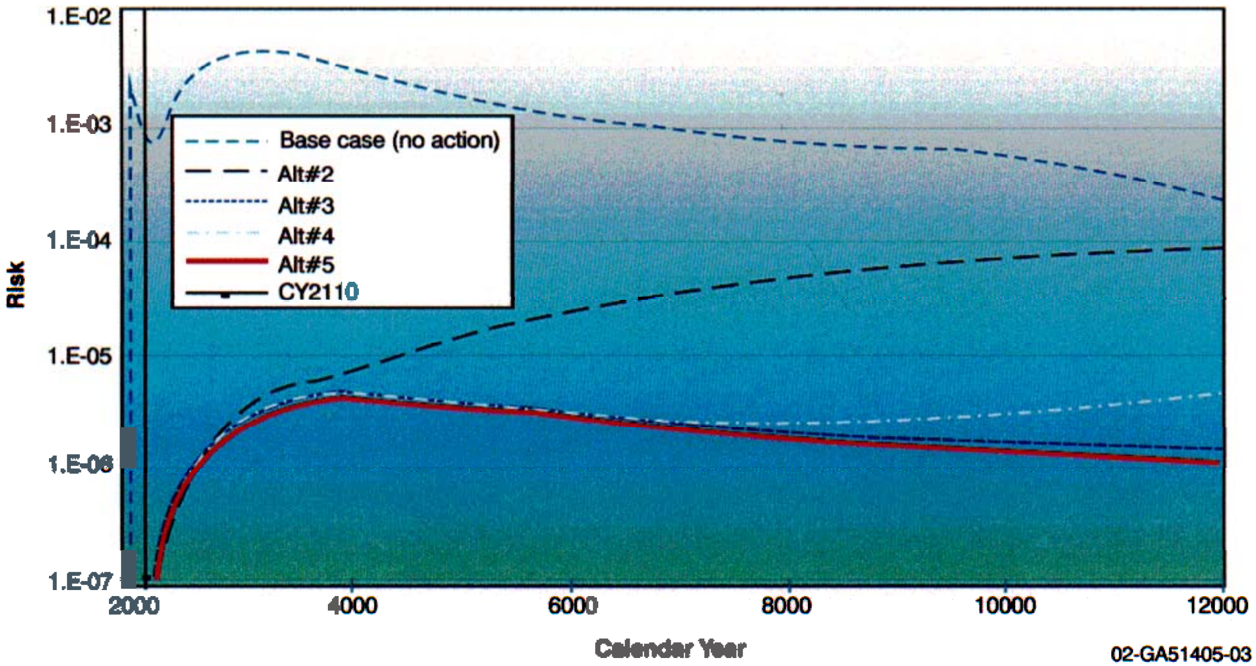

Figure 5-3. Carcinogenic risk in area groundwater for each alternative.

The Surface Barrier alternative would leave significant volumes of untreated waste onsite and thus, of all action alternatives is the least permanent solution. This alternative would require a long-term commitment to maintaining the cap system to ensure conformance with RAOs. Both the ISG and ISV alternatives immobilize contaminants through treatment, while the RTD alternative would reduce mass by removing and treating TRU waste. The ISV and RTD alternatives would reduce the mass of contamination in the SDA and therefore provide a greater degree of permanence than the ISG alternative.

5.1.3 Reduction in Toxicity, Mobility, and Volume through Treatment

The ISV and RTD alternatives would provide the greatest reduction in toxicity, mobility, and volume through treatment. The ISV alternative would destroy organic COCs and encapsulate TRU contaminants in durable glass-like monoliths. The RTD alternative would involve removing the majority of the waste containing TRU COCs from the site. Any retrieved waste returned to the site would be treated for hazardous constituents before disposal. For all the action alternatives (i.e., Surface Barrier, ISG, ISV and RTD), remote-handled waste containing C-14, Tc-99, and I-129 located within some trenches and SVRs would be encapsulated in place using ISG.

The ISG alternative would not significantly reduce the volume or treat the toxicity of the site contaminants. Instead, this alternative reduces contaminant mobility through chemical stabilization and encapsulation. This alternative would include ISTD as a pretreatment in high organic areas within the SDA. Applying this technology would reduce volume and toxicity of VOCs in the source term and thereby would minimize future operational requirements for the existing OCVZ system.

The Surface Barrier alternative primarily relies on placement of a low-permeability cover to reduce mobility of site contaminants. As such, this alternative would not provide for a major reduction of contaminant toxicity, mobility, or volume through treatment. The only exceptions are treating high organic areas with ISTD and treating activation and fission products within the SVRs and trench areas using ISG.

5.1.4 Short-Term Effectiveness

Short-term effectiveness criteria pertain to protecting the community and workers during remediation. An assessment of the potential short-term risks associated with each alternative conducted for this PERA is presented in Schofield (2002). Results of the assessment for each selected alternative are summarized in Figure 5-4.

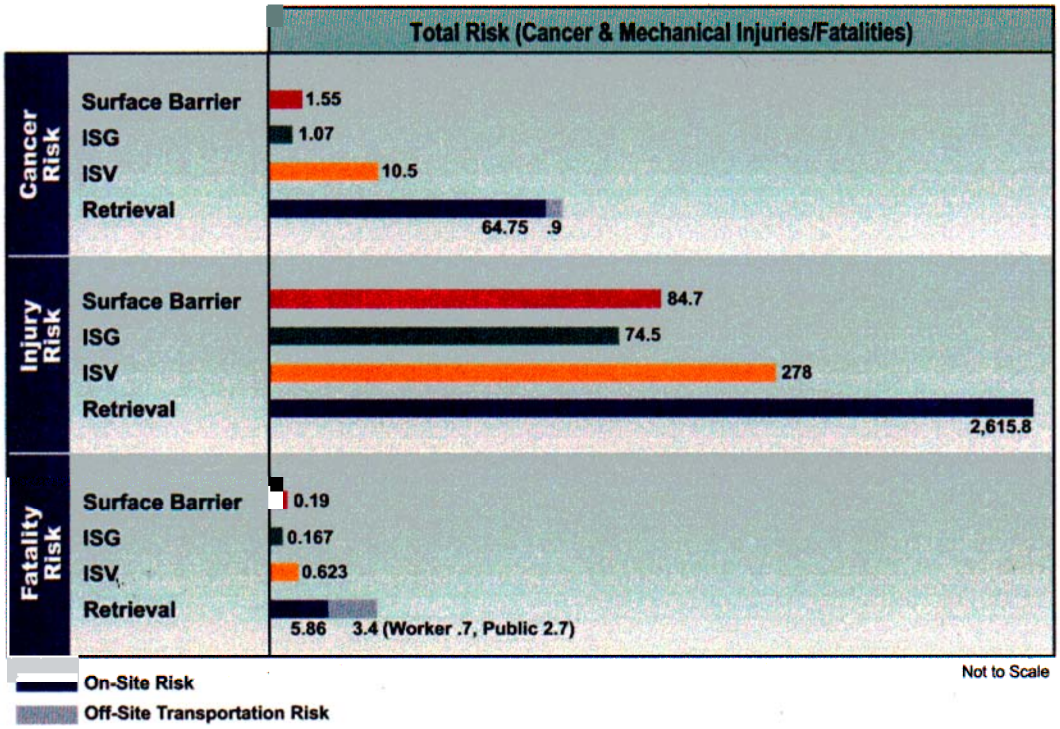

Figure 5-4. Short-term risk summary.

Results are presented separately in terms of the number of latent cancers, mechanical injuries, and fatality risks for each action alternative over the course of its implementation. It is inappropriate to sum all of the risks for an alternative because this would portray a skewed representation of the total risk. The number of mechanical injuries would always be much greater than the number of mechanical fatalities or latent cancers when calculated for the entire schedule of a remedial alternative.

As presented, the RTD alternative would have the greatest short-term risks to workers and the general public. Short-term risks calculated for ISV would be less than those for RTD, but would be greater than those presented for the ISG and Surface Barrier alternatives. The RTD and ISV alternatives would require additional engineering and administrative controls to ensure short-term effectiveness.

For the RTD alternative, potential risks to the public were estimated (see Figure 5-4). Risks to the public are primarily attributable to traffic accidents associated with transport of TRU waste from the SDA to WIPP.

5.1.5 Implementability

The No Action alternative would be the most implementable, requiring no changes in current conditions. This alternative only requires continued operation of existing monitoring networks.

Supplemental remedial technologies are common to all action alternatives. Supplemental technologies include ISG in SVRs and selected trenches to encapsulate activation and fission products, foundation grouting to reduce subsidence potential, retrieval of Pad A, and ISTD in high VOC areas. These technologies are all implementable, but will require additional analysis, design, and testing before they can be deployed.

For the Surface Barrier alternative, designs, materials, equipment, and construction techniques are readily available for constructing the cover.

The ISG alternative is implementable because it has been extensively researched for SDA-specific implementation. An examination of potential interference areas and careful selection of grout types would be and important component of remedial design. A particular concern is stabilizing Pad A waste that contains high concentrations of nitrates. Special equipment and procedures would have to be implemented to ensure worker safety for all intrusive technologies implemented at the SDA. However, compared to other intrusive treatment and retrieval actions, Pad A retrieval would pose the fewest difficulties.

The ISV alternative is less implementable than either the Surface Barrier or the ISG alternatives. Though ISV can adequately treat TRU waste and produce a highly durable and leach-resistant waste form, design uncertainties regarding safety requirements, off-gas treatment, and interference from various waste forms substantially reduce implementability of this alternative. New ISV designs, in particular the planar ISV technology, could effectively mitigate many traditional hazards. but planar ISV has not been sufficiently demonstrated on the variety and type of waste found in the SDA. Extensive analysis, design, and testing would be required before ISV could be implemented on the full-scale required at the SDA.

Implementing RTD would require the complex interaction of several remedial activities requiring site-specific design. The basic activities involving retrieving, repackaging, and safely storing RFP TRU waste streams are potentially implementable and have been demonstrated in varying degrees at other DOE facilities.

5.1.6 Cost

Cost comparisons for the alternatives are presented in Figure 5-5. As shown, the RTD alternative has the highest cost, at a projected net present worth of $3,780 million ($6,889 million, in total FY 2002 dollars). The RTD costs have a high degree of uncertainty because of radiological, chemical, and physical variability of the SDA waste. This variability could affect performance of specific technologies and result in significant impacts on productivity rates.

The next highest cost is for ISV and its net present value is estimated at $1,197 million with a total FY 02-dollar cost of approximately $1,815 million. This is considerably higher than costs estimated for the other in situ treatment alternative, ISG, that is estimated to have a net present value of $823 million and a total FY 02 dollar cost of $1,118 million.

The lowest cost alternative, with the exception of the No Action alternative, is the Surface Barrier alternative. The projected net present value for the Surface Barrier alternative is $616 million and the total FY 02-dollar cost is $842 million.

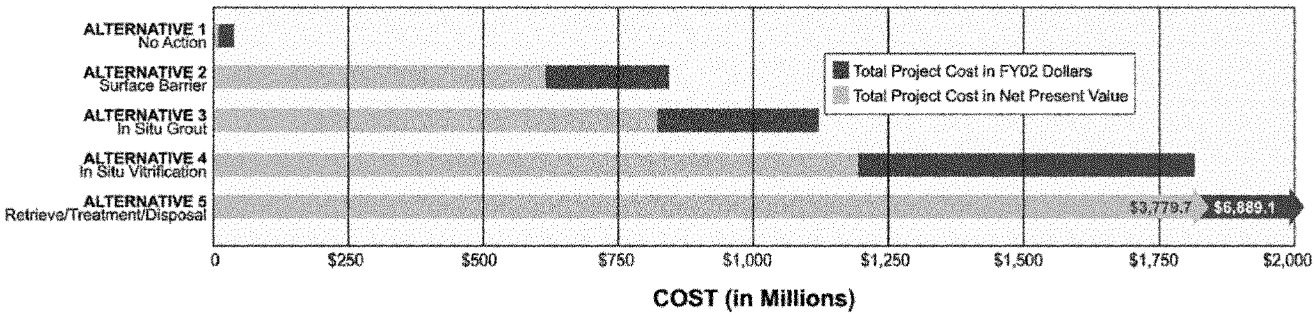

Figure 5-5. Cost summary.

5.2 Recommendations

This section provides a summary of proposed studies for developing the future WAG 7 feasibility study. Initial development of the feasibility study has been completed in this PERA, which provides RAOs, GRAs, technology and process option screening, and assembly of alternatives. The focus of the future feasibility study effort will be to refine and update the detailed analysis of alternatives presented in Section 4 and substantially expand the comparative analysis of assembled alternatives. Recommended areas of refinement include the following:

- Improve precision in descriptions of waste areas and volumes that require remediation using data from probing and probehole monitoring, waste inventory updates, and updates to WasteOScope

- Identify, quantify, and assess alternatives for special-case waste streams that could impede remediation, such as irradiated fuel materials and beryllium reflector blocks.

- Refine evaluation of long-term effectiveness and permanence, and reduction of mobility, toxicity, and volume through treatment using results from bench-scale tests; in particular enhance the ISTD effectiveness evaluation

- Refine waste form parameters for the feasibility study risk assessment modeling using results from the bench-scale and updated information from scientific literature

- Examine in-depth technical and administrative issues associated with implementing alternatives using results of safety and hazard assessments, and revise the short-term effectiveness and implementability evaluations accordingly

- Further define the WIPP waste acceptance criteria and process as the would apply to the RTD alternative and define procedures for characterizing and packaging the waste

- Review assumptions to cost estimates, verify assumptions that could have substantial impact on cost estimates (e.g., availability of borrow sources) and revise estimates.

To address these issues, the feasibility study should incorporate information available from waste inventory and waste zone mapping updates, probing and probehole monitoring, environmental monitoring, information from the OU 7-10 Glovebox Excavator Method Project, and any other source of information that becomes available.

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Appendix A

Applicable or Relevant and Appropriate Requirements

Appendix A

A.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Table A-1. Potential chemical-specific applicable or relevant and appropriate requirements and requirements to be considered.

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy[a]
		Air		
Idaho Code, Sections 39-105 and 39-107	Idaho Toxic Air Pollutants (IDAPA 58.01.01.585 and .586)	The release of carcinogenic and non-carcinogenic contaminants into the air must be estimated before the start of construction, controlled if necessary, and monitored during excavation and sorting of soil. Screening emission levels and acceptable ambient concentrations (AAC) for non-carcinogens are provided.	The requirements of Idaho's toxic air pollutants have been determined to be applicable because carcinogenic and non-carcinogenic air contaminants may be present.	A
Idaho Code, Sections 39-105 and 39-107	Idaho Ambient Air Quality Standards for Specific Air Pollutants (IDAPA 58.01.01.577)	These standards establish ambient air quality standards for particulate matter, sulfur oxides, ozone, nitrogen dioxide, fluorides and lead.	The requirements of Idaho's ambient air pollutants have been determined to be applicable because these pollutants may be present.	A
National Emission Standards for Hazardous Air Pollutants (NESHAPs) (42 USC 7412 *et seq.*)	National Emission Standards for Hazardous Air Pollutants (40 CFR 61.01 through 61.17 Subpart A)	This regulation provides general requirements for facility operations that emit regulated hazardous air pollutants. The regulation applies to any stationary source for which a standard has been prescribed.	These requirements are applicable to remedial actions that have the potential to release hazardous air emissions to unrestricted areas.	A
NESHAPs (42 USC 7412 *et seq.*)	Radionuclide Emissions from Department of Energy (DOE) Facilities (40 CFR 61.90 through 61.97 Subpart H)	Emission of radionuclides to the ambient air from DOE facilities will not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/year (40 CFR 61.92).	This emission requirement is applicable because radionuclide contaminants are present.	A

Table A-1. (continued).

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy[a]
		To Be Considered		
Radiological Protection	Radiation Protection of the Public and the Environment (DOE Order 5400.5)	This DOE Order establishes standards for DOE operations with respect to protection of the public and the environment against undue risk to radiation. This order sets limits for the annual effective dose equivalent at 100 mrem from all exposure pathways, but allows 500 mrem if avoidance of higher exposure is impractical. An annual effective dose equivalent from drinking water supplies operated by DOE is set at 4 mrem and states that liquid effluent from DOE activities will not cause public drinking water systems to exceed EPA MCLs.	This DOE Order is TBC because it addresses radioactive contaminants of concern at the site. It is not an ARAR because it is not a formally promulgated regulation. Compliance with DOE orders is required at WAG 7.	TBC
Radiological Protection	Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination, August 22, 1997 (EPA OSWER No. 9200.4-18)	This memorandum presents clarification for establishing protective cleanup levels for radioactive contamination at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites. EPA has determined that the dose limits established in the Nuclear Regulatory Commission (NRC) Radiological Criteria for License Termination (62 FR 39058, July 21, 1997) (25 mrem/year which is equivalent to 5×10^{-4} increase lifetime risk) will not provide a protective basis for establishing preliminary remediation goals (PRGs) under CERCLA. A dose of 15 mrem/year effective dose equivalent (equivalent to 3×10^{-4} increase lifetime risk) should generally be the maximum dose limit for humans.	This memorandum is a TBC because it addresses radioactive contaminants of concern at the site. It is not an ARAR because it is not a formally promulgated regulation. The cleanup level identified in this memorandum, though a TBC is considered by EPA to be more protective than NRC standards and should be considered in setting media cleanup standards.	TBC

a. A=Applicable requirement, RA=Relevant and appropriate requirement, TBC=Requirement to be considered.+
IDAPA=Idaho Administrative Procedures Act; EPA=Environmental Protection Agency; MCL=Maximum Contaminant Level; OSWER=Office of Solid Waste and Emergency Response

Table A-2. Potential Location-Specific ARARs and TBCs.

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy[a]
Native American Graves Protection and Repatriation Act of 1990 (25 USC 3001 *et seq*., P.L.101-601)	Native American Graves Protection and Repatriation Regulations (43 CFR 10)	These regulations require the protection of Native American burial sites and funerary objects. If Native American graves are discovered within remediation areas, project activities must cease and consultation must take place between the U.S. Department of Interior and the affected tribe.	These regulations are applicable if Native America human remains or burial objects are discovered where remedial activities are being conducted.	A
National Historic Preservation Act of 1966 (16 USC 470 *et seq*.)	Protection of Historic Properties (36 CFR Part 800; 40 CFR 6.301(b); Executive Order 11593; National Historic Landmarks Program (36 CFR Part 65); National Register of Historic Places (36 CFR Part 60)	The National Historic Preservation Act and its implementing regulations require that historically significant properties be protected. The act requires that agencies undertaking projects must evaluate impacts to properties listed on or eligible for inclusion on the National Register of Historic Places. The National Register of Historic Places is a list of sites, buildings, or other resources identified as significant to United States history. An eligibility determination provides a site the same level of protection as a site listed on the National Register of Historic Places. The regulations implementing the act require that the lead agency for a project identify, evaluate, and determine the effects of the project on any cultural resource sites that may be within the area impacted by the project. The implementing regulations require that negative impacts be resolved.	This regulation is applicable to remedial actions at WAG 7 if buildings/structures near WAG 7 are eligible for the National Register of Historic Places.	A
Archeological and Historic Preservation Act of 1974 (16 USC 469 *et seq*.)	Preservation of Historic, Prehistoric, and Archeological Data (40 CFR 6.301[c])	This act requires that actions conducted at the site must not cause the loss of any archeological and historic data. This act mandates preservation of the data and does not require protection of the actual facility. Where a site is determined to be eligible for the National Register and mitigation is unavailable, artifacts and data will be recovered and preserved prior to commencement of the remedial action.	This requirement is applicable if archeological or historic sites are identified within WAG 7.	A

Table A-2. (continued).

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy[a]
Archaeological Resources Protection Act of 1979 (16 USC 470aa -ii)	Protection of Archaeological Resources (43 CFR 7)	Federal agencies must identify possible effects of proposed remedial activities on historic properties (cultural resources). If historic properties or landmarks eligible for, or included in, the National Register of Historic Places exist within remediation areas, remediation activities must be designed to minimize the effect on such properties or landmarks.	This regulation is applicable to remedial actions at WAG 7 if buildings/structures near WAG 7 are potentially eligible for the National Register of Historic Places.	A
Idaho Preservation of Historic Sites (Idaho Statute 67-4601 *et seq.*) and Idaho State Historical Society (Idaho Statute 67-4113 *et seq.*)	Preservation of Historic Sites (Idaho Statute 67-4601 *et seq.*) and Idaho State Historical Society (Idaho Statute 67-4113 *et seq.*)	This regulation covers historical sites and historical districts within the state of Idaho and the excavation of archaeological resources. The State Historical Society publishes the National Register of Historic Places for Idaho.	These statutes may be applicable if historical sites or archaeological resources are present.	A
Endangered Species Act of 1973 (16 USC 1531 *et seq.*)	Protection of Endangered Species (50 CFR 402; 40 CFR 6.302[h])	This Act protects endangered or threatened species and their habitat. If endangered or threatened species are in the vicinity of remediation work, U.S. Fish and Wildlife Service (USFWS) must be consulted and the remediation activities must be designed to conserve endangered or threatened species and habitats.	The Endangered Species Act is applicable if threatened or endangered species are identified in areas where remedial activities will occur.	A
Fish and Wildlife Coordination Act (16 USC 661 *et seq.*)	Protection of Fish and Wildlife (40 CFR 6.302 [g])	These rules require consultation with the USFWS (and State of Idaho Department of Fish and Game) when any federal department or agency proposes or authorizes any modification of stream or other water body greater than 10 hectares, and provide adequate provisions for protection of fish and wildlife resources. Certain remedies may result in the temporary or permanent modification of naturally occurring water bodies and may require the construction of mitigated wetlands in other areas.	These rules are applicable if any modification of stream or other water body greater than 10 hectares is proposed.	A

Table A-2. (continued).

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy[a]
Idaho Classification and Protection of Wildlife (Idaho Statute 36-201)	Rules for Classification and Protection of Wildlife (IDAPA 13.01.06)	The Idaho Department of Fish and Game classifies wildlife as game, protected nongame, endangered, threatened, and species of special concern. None of the protected nongame, species of special concern, threatened, or endangered species may be taken or possessed, except as provided by Idaho Fish and Game.	These rules are applicable if protected wildlife are present in the area.	A
Executive Order 11988 Flood Plain Management (May 24, 1997)	Compliance with Flood-Plain/Wetlands Environmental Review Requirements (10 CFR 1022)	This regulation requires DOE and other Federal agencies to comply with the requirements of Executive Order 11990, *Protection of Wetlands*, and Executive Order 11988, *Flood-Plain Management*. Executive Order 11988 requires DOE procedures to ensure that any actions conducted in a flood plain consider flood hazards. Executive Order 11990 requires the protection of wetlands from destruction. The executive orders require that federal agencies implement these considerations through existing federal requirements, such as National Environmental Policy Act (NEPA) requirements. This regulation specifies that DOE prepare a flood-plain/wetlands assessment that includes a discussion of purpose and need, a project description, location of wetlands with respect to the project, high hazard areas located in the flood plain, and potential positive and negative effects on flood plains/wetlands. The assessment is also to include descriptions of alternatives to the proposed action that may be necessary to avoid potential negative impacts. The flood-plain/wetlands assessment would be prepared concurrent with and incorporated into the feasibility study, as necessary.	Though WAG 7 has not been officially designated by DOE as a flood plain, past flooding events demonstrate that these regulations may be applicable. There are no wetlands onsite.	A
NEPA (42 USC 4321 *et seq.*)	Protection of Flood Plains (Executive Order 11988; 40 CFR 6.302[b]; 40 CFR 6, Appendix A)	Requires federal agencies to evaluate the potential effects of action they may take in a flood plain to avoid the adverse impacts associated with direct and indirect development of a flood plain.	The location standards established for hazardous waste management facilities are relevant and appropriate to remedial actions at WAG 7 because of the potential for periodic floodings.	RA

Table A-2. (continued).

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy[a]
Resource Conservation and Recovery Act (RCRA) of 1976, (42-USC 6901)	Remediation Sites Located within 100-Year Flood Plains (40 CFR 264.1[j][7])	For remediation waste management sites subject to regulation under 40 CFR 264 Subparts I through O and Subpart X, the treatment, storage, and disposal facility (TSDF) owner/operator must design, construct, operate, and maintain a unit within a 100-year flood plain to prevent washout of any hazardous waste by a 100-year flood, unless the owner/operator can meet the demonstration of § 264.18(b).	This requirement is applicable because WAG 7 is a remediation waste management site subject to potential floodings.	A
RCRA (42 USC 6901)	Location Standards for TSDFs Located within Flood Plains (40 CFR 264.18[b])	The regulations require that waste management facilities located within a 100-year flood plain meet specific design standards for protection against floods. Facility operators have the option to demonstrate that facility procedures ensure that waste will be removed prior to flood waters reaching the facility or that no adverse effects to human health or the environment will result if the facility floods.	The location standards established for hazardous waste management facilities are applicable to remedial actions at WAG 7 because of the potential for periodic floodings.	A

a. A=Applicable requirement, RA=Relevant and appropriate requirement, TBC=Requirement to be considered.

IDAPA=Idaho Administrative Procedures Act; WAG=Waste Area Group;

Table A-3. Potential Action-Specific ARARs and TBCs.

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy [a]
Water				
Idaho Code, Sections 39-105, 39-107, 39-120 and 39-126	Idaho Groundwater Quality Rule Policies (IDAPA 58.01.11.006)	It is the policy of the State of Idaho to maintain and protect existing high quality of the state's groundwater. Existing and projected future beneficial uses of groundwater shall be maintained and protected, and degradation that would impair existing and projected future beneficial uses of groundwater and interconnected surface water shall not be allowed.	These requirements are applicable because discharge from the Site may potentially impact groundwater and surface quality of the state.	A
Clean Water Action of 1977 (33 USC 121 *et seq.*)	National Pollutant Discharge Elimination System (NPDES) (40 CFR 122.26)	This section of the NPDES regulation requires industrial facilities to obtain an NPDES stormwater discharge permit. Substantive requirements include monitoring and implementation of best management practice for stormwater discharges from construction activities.	The Idaho National Engineering and Environmental Laboratory has a general storm-water discharge permit. A project-specific storm-water pollution plan is required for construction activities that occur at WAG 7.	A
RCRA (42 USC 6901)	Standards for Owners and Operators of TSD Facilities – General Groundwater Monitoring (40 CFR 264.97)	These standards provide for the implementation of a groundwater monitoring program capable of determining the facility's impact on the groundwater in the uppermost aquifer underlying the facility.	Groundwater monitoring programs are applicable because hazardous constituents are present and may impact groundwater quality.	A
Idaho Code, Section 37-2101, 39-101	Public Drinking Water Systems (IDAPA 58.01.08)	This rule establishes requirements to control and regulate the design, construction, operation, maintenance, and quality control of public drinking water systems. Sections of the 40 CFR Parts 141 and 143 are incorporated by reference.	This rule is applicable if new drinking water source is developed in support of remedial activities.	A
Idaho Code, Section 39-101	Wastewater-Land Application Permit Rules	These rules establish the procedures and requirements for the issuance and maintenance of pollution source permits for the treatment of municipal and industrial wastewaters by application to land.	This rule is applicable if wastewater generated from remedial activities is applied on land.	A

Table A-3. (continued).

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy [a]
Idaho Code, Section 42-238	Well Construction Standards Rule (IDAPA 37.03.09)	This rule requires that provision be made for regulating water well construction. The rule contains minimum standards for constructing and abandoning cold water wells, health standards, and drilling permit requirements.	This rule is applicable if groundwater wells are constructed as part of the remedial actions.	A
		Air		
Idaho Code, Sections 39-105 and 39-107	Idaho Toxic Substances (IDAPA 58.01.01.161)	Any contaminant which is toxic to human or animal life or vegetation will not be emitted in quantities or concentrations as to injure or affect human or animal life or vegetation.	This requirement is applicable because hazardous contaminants are present in WAG 7.	A
Idaho Code, Sections 39-105 and 39-107	Idaho Polychlorinated Biphenyls (PCBs) (IDAPA 58.01.01.164)	This section prohibits the burning of any material containing greater than 5 ppm PCBs, except for incineration for the purpose of disposal. A permit is required for constructing or modifying a PCB incinerator. The use of best available control technology and monitoring instrumentation is required.	This requirement is applicable if materials containing greater than 5 ppm of PCBs are incinerated.	A
Idaho Code, Sections 39-105 and 39-107	Idaho Demonstration of Preconstruction Compliance with Toxic Standards (IDAPA 58.01.01.210)	A new or modified stationary source must demonstrate preconstruction compliance with all applicable local, state, or federal emission standards, National Ambient Air Quality Standards, and toxic air pollutants listed in IDAPA 58.01.01. 585 and 586. For remediation sources subject to CERCLA, if the estimated ambient concentration at the point of impact is greater than the acceptable ambient impacts listed in Sections 585 and 586, Best Available Control Technology shall be applied and operated until the estimated uncontrolled emissions from the remediation source are below the acceptable ambient concentration (IDAPA 58.01.01.210.16).	This requirement is applicable if new or modified stationary sources of air pollutants are constructed.	A
Idaho Code, Sections 39-105 and 39-107	Requirements for Portable Equipment (IDAPA 58.01.01.500.02)	Portable equipment for sorting and removing the soils, and any portable support equipment must be operated to meet state and federal air emissions rules.	These requirements are applicable if portable equipment is used to handle hazardous materials.	A

Table A-3. (continued).

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy [a]
Idaho Code, Sections 39-105 and 39-107	Idaho Prevention of Significant Deterioration Increments (IDAPA 58.01.01.581)	This section establishes the allowable degree of deterioration for the areas within the State of Idaho that have air quality better than ambient standards. Maximum allowable increases for particulates, sulfur dioxide, and nitrogen oxide are established for areas designated as Class I, II, or III.	This requirement is applicable if remedial action results in significant deterioration of ambient air quality.	A
Idaho Code, Sections 39-105 and 39-107	Idaho Visible Emissions (IDAPA 58.01.01.625)	Discharge of any air pollutant into the atmosphere from any point of emission for a period or periods aggregating more than 3 minutes in any 60 minute period which is greater than 20% opacity is prohibited.	This requirement is applicable if remedial action results in increase in opacity.	A
Idaho Code, Sections 39-105 and 39-107	Idaho Fugitive Dust (IDAPA 58.01.01.650, 651)	These standards require control of dust at all times, especially during excavation, sorting, and removal of soil.	The fugitive dust requirements are applicable if fugitive dust is generated during remediation.	A
Idaho Code, Sections 39-105 and 39-107	Idaho Fuel Burning Equipment – Particulate Matter (IDAPA 58.01.01.675 through 681)	These sections establish particulate matter emission standards for fuel burning equipment.	This requirement is applicable if fuel burning equipment is used.	A
Idaho Code, Sections 39-105 and 39-107	Idaho Particulate Matter – Process Equipment Emission Limitations on or after July 2, 2000 (IDAPA 58.01.01.710)	These requirements establish particulate matter emission limitations for nonfugitive emissions from process equipment. These requirements apply to process equipment operating on or after July 1, 2000.	This requirement is applicable if nonfugitive emissions are generated from process equipment.	A
Idaho Code, Sections 39-105 and 39-107	Idaho Rules for Sulfur Content (IDAPA 58.01.01.725)	This section establishes requirements to prevent excessive ground level concentrations of sulfur dioxide from fuel burning sources in Idaho.	This requirement is applicable if sulfur dioxide from fuel burning sources is emitted.	A

Table A-3. (continued).

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy [a]
Idaho Code, Sections 39-105 and 39-107	Idaho Rules for Control of Incinerators (IDAPA 58.01.01.785)	This section establishes requirements to prevent excessive emissions of particulate matter from incinerators.	This requirement is applicable if incinerator is constructed and operated on site.	A
Clean Air Act of 1977 (42 USC 7401 *et seq.*)	Standards of Performance for New Stationary Sources (40 CFR 60)	These requirements provide standards for new stationary sources or modification of existing sources.	These requirements are applicable if remedial actions include new or modification of existing stationary sources.	A
Clean Air Act of 1977 (42 USC 7401 *et seq.*)	National Emission Standards for Hazardous Air Pollutants (40 CFR 61)	This regulation provides general requirements for facility operations that emit regulated hazardous air pollutants. The regulation applies to any stationary source for which a standard has been prescribed.	These requirements are applicable to remedial actions that have the potential to release hazardous air emissions to unrestricted areas.	A
Clean Air Act of 1977 (42 USC 7401 *et seq.*)	Radionuclide Emission Monitoring (40 CFR 61.93)	Monitoring is required at release points that have potential to discharge radionuclides which could causes an Effective Dose Equivalent (EDE) in excess of 1% of the standard (0.1 mrem/year) to any member of the public.	These monitoring requirements are applicable because radionuclide contaminants are present.	A
Clean Air Act of 1977 (42 USC 7401 *et seq.*)	Radionuclide Emission Compliance (40 CFR 61.94[a])	Compliance with radioactive contamination release standards will be determined by calculating the highest effective dose equivalent to any member of the public at any offsite point where there is a residence, school, business or office. Submittal of annual monitoring reports is also required.	These requirements are applicable because radionuclide contaminants are present.	A

Table A-3. (continued).

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy [a]
Clean Air Act of 1977 (42 USC 7401 *et seq.*)	National Emission Standards for Asbestos, Standard for Demolition and Renovation (40 CFR 61.145 through 150)	This section specifies that facilities are to be inspected for the presence of asbestos prior to demolition. The standard defines regulated asbestos-containing materials and establishes removal requirements based on quantity present and handling requirements. These requirements also specify handling and disposal requirements for regulated sources having the potential to emit asbestos. Specifically, no visible emissions are allowed during handling, packaging, and transport of asbestos-containing materials.	These requirements are applicable if remedial actions require demolition of buildings or structures containing regulated asbestos-containing materials or such materials are exhumed from the ground.	A
Clean Air Act of 1977 (42 USC 7401 *et seq.*)	National Emissions Standards for Hazardous Air Pollutants (NESHAPs) for Source Categories (40 CFR 63)	These standards regulate specific categories of stationary sources that emit (or have the potential to emit) one or more hazardous air pollutants. Subpart EEE (40 CFR 63.1200 through 1213), NESHAP for Hazardous Waste Combusters (which include hazardous waste burning incinerators, cement kilns, and lightweight aggregate kilns) establishes the Maximum Achievable Control Technology (MACT) standards for chlorinated dioxins and furans, mercury, particulate matter, semivolatile metals, low volatile metals, hydrogen chloride, and chlorine gas (combined), carbon monoxide, hydrocarbons, and destruction and removal efficiency. MACT standards for Site remediation as a source category are in the process of being proposed.	The substantive portions of this regulation are applicable if remedial actions include on-Site hazardous waste burning incinerators.	A
Clean Air Act of 1977 (42 USC 7401 *et seq.*)	National Ambient Air Quality Standards (40 CFR 50)	These requirements establish ambient air quality standards for emissions of criteria pollutants such as lead and particulate matter. Specific release limits for particulate matter is set at 50 $\mu g/m^3$ annually or 150 $\mu g/m^3$ per 24-hour period.	These standards are applicable to any airborne release of criteria pollutants that may be generated during remedial activities.	A

Table A-3. (continued).

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy [a]
		Hazardous Materials		
Oil Pollution Act of 1990 (33 USC 1321 and 1361)	Oil Pollution Prevention (40 CFR Part 112)	This part establishes procedures, methods and equipment, and other requirements for equipment to prevent the discharge of oil from non-transportation-related onshore and offshore facilities not or upon the navigable waters of the U.S. or adjoining shorelines.	This regulation is applicable because there is the potential of discharge of oil into the Big Lost River from WAG 7 during remedial activities.	A
Resource Conservation and Recovery Act of 1976 (RCRA) (42 USC 6901), Hazardous Waste Management Act of 1983 (Idaho Code, 39-4401 *et seq.*) and Hazardous Waste Facility Siting Act of 1985 (Idaho Code, 39-5801 *et seq.*)	Land Disposal Restrictions (40 CFR 268 and IDAPA 58.01.05.011)	These requirements prohibit the placement of restricted RCRA hazardous waste in land-based units such as landfills, surface impoundments, and waste piles until treated to standards considered protective for disposal. Specific treatment standards are included in requirements.	These requirements are applicable to the treatment and disposal of RCRA hazardous waste from WAG 7 if placement of restricted wastes occur.	A
Toxic Substances Control Act (TSCA) of 1976 (15 USC 2601 *et seq.*)	Polychlorinated Biphenyls (PCBs) Storage and Disposal (40 CFR 761 Subpart D)	These requirements identify soil remediation standards for sites contaminated with PCBs. Specific requirements include disposal of PCB remediation waste, storage for disposal of PCBs, PCB incinerator and chemical landfill technical requirements, decontamination and manifesting of PCB waste offsite.	These requirements are applicable in setting PCB media cleanup standards and disposal requirements if the TSCA waste is retrieved, treated, and reburied on site.	A

Table A-3. (continued).

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy [a]
RCRA (42 USC 6901)	Hazardous Waste Identification and Listing of Hazardous Waste (40 CFR 261)	These requirements specify that a solid waste is hazardous if it exhibits any of the characteristics of a hazardous waste, i.e., ignitability, corrosivity, reactivity, and toxicity as determined by a toxicity characteristic leaching procedure (TCLP). A solid waste is managed as a hazardous waste if it is a "listed" waste under 40 CFR 261 Subpart D.	These requirements are applicable because potentially hazardous wastes are present.	A
RCRA (42 USC 6901)	Generator Standards (40 CFR 262)	These requirements specify accumulation periods, packaging, training, emergency preparedness planning, and recordkeeping procedures.	Regulatory requirements for facilities that generate hazardous waste are applicable if WAG 7 remedial actions involve generation and off-Site disposal of hazardous waste.	A
RCRA (42 USC 6901)	General Facility Standards for Owners and Operators of Remediation Waste Management Sites (40 CFR 264.1[j][1] through [13])	Requirements of 40 CFR 264 Subparts B (General Facility Standards), C (Preparedness and Prevention), and D (Contingency Plan and Emergency Procedures), and 264.101 (Corrective Action for Solid Waste Management Units) do not apply to remediation waste management sites. Owner/operators of remediation waste sites will be able to meet general performance standards if they comply with 264.(j)(1) through (13).	These requirements are applicable because WAG 7 is considered as a remediation waste site.	A

Table A-3. (continued).

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy[a]
RCRA (42 USC 6901)	Standards for Owners and Operators of TSD Facilities (40 CFR 264) (IDAPA 58.01.05)	This regulation sets standards for owners and operators of hazardous waste treatment storage, and disposal facilities. Standards include general facility requirements (Subpart B), preparedness and prevention (Subpart C), contingency plan and emergency procedures (Subpart D), releases from Solid Waste Management Units (Subpart F), closure and post closure requirements (Subpart G), use and management of containers (Subpart I), tank systems (Subpart J), surface impoundment (Subpart K), waste piles (Subpart L), landfills (Subpart N), incinerators (Subpart O), corrective action for solid waste management units (Subpart S), miscellaneous units (Subpart X), and air emission standards for process vents (Subpart AA), equipment leaks (Subpart BB), and tanks, surface impoundments, and containers (Subpart CC), and containment buildings (Subpart DD).	Regulatory requirements for owners and operators of hazardous waste storage, treatment, or disposal facilities are applicable if a new hazardous waste treatment facility will be constructed on site.	A
		To Be Considered		
Radiological Protection	**Radioactive** Waste **Management** (DOE Order 435.1)	The objective of DOE Order (DOE O 435.1) is to ensure that all DOE radioactive waste is managed in a manner that is protective of the worker, public health and safety, and the environment. The Radioactive Waste Management Manual (DOE M 435.1) establishes specific responsibilities for implementing radioactive waste management practices for DOE's high-level waste, transuranic waste, low-level waste, and the radioactive component of mixed waste. The Waste Management Manual catalog's existing procedures and practices that ensure all DOE elements and contractors continue to manage DOE's radioactive waste in a manner protective of the worker, public health and safety, and the environment. The Radioactive Waste Management Guide (DOE G 435.1) provides suggestions and acceptable ways of implementing DOE O 435.1.	The DOE Order is TBC because it addresses residual radioactive material. Compliance with DOE orders is required at the WAG 7.	TBC

Table A-3. (continued).

Category/ Statute	Citation	Identification of Requirement	Rationale for Use	Relevancy[a]
Radiological Protection	Guidance for a Composite Analysis of the Impact of Interacting Source Terms on Radiological Protection of the Public from DOE Low-Level Waste Disposal Facilities (DOE 1996)	The Composite Analysis provides an estimate of the cumulative radiological impacts from active and planned low-level radioactive waste disposal actions and other potentially interacting radioactive waste disposal sources that will remain following closure.	This Guidance from DOE is TBC if radiological contaminants are left in place. Compliance with DOE orders is required at the WAG 7.	TBC
Radiological Protection	Joint NRC/EPA Guidance on Testing Requirements for Mixed Radioactive and Hazardous Waste (FR Vol. 62, No. 224, November 20, 1997)	This guidance document specifies testing requirements for mixed low-level radioactive and hazardous waste. The guidance emphasizes the use of process knowledge to determine if a waste is hazardous and offers two strategies for helping to maintain radiation exposure as low as reasonably achievable (ALARA) if testing is required.	This TBC guidance document is intended for NRC licensees. However, it can also be used to address testing requirements for mixed low-level waste present on-Site.	TBC

a. A = Applicable requirement; RA = Relevant and appropriate requirement; TBC = Requirement to be considered.

WAG=Waste Area Group; IDAPA=Idaho Administrative Procedures Act; TSD=treatment, storage, and disposal (facility);

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Appendix B

Remedial Technologies and Process Options Identification and Screening

Appendix B

B.1 REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS IDENTIFICATION AND SCREENING

Table B-1. Remedial technologies and process options identification and screening.

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
No Action						
None	**None**	This option entails no active remedial activities beyond existing site access controls and/or environmental monitoring currently conducted at the INEEL as part of site-wide activities.	This option is not effective at reducing COCs and/or risk to human health and the environment.	This option is implementable.	Implementation costs are expected to be low in relation to other solutions.	Retained as baseline comparison.
Institutional Control						
Land-use restrictions	**Zoning, local permits and ordinances, use restrictions, easements, covenants, deed notices, public advisories**	Land-use restrictions comprise local, state, and federal controls to restrict future land use and exposure to site contaminants (see main text for descriptions). Potential restrictions include controls on future use of area groundwater.	Land-use restrictions may control exposure pathways that could result in an unacceptable risk to human health. This option does not address ecological exposures. Deed notices and public advisories may discourage inappropriate use, but are not legally binding.	This option is implementable.	Costs are expected to be moderate to low in relation to engineered solutions.	Retained.
Access controls	**Fencing**	Fencing involves enclosing individual or contiguous areas within a physical barrier, such as a chain-link fence with a locking gate. This institutional control reduces risks to human health by inhibiting direct exposure to wastes and contaminated soil. Access restrictions could reduce environmental risk by limiting exposure to some animals.	Long-term effectiveness depends on enforcement and maintenance. This option could address some ecological exposures.	This option is administratively and technically implementable.	The fencing option has low capital and O&M costs, in relation to other action-specific remediation approaches.	Retained.
	Signage	Signage typically is placed at the site to inform potential intruders of site dangers and indicate restricted access.	The signage option is marginally effective as a single option. It is best combined with fencing and other access use modification. However, it does not address ecological risk.	This option is administratively and technically implementable.	The signage option has low capital and O&M costs in relation to other action-specific approaches.	Retained.
Environmental monitoring	**Groundwater, air/dust, soil, biota, surface water, and moisture**	This option consists of periodic media monitoring to evaluate future environmental conditions and effectiveness of implemented remedial actions (see main text for descriptions).	The effectiveness of the environmental monitoring option is not applicable.	This option is administratively and technically implementable.	The relative costs of this option are low to moderate.	Retained.
Containment						
Surface controls/ diversions	**Site grading**	Site grading would recontour the surface of the SDA—or individual disposal pits, trenches, and vaults—to route water away from the waste zones and reduce infiltration. Site grading could include creation of drainage swales and/or surface water control berms. Drainage swales would facilitate transport of surface water away from the waste areas. Berms could be used around the perimeter of the SDA to prevent surface water run-on from adjacent areas.	Surface controls/diversions are effective at minimizing infiltration, but are susceptible to erosion as a stand-alone option.	This option is easily implementable.	Capital and O&M costs vary depending on project scope, but are expected to be low in relation to other surface treatments.	Retained.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Erosion control/ vegetation	Erosion-control measures include physical covers—such as rock, concrete facing, or asphalt—to provide protection against impacts due to precipitation, wind, and surface water movement. Vegetation may provide this type of erosion control as well as physical cover. Vegetation provides transpiration, which removes water from the surface to a relatively shallow depth and reduces surface water infiltration. This type of surface treatment can be self-sustaining and long lasting within a given climatic zone.	This option is effective at extending the life of the capping process option. All erosion-control measures will require periodic maintenance to ensure protectiveness.	This option is implementable and is a common technology. Vegetative covers may be difficult to sustain due to climatic conditions.	Capital costs vary depending on the type of process option, but are expected to be low in relation to other surface treatments. The O&M costs are expected to be moderate.	Retained.
Surface barriers	**Engineered single-layer cover**	Single-layer covers would consist of a designed thickness of a single type of material, which could include compacted soil, asphalt, concrete, or geomembrane. Covers could be used to isolate the SDA source term and provide either short-term or long-term protectiveness. The following items are different types of single-layer covers: • Soil layers could use either natural clay or a bentonite-soil blend. Clay properties such as plasticity index and particle size gradation would be specified to achieve permeability requirements. Soils would be compacted, as required, to provide consistency and achieve performance requirements. Granular soils (i.e., sands and gravels) could also be used to provide a physical barrier. • Asphalt is a common cover used to control and minimize surface water infiltration. • Concrete also could be considered as a surface barrier to prevent direct access to waste. The slab would need to be designed to withstand potential settlement that could result in cracking. A gravel layer likely would be used underneath the concrete for stress distribution. In addition, reinforcements could be installed to minimize cracking over the design life. • Geomembranes include the number of commercially available synthetic materials that could be used to prevent surface water infiltration. The effective life of geosynthetics exposed to weather generally does not exceed 20 years.	This process option is considered to be marginally effective in achieving the project RAOs. The soil cover would be susceptible to biointrusion and desiccation cracking, which will affect long-term effectiveness. Though asphalt is a flexible cover that can be designed to control surface water infiltration, environmental forces will degrade its integrity over time, and the cover would require periodic replacement. A concrete cover would prevent direct intrusion into the waste, but its rigid nature and potential for cracking hinders its ability to achieve RAOs; as such, a concrete cover is not considered an effective long-term protective barrier. Geomembranes also have limited effective lives when exposed to the environment and will require periodic replacement.	This option is implementable. The engineered single-layer cover is a common, well-known process option that uses readily available materials.	Capital costs are expected to be low to moderate in relation to other surface capping options. The O&M costs are expected to be high, requiring complete, periodic replacements.	This option has not been retained as a stand-alone process option for long-term protectiveness due to its inability to maintain integrity for the performance period required at the SDA. Individual design elements (i.e., soil, asphalt, concrete, and geomembranes) have been retained as individual design elements for assembly into the multilayer cover process option. Process option has been retained for application as a short-term protective measure during implementation of remedial activities at the site.
	Engineered multilayer cover	A number of multilayer cover designs could be potentially implementable at the site. The covers have been established to provide long-term protectiveness of contaminated sites and are designed to prevent biotic intrusion and control surface water infiltration. Potential designs include: • Standard RCRA Subtitle C cap • Modified RCRA Subtitle C cap • Long-term composite cover • ICDF cover. Specific design elements for the cover systems are presented in the main text.	This option is effective at minimizing infiltration and providing a barrier between contaminants and humans and burrowing animals. Design life varies between 30 (standard Subtitle C barrier) to 1,000 years (long-term composite cover and the ICDF cover).	This option is implementable. The engineered multilayer cover is a common, well-known process option using available materials. Borrow source evaluation will be required during design to verify availability of onsite sources for soil and rock.	Capital costs are expected to be moderate in relation to other surface capping options. The O&M costs are expected to be moderate.	Retained.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Biotic barriers	A biotic barrier generally consists of one or more layers of coarse gravel and/or cobbles compacted to maximum density, which is intended to impede burrowing animals and human penetration. A number of potential biotic barrier designs are available, but the SL-1 cap was selected as the representative process option for this FS. The SL-1 cap, designed for INEEL's WAG 5 Power Burst Facility, consists of layers of basalt cobbles underlain and overlain by gravel, with a rock armor surface. This cap, with a total 1.8 m (6 ft) minimum thickness, was designed to control surface exposures to radionuclides and to inhibit biotic intrusion for approximately 400 years (DOE-ID/EM 1997).	This option is effective at providing a barrier between contaminants and humans and burrowing animals, but is not effective at minimizing surface water infiltration.	This option is implementable. The biotic barriers option is a common, well-known process option that uses available materials. Borrow source evaluation will be required during design to verify availability of onsite sources for rock.	Capital costs are expected to be low to moderate in relation to other surface capping options. The O&M costs are expected to be low in relation to other surface capping options.	Retained.
Lateral barriers	**Slurry wall**	A slurry wall consists of a backhoe or excavator-constructed trench held open with a colloidal clay and water slurry, then backfilled with a low-permeability material. Various types of backfill include soil-clay mixtures and soil-cement mixtures. The primary construction technique is the continuous-trenching method. This process option can be combined with other types of lateral barriers. Slurry walls are generally 1 m (3 ft) thick with attainable depths of over 30.5 m (100 ft).	Slurry wall is a proven technology, which will be effective in providing a barrier to the subsurface conditions within the SDA. In situ permeability and continuity are not easily monitored; so downgradient-monitoring wells should be used. Permeability for the continuous trenching technique can reach 10^{-6} to 10^{-7} cm/s.	This option is implementable. The slurry wall option is a common, well known process option, which uses standard earthwork equipment and commercially available and onsite materials. Excavation equipment can be sized to provide penetration in soils and basalt, as required to achieve design-required depths.	Capital costs are expected to be low to moderate in relation to other lateral barriers.	Retained.
	Grout curtain	Jet and permeability grouting techniques are used to inject grout at high pressures into the sides of a borehole to create columns of modified soil that overlap to form a low-permeability wall. Installation employs a grout tube drilled to depth in the soil to form a column by grouting from the bottom up with an ultrafine Portland cement. Multiple layers of columns form the wall. This process option for groundwater cutoff has been used for decades in dam construction and has been used with success at some sites, but is relatively new for environmental contamination applications (CH2M HILL 1996). Grout curtains may be 1 m or more, depending on the number of layers of columns used to create the barrier. Depths over 23 m (75 ft) are attainable.	Grout curtain is a proven technology, which is effective at minimizing migration of groundwater across the barrier and, if properly designed, could be effective in the subsurface conditions within the SDA. Permeability (depending on the grout type and construction technique) ranges from 10^{-5} to 10^{-7} cm/s. Monitoring convergence of the columns at depth is difficult. Lack of continuity in the grout curtain could substantially reduce the effective permeability.	Grout curtain is a proven technology and can be installed with conventional equipment and commercially available materials. Jet grouting can be used effectively in soil types ranging from gravel to heavy clays (Mutch, Ash, and Caputi 1997) and has been repeatedly demonstrated on soil and waste sites.	Capital costs are expected to be moderate to high in relation to other lateral barriers. If properly designed, the grouted matrix would be stable in the SDA environment and, as such, the O&M costs are projected to be minor.	Retained.
	In-place soil mixing	Multiaxis augers and mixing paddles are used to construct overlapped columns that form a continuous wall of mixed soil and cement, bentonite, or other admixture. This process, which was developed in Japan, has been used in the U.S. for several years. The barrier is generally 0.5 to 1 m thick and can attain depths of over 30.5 m (100 ft), depending on soil conditions.	In-place soil mixing is effective at minimizing migration of groundwater across the barrier. Permeability (depending on the amount of gravel in the mixed geologic material) ranges from 10^{-5} to 10^{-7} cm/s.	The in-place soil mixing option is implementable. Multiple auger systems penetrate most geologic conditions and would be implementable in soil and basalt layers underlying the SDA.	Capital costs are expected to be moderate to high in relation to other lateral barriers. Relative O&M costs are expected to be minor.	Retained.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Sheet-piling barrier	Steel sheet pile technology has evolved to address containment of contamination. Sheet piles are driven, vibrated, or jetted to depth and are constructed with sealable joints to reduce leakage through the sheet pile interlocks. The effectiveness of the sealable joints, including the compatibility with waste, would need to be specifically evaluated. Sheet piles have been used for years in geotechnical applications. Sheet pile panels vary in thickness on the order of 1 cm. Depths up to 23 m (75 ft) are typically attainable, depending on the soil type and density. Depths of 91.4 m (300 ft) are possible in unconsolidated deposits lacking boulders.	The sheet-piling barrier option is effective at minimizing migration of groundwater across the barrier. Permeabilities of 10^{-7} cm/s are achievable and 10^{-8} to 10^{-9} cm/s may be achieved, depending on the soil type. This option can be combined with slurry wall techniques for greater effectiveness.	Sheet piling is a common technology using standard equipment and commercially available materials. Piling could be installed in the near surface soils within the SDA; however, penetration in the underlying basalt to achieve required design depth is questionable. Piling is not implementable around hot spots within a pit or trench because of difficulty driving piles through drums or other containers.	Capital costs are expected to be high in relation to other lateral barriers. Long-term degradation of the piling could require complete periodic replacement.	Not retained—implementability and cost considerations.
	In situ vitrification barrier	In situ vitrification uses electric heat to melt soil into a mass of fused glass similar to obsidian. For barrier wall construction, two or four electrodes inserted into the ground transmit currents to the soil until it melts. The electrodes then sink through the molten soil, advancing the melt zone downward. Panels of soil up to 13.7 m (45 ft) in diameter could be processed at a time. Each succeeding panel would overlap (i.e., melt into) the adjacent panel to increase the areal extent of the barrier. In situ vitrification is a demonstrated technology for processing contaminated soil and buried wastes.	An ISV barrier may be effective at minimizing lateral infiltration if used in combination with surface soil barriers to promote evapotranspiration. The barrier is impermeable to penetration by animals and plant roots. The final cooled product is very durable and impermeable except where fractured. In situ vitrification has not been used as a lateral barrier previously, though the technology has been investigated for such use.[a]	This option is potentially implementable. The availability of ISV equipment is limited and may require project-specific fabrication.	Capital costs are expected to be high in relation to other lateral barriers. The O&M costs are expected to be low in relation to other lateral barriers due to the high durability of the melted zone.	Not retained—process is not demonstrated for this application.
	Ground-freezing barrier	A ground-freezing barrier is implemented by drilling rows of pipes to depth around the containment area. Cooled brine freezes the area between the pipes. A refrigeration plant cools the brine and keeps the system frozen. The refrigeration must be maintained for as long as the barrier is needed. Ground freezing has been used successfully for a number of applications, including drilled shaft construction in high water table areas (temporary applications). The barrier thickness is usually on the order of 9 to 12 m (30 to 40 ft). Depths up to 23 m (75 ft) are attainable, but would be limited by well-drilling capabilities.	This option is potentially effective. If properly designed and operated, the process option would provide a strong, low-permeability barrier around the SDA. Advantages include the ability to turn off the option in the future should new requirements or technologies become available. This option is currently implemented at ORNL for containment of Sr-90 in the HRE pond (DOE 1997).	This option is implementable. Required equipment is commercially available from experienced contractors. Process requires long-term commitment to the O&M Program.	Capital costs are expected to be high in relation to other lateral barriers. The O&M costs are expected to be high in relation to other lateral barriers due to the long design life required.	Not retained—high relative capital and O&M costs.

a. J. Hansen, AMEC's GeoMelt Project Manager for the INEEL, telephone communication with Tami Thomas, CH2MHILL, January 12, 2001

Table B-1. (continued)

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
Subsurface horizontal barrier (in situ liner)	**Block displacement**	Block displacement vertically displaces a large mass of earth with a low-permeability material. The technique forms a horizontal barrier below the surface by pumping slurry (usually a soil bentonite and water mixture) into a gridded series of notched injection holes. To create a horizontal barrier, high-pressure air is pumped through a notching nozzle extended to the bottom of a borehole drilled to the planned depth of barrier. The air displaces mud and groundwater. Then, sand is injected through the nozzle to erode a notch radially out from the base of the borehole. When the desired notch size has been created, slurry is pumped through the line until the entire notch and casing are filled. Then, additional slurry is pumped under low pressure to lift the ground. The subsurface barrier thickness is generally on the order of 15 cm (6 in.) to over 0.3 m (1 ft).	Block displacement is effective in certain geologic conditions; however, this technology is considered not applicable to the SDA due to the presence of the basalt layer, which immediately underlies the source term in some areas and the unconsolidated nature of the waste. A pilot test would be required to determine whether the zone beneath the waste could be adequately separated for grouting using air pressure or cutting techniques.	The availability of this technology and experienced contractors is limited. The technology may not be implementable due to subsurface conditions within the SDA.	Capital costs are projected to be high. If implementable, multiple applications of the technology would be required to cover disposal areas.	Not retained—process is incompatible with basalt at the base of disposal areas and unconsolidated subsurface (waste) conditions.
	Grout-injection horizontal barrier	The process of using grout as a horizontal subsurface barrier is similar to block displacement, in that grout is pushed through a borehole and injected at depth in a gridded pattern with overlap to achieve horizontal continuity. Viscous liquid barrier is another low-pressure technology, which injects low-viscosity liquid across the interval of the barrier in a similar grid pattern. The viscous liquid flows into pore space in the formation before setting up and sealing off the waste zone. Jet grouting uses a high-pressure pump to inject various grouts radially into the formation across a given interval and again at gridded locations across the zone to be sealed.	This option is potentially effective in basalt materials underlying the SDA. Very low hydraulic conductivities have been demonstrated with grouted barriers. However, it is difficult to verify that the subsurface area has been uniformly treated, and the installation of lysimeters below the grouted zone will be required to verify compliance with RAOs.	This option is potentially implementable. The grout-injection horizontal barrier option requires drilling through the waste or horizontal drilling/coring under the waste. Most grouting techniques could be implemented through drill strings or boreholes, which can be drilled through most areas of the waste. Waste obstruction could limit spacing between boreholes.	Capital costs are expected to be high. If properly designed, the grouted matrix would be stable in the SDA environment and, as such, the O&M costs are projected to be minor.	Retained

Table B-1. (continued)

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	In situ vitrification liner	In situ vitrification potentially could produce a subsurface horizontal barrier as well as a lateral barrier if the technique involves injecting the starter path at depth and beginning the melt below the waste. For horizontal barrier construction, four electrodes would be inserted vertically in a square or rectangular configuration to a depth below the buried waste. With the application of electrical current to the electrodes, the subsurface starter path would melt and incorporate soil and/or basalt below the starter path into the melt. As the electrodes sink through the molten material, the melt zone would advance downward. Panels up to 13.7 m (45 ft) in diameter could be processed at a time. Each successive melt would overlap (melt into) the previous panels, thereby expanding the ISV barrier until its areal objectives were met.	An in situ vitrification liner probably is not fully effective at minimizing migration of leachates across the barrier. Though the product is very durable and impermeable, the large glass "plate" created will fracture to some extent as a result of shrinkage upon cooling and the effects of seismic activities. The liner has not been used thus far as a subsurface barrier, though the vendor has indicated the viability of such use (Buelt et al. 1987).	In situ vitrification has not been used to produce a subsurface barrier alone, though the subsurface planar configuration illustrates its potential feasibility. A treatability test would be required to determine implementability. Implementation issues are similar to those of ISV for processing buried waste.	Capital costs are expected to be high.	Not retained—not demonstrated for this application.
	Ground-freezing liner	A frozen ground barrier may be constructed to create a subsurface horizontal barrier similar to its use as a lateral barrier. Difficulty may arise from vertical drilling through the waste or horizontal drilling beneath the waste to install brine piping under central areas of the pits. Cooled brine is circulated to freeze the area between the pipes. A refrigeration plant cools the brine and keeps the system frozen. Refrigeration must be maintained for as long as the barrier is needed. The barrier probably would be 1 to 2 m (4 to 6 ft) thick with the attainable area limited by well drilling capabilities. A V-shaped subsurface containment could be created with horizontal drilling into the basalt.[b]	This option is potentially effective. If properly designed and operated, the process option would provide a strong, low-permeability barrier around the SDA. The ground-freezing liner option is currently in use at ORNL.[b] Advantages include the ability to turn off the option in the future should new requirements or technologies become available.	This option is potentially implementable. Required equipment is commercially available from experienced contractors. Brine piping would need to be installed in the basalt under the waste zone. This could be accomplished by drilling through the waste, coring through basalt, and/or horizontal drilling.[b] The process is being implemented at ORNL.[b] Process requires long-term commitment to the O&M Program.	Capital costs are expected to be high. The O&M costs are expected to be high in relation to other lateral barriers due to the long design life required.	Not retained—projected high capital and O&M costs and difficulty with drilling options.

b. D. Mageau, RKK Cryocell, personal communication with Tami Thomas, CH2MHILL, March 6, 2001

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
In Situ Treatment						
Physical treatment	**Soil vapor extraction**	Soil vapor extraction consists of an array of extraction wells, screened within the zone of contamination, that are equipped with an extraction pump capable of pulling enough air to maintain a vacuum within the zone of influence. Soil gases are pulled off and directed into a process train, which treats the gases before emission to the atmosphere. The system can be run intermittently (pulsed) once the extracted mass-removal rate has leveled off. Pulsed operation can increase the effectiveness of the process. Soil vapor extraction addresses only volatile and some semivolatile contaminants and may enhance biodegradation of low-volatility organic compounds. A geosynthetic material may be required over the surface of the SDA during this process to prevent short circuiting (breakthrough at the ground surface). Soil that has a high percentage of fines and a high degree of saturation will require higher vacuums and/or will hinder operation of the process. Application in soils with highly variable permeabilities may exhibit uneven delivery of gas flow resulting in less effectiveness in the lower permeability areas (FRTR 2001).	Soil vapor extraction is potentially effective at reducing volatile and semivolatile organic contaminants in the source term within the SDA. It preferentially removes materials from high-permeability zones, but can be pulse-operated to allow diffusion to increase removal. Soil vapor extraction is not effective for nonvolatile organics, most inorganics, and radionuclides. Technology is not suited for buried, containerized wastes. Application in the SDA may require preconditioning of the source term to breach intact containers.	This option is potentially implementable. The SVE system is currently in operation at the site in the underlying vadose zone soils; however, the implementation of this technology directly in the source term is unproven. Treatability testing will be needed to identify off-gas emission treatment requirements.	Capital costs are expected to be low in relation to other in situ treatments. The O&M costs are expected to be moderate in relation to other in situ VOC treatments.	Retained.
	Permeation/low-pressure grouting	Permeation grouting involves injecting low-viscosity grout formulations into the subsurface under gravity feed or low pump pressures. The grout permeates porous media and has been shown to encapsulate waste debris. Previously proven grouts include colloidal silica, polysiloxane, ultra-fine cement-based grouts, and polyacrylamide.	This option is effective. Very low permeabilities can be achieved in porous homogeneous media. At heterogeneous sites, it is difficult to ensure consistent applications across the subsurface.	This option is not implementable for most areas of the SDA. This process depends on the permeability, microstratigraphy, and porosity of the formation to be grouted and is most effective in media with homogeneous characteristics (Hayward Baker 2001).	Capital costs are expected to be low in relation to other in situ treatments. If properly designed, the grouted matrix would be stable in the SDA environment and, as such, O&M costs are projected to be minor.	Not retained due to the extent of low-permeability soil in the SDA.
	High-pressure jet grouting	Jet grouting involves the use of a positive displacement pump to deliver grout to a drill rig, which injects the material into the waste zone through the drill string at 6,000 psi (400 bar). A thrust block—a massive concrete template with holes spaced 61 cm (2 ft) apart on its surface and a void space beneath— is used to ensure that the grid spacing is maintained and workers are protected from returning contaminated grouts. The grout may be injected as the drill casing is inserted and/or as it is removed from full depth. The process requires site characterization and material testing to determine a suitable grouting agent. Many different grouts are available, including chemical grouts, that are injected as solutions rather than suspensions of particles in a fluid medium that defines cementitious grouts (USACE 1995). A dense, low-porosity grout can be used to chemically and physically bind the waste for long-term stabilization.	This option is effective. Jet grouting can be used effectively in soil types ranging from gravel to heavy clays (Mutch, Ash, and Caputi 1997) and has been repeatedly demonstrated on soil and waste sites. Injection grouting has been demonstrated to significantly reduce hydraulic permeability. In addition, certain grout types chemically alter infiltrating water, thereby reducing the solubility potential of contaminants. As with other in situ techniques, verification that all areas have been uniformly treated is difficult. This necessitates long-term monitoring of leachate to ensure protectiveness. Jet grouting can also be used to minimize landfill subsidence, which improves the performance of low-permeability cover systems.	This option is implementable. Process option has been researched for SDA-specific application. Techniques to control the potential spread of contamination resulting from contaminated grout returns have not yet been demonstrated.	Capital costs are expected to be moderate in relation to other in situ treatments. If properly designed, the grouted matrix would be stable in the SDA environment and, as such, the O&M costs are projected to be minor.	Retained.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	In situ enhanced soil mixing	In situ enhanced soil mixing is a process that has been used to remediate soils contaminated with VOCs, especially those of fine-grained nature. A single-blade auger or a combination of augers ranging from 1 to 4 m (3 to 12 ft) in diameter is used to mix the soils. This process option is combined with a number of other process options to either remove or stabilize COCs in place. The four main options for soil mixing include (1) combination with vapor extraction and ambient air injection, (2) vapor extraction and hot air injection, (3) hydrogen peroxide injection, and (4) grout injection for solidification/stabilization.	In situ enhanced soil mixing is potentially effective at treating COCs, depending on the combination of processes used. With SVE, the mixing can be used to enhance stripping action. In situ peroxidation oxidizes VOCs, while mixing cement grout under pressure can solidify the subsurface mass. However, the effectiveness of this technology in the SDA source term is questionable due to the presence of large metal debris and containerized wastes.	This option has a low implementability. Process option has not been demonstrated in buried waste environment containing TRU waste and HLW. Site-specific designs are required to protect workers and prevent contaminant releases during implementation.	Capital costs are expected to be high in relation to other in situ treatments.	Not retained—process option is considered not implementable on buried wastes within the SDA.
Chemical treatment	**Soil flushing**	For this process, water is applied to the soil (sometimes with an additive to enhance contaminant solubility). Contaminants are dissolved into the pore water, extracted through wells, and then sent through a treatment train. Co-solvent flushing is an adaptation of soil flushing that uses a solvent mixture (e.g., water plus a miscible organic solvent such as alcohol). The target contaminant groups include inorganics (including radioactive contaminants), though VOCs, SVOCs, fuels, and pesticides also may be treated. The process is more applicable to coarse-grained soil conditions (FRTR 2001).	The effectiveness of soil flushing is low. Water or co-solvent soluble COCs may be dissolved using this method. However, the low permeability of the SDA soil and relative insolubility of many contaminants would inhibit the effectiveness of this process option.	Soil flushing is not implementable. The process requires a flow of water through the waste. In addition, the potential contamination and nuclear criticality hazards could limit its acceptability.	Capital costs are expected to be moderate in relation to other in situ treatments.	Soil flushing has not been retained due to the nature of buried wastes and subsurface conditions within the SDA and risk associated with the mobilization of contaminants resulting from the addition of water to the source term.
	Chemical leaching	Contaminated wastes are leached with appropriate leaching solution and the elutriate is collected in a series of shallow well points or subsurface drains. This process option is more commonly performed as an ex situ technology, thereby eliminating concerns about toxicity of residual leachant.	Chemical leaching is moderately effective. While chemical leaching may result in the mobilization and removal of some COCs, the low permeability of the SDA soil and relative insolubility of contaminants such as Pu-02 would inhibit the effectiveness of this technology.	Chemical leaching is not implementable. As the bottom of the wastes are in contact with or close to the underlying fractured basalt, it would be difficult to collect the elutriate, which, if released, could further contaminate the vadose zone.	Capital costs are expected to be high in relation to other in situ treatments.	Not retained—risk involved with adding water and/or chemicals to the SDA.
	Hydrolysis	Hydrolysis is used to break down certain chemicals by reacting them with water. Many pesticides—including aliphatic halides, amides, carbonates, and others—are susceptible to partial decomposition by hydrolysis (McBride 1994). Use of this mechanism for in situ treatment is primarily related to biological processes, though it has been used for degradation of explosives and has been investigated for immobilization of radioactive elements (Nash 2000).	Hydrolysis is potentially effective. While hydrolysis is a chemical mechanism that could reduce toxicity and/or mobility of certain COCs, with the exception of biologically mediated hydrolysis, this technique has not been proven as an in situ process.	More information is required regarding how the mechanism would be catalyzed and what reaction rates would be achievable for the COCs in the SDA.	Capital costs are expected to be moderate to high in relation to other in situ treatments.	Not retained— process remains experimental in nature.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Reduction/ oxidation manipulation	Reduction/oxidation reactions chemically convert hazardous contaminants (primarily metals) to less toxic and/or less mobile or inert compounds (CPEO 1998). Materials that can be injected into the subsurface to provide in situ oxidation include iron filings (zero-valent iron) and potassium permanganate grout. In situ reduction/oxidation manipulation creates a treatment zone in the subsurface for remediation of reduction/oxidation-sensitive contaminants in groundwater, including chromate, uranium, technetium, some chlorinated solvents, and some explosive compounds. Aquifer sediments can be chemically manipulated (reduced) so that they become the reactive media. Numerous mechanisms are available for either reducing or oxidizing contaminants. In situ hydrous pyrolysis/oxidation oxidizes DNAPL through the injection of steam and oxygen in contaminated soils (WPI 1998). This process is described below under "Steam Injection."	This option is potentially effective. Reduction/oxidation reactions chemically convert hazardous contaminants to less toxic and/or less mobile or inert compounds. Gaseous reduction is also being tested on chromate-contaminated sites.	This option is moderately implementable. Process is not well tested on contaminants identified at the SDA. The wide variety of contaminants may work against this process, as some contaminants may immobilize on reduction, while others may mobilize.	Process is not cost effective for high contaminant concentrations because of the large amounts of oxidizing agent required (FRTR 2001).	Not retained— process remains experimental and unproven on COCs at the SDA.
Thermal treatment	**In situ thermal desorption**	In situ thermal desorption combines thermal principles with soil vapor extraction. The subsurface is heated using a number of potential technologies, which include in situ thermal desorption, steam injection, and radio frequency heating. Vapors are extracted via extraction wells, screened within the zone of contamination, and equipped with extraction pumps capable of maintaining a vacuum within the zone of influence. Soil gases are recovered and directed through a process train that treats the gases before emission to the atmosphere, as in traditional SVE (CPEO 1998).	In situ thermal desorption is potentially effective at removing SVOCs and VOCs with an SVE system. The use of ISTD would increase the degree of organic contaminant extraction over that achievable by conventional SVE and potentially destroy other hazardous organic materials by oxidation and pyrolysis. The effectiveness of thermal technologies to support ISTD is discussed below.	This option is potentially implementable. The implementability of specific thermal treatment technologies to support ISTD is discussed below.	Capital costs are expected to be moderate in relation to other in situ treatments.	Retained.
	Thermal conductance	Thermal conductance uses electrical resistance heating elements through rods in a thermal well system. Applications to date have been up to 4.3 m (14 ft) deep (USACE 2000). The waste and contaminated soil are heated to temperatures between 315 and 538°C (600 and 1,000°F) to vaporize and destroy most organics. An aboveground vapor vacuum collection and treatment system destroys or absorbs the remaining organics and vents carbon dioxide and water. Achieving temperatures up to 427°C (800°F) may take 3 months or longer. While generally applied to organic contaminants, the process reportedly "has the potential to chemically stabilize plutonium and other radionuclides and metals and reduce their mobility" (Jorgensen et al. 1999).	Thermal conductance can remove volatile and semivolatile COCs effectively as well as potentially destroy combustible organics, depending on the temperatures and heating times maintained. Vapors are removed and those that are not destroyed are treated in an off-gas treatment train (Jorgensen et al. 1999). However, the effectiveness in treating containerized contaminants remains undetermined.	This option is potentially implementable. Treatability study is required before implementation. Impact on criticality potential requires evaluation.	Capital costs are expected to be high in relation to other in situ treatments.	Retained.
	Steam injection/ dynamic underground stripping	Steam injection/DUS targets organics, especially SVOCs and fuels, but also can be used to recover some inorganics. Steam is injected into the subsurface through injection wells. Vaporized contaminants, air, and water are recovered with vacuum extraction wells and treated. The process has been used for years in the petroleum industry to enhance oil field production; its basic aspects are understood. It has been used for remediation at depths between 1.5 and 36.5 m (5 and 120 ft). Dynamic underground stripping has also been used with bioremediation by injecting oxygen after the steam process to enhance microbial metabolism (CPEO 1998; DOE-ID/EM 1997).	Steam injection/DUS effectively vaporizes VOCs and SVOCs in environmental media so that the COCs can be recovered in an off-gas treatment train. The process requires injected steam to contact the surfaces of contaminated soil particles and is therefore dependent on air conductivity of the subsurface. The process has limited applicability in fine-grained materials or in waste zones with irregular permeabilities.	This option is potentially implementable. The process would need to be tested to demonstrate that the COCs would be adequately captured in the recovery and extraction system. In addition, evaluations would have to demonstrate that the steam would not act as a moderator that would increase the potential of a criticality event.	Capital costs are expected to be moderate in relation to other in situ treatments.	Not retained—process option not conducive to waste configuration and fine-grained native soils. Process option could result in mobilization of contaminants from the source term.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Radio frequency heating	Like a traditional thermal desorption process, RFH heats soil to volatilize certain organic contaminants, especially VOCs and SVOCs. This process uses radio frequency energy applied through exciter electrodes to heat the subsurface. Closely spaced electrodes are required, as each heating zone has an approximate 1-m (3-ft) radius of influence. Operating temperatures, selected for the target contaminants, are generally on the order of 150°C (302°F), but can reach up to 1,330°C (2,426°F) at exciter electrodes (EPA 1995). Soil gases are recovered with vacuum extraction and directed through a process train, which treats the gases before emission to the atmosphere (as in traditional SVE). Use of the RFH process is limited to the vadose zone and is not effective near or below the water table.	Effectiveness is equivalent to thermal desorption for VOCs, SVOCs, and combustible organics (>250°C) given closely spaced electrodes.	Radio frequency heating is potentially implementable. Treatability study is required to determine effectiveness for containerized waste (Jorgensen et al. 1999). Impact on criticality potential requires evaluation.	Capital costs are expected to be moderate in relation to other in situ treatments.	Retained.
	In situ vitrification	In situ vitrification uses electrical heat to melt soil and waste into a mass of fused glass similar to obsidian. Electrodes inserted into the ground in a square array transmit currents to the soil until it melts, thus volatilizing VOCs and SVOCs and immobilizing other COCs in the process. As the electrodes sink through the molten material, the melt zone advances downward. Off-gases from the process are collected and treated. Planar ISV provides preferential pathways for the escape of vapors between the two planar melts until they fuse together. A 3-m (10-ft) thick cover of unconsolidated materials is maintained over the melt zone in the application of planar ISV. This protects equipment and personnel at the surface from exposure to heat and molten soil expulsions. Melts up to 13.7 m (45 ft) in diameter have been produced. Melts can be overlapped to treat a large site. The attainable depth of ISV has been increasing as the technology improves. Currently, the deepest ISV melt has penetrated to 8 m (26 ft) below the ground surface (MSE Technology Applications 1999).	In situ vitrification is a demonstrated technology for treating contaminated soil and buried waste. In situ vitrification effectively volatilizes VOCs and SVOCs, pyrolyzes all other organics, and immobilizes most inorganics and radionuclides into inert glass monoliths. Some waste species remain as metals in the melts. The preferred ISV option, planar ISV, shows promise for melting to the required depths and for minimizing molten soil expulsions.	In situ vitrification is potentially implementable. Treatability testing is needed to demonstrate implementability for the SDA. The issues of underground fires and control of molten soil expulsions require resolution. Criticality potential is not thought to be adversely impacted by ISV (Farnsworth 2001).	Capital costs are expected to be moderate to high in relation to other in situ treatments.	Retained.
Electrokinetic treatment	**Electrokinetic remediation**	Electrokinetic remediation removes metal and radionuclide contaminants from the soil by applying a low-level direct current to the contaminated zone with electrodes placed in the ground. Electrokinetic remediation uses electromigration of ionic species and electro-osmosis. The process works in low-permeability soils, imposing a high degree of control of flow direction as ions move along electric field lines determined by electrode placement. Contaminants are extracted from the circulating electrolytes inside the electrodes.	Effectiveness depends on interfering chemicals and adequate current density (USACE 2000). Electrokinetic remediation may be effective in fine-grained soils where most extraction methods are less efficient (EPA 1999).	This option is difficult to implement. Electrokinetic treatment is a relatively new process that has not been tested for buried waste. Field-scale test results for the U.S. Army were disappointing (USACE 2000).	Capital costs are expected to be high in relation to other in situ treatments.	Not retained—experimental and unproven for buried waste.
Biologic treatment	**In situ anaerobic bioremediation**	In situ anaerobic biological degradation is generally used for particular contaminants that are not readily degraded by aerobic treatment, such as highly substituted aliphatics and highly chlorinated aromatics including tetrachloroethene, PCBs, and hexachlorobenzene. A typical anaerobic system injects an electron donor substrate into the subsurface (EPA 1999). Airflow into the treatment zone may need to be controlled so that anoxic conditions are maintained.	In situ anaerobic bioremediation can be effective at reducing highly substituted aliphatics and highly chlorinated aromatics and nitrates in groundwater and soils, depending on subsurface conditions. It may not be effective in low-permeability conditions or in containerized waste. This option is not well suited to fine-grained soils (CPEO 1998).	This option may not be implementable because of the difficulty in maintaining anoxic conditions at large scale and the need to inject electron donor substrate (such as acetate) into the subsurface, which may affect criticality potential.	Capital costs are expected to be low in relation to other in situ treatments.	Not retained—process is not well proven for site conditions.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	In situ aerobic bioremediation	In situ aerobic biological treatment results in the transformation and/or mineralization of organic contaminants caused by the activities of naturally occurring or specifically engineered microorganisms. Depending on the microbial population and dominant processes, these activities can either break down organic contaminants or mobilize inorganic contaminants for removal. Microbes are affected by temperature, moisture, nutrients, and oxygen, which can be optimized to maximize treatment. Also, specific microbial organisms can be injected to target a particular contaminant. A typical system injects oxygen and/or other nutrients to enhance the growth of microbial populations. Aerobic degradation involves higher metabolic rates and is generally preferred over anaerobic systems. However, the process options may be combined to address particular contaminants that would benefit first from anaerobic degradation, then aerobic degradation (EPA 1999).	This option can be effective at reducing certain aerobically degradable organics, as well as potentially mobilizing metals for recovery. Some chemicals may be degraded to more toxic products: trichloroethene to vinyl chloride (CPEO 1998). In situ aerobic bioremediation may not be effective in low-permeability conditions or in containerized waste.	This option is moderately implementable, but is difficult to control, especially in fine-grained soils (CPEO 1998). Treatability study would be required.	Capital costs are expected to be low in relation to other in situ treatments.	Not retained—process is not well proven for site conditions.
Retrieval						
Contamination control	**Confinement/ enclosure**	Confinement enclosures prevent the spread of airborne contaminants by surrounding or enclosing a piece of equipment, decontamination pad, or an entire site. The enclosures are made of plastic, metal, fiberglass, or other material. These enclosures may be relatively lightweight and portable (e.g., Moducon) or may be substantially more sturdy and less portable (e.g., Butler Building). Enclosures would have to be compatible with the technologies used during remediation.	The confinement/enclosure option is effective in preventing the spread of airborne contaminants during retrieval operations if designed, constructed, and operated correctly.	This option is implementable and readily available. Site-specific enclosure may be required.	Costs will depend on specific conditions and design requirements.	Retained.
	Ventilation/ vacuum systems	Ventilation systems use laminar airflow at the digface of an excavation and within enclosures to direct dust to HEPA filter units. Systems would be designed for site-specific conditions and may be used in conjunction with other technologies to minimize the spread of airborne contaminants. Vacuum systems remove loose particles from equipment/structures and draw in dust and debris generated during excavation. Vacuum systems, used to control dust in close proximity to the vacuum, are readily available.	This is a proven process option. It is effective in controlling and directing airborne contaminants and dust away from work areas if designed, constructed, and operated correctly.	This option is implementable. Site-specific design is required. A wide variety of equipment is readily available. Off-gas treatability testing is required to ensure compliance with RAOs.	Costs are expected to be relatively low.	Retained.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Foams, sprays, misters, fixatives, and washes	These processes can be applied quickly and remotely to perform a variety of functions—including controlling odors, VOCs, dust, and other emissions—by creating a barrier between the work surface and the atmosphere, fixing loose airborne and/or settling contamination to a surface, and decontaminating personnel, the atmosphere, or equipment. The processes are readily available in nontoxic, nonhazardous, nonflammable, and biodegradable forms and range from water to polymeric mixtures. Commonly used fixatives include aerosol fogs and strippable coatings, which can be used to either secure contamination or decontaminate the atmosphere or equipment. Aerosol fogs are used to capture and hold airborne contaminants and prevent contaminants on the surface from becoming airborne. Strippable coatings can be applied to clean or dirty surfaces. When applied to contaminated surfaces, the coating attracts, absorbs, and chemically binds the contaminants in its polymeric structure. When applied to clean surfaces, the coating protects the area from contamination. Other common methods of decontamination include sprays and washes, which are chemicals that can be sprayed on and then wiped off.	This is a proven process option. Foams, sprays, misters, fixatives, and washers are effective at controlling emissions, dust, and source material; they are also effective at decontaminating equipment to a certain degree, but not 100%.	This option is implementable. Systems are readily available and many technologies are well developed. Foams, sprays, misters, fixatives, and washers can be effectively applied remotely.	Costs are expected to be relatively low if standard equipment is used.	Retained.
	Electrostatically charged plastic	Electrostatically charged plastic and electrostatic curtains can be used as barrier walls to minimize the spread of contamination from one location to another, but do not collect dust once it becomes airborne. The curtains can be used upstream of emission-filtering systems to neutralize charged dust particles. Electrostatically charged plastic can be used in enclosures to minimize the airborne particles in dust.	Electrostatically charged plastic is effective at minimizing the spread of contamination from one location to another, but not in collecting dust once it becomes airborne.	The electrostatically charged plastic option is difficult to implement. Plastic sheets would be cumbersome in an excavation and would only collect dust generated near the sheet.	Costs would depend on application and site-specific design requirements.	Not retained—technology not applicable to large area retrieval actions.
	In situ stabilization	In situ soil stabilization controls contamination in the soil and waste matrix. Grout, resin, or polymer (e.g., EKOR) may be injected into the waste to solidify it before retrieval. Other stabilizing technologies that could be used include vitrification and ground freezing.	Effective ISG, ISV, and ground freezing would be successful at stabilizing waste and soils in place and minimizing contaminant-control requirements during retrieval actions.	In situ stabilization is implementable. The implementability of the ISV, ISG, and ground freezing technologies is discussed in this table. Retrieval action and equipment would have to be specifically designed to address stabilized matrix.	Costs vary widely depending on the stabilizing technology used.	Retained.
Excavation methods	**Standard construction equipment**	A variety of standard heavy-construction equipment is available to remove buried waste and overburden soil. Front-end loaders, backhoes, and trenchers are three common types of excavation equipment that have been used to remove buried hazardous waste. The front-end loaders are used for digging, lifting, dumping, and hauling. The backhoe is used for trench digging and small area excavations and is frequently used in a backhoe and front-end loader combination. Trenchers are similar to backhoes in their function, but have a smaller carrying capacity and thus would be used in smaller excavation and grading applications. Dozers are used to remove soil covers.	Standard construction equipment is effective at performing the material-handling tasks for which they were designed, but is not effective at protecting workers from exposure. In areas of contamination, standard equipment must be combined with other protective process options.	This option is implementable. A wide range of equipment is readily available for the wide range of tasks required.	Capital costs depend on the type of equipment needed, but are expected to be low in relation to remote excavation methods or modified equipment for a sealed environment. The O&M costs are expected to be low in relation to remote methods.	Retained.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Standard construction equipment with modification	Conventional equipment—such as front-end loaders, backhoes, and trenchers—can be modified in a variety of ways to provide better protection to the operator in highly contaminated environments. Modifications may include (but are not limited to) a shielded cabin, a sealed and pressurized cabin with filtered air, or a sealed and pressurized cabin with supplied air. Shielded excavators have been used successfully (e.g., Hanford). In addition, equipment with pressurized and sealed cabs has been successfully used (with supplied air at Niagara Falls and filtered air at Maralinga).	Standard construction equipment is effective at performing material-handling tasks and also at protecting workers when combined with contamination control.	This option is implementable and proven in contaminated environments.	Capital costs are expected to be moderate to high, depending on project requirements.	Retained.
	Remotely operated equipment	Remotely operated excavators have been used at sites to remove hazardous, pyrophoric, and radioactive wastes with remote controls and remote end-effectors that maintain distance between the source and the operator. The technology to modify standard heavy equipment is available, and remote excavators have been demonstrated. Remotely operated vacuum systems could remove soil and small loose debris from an isolated area. This option would not be used to remove the buried waste, but could be used to remove portions of the soil overburden or underburden if standard heavy equipment was not feasible. A nozzle offers remote control and long-distance extension to control operator exposure. Remotely operated cranes could be used to remove buried waste in a precise manner, offer ease of control, and can be stationary or portable. There are several types of cranes available, including a 24.4-m (80-ft) remotely operated gantry crane designed at the INEEL.	Remotely operated equipment is effective at removing buried waste, as demonstrated in cold tests. However, experience with this option as a digging device to remove buried waste is limited. Remotely operated vacuum systems are effective at removing dry soil and small loose debris from isolated areas. However, they have limited effectiveness on hard-packed clays and moist material. Remotely operated cranes are effective at removing buried waste from precise locations, at protecting operator(s) from exposure, and for hanging other equipment (e.g., monitors and misters) over an excavation area. However, any riggers required for specific removals would need to be protected by other process options.	This option is implementable and has become more recently available for purchase rather than for lease or by special design.	Capital costs are expected to be moderate to high in relation to other retrieval process options and depending on project-specific requirements.	Retained.
Ex Situ Treatment						
Physical Treatment	**Screening/ classification**	Different-sized sieves and screens separate material types into smaller volumes. Screening/classification equipment includes grizzly shakers and rotary trommels. The process can separate out oversized material as a pretreatment step for further processing. For separation of contaminants, excavated soil can be passed through progressively finer screen sizes to separate fine-grained from coarse-grained fractions. Most contaminants tend to bind to soil fines (silts and clays) rather than to coarse components (coarse types of sand, gravel, and cobble). This process option may be used alone or in combination with other treatment process options to reduce the volume of contaminated materials for disposal. Standard process equipment or remotely operable, specially designed equipment may be used in this option. Screening processes are well-established technologies used in many applications.	This option is effective at separating soils or other materials by size. Sieving/screening is a well-established technology for wastewater treatment, soil, sediments, and sludge and as a pretreatment step for waste processing. Its value as the sole method of contaminant separation is limited.	This option is implementable with standard equipment. It may be utilized remotely. Design considerations include techniques to prevent and clear clogging of the equipment.	Capital costs are expected to be low in relation to other ex situ treatments, depending on the dust control measures required.	Retained.
	Sizing	Sizing consists of reducing the size of larger pieces of soil, rock, or other materials with cutting, shredding, and/or crushing machinery. Various types of equipment standard to the waste processing, recovery, mining, and demolition industries may be used. This equipment includes jaw crushers, gyratory crushers, hammermills, shear shredders, and dual-auger shredders. Standard industrial equipment is robust and proven (UIMME 2001).	This option is effective at reducing the size of larger soil and rock particles, concrete, wood, some metals, construction debris, and many other waste materials. It is important as a pretreatment step for some process technologies.	Sizing is implementable for certain portions of the waste stream.	Costs are expected to be low to medium in relation to other ex situ treatments.	Retained.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Compaction	Compaction is the process of applying high pressure to the wastes to reduce void space and achieve volume reduction. The volume reduction achieved is a function of void space in the waste, the force applied by the press, the bulk density of the material, and the spring-back characteristics of the waste. Supercompactors can achieve a 2 to 4 volume reduction factor for noncompactible waste and 6 to 7 for compactible waste. Volume reduction can be improved by preshredding the waste (DOE 1996).	This option's effectiveness depends on the characteristics of the waste material. Compaction is a well-proven treatment technology in both nuclear and nonnuclear industries.	Compaction is implementable for certain portions of the waste stream.	Costs are expected to be low in relation to other ex situ treatments.	Retained.
	Gravity separation	Gravity separation is a solid/liquid separation process that exploits a density difference between the solid- and liquid-phase densities. Equipment size and effectiveness of gravity separation depend on the solids' settling velocity, which is a function of the particle's size, density difference, fluid viscosity, and concentration. Gravity separation also is used to remove immiscible oil phases and for classification where particles of different sizes are separated. This technique is often preceded by coagulation and flocculation to increase particle size, thereby allowing the removal of fine particles (FRTR 2001).	This option's effectiveness depends on the solids' settling velocities. Gravity separation is a well-established process for treatment of wastewater, soil, sediment, and sludge.	The gravity separation option is implementable. This option requires slurry formation with waste. It generates secondary wastes in the form of wastewater.	Capital cost is expected to be low in relation to other ex situ treatments.	Retained.
	Magnetic separation	Magnetic separation is used to extract slightly magnetic radioactive particles and metals from host materials such as water, soil, or air. Uranium and plutonium compounds are slightly magnetic, while most host materials are not magnetic. The process operates by passing contaminated fluid or slurry through magnetized media. The magnetized media contain a magnetized matrix, such as steel wool, that extracts the slightly magnetic contamination particles from the slurry. Magnetic separation is a new technique to remove radioactive contaminants from soil and has recently been bench-scale tested at DOE sites (FRTR 2001).	Magnetic separation is effective at removing slightly magnetic radioactive and metal particles from water, soil, or air, as shown in the bench-scale test. New technology has not been tested at full scale.	Magnetic separation is technically implementable. This option requires slurry formation with waste. It generates secondary waste in the form of wastewater.	Capital costs are expected to be low in relation to other ex situ treatments.	Not retained—process has not been proven at full scale.
	Electrostatic separation	Electrostatic separation of materials is based on differences in surface conductivity and preferential charging and attraction of materials to an electric field of opposite charge. A variety of electrostatic separation equipment is available, depending on the type of material to be separated. The process can be used for nonconductors, mineral processing, recycling, and laboratory- or pilot-scale devices (Carpco 2001). For mineral processing, minerals essentially are sprayed with electrons from the active electrode and develop a charge that pins them to the grounded rotor. Conductors, however, immediately lose the charge and drop straight down. Semiconductors and nonconductors stay pinned longer, thus separating (UIMME 2001).	Electrostatic separation is effective at separating different types of materials. It is a proven, commercially available process (Carpco 2001).	The electrostatic separation option is implementable. Materials would require screening and sizing (UIMME 2001).	Capital costs are expected to be moderate in relation to other ex situ treatments.	Retained.
	Gamma monitor, conveyor, and gate system	This process option combines a feed hopper, a conveyor belt, gamma spectroscopy, and a gate to separate soils into categories based on gamma activity. The gamma monitoring, conveyor, and gate system are most effective in reducing the volume of contaminated material requiring treatment and disposal, when combined with other technologies. Used for design of Pit 9, this option has been successfully demonstrated to reduce volumes of radiologically contaminated soil at several locations (SNL 1999).	This option is effective at sorting radioactive materials from nonemitting or low-emitting materials. Materials must be sized to <5 cm (2 in.) in diameter. The system has been successfully used at SNL, ER 16 in 1998 (SNL 1999).	This option is implementable. However, it must be combined with sizing process options.	Capital costs are expected to be moderate in relation to other ex situ treatments.	Retained.

Table B-1. (continued)

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Flotation	Flotation separates fine-grained from coarse-grained sediment and soil by increasing differences in their settling velocities in a clarifier. The process is only applicable to contaminants that are preferentially partitioned on the fine-particle fraction of the soil. Coarse-grained material settles to the bottom, while fine-grained particles rise to the surface where they can be recovered by skimmers. The process is technically implementable with standard process equipment (UIMME 2001).	Flotation is effective at separating fine-grained fractions from coarse-grained fractions. Effectiveness of contamination removal depends on the degree of contaminant association with a particular size fraction.	This flotation option is implementable. This option requires slurry formation, and it generates secondary waste in the form of wastewater.	Costs are expected to be low in relation to other ex situ treatments.	Retained.
Chemical treatment	**Fixation/ stabilization**	Chemical fixation and stabilization process options immobilize radioactive and hazardous constituents in waste by mixing in additives that bind or absorb the waste into a solid waste form. This option may be required prior to waste packaging for shipment or storage to immobilize liquids and/or contaminants. Processes use either organic or inorganic additives, which either serve as chemical bonding agents/ absorbents or provide containment. Additives include Portland cement, modified sulfur cement, and polymers (DOE 1996).	Fixation/stabilization is effective at absorbing liquids and immobilizing waste forms and binding them into a solid waste form.	The fixation/stabilization option is implementable. Treatability studies would be needed to define process variables such as additives, concentrations, and mixing times.	Capital costs are expected to be moderate in relation to other ex situ treatments.	Retained.
	Soil washing	Soil washing uses an aqueous solution and detergent to remove organic material from the surface of soil particles and separates fine particulates, which contain most of the organic contaminants in the porous fines, from the coarse soil. Soil washing does not destroy the organic material, but produces three products: (1) a wastewater stream, (2) a sludge of contaminated fine particulates, and (3) soil that may contain regulated levels of heavy metals and radionuclides. Soil washing is applicable to soils contaminated with a wide variety of heavy metals, radionuclides, and organic contaminants. Additional treatment steps may be required to address hazardous levels of washing solvent remaining in the treated residuals. The wash solution also would require treatment and proper disposal. Equipment and space requirements for soil washing systems are extensive, and soil-washing operations tend to be complex (DOE 2000).	Removal efficiency of contaminants and fine-grained material from coarse-grained material depends on contaminant solubility in the wash solution, residence time, and affinity for the matrix. The system may not be applicable to waste streams containing both metals and organics. Removing organics adsorbed onto clay-size particles may prove difficult (DOE 2000).	Soil washing is moderately implementable. Waste must be sized before processing; separated contaminants require treatment. Treatability study is required to formulate surfactant. This process generates secondary waste in the form of wastewater.	Capital costs are expected to be high in relation to other ex situ treatments. Additional costs are required for the treatment of separated contaminants and secondary waste streams.	Not retained—limited application for SDA wastes. Not cost effective in relation to other ex situ treatments.
	Acid extraction	Acid extraction uses hydrochloric acid to extract heavy metal contaminants from soils. In this process, soils are first screened to remove coarse solids. Hydrochloric acid is then introduced to the soil in the extraction unit. The residence time in the unit varies depending on the soil type, contaminants, and contaminant concentrations. The soil and extractant are separated with hydrocyclones. When extraction is complete, the solids are rinsed with water to remove entrained acid and metals. The extraction solution and rinse waters are regenerated, and the heavy metals are concentrated in a form potentially suitable for recovery. During the final step, the soils are dewatered and mixed with lime and fertilizer to neutralize any residual acid (FRTR 2001).	Acid extraction is effective at removing metals from soil and sludge (FRTR 2000).	The acid extraction option is implementable. It requires physical separation, which may include screening, density separation, flotation, and magnetic separation as a pretreatment. Acid extraction generates secondary waste in the form of spent chemicals and wastewater.	Costs are expected to be moderate to high in relation to other ex situ treatments. Efficiency of scale is expected (FRTR 2001).	Retained.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Solvent extraction	Organic solvents are used commonly to extract contaminants from soil. Solvent extraction uses a solvent to remove soluble contaminants from the waste (not unlike dry cleaning). Depending on site-specific conditions, the process may function as a stand-alone option or in combination with other options, such as solidification/stabilization, incineration, or soil washing. Removal efficiency is highly variable, depending on the individual contaminant solubility in the solvent, residence time, affinity to the matrix, and moisture content. Organically bound metals can be extracted along with the target organic contaminants, thereby creating residuals with special handling requirements. Traces of solvent may remain within the treated soil matrix, which makes the toxicity of the solvent an important consideration. Secondary waste includes spent solvents (DOE 2000).	Solvent extraction has proven effective in treating soil containing primarily organic contaminants such as PCBs, VOCs, halogenated solvents, and petroleum wastes. This option is difficult to use on waste containing multiple complex contaminants.	The solvent extraction option is moderately implementable. Waste must be sized before processing; separated contaminants require treatment. Treatability study is required to formulate solvent. Process generates less secondary waste than soil washing.	Capital costs are expected to be high in relation to other ex situ treatments. Additional costs are required for the treatment of separated contaminants and secondary waste streams.	Retained.
	Dehalogenation	Dehalogenation involves adding reagents to soils contaminated with halogenated organics and heating the mixture. The dehalogenation process is achieved through either the replacement of the halogen molecules or the decomposition and partial volatilization of the contaminants. This option is potentially applicable if combined with other processes to address inorganic and radionuclide COCs. This relatively mature and simple technology operates at a low temperature with low off-gas and good destruction efficiencies for chlorinated compounds.	Dehalogenation has been successfully field tested in treating PCBs. The process option can be used, but may be less effective against selected halogenated VOCs. Process meets regulatory requirements for treating PCB-contaminated soil, but remaining chlorinated organics may require further treatment. Processes are slow (FRTR 2001). Potential concerns include (1) further treatment of nonchlorinated organics, (2) the amount of pretreatment needed to maximize exposure of the chlorinated compounds, (3) the ability to treat the diversity of wastes (waste pH and moisture content appear to be important), and (4) safety associated with handling sodium and anhydrous ammonia and high system pressure in a radioactive environment (DOE 2000; FRTR 2001).	Dehalogenation is moderately implementable. Treatability tests may be required to determine the operating parameters of the unit. Off-gas treatment is required for VOC and dust. Dehalogenation may require a nitrogen blanket to avoid explosive conditions (DOE 2000; FRTR 2001).	This technology generally is not cost effective for large waste volumes (FRTR 2001).	Not retained—process not cost effective for SDA wastes in relation to other available processes. This is a very specific treatment for limited COCs.
	Hydrolysis	The D-Plus (Sinre/DRAT) process involves the use of chemical inputs to stimulate enzymes and provide a favorable chemical environment (alkaline, reducing, anaerobic) for hydrogenation, dehalogenation, and hydrolysis chemical reactions. The technology, which is a biochemical process, uses heat to break carbon-halogen bonds and volatilize light organic compounds. Other processes utilizing hydrolysis to break down organic chemicals are primarily related to biological treatment (EPA 1994).	Hydrolysis is potentially effective in bioremediation. This option employs water and catalyst to break down organic contaminants. This is not a commercialized process (EPA 1994).	Hydrolysis is moderately implementable for chlorinated organics. Treatability study is required to demonstrate applicability on SDA wastes. This option is not yet available on a commercial scale (EPA 1994).	The relative cost of hydrolysis is unknown	Not retained—process is not fully proven.

.able B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Reduction-oxidation manipulation	Re-dox reactions chemically convert hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile, and/or inert. Re-dox reactions involve the transfer of electrons from one compound to another. Specifically, one reactant is oxidized (loses electrons) and one is reduced (gains electrons). Re-dox reactions can be used to detoxify, precipitate, or solubilize metals or organics. Metals and radionuclides are retained in solution and need to be treated. Chemical re-dox is a full-scale, well-established process option. Enhanced systems are now being used more frequently to treat contaminants in soil. This option can be operated with standard process equipment in batch or continuous modes. However, process control is difficult if waste composition varies significantly (DOE 1996).	Chemical oxidation destruction efficiency depends on the organic material treated, the oxidizing agent used, and residence time. The effectiveness of re-dox processes in treating wastes also depends on system design and operating parameters. Solids and immiscible liquids are difficult to treat with some processes.	Re-dox is moderately implementable. Waste stream would require demonstration to determine efficiency. Waste requires pretreatment for size reduction and slurry formation. Wastewater and precipitated sludge would require treatment. Treatability studies would be required for a particular waste stream (DOE 1998).	Costs are not well understood, but may be competitive with incineration.	Not retained—limited application for SDA waste.
	Neutralization	Neutralization is used to adjust basic or acidic waste to an acceptable pH range by adding alkaline waste or chemical reagents to acidic waste or vice versa. This may be needed to reduce reactivity or corrosivity. The process is reliable, readily available, and employs standard process equipment (DOE 1996).	This process option is effective at neutralizing materials at any pH. Corrosivity of waste and reagents may be hazardous.	Neutralization is implementable. Construction materials must be resistant to corrosivity.	Capital costs are expected to be moderate in relation to other ex situ treatments.	Neutralization has been retained for its value as a pretreatment process.
Thermal treatment	**Incineration**	Incineration is widely used to thermally destroy the organic constituents of a waste, both to reduce the volume and to produce more easily handled ash products. High temperatures (760 to 1,200°C) volatilize and combust (in the presence of oxygen) halogenated and other refractory organics in hazardous wastes. Waste constituents that can be efficiently destroyed include organic and combustible substances. Typical process configurations include rotary kilns, multiple hearth incinerators, fluidized bed combusters, and liquid injection incineration.	Incineration is effective for treating organic waste including PCBs, reducting waste volume, and producing ash waste form. Incineration is a well understood process with a long history of application in industry and DOE and DOD operations.	Incineration is technically implementable and accepts all waste forms. Frequent maintenance is required. Secondary waste is generated in the form of ash. Incineration relies on off-gas treatment, and it has low public acceptance.	Costs are expected to be high in relation to other nonthermal ex situ treatments.	Incineration has been retained, but would be difficult to implement at the INEEL due to difficulties with past approvals for incineration at this site.
	Off-gas treatment —catalytic oxidation	Catalytic oxidation equipment is used for destroying contaminants in exhaust gases from many remedial activities. It can also be used for destroying contaminants in exhaust gases from thermal treatment systems. The catalyst accelerates the rate of oxidation at much lower temperatures than those required by conventional thermal oxidation. The VOCs are thermally destroyed at temperatures typically ranging from 320 to 540°C. Catalytic oxidation is a mature technology and an alternative to conventional thermal oxidation for many contaminated gas streams. However, some catalysts are subject to damage by chlorinated hydrocarbons and some heavy metals (e.g., lead) in the gas stream. Most catalytic oxidation systems are subject to degradation from particulate in the gas stream. Destruction of halogenated compounds requires special catalysts, special materials or construction, and the addition of a flue gas scrubber to reduce acid gas emissions.	Despite its relatively newer application in remedial activities, catalytic oxidation is a mature technology, and its status as an implementable technology is well established for selected gas streams.	This option is moderately implementable as a nonincineration technology for the oxidation of off-gas from primary thermal oxidation processes. Technical difficulties include possible short catalyst life due to off-gas contaminants. Applications to treatment of off-gas from solid waste thermal treatment systems are unknown.	Capital costs are expected to be moderate in relation to other ex situ treatments.	Retained.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Pyrolysis	Pyrolysis breaks down organic compounds under high temperature in an oxygen-deficient environment. This system forms inorganics, including heavy metals, into an insoluble solid char residue. A thermal oxidizer is required to combust the produced volatile organics and carbon monoxide. Equipment configurations are similar to those used for incineration (e.g., rotary kiln, rotary hearth furnace, and fluidized bed furnace). In Europe, pyrolysis has been used historically on tires and polymer waste where the pyrolysis gas is used for energy recovery (Uhamburg 2001). Advantages over incineration are primarily lower off-gas volume and less particulate carryover.	Pyrolysis has high destruction efficiency and is a proven technology for some applications. Volume reduction is less than incineration or steam reforming due to char residue. The process is applicable for the separation of organics from most waste forms.	Pyrolysis is implementable, but may not be applicable to waste at the SDA. Secondary waste is generated in the form of char. This option relies on off-gas treatment. Pyrolysis may have a low public acceptance due to its similarity to incineration.	Costs are slightly lower than those of incineration due to lower off-gas volumes.	Not retained—proven applications remain narrowly focused.
	Steam reforming	Steam reforming operates in a reducing environment and uses a super-heated steam to convert organics to a hydrogen-rich synthesis gas and chlorinate compounds to HCl. These gases can be oxidized in a thermal oxidizer or discharged directly to the atmosphere after appropriate cleanup. This option can remove and destroy organic components in a waste stream or reduce organic material to a small volume of ash. Most radionuclides and heavy metals are retained in the ash. Typical steam reforming can take place in many different chamber configurations, including fluidized bed and rotary kiln. Steam reforming also can be used to volatilize organics directly from waste drums to remove and destroy organic components in the waste stream. Steam reforming is a mature process option applicable to a wide variety of waste streams. The requirements for sorting and sizing waste depend on the equipment configuration.	Steam reforming has high destruction efficiency for organic material. Process option is applicable to a wide variety of waste forms. Applicability to radioactively contaminated inert solids requires demonstration (DOE 2000).	Steam reforming is implementable for organic COCs. This option generates secondary waste in the form of ash and bed material, off-gas, and wastewater (DOE 2000). Steam reforming relies on an off-gas treatment system.	Costs are comparable with those of incinerators (DOE 2000).	Retained.
	Supercritical water oxidation	Supercritical water oxidation destroys organic waste with the use of an oxidant in water at temperatures and pressures above the critical point of water (705°F) and 218 atm. Under these conditions, organic materials and gases become highly soluble in water—making rapid, complete oxidation possible using water as a carrier medium. This process is a compact, totally closed system. Waste streams applicable to this process option must be in a liquid or slurry form and include organic low-level radioactive waste or mixed waste. The process runs at low temperatures relative to other thermal treatments with very low off-gas by-products and effluents that are easy to manage. This is a relatively mature process option with a long history of development for specific applications. However, the high pressure and corrosiveness of the system present safety concerns, and the process option may require substantial pretreatment of waste to ensure that the waste is in liquid or slurry form (DOE 2000, 1996).	This option has high destruction efficiency for organic material and is not applicable to inorganics and radionuclides. Issues regarding long-term reliability and safety need to be resolved (DOE 2000).	Supercritical water oxidation is moderately implementable. This option requires waste sorting and slurry formation. Metals precipitate as salts and oxides, which can plug the reactor. Demonstrations are still needed (DOE 2000).	Costs are not well understood, but may be competitive with incineration.	Not retained—limited applicability for SDA waste forms.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	Thermal desorption	Thermal desorption is a process that heats waste to volatilize water and organic contaminants. Thermal desorption is used for soil, sludge, and other solid media contaminated with organics. In most thermal desorption processes, contaminated material is fed into dryers. A carrier gas or vacuum system transports volatilized water and organics to a gas treatment system. The dryer temperatures and residence times designed into these systems volatilize selected contaminants, but will typically not oxidize them. Two common thermal desorption systems are the rotary dryer and thermal screw. Rotary dryers are horizontal cylinders that can be indirect- or direct-fired. For the thermal screw units, screw conveyors or hollow augers are used to transport the medium through an enclosed trough. Hot oil or steam circulates through the auger to indirectly heat the medium.	Thermal desorption effectively transfers organic contaminants into the vapor phase where they can be captured and treated. Thermal desorption may pyrolyze nonvolatile organics, depending on the operating temperature. Efficiency depends on temperature, residence time, moisture content, and matrix affinity. This is a well-known, mature technology (DOE 2000).	Thermal desorption is implementable. Most of the hardware components for thermal desorption systems are readily available off the shelf. Significant sorting and sizing of waste are required. Off-gases, condensed liquids, and activated carbon require treatment (DOE 2000).	Thermal desorption may be more expensive than incineration, depending on the treatment requirements of secondary waste.	Retained.
	Vitrification	Vitrification processes employ heat to drive off organic materials and melt the inert materials into a glass or slag. The high temperatures destroy or volatilize the organic constituents with few by-products. These systems are primarily designed to immobilize hazardous or radioactive substances within a nonleachable, long-life, solid, and glass-like form that can meet shipping and storage criteria. Materials such as heavy metals and radionuclides are incorporated into the melt. In addition to solids, the process can be applied to waste liquids, wet or dry sludge, and combustible materials. This process can operate in a reducing or steam-reforming mode. Viable technologies include joule-heated melters, plasma torch systems, and DC arc melters (DOE 2000).	Vitrification high destruction efficiencies and volume reduction. Some systems can treat waste or media without pretreatment. This option produces a stable waste form. Some COCs may be volatilized requiring treatment in an off-gas system. Off-gas volumes are less than those of incineration (DOE 2000).	Vitrification is implementable and is a mature technology. This option generates off-gas and wastewater secondary waste types. Vitrification may require a pilot test of SDA-type waste to determine radionuclide partitioning. Safety and reliability concerns exist regarding water-cooled plasma torch systems (DOE 2000).	Vitrification is competitive with the incinerator option (DOE 2000).	Retained.
	Molten metal system	The system heats waste in a reducing mode to destroy organics and reduce inorganics to metal ingots and slag, which produces a stable waste form. Molten aluminum system can treat most waste forms and materials. Off-gas systems are required and may result in secondary wastewater, which will require treatment. Refractory lining stability must be matched to the waste stream, and refractory life is unknown when treating a heterogeneous mixture of waste.	The molten metal system's ability to destroy organics and retain metals and radionuclides needs demonstration (DOE 2000).	The molten metal system is not implementable. This option requires further study and demonstration on radioactive waste (DOE 2000).	Capital costs are expected to be relatively high. Costs are comparable to costs of incineration (DOE 2000).	Not retained—system is not a proven technology.
	Molten salt system	Organic waste and oxygen are injected into a hot molten salt bath that provides the thermal energy to break down organic material and the medium to enable intimate contact between oxygen and organic fragments. The process is used for combustible liquids, slurries, and solid particles. Spent salt is an example of secondary waste. A salt recovery system is normally employed. Waste must be sorted and sized to less than 0.32 cm in diameter. The technology is relatively mature, but its long-term reliability and ability to destroy organics and retain metals and radionuclides must be demonstrated (DOE 2000).	The molten salt system's ability to destroy organics and retain metals and radionuclides needs demonstration (DOE 2000).	This option is moderately implementable. Refractory corrosion and failure are issues. Salt viscosity may lead to freezing and requires monitoring. In addition, this option requires sizing of waste to <0.32 cm (DOE 2000).	Capital costs are expected to be relatively high. Costs are comparable to costs of incineration, but salt recovery to reduce secondary waste will increase cost (DOE 2000).	Not retained—effectiveness has not been proven.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
Electrokinetic treatment	**Mediated electrochemical oxidation**	Electrokinetic treatment is an aqueous, low-temperature (<80°C) process that treats mixed waste by electrochemically oxidizing the organic components of mixed waste into carbon dioxide and water. The inorganic components of the waste go on to the final forms system, where they are immobilized. This option appears suited for destroying aqueous organic liquids, organic liquids, and some organic solids that can be pulped or slurried. Metals may be dissolved in the analyte solution. This requires two secondary systems—acid recovery and silver recovery—both of which are important for economic operation. It is not clear whether recovery and reuse are possible or economically viable with radionuclide contaminants. Off-gas system is required (DOE 2000; FRTR 2001).	Mediated electrochemical oxidation's effectiveness has not been fully proven, and its ability to treat PCBs is uncertain.	Mediated electrochemical oxidation has not been fully demonstrated. This option requires significant pretreatment. Corrosion and erosion are concerns (DOE 2000).	It is unclear whether this process can be economically viable. The use of the system remains to be demonstrated in the presence of radionuclides (DOE 2000).	Not retained—not fully proven.
Biological treatment	**Aerobic degradation**	Bacteria indigenous to the soil or specifically cultured bacteria are used to biologically degrade organic contaminants. Aerobic degradation, performed by microorganisms that require oxygen for growth, is commonly used to degrade toxic organic petroleum contaminants to nontoxic by-products, thereby reducing the waste volume requiring disposal. Aerobic process residues are usually CO, CO_2, H_2O, salts, and biomass sludge (dead cell material). Because contaminants must be available to the microorganisms, contaminants that are not water-soluble are more difficult to treat. Though chlorinated organics are difficult to treat, some bacteria do degrade chlorinated organics in the course of metabolizing other more easily degraded compounds. Several processes for ex situ aerobic degradation exist, such as the use of a containment cell, land farming, and bioreactors/composting. Aerobic degradation is a well-developed, highly effective method to treat organic contaminants[c] (EPA 1994).	Efficiency is dependent on the contaminant as nutrient for microbial population, oxygen concentration, temperature, and pH (EPA 1994).	Aerobic degradation is marginally implementable. Microbe populations are easily upset by contaminant/nutrient balance, oxygen concentration, temperature, and pH. Waste must be sized. Biomass, wastewater, and off-gases require treatment. Large system is needed due to slow process time (EPA 1994).	Aerobic degradation may be more expensive than incineration due to frequent shutdown and maintenance issues and additional treatment requirements (EPA 1994).	Not retained—limited applicability for SDA waste contaminants.
	Anaerobic degradation	Bacteria indigenous to the soil or specially cultured bacteria are used to biologically degrade organic contaminants. Anaerobic degradation is carried out in the absence of oxygen and yields methane, carbon dioxide, and biomass. Since the contaminants must be available to the microorganisms, contaminants that are not water-soluble (e.g., solids and immiscible organics) are more difficult to treat. Chlorinated organics are difficult to treat because their degradation is not a significant source of energy for the bacteria. Several options for ex situ anaerobic degradation exist, including the use of a containment cell, bioreactors, and others[c] (EPA 1994).	Efficiency is dependent on contaminant as nutrient for microbial population, oxygen concentration, temperature, and pH (EPA 1994).	Process times are slower than aerobic degradation due to generally lower microbial metabolism (EPA 1994).	Anaerobic degradation may be more expensive than incineration due to frequent shutdown and maintenance issues and additional treatment requirements (EPA 1994).	Not retained—limited applicability for SDA waste contaminants.

c. DOE-RL, 1996, "Corrective Measures Study for the 100-NR-1 and 100-NR-2 Operable Units, Richland, Washington (Draft)," DOE/RL-95-111, Rev. A, U.S. Department of Energy, Richland, Washington, November 1996

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
Storage and Disposal						
Onsite storage and disposal	**Temporary onsite storage**	A containment structure must be created for onsite staging and storage of waste that has been retrieved from the SDA before the waste can be transported to either an off-Site or on-Site disposal or ex situ treatment facility. Design would be in accordance with state and federal requirements for temporary storage facilities and would be sized as required to meet processing requirements.	Structure would be designed to effectively contain waste and COCs during staging between retrieval and treatment or disposal. Secondary containment of the stored waste would be required.	Temporary onsite storage is implementable.	Costs are expected to be low in relation to other process options within this GRA (with consideration to the temporary nature of this option).	Retained.
	RWMC (SDA)	The RWMC is located in WAG 7 at the INEEL site and can accept some low-level contaminated soil. However, RCRA-regulated hazardous materials cannot be disposed of permanently at the RWMC, and waste acceptance criteria are strict (DOE-ID 2002).	This option is effective for a very narrowly focused portion of the waste in the SDA.	This option is implementable. Additional capacity is not available to receive retrieved SDA waste. Any disposal would require screening for very specific acceptance criteria (DOE-ID 2002).	Costs are expected to be low in relation to other disposal options.	Not retained – operational and capacity constraints.
	ICDF	The ICDF will be located in WAG 3 at the INEEL site, and the facility will open and begin accepting shipments of low-level radioactive waste in 2003. Roadways would be used for transportation.	The ICDF is effective for long-term disposal. Facility is designed with triple liner and other features for low-level radioactive waste and mixed low-level waste.	This option is potentially implementable for limited volume of low-level radioactive waste and mixed waste, depending on available capacity for non-WAG 3 waste. The MLLW must be treated to meet the waste acceptance criteria.	Costs for disposal are expected to be low in relation to offsite disposal options.	Retained
	CFA landfill	The CFA landfill, located in WAG 4 at the INEEL site, accepts nonhazardous industrial waste from INEEL sites. Roadways would be used for transportation.	The CFA landfill is effective for nonhazardous, nonradioactive industrial waste.	The CFA landfill is not implementable for LLW or MLLW streams from the SDA. However, the CFA landfill is potentially implementable for the nonhazardous portion of retrieved waste if it is segregated out.	Costs for this waste stream are expected to be low to moderate in relation to other disposal options.	Not retained
	Engineered onsite facility	An engineered facility would be constructed within the SDA for the disposal of LLW and treated MLLW. The facility would be designed in accordance with RCRA Subtitle C lined landfill requirements with leachate collection/treatment and landfill gas collection/treatment systems.	An engineered onsite facility is effective for the disposal of LLW and treated MLLW. The approved WAG 3 ICDF design has been identified for this process option. The facility would not be effective for the disposal of TRU waste.	This option is potentially implementable and would entail standard construction with available materials. Lead time would be required for development of waste acceptance criteria, design approval, and construction.	Costs are projected to be lower than disposal at offsite facilities.	Retained.
: disposal	**Nevada test site**	This facility, located in southwestern Nevada, accepts low-level radioactive industrial waste and mixed low-level radioactive waste. Roadways would be used for transportation.	The Nevada test site is an effective option.	Implementability depends on the approval of INEEL waste characterization procedures.	Costs for this waste stream are expected to be high in relation to other disposal options.	Retained.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments
	WIPP	This facility—located in Carlsbad, New Mexico—accepts defense-related, contact-handled TRU waste only. Remote-handled TRU waste is expected to be accepted in the near future following approval of a proposed RCRA permit modification. Mixed TRU waste is acceptable under specific waste codes.	The WIPP is an effective option.	This option is implementable. The TSA waste is currently being transported to the WIPP. Acceptance of SDA waste depends on the approval of INEEL waste characterization procedures.	Costs for the TRU waste stream are expected to be high.	Retained.
	Barnwell Waste Management Facility	This facility—located in Barnwell, South Carolina—accepts low-level radioactive waste. Waste is contained in concrete vaults and then buried. Roadways would be used for transportation.	The Barnwell Waste Management Facility would be moderately effective due to concrete vault containment prior to direct burial.	Implementability depends on the approval of INEEL waste characterization procedures.	Costs are expected to be high in relation to other disposal options.	Retained.
	Environmental Restoration Disposal Facility	This facility—located in Richland, Washington—accepts low-level radioactive waste, but currently does not accept mixed waste. Roadways would be used for transportation.	The Environmental Restoration Disposal Facility would be effective for disposal of low-level radioactive waste.	This option is implementable for low-level radioactive waste if material is treated and/or segregated before shipment. The Environmental Restoration Disposal Facility is not currently approved for mixed waste. Implementability depends on the approval of INEEL waste characterization procedures.	Costs are expected to be high in relation to other disposal options.	Retained.
	Envirocare	This facility—located in Clive, Utah—accepts low-level radioactive waste, mixed low-level radioactive waste, and radioactive PCB waste. Treatment options available at the site include stabilization, reduction/oxidation, deactivation, neutralization, and macroencapsulation and microencapsulation.	Envirocare would be highly effective due to its ability to treat incoming waste at the disposal site.	Implementability depends on approval of INEEL waste characterization procedures.	Costs are expected to be high in relation to other disposal options.	Retained.
	WCS	This facility—located in Andrews County, Texas—is a treatment, storage, and disposal facility that will be permitted for low-level radioactive, RCRA, and TSCA mixed waste treatment and disposal. Radioactive concentrations in excess of Class C and TRU limits can be accepted for treatment. The low-level waste permit is pending. Disposal units are RCRA compliant with independent liner and leachate collection systems. Cells are enclosed in a natural clay barrier. The WCS is accessible by rail from the INEEL.	The WCS would be highly effective due to its ability to treat incoming waste at the disposal site and the wide range of waste accepted.	Implementability depends on the approval of INEEL waste characterization procedures.	Costs are expected to be high in relation to other disposal options.	Retained.
	U.S. Ecology	This facility—located in Richland, Washington—accepts low-level radioactive waste and uses direct burial disposal. Roadways would be used for transportation.	The U.S. Ecology option has a low effectiveness due to their direct-burial disposal practices.	Implementability depends on the approval of INEEL waste characterization procedures.	Costs are expected to be high in relation to other disposal options.	Retained.
	Yucca Mountain	This facility—located in Nye County, Nevada—is currently under construction as a permanent repository for high-level waste.	Yucca Mountain would be potentially effective.	Yucca Mountain is not currently available for disposal. It is still under construction.	Costs are expected to be high in relation to other disposal options.	Retained.

Table B-1. (continued).

Remedial Technology	Process Option	Description	Effectiveness	Implementability	Relative Cost	Screening Comments

CFA = Central Facilities Area
COC = contaminant of concern
DC = dual component
DNAPL = deuse nonaqueous phase liquid
DOD = U.S. Department of Defense
DOE = U.S. Department of Energy
DOE-ID = U.S. Department of Energy Idaho Operations Office
DUS = dynamic underground shipping
EM = Environmental Management
GRA = general response action
HEPA = high-efficiency particulate air
HLW = high-level waste
HRE – Homogeneous Reactor Experiments (Oak Ridge)
ICDF = INEEL CERCLA Disposal Facility
INEEL = Idaho National Engineering and Environmental Laboratory
ISG = in situ grouting
ISTD = in situ thermal desorption
ISV = in situ vitrification
LLW = low-level waste
MLLW = mixed low-level waste
O&M = operations and maintenance
ORNL = Oak Ridge National Laboratory
PCB = polychlorinated biphenyl
RAO = remedial action objective
RCRA = Resource Conservation and Recovery Act
Re-dox = reduction-oxidation manipulation
RFH = radio frequency heating
RWMC = Radioactive Waste Management Complex
SDA = Subsurface Disposal Area
SL-1 = Stationary Low-Power Reactor No. 1
SNL = Sandia National Laboratory
SVE = soil vapor extraction
SVOC = semivolatile organic compound
TRU = transuranic
TSA = Transuranic Storage Area
TSCA = Toxic Substances Control Act
VOC = volatile organic compound
WAG = waste area group
WCS = Waste Control Specialists
WIPP = Waste Isolation Pilot Plant

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Appendix C

Detailed Analysis of Alternatives

Appendix C
Detailed Analysis of Alternatives

Table C-1. Detailed analysis of alternatives.

Evaluation Criterion and Analysis Factors	Alternative #1 No Action	Alternative #2 Surface Barrier	Alternative #3 In Situ Grouting	Alternative #4 In Situ Vitrification	Alternative #5 Retrieval, Treatment, and Disposal
Overall Protection of Human Health and the Environment					
Will risk be at acceptable levels?	No. No action is conducted at the site; therefore, risks will remain at current levels.	Yes. Based upon preliminary risk modeling, it is predicted that site risks associated with waste and contaminated soil within the SDA will be reduced to acceptable levels. However, combined risks, including impacts from postulated contaminants previously released to the underlying vadose zone, result in groundwater levels that exceed threshold carcinogenic and noncarcinogenic criteria.	Yes. Based upon preliminary risk modeling, it is predicted that site risks associated with the waste and contaminated soil within the SDA will be reduced to acceptable levels. However, combined risks, including impacts from postulated contaminants previously released to the underlying vadose zone, result in groundwater levels that exceed threshold carcinogenic and noncarcinogenic criteria.	Yes. Based upon preliminary risk modeling, it is predicted that site risks associated with the waste and contaminated soil within the SDA will be reduced to acceptable levels. However, combined risks, including impacts from postulated contaminants previously released to the underlying vadose zone, result in groundwater levels that exceed threshold carcinogenic and noncarcinogenic criteria.	Yes. Based upon preliminary risk modeling it is predicted that site risks associated with the waste and contaminated soil within the SDA will be reduced to acceptable levels. However, combined risks, including impacts from postulated contaminants previously released to the underlying vadose zone, result in groundwater levels that exceed threshold carcinogenic and noncarcinogenic criteria.
Timeframe to achieve acceptable levels?	Acceptable levels are not met with this alternative.	It is predicted that the surface barrier (Phase 1) and waste zone-specific in situ treatments can be completed within 11 years following the ROD signature.	It is predicted that in situ treatment with ISG can be completed and the surface barrier constructed within 13 years following the ROD signature.	It is predicted that in situ treatment with ISV can be completed and the surface barrier constructed within 24 years following the ROD signature.	It is predicted that the waste can be retrieved and the surface barrier constructed within 31 years following the ROD signature.
Will the alternative pose any unacceptable short-term or cross-media impacts?	No. No action is conducted at the site; therefore. risks will remain at current levels.	No. Minimal intrusive work. Potential short-term risks can be addressed through proper engineering controls and administrative management.	No. Technology extensively researched for SDA application. Potential short-term risks can be addressed through proper engineering controls and administrative management.	Uncertain. Worker protection and potential contaminant migration concerns (air emissions/organic recondensation in subsurface) need to be further researched.	Uncertain. Worker protection and potential contaminant migration concerns (air emissions) need to be further researched.
Will the alternative impact natural resources?	No. No action is conducted at the site; therefore, risks will remain at current levels.	Natural resources will not be impacted, as the site area is currently disturbed. Potential impacts are associated with the use of off-Site borrow sources and the infringement on adjacent areas for cap construction and staging. Potential for fugitive dusts during implementation can be managed.	Natural resources will not be impacted, as the site area is currently disturbed. Potential impacts are associated with the use of off-Site borrow sources and the infringement on adjacent areas for cap construction and staging. Potential for fugitive dusts during implementation can be managed.	Natural resources will not be impacted, as the site area is currently disturbed. Potential impacts are associated with the use of off-Site borrow sources and the infringement on adjacent areas for cap construction and staging. Potential for fugitive dusts during implementation can be managed.	Natural resources will not be impacted, as the site area is currently disturbed. Potential impacts are associated with the use of off-Site borrow sources and the infringement on adjacent areas for cap construction and staging. Potential for fugitive dusts during implementation can be managed.
What restoration actions may be necessary?	None	None are anticipated with the exception of borrow site, staging area, and haul road restoration.	None are anticipated with the exception of borrow site, staging area, and haul road restoration.	None are anticipated with the exception of borrow site, staging area, and haul road restoration.	None are anticipated with the exception of borrow site, staging area, and haul road restoration.
Will residual contamination (following remediation) be a potential problem?	Yes. Site contamination is not altered by this alternative.	No. However, waste remains untreated on-Site and will require commitment to a long-term maintenance program.	No. It is predicted that risks will be within an acceptable range. However, long-term stability of grout must be verified.	No. It is predicted that risks will be within an acceptable range. Stable long-term matrix.	No. It is predicted that risks will be within an acceptable range.
Compliance with ARARs					
Are chemical-specific ARARs met?	No. Chemical-specific ARARs are not met as the alternative does not meet the RAOs.	Yes. Evaluations indicate that groundwater standards will be met, excluding the vadose zone contribution.	Yes. Evaluations indicate that groundwater standards will be met, excluding the vadose zone contribution.	Yes. Evaluations indicate that groundwater standards will be met, excluding the vadose zone contribution. Uncertainties regarding potential air emissions will require further evaluations during design.	Yes. Evaluations indicate that groundwater standards will be met, excluding the vadose zone contribution. Uncertainties regarding potential air emissions will require further evaluations during design.

Table C-1. (continued).

Evaluation Criterion and Analysis Factors	Alternative #1 No Action	Alternative #2 Surface Barrier	Alternative #3 In Situ Grouting	Alternative #4 In Situ Vitrification	Alternative #5 Retrieval, Treatment, and Disposal
Are location-specific ARARs met?	Yes. No areas are disturbed or impacted.	Yes. Alternative can be designed to achieve identified requirements.	Yes. Alternative can be designed to achieve identified requirements.	Yes. Alternative can be designed to achieve identified requirements.	Yes. Alternative can be designed to achieve identified requirements.
Are action-specific ARARs met?	Not applicable as no actions are conducted.	Yes. All actions can be designed and implemented consistent with identified requirements.	Yes. All actions can be designed and implemented consistent with identified requirements.	Yes. All actions can be designed and implemented consistent with identified requirements. Uncertainties regarding the alternative's ability to meet air emissions standards will require further evaluation during design to ensure compliance.	Yes. All actions can be designed and implemented consistent with identified requirements.
Long-Term Effectiveness and Permanence					
Magnitude of residual risks					
What is the magnitude of the remaining risks?	Site risks as defined in the IRA will continue.	Implementation of this alternative will be sufficient to reduce risk levels associated with future releases from the source term to below 1E-04 and HI to less than 1, excluding the vadose zone contribution.	Implementation of this alternative will be sufficient to reduce risk levels associated with future releases from the source term to below 1E-04 and HI to less than 1, excluding the vadose zone contribution.	Implementation of this alternative will be sufficient to reduce risk levels associated with future releases from the source term to below 1E-04 and HI to less than 1, excluding the vadose zone contribution.	Implementation of this alternative will be sufficient to reduce risk levels associated with future releases from the source term to below 1E-04 and HI to less than 1, excluding the vadose zone contribution.
What remaining sources of risk can be identified?	Untreated waste remains onsite as a potential source of future risk.	The alternative requires long-term maintenance of cap to mitigate risks associated with untreated waste, which remains onsite.	Stabilized and unstabilized waste will remain onsite. Exposure pathways are expected to be minimal or eliminated.	Stabilized and unstabilized waste will remain onsite. Exposure pathways are expected to be minimal or eliminated.	All TRU waste will be removed from the site. Treated and untreated LLW will remain. However, exposure pathways are expected to be minimal or eliminated.
Will a five-year review be required?	Yes.	Yes.	Yes	Yes.	Yes.
Adequacy and reliability of controls					
What is the likelihood that the technologies will meet required process efficiencies or performance specifications?	Not applicable	High. Established technology. Surface barrier design is currently being researched for implementation at ICDF.	Technology extensively researched by DOE at INEEL for site-specific implementation. Anticipated to be effective in meeting performance objectives.	Uncertain. Effectiveness of technology on variable SDA waste needs to be verified.	Uncertain. Ability to retrieve and treat waste to meet regulatory and/or waste acceptance criteria needs to be verified
What type, degree, and requirements of long-term monitoring are required?	Long-term monitoring will include groundwater, vadose zone, soil, surface water, air, perimeter, and biological monitoring.	Long-term monitoring will be implemented to evaluate the effects of the surface barrier. Program could be reduced in the future based on the results of the five-year reviews.	Long-term monitoring will be implemented to evaluate the effects of the grouting and surface barrier. Program could be reduced in the future based on the results of the five-year reviews.	Long-term monitoring will be implemented to evaluate the effects of the vitrification and surface barrier. Program could be reduced in the future based on the results of the five-year reviews.	Long-term monitoring will be implemented to evaluate the effects of the treatment and surface barrier. Program could be reduced in the future based on the results of the five-year reviews.
What operations and maintenance functions must be performed?	None	General maintenance and periodic repair of the surface barrier are anticipated.	General maintenance and periodic repair of the surface barrier are anticipated.	General maintenance and periodic repair of the surface barrier are anticipated.	General maintenance and periodic repair of the surface barrier are anticipated.
What difficulties and uncertainties may be associated with long-term operations and maintenance?	Not applicable.	No difficulties are anticipated. Subsidence-related damage could affect cap integrity.	No difficulties are anticipated. Long-term integrity of grouted waste needs to be verified.	No difficulties are anticipated.	No difficulties are anticipated.
What is the potential need for replacement of technical components?	Not applicable	Routine inspections and barrier maintenance are expected to keep this potential at a minimum.	Routine inspections and barrier maintenance are expected to keep this potential at a minimum.	Routine inspections and barrier maintenance are expected to keep this potential at a minimum.	Routine inspections and barrier maintenance are expected to keep this potential at a minimum.

Table C-1. (continued).

Evaluation Criterion and Analysis Factors	Alternative #1 No Action	Alternative #2 Surface Barrier	Alternative #3 In Situ Grouting	Alternative #4 In Situ Vitrification	Alternative #5 Retrieval, Treatment, and Disposal
What is the magnitude of the threats or risks should the remedial action need replacement?	Not applicable.	Replacement of surface barrier can be readily implemented with minimal risk.	The majority of the site waste has been incorporated in a stable grout monolith Additional ISG applications can be implemented with minimal risk.	The majority of the site waste has been incorporated in a stable glass-like monolith thereby minimizing potential risks, which could affect future remedial action requirements at the site.	The majority of the site waste has been removed or treated for hazardous constituents, thereby minimizing potential risks.
What is the degree of confidence that controls can adequately handle potential problems?	Not applicable.	Long-term monitoring and maintenance will adequately handle potential problems.	Long-term monitoring and maintenance will adequately handle potential problems.	Long-term monitoring and maintenance will adequately handle potential problems.	Long-term monitoring and maintenance will adequately handle potential problems.
What are the uncertainties associated with land disposal of residuals and untreated waste?	Not applicable.	Not applicable	Uncertainties are associated with the treatment technologies required for treating the retrieved Pad A waste to regulatory levels (ARARs) or risk-based levels (PRGs).	Uncertainties are associated with the treatment technologies required for ISV of the retrieved Pad A waste to regulatory levels (ARARs) or risk-based levels (PRGs).	Shipments of TRU waste to the WIPP are exempt from specific LDRs. Uncertainties are associated with some of the treatment technologies for treating the remaining waste to regulatory levels (ARARs) or risk-based levels (PRGs) prior to on-Site disposal.
Reduction of Toxicity, Mobility, or Volume through Treatment					
Treatment process and remedy					
Does the treatment process employed address the principal threats?	No. There are no treatment processes.	Partially. The ISG technology is implemented to address the risks associated with the activation/fission products in the SVRs and trenches. The ISTD is implemented to address risks associated with VC waste streams.	Yes. Grouting will be applied to all waste sites that pose a potential risk, including those sites containing TRU contaminants.	Yes. The ISV and ISG will be applied to all waste sites that pose a potential risk.	Yes. Those sites containing TRU contaminants will be retrieved and disposed of off-Site. Retrieved MLLW will be treated for hazardous constituents and disposed of on-Site. Activation/fission products in SVRs and remaining trenches will be stabilized in-place using the ISG technology.
Are there any special requirements for the treatment process?	No. There are no treatment processes.	Yes. Specialized grout mixes could be required to stabilize waste. The ISTD emission controls/treatment system must be designed to address potential variability in waste stream.	Yes. Specialized grout mixes could be required to stabilize waste. The ISTD emission controls/treatment system must be designed to address potential variability in waste stream.	Yes. Pretreatment of waste will be required to reduce potential MEEs. Emission controls/treatment must be designed to address potential variability in waste stream. Specialized grout mixes could be required to stabilize waste.	Yes. Treatment systems for on-Site waste disposal must be designed to address potential variability in waste stream and meet specific WAC/LDR requirements and control contaminant releases. Specialized grout mixes could be required to stabilize waste.

Table C-1. (continued).

Evaluation Criterion and Analysis Factors	Alternative #1 No Action	Alternative #2 Surface Barrier	Alternative #3 In Situ Grouting	Alternative #4 In Situ Vitrification	Alternative #5 Retrieval, Treatment, and Disposal
Amount of hazardous material destroyed or treated					
What portion (mass, volume) of the contaminated material is destroyed?	None. There are no treatment processes.	The only destructive treatment process involves the ISTD technology in the high organic waste stream areas.	For the ISG technology, contaminated material is encapsulated not destroyed. High organic waste streams will be reduced with the application of the ISTD technology.	Organics are destroyed or removed as part of the off-gas during the thermal desorption and vitrification process. Off-gas treatment may either fix or destroy these materials. Other contaminants are stabilized not destroyed.	Organics are destroyed or removed as part of the thermal treatment process for some non-TRU waste that will be disposed of on-Site. Other contaminants are stabilized or moved to a different location but are not destroyed.
What portion (mass, volume) of the contaminated material is treated?	None. There are no treatment processes.	Activation/fission products will be treated in situ with ISG. High organic waste streams will be treated with the ISTD technology.	All waste containing groundwater COCs will be grouted.	All waste containing groundwater COCs will be treated with either ISV or ISG.	All waste containing groundwater COCs will be either retrieved and treated for disposal or treated in place with ISG.
Reduction in toxicity, mobility, or volume					
To what extent is the total mass of toxic contaminants reduced?	None. There are no treatment processes.	Partial. The ISTD will destroy organic COCs in high-concentration waste steam areas. Other contaminants will either remain untreated onsite or stabilized in place using ISG.	Partial. The ISTD will destroy organic COCs in high-concentration waste steam areas. The remaining contaminant mass will be encapsulated in a grouted monolith.	Organic contaminants are either destroyed or removed by the pretreatment (ISTD) or vitrification process.	Organics are destroyed or removed as part of the thermal treatment process for some non-TRU waste that will be disposed of on-Site. Other contaminants are stabilized or moved to a different location but are not destroyed.
To what extent is the mobility of toxic contaminants reduced?	None. There are no treatment processes.	The mobility of the contaminants is reduced by the placement of a low-permeability cap. The encapsulation of the activation/fission products in SVRs and trenches would significantly reduce contaminant mobility in these areas.	Significant reduction in the contaminant mobility is realized as the material is encapsulated using the ISG technology.	Significant reduction in the contaminant mobility is realized as the material is fixed in the vitrified form or stabilized in place by ISG.	Waste/soil containing groundwater COCs will be removed and all TRU waste will be disposed of off-Site. Remaining material will be treated for its hazardous components and disposed of on-Site.
To what extent is the volume of toxic contaminants reduced?	None. There are no treatment processes.	Only the volume of organic contaminants in the high-concentration waste streams is reduced.	Only the volume of organic contaminants in the high-concentration waste streams is reduced.	Organic contaminants will be either destroyed or removed through the ISV/ISTD process.	Organic contaminants will be either destroyed or removed through the ex situ treatment process.
Irreversibility of the treatment					
To what extent are the effects of the treatment irreversible?	Not applicable to this alternative. There are no treatment processes.	The ISTD will destroy the organic COCs within high-concentration areas. The ISG is applied only to activation/fission product waste located in trenches and SVRs. The grouted material is extremely durable and not easily reversed.	The ISTD will destroy the organic COCs within high-concentration areas. If properly designed and implemented, the grouted monolith resulting from the ISG process is extremely durable and not easily reversed.	Organic COCs within waste and soil will be destroyed. The vitrified material is extremely durable and is not reversible.	The ex situ treatment for hazardous organic constituents before on-Site disposal will not be reversible.
Type and quantity of treatment residuals					
What residuals remain?	Not applicable to this alternative. There are no treatment processes.	The ISG technology will be applied to the activation/fission product waste	None. No treatment residuals are associated with the ISG technology requiring disposal.	As this is an in situ treatment application, all materials remain at the site.	All treatment residuals will remain on-Site. The TRU waste will be transported off-Site for disposal.
What are their quantities and characteristics?	Not applicable	Waste in the SVRs and selected trench areas will be encapsulated in grout monolith.	As this is an in situ treatment application, all quantities remain at the site.	As this is an in situ treatment application, all quantities remain at the site.	All retrieved non-TRU waste will be treated and placed in an on-Site engineered facility.

Table C-1. (continued).

Evaluation Criterion and Analysis Factors	Alternative #1 No Action	Alternative #2 Surface Barrier	Alternative #3 In Situ Grouting	Alternative #4 In Situ Vitrification	Alternative #5 Retrieval, Treatment, and Disposal
What risks do treatment residuals pose?	Not applicable.	Limited. Contaminants are encapsulated in the grout and a barrier is placed over the surface to prevent intrusion.	Limited. Contaminants are encapsulated in the grout and a barrier is placed over the surface to prevent intrusion.	Limited. Contaminants are fixed in the vitrified melt and a barrier is placed over the surface to prevent intrusion.	Limited. All materials will be treated for their hazardous components before to on-Site disposal. In addition, a barrier is placed over the surface to prevent intrusion.
Statutory preference for treatment as a principal element					
Are principal threats within the scope of the action?	No. Principal threat areas are not addressed in this alternative.	Yes. Principal threat areas are addressed in this alternative.	Yes. Principal threat areas are addressed in this alternative.	Yes. Principal threat areas are addressed in this alternative.	Yes. Principal threat areas are addressed in this alternative.
Is treatment used to reduce inherent hazards posed by principal threats at the site?	No. There are no treatment processes.	Yes. The ISG is used to treat the activation/fission product waste in SVRs and trenches. The ISTD is used to destroy organic COCs in high-concentration waste streams.	Yes. Groundwater COCs will be destroyed or encapsulated in a stable grout monolith.	Yes. Groundwater COCs will be treated either through ISTD/ISV or ISG.	Yes. The COC-bearing waste streams will be retrieved and treated before disposal. The TRU materials will be disposed of off-Site, but will not be treated. The ISG will be used to treat the activation/fission product waste in SVRs and trenches.
Short-Term Effectiveness					
Protection of community during remedial actions					
What are the risks to the community during remedial actions that must be addressed?	None. Implementation of this alternative will pose no additional risks to the community.	Implementation may pose low risk to the community due to potential release of fugitive dust and the use of off-Site borrow sources.	Potential releases of fugitive dust during earthwork operations.	Potential release of fugitive dust during earthwork operations. Additional research required to provide appropriate engineering controls to address potential contaminant release including emissions and MEEs during ISV implementation.	Potential release of fugitive dust during earthwork operations. Off-Site transport of TRU waste is required with potential industrial and radiological hazards to off-Site communities. Additional research is required to provide appropriate engineering controls to address contaminant releases during retrieval/treatment.
How will the risks to the community be addressed and mitigated?	Not applicable.	Developing a stringent traffic control plan would mitigate risks. In addition, appropriate engineering controls and contingency plans will be developed and implemented during the barrier installation. No contaminated material will be exposed during the installation. Community risks are considered to be negligible for this alternative.	Developing a stringent traffic control plan would mitigate risks. In addition, particulate emissions will be controlled using dust-suppression techniques and contaminant releases, if any, will be captured and treated.	Developing a stringent traffic control plan would mitigate risks. In addition, particulate emissions will be controlled using dust-suppression techniques and contaminant releases, if any, will be captured and treated. Properly designed, redundant emission control systems will be implemented for ISTD and ISV technologies. The MEEs during ISV implementation will be minimized through ISTD pretreatment, the placement of a soil cover, and the application of planar ISV.	Developing a stringent traffic control plan would mitigate risks, and particulate emissions will be controlled using dust-suppression techniques. Properly designed, redundant emission control systems will be implemented for double-containment treatment and retrieval buildings.
What risks remain to the community that cannot be readily controlled?	None.	Minimal. Increased traffic will occur at some locations in adjacent off-Site areas.	Minimal. Increased traffic will occur at some locations in adjacent off-Site areas.	Uncertain. Further research is needed to establish implementation requirements for SDA-specific ISV application.	Uncertain. Further research is needed to establish implementation requirements for SDA-specific retrieval action. Traffic would significantly increase off-Site due to waste shipments to WIPP.

Table C-1. (continued).

Evaluation Criterion and Analysis Factors	Alternative #1 No Action	Alternative #2 Surface Barrier	Alternative #3 In Situ Grouting	Alternative #4 In Situ Vitrification	Alternative #5 Retrieval, Treatment, and Disposal
Protection of workers during remedial action					
What are the risks to the workers that must be addressed?	No additional risks to workers.	Potential physical risk to moving equipment. Potential release of fugitive dust during the construction. During Pad A retrieval and ISTD implementation, workers have a potential risk of direct radiation and/or inhalation hazards from waste buried at the site.	Potential physical risk to moving equipment. Potential release of fugitive dust during the construction. During Pad A retrieval, and ISG and ISTD implementation, workers have a potential risk of direct radiation and/or inhalation hazards from waste buried at the site.	Potential physical risk to moving equipment. Potential release of fugitive dust during the construction. During Pad A retrieval, and ISG, ISTD and ISV implementation, workers have a potential risk of direct radiation and/or inhalation hazards from waste buried at the site. Potential MEE hazards during the implementation of ISV.	Potential physical risk to moving equipment. Potential release of fugitive dust during construction. During retrieval and material handling activities, and the implementation of ISG, and ISTD, workers have a potential risk of direct radiation and/or inhalation hazards from waste buried at the site.
How will the risks to the workers be addressed and mitigated?	Not applicable	Risks will be mitigated through training and the use of on-Site safety observers, engineering controls, administrative controls (INEEL health and safety protocols), and PPE (where appropriate). Dust suppression techniques will be used for high-traffic areas. Grouting equipment has been engineered to capture contaminants that could be given off during the operation.	Risks will be mitigated through training and the use of on-Site safety observers, engineering controls, administrative controls (INEEL health and safety protocols), and PPE (where appropriate). Dust-suppression techniques will be used for high-traffic areas. Grouting equipment has been engineered to capture contaminants that could be given off during the operation.	Risks will be mitigated through training and the use of on-Site safety observers, engineering controls, administrative controls (INEEL health and safety protocols), and PPE (where appropriate). Dust-suppression techniques will be used for high-traffic areas. The ISV technologies have been engineered to provide the capture of contaminants that could be given off during the operation. Mitigation of MEEs by pretreating waste with ISTD and by placing 3 m (10 ft) of overburden over the melt area.	Risks will be mitigated through training and the use of on-Site safety observers, engineering controls, administrative controls (INEEL health and safety protocols), and PPE (where appropriate). Dust-suppression techniques will be used for high-traffic areas. Remote equipment will be used, where appropriate, to minimize worker exposure Contaminant control systems will be designed with redundant measures to minimize uncontrolled contaminant releases.
What risks remain to the workers that cannot be readily controlled?	Not applicable	Risks associated with surface barrier construction will be minimal. Risks are associated with Pad A retrieval, and ISTD and ISG implementations will be mitigated through training and the use of on-Site safety observers, engineering controls, administrative controls (INEEL health and safety protocols), and PPE (where appropriate).	Minimal. The ISG application has been researched at INEEL to provide for worker protection. Risks associated with Pad A retrieval and ISTD implementation will be mitigated through training and the use of on-Site safety observers, engineering controls, administrative controls (INEEL health and safety protocols), and PPE (where appropriate).	Uncertain. Further research is needed to establish implementation requirements for SDA-specific ISV application.	Uncertain. Further research is needed to establish implementation requirements for SDA-specific retrieval action.
Environmental Impacts					
What environmental impacts are expected with the construction and implementation of the alternative?	None. No additional risks are posed to the environment.	Cultural resource could be impacted in proposed borrow sites and in areas adjacent to SDA affected by remedial actions. Fugitive dust releases could occur during the borrow material work activities and implementation of the engineered surface barrier, possibly affecting the outlying areas.	Cultural resource could be impacted in proposed borrow sites and in areas adjacent to SDA affected by remedial actions. Fugitive dust releases and potential contaminant releases could occur during implementation.	Cultural resource could be impacted in proposed borrow sites and in areas adjacent to SDA affected by remedial actions. Fugitive dust releases and potential contaminant releases could occur during implementation.	Cultural resource could be impacted in proposed borrow sites and in areas adjacent to SDA affected by remedial actions. Fugitive dust releases and potential contaminant releases could occur during implementation.

Table C-1. (continued).

Evaluation Criterion and Analysis Factors	Alternative #1 No Action	Alternative #2 Surface Barrier	Alternative #3 In Situ Grouting	Alternative #4 In Situ Vitrification	Alternative #5 Retrieval, Treatment, and Disposal
What are the available mitigation measures to be used and what is their reliability to minimize potential impacts?	Not applicable.	Potentially impacted areas will be screened to minimize and mitigate potential damages to cultural resources. Dust-suppression techniques also will be used for high-traffic areas.	Potentially impacted areas will be screened to minimize and mitigate potential damages to cultural resources. Dust-suppression techniques also will be used for high-traffic areas. Engineered controls will be implemented to mitigate the potential release of contaminants.	Potentially impacted areas will be screened to minimize and mitigate potential damages to cultural resources. Dust-suppression techniques also will be used for high-traffic areas. Engineered controls will be implemented to mitigate the potential release of contaminants.	Potentially impacted areas will be screened to minimize and mitigate potential damages to cultural resources. Dust-suppression techniques also will be used for high-traffic areas. Engineered controls will be implemented to mitigate the potential release of contaminants.
What are the impacts that cannot be avoided should the alternative be implemented?	Not applicable.	None known.	None known.	Uncertain. Further research is needed to establish implementation requirements for SDA-specific ISV application.	A significant increase in traffic would occur both on-Site and off-Site.
Time until remedial action objectives are achieved					
How long until protection against the threats being addressed by the specific action is achieved?	Protection is not achieved.	It is predicted that the surface barrier (Phase 1) can be completed within 13 years following the ROD signature.	It is predicted that in situ treatment can be completed and the surface barrier constructed within 14 years following the ROD signature.	It is predicted that in situ treatment can be completed and the surface barrier constructed within 24 years following the ROD signature.	It is predicted that the waste can be retrieved and the surface barrier constructed within 31 years following the ROD signature.
How long until any remaining site threats will be addressed?	Site threats are not addressed.	Not applicable.	Not applicable.	Not applicable.	Not applicable.
How long until RAOs are achieved?	The RAOs are not achieved.	All RAOs are met upon completion of the action.	All RAOs are met upon completion of the action.	All RAOs are met upon completion of the action.	All RAOs are met upon completion of the action.
Implementability					
Technical feasibility					
What difficulties may be associated with construction?	No construction or operation.	Construction techniques are standard practice. Solidifying the subsurface to minimize subsidence will be moderately difficult.	Few difficulties are expected. Technology implementation has been extensively researched to define site-specific requirements. The need to control potential contamination spread from the drill string will pose moderate difficulty.	Specialized equipment with site-specific design criteria is required. Additional treatability testing is needed to address contamination control, pretreatment, and worker protection issues.	Potential variability in waste materials and contaminant characteristics will require specialized equipment with site-specific design criteria.
What uncertainties are related to construction?	No construction or operation	Standard earthwork practices. The subgrade stabilization process (jet grouting) has not been tested to verify site-specific application requirements.	Potential for interference from certain types of waste may limit areas that grouting can be applied. Of particular concern is the high nitrate-concentrated waste in Pad A.	The site-specific design requirements for safety components have not yet been derived.	Waste stream variability and potential implications to contamination control, worker protection, treatment, and waste handling requirements. The availability of a future disposal site of adequate capacity for the TRU waste is uncertain.
What is the likelihood that technical problems will lead to schedule delays?	No construction or operation	Standard earthwork operation. However, problems encountered with stabilizing the subgrade could lead to schedule delays.	The technology uses relatively few pieces of equipment, each of which are commonly used in construction work. The contamination control system (e.g., seals, bags, ventilation) may contribute to some delays, as its reliability is unknown.	Because of the uncertainties related to the design and operation of the technology, implementation issues associated with the variability of the SDA waste and specific contamination control requirements could lead to schedule delays.	The likelihood for schedule delays is great, considering the number of systems and components and the first-of-a-kind nature of the retrieval and treatment facilities.

Table C-1. (continued).

Evaluation Criterion and Analysis Factors	Alternative #1 No Action	Alternative #2 Surface Barrier	Alternative #3 In Situ Grouting	Alternative #4 In Situ Vitrification	Alternative #5 Retrieval, Treatment, and Disposal
What likely future remedial actions may be anticipated?	Five-year reviews may show cause for additional action. Such actions may require a second feasibility study to evaluate actions, including containment, treatment, or removal. Further migration of contaminants to adjacent media should be anticipated and potentially increasing any future remediation requirements associated with the SDA waste.	Risk modeling has shown that this alternative will be protective, and, if properly implemented, additional remedial measures are not anticipated. Long-term maintenance and periodic repair of the cap will be required.	Risk modeling has shown that this alternative will be protective (if properly implemented), and additional remedial measures are not anticipated. The long-term durability of the grouted waste will need to be verified. Long-term maintenance and periodic repair of the cap will be required.	Risk modeling has shown that this alternative will be protective (if properly implemented), and additional remedial measures are not anticipated. The ISV produces a stable, high-quality waste form. Additional remedial measures are not anticipated. Long-term maintenance and periodic repair of the cap will be required.	Risk modeling has shown that this alternative will be protective (if properly implemented), and additional remedial measures are not anticipated. Long-term maintenance and periodic repair of the cap will be required.
How difficult would it be to implement the additional remedial actions, if required?	The no action alternative would not preclude or inhibit future action, if required.	Additional actions would require the full or partial removal of the surface barrier.	The ease of additional actions depends on the type of grout used. Several candidate grouts, for example, are "soft" and may aid future retrievals by minimizing contamination spread. Other grouts are rock hard and would preclude conventional excavation. The presence of a multilayer cover also would be a hindrance.	Very difficult, due to the size and hardness of the resultant monolith.	Additional actions would not be difficult. The presence of a multilayer cover would be the greatest hindrance.
Do migration or exposure pathways exist that cannot be monitored adequately?	Migration and exposure pathways are easily monitored under this alternative.	Migration and exposure pathways are easily monitored under this alternative.	Migration and exposure pathways are easily monitored under this alternative.	Migration and exposure pathways are easily monitored under this alternative.	Migration and exposure pathways are easily monitored under this alternative.
What risks of exposure exist should monitoring be insufficient to detect failure?	Exposure risks would be equal to those identified in the IRA.	If portions of the surface barrier fail, impacts to downgradient groundwater could occur.	If portions of the grout failed to adequately reduce contaminant leaching, the resulting risks to groundwater would be less than or equal to the risks calculated in the BRA. The most likely failure is that a small area was not completely grouted.	If portions of the vitrification failed to adequately reduce contaminant leaching, the resulting exposure risks would be less than or equal to the risks calculated in the BRA. The most likely failure is that a small area was not completely vitrified.	During the remedial action, the risks of exposure are great, should monitoring be insufficient to detect failure. Over the long-term, the risk of exposure is significantly reduced as the majority of contaminants are removed from the site.
Administrative feasibility					
What steps are required to coordinate with other agencies?	This alternative will not require additional permitting with other agencies.	This alternative will not require additional permitting with other agencies.	This alternative will not require additional permitting with other agencies.	Off-gas treatment requirements, processes, and systems will be negotiated with the IDEQ and EPA. The issue of air emissions may require further coordination with other public organizations.	Transportation, air emissions, and disposal issues would have to be coordinated with multiple agencies across multiple states.
What steps are required to set up long-term or future coordination among agencies?	A long-term institutional control plan would have to be negotiated with the regulatory agencies to continue monitoring.	A long-term institutional control plan would have to be negotiated with the regulatory agencies to continue monitoring and restrict future land use.	A long-term institutional control plan would have to be negotiated with the regulatory agencies to continue monitoring and restrict future land use.	A long-term institutional control plan would have to be negotiated with the regulatory agencies to continue monitoring and restrict future land use.	A long-term institutional control plan would have to be negotiated with the regulatory agencies to continue monitoring and restrict future land use.
Can permits for off-Site activities be obtained if required?	There would be no off-Site activities under this alternative.	There would be no off-Site activities under this alternative.	There would be no off-Site activities under this alternative.	There would be no off-Site activities under this alternative.	It is anticipated that permits for off-Site disposal could be obtained.

Table C-1. (continued).

Evaluation Criterion and Analysis Factors	Alternative #1 No Action	Alternative #2 Surface Barrier	Alternative #3 In Situ Grouting	Alternative #4 In Situ Vitrification	Alternative #5 Retrieval, Treatment, and Disposal
Availability of services and materials					
Are adequate treatment, storage capacity, and disposal services available?	Treatment, storage, and disposal services are not needed.	Adequate construction and ISG equipment are available.	Adequate construction and ISG equipment are available.	Limited ISV equipment is currently available.	The availability of disposal facilities of sufficient capacity for the disposal of TRU waste is questionable.
How much additional capacity is necessary?	Not applicable.	Not applicable	Not applicable.	Additional ISV equipment would have to be manufactured to implement the alternative.	Site-specific retrieval, waste handling, and treatment equipment will have to be manufactured. The predicted volume of TRU waste within the SDA that would be retrieved and disposed of exceeds the entire capacity of WIPP.
Does the lack of capacity prevent implementation?	Not applicable.	No	No.	No	The lack of available off-Site disposal capacity for TRU could prevent implementation of alternative.
What additional provisions are required to ensure the needed additional capacity?	Not applicable.	Not applicable	Not applicable.	Not applicable	Documentation and coordination with WIPP to generate increased capacity as required to accommodate predicted SDA TRU waste.
Are necessary equipment and specialists available?	Not applicable	Necessary equipment and specialists are available or can be transported to the site	Necessary equipment and specialists are available from qualified vendors.	Specialists and services are very limited Necessary equipment may have to be designed and constructed.	Necessary equipment would have to be designed, fabricated, and tested. Specialists would have to be trained.
What additional equipment and specialists are required?	Not applicable.	None.	None.	Off-gas treatment systems would have to be designed and built.	Confinement systems, fissile material monitors, etc.
Does the lack of equipment and specialists prevent implementation?	Not applicable.	No.	No	It is anticipated that the necessary equipment can be designed and fabricated and specialists trained during an extended design and action phase.	It is anticipated that the necessary equipment can be designed and fabricated and specialists trained during an extended design and action phase.
What additional provisions are required to ensure the needed equipment and specialists?	Not applicable.	None	None	Testing and design of the planar ISV technology should be conducted to identify site-specific requirements.	Continued investigation of characterization and treatment processes.
Are technologies under consideration generally available and sufficiently demonstrated for the specific application?	Not applicable.	The necessary technologies are available and sufficiently demonstrated.	The technologies are available commercially from multiple vendors. The technology has been demonstrated at the INEEL.	The necessary technology is available from one commercial firm. The technology is not sufficiently demonstrated for the specific application in SDA waste.	Technologies under consideration are generally available. However, site-specific applications have not been demonstrated.
Will technologies require further development before they can be applied full-scale to the type of waste at the site?	Not applicable.	No specialized technologies are required for the surface barrier construction. Additional development and testing of contamination control systems may be required for the pretreatment activity.	Prototype ISG equipment has already been tested at the INEEL. Additional testing is required to complete the safety analysis and remedial design.	Substantial analysis, design, and testing will be required before full-scale application. Additional testing is required to complete the safety analysis and remedial design.	Equipment for real-time monitoring for fissile mass may not be immediately available. Remotely operated excavation techniques, if used, may require additional development. Nondestructive assay equipment for waste bins requires development. Large-scale confinement systems to mitigate airborne alpha contamination may require development.

Table C-1. (continued).

Evaluation Criterion and Analysis Factors	Alternative #1 No Action	Alternative #2 Surface Barrier	Alternative #3 In Situ Grouting	Alternative #4 In Situ Vitrification	Alternative #5 Retrieval, Treatment, and Disposal
When should the technology be available for full-scale use?	Not applicable	No specialized technologies are required.	Prototype equipment has already been tested at the INEEL.	Uncertain. Technology-specific application requirements need to determined.	Uncertain. Extensive research required to define detailed technology requirements.
Will more than one vendor be available to provide a competitive bid?	Multiple vendors are available for all aspects of the work.	Multiple vendors are available for all aspects of the work.	Multiple vendors are available for all aspects of the work.	Uncertain	Multiple vendors are available to provide most components. However, it is uncertain whether vendors are available to provide an integrated system and service.
Cost					
Capital Cost (FY-02 $)	0	270,350,000	1,576,560,000	2,166,320,000	6,725,680,000
O&M Cost (FY-02 $)	38,810,000	87,440,000	57,520,000	57,600,000	54,120,000
Net Present Value	5,540,000	160,940,000	776,370,000	951,650,000	2,324,160,000

ARAR = applicable or relevant and appropriate requirement
BRA = baseline risk assessment
COC = contaminant of concern
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
ICDF = INEEL CERCLA Disposal Facility
IDEQ = Idaho Department of Environmental Quality
INEEL = Idaho National Engineering and Environmental Laboratory
IRA = Interim Risk Assessment
ISG = in situ grouting
ISTD = in situ thermal desorption
ISV = in situ vitrification
LDR = land disposal restriction
LLW = low-level waste
MEE = melt expulsion event
MLLW = mixed low-level waste
O&M = operations and maintenance
PPE = personal protective equipment
PRG = preliminary remediation goal
RAO = remedial action objective
ROD = Record of Decision
SDA = Subsurface Disposal Area
SVR = soil vault row
TRU = transuranic
WAC = waste acceptance criteria
WIPP = Waste Isolation Pilot Plant

Appendix D

Alternative Cost Estimates

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Attachment D-6—Operable Unit 7-13/14 Feasibility Study Cost Estimate for the Limited Action Alternative D-157

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COST ESTIMATE SUMMARY

WAG 7, FS COST ESTIMATES

OU7-13/14 DRAFT COMPREHENSIVE FS

INEEL - RWMC

DESCRIPTION	NO ACTION	SURFACE BARRIER	IN SITU GROUT (ISG)	IN SITU VITRIFICATION (ISV)	RETRIEVAL/ TREATMENT AND DISPOSAL (RTD)	LIMITED ACTION	FULL ENCAPSULATION
FFA/CO Management and Oversight							
WAG 7 Management	NA	26,645,000	26,645,000	68,886,000	81,977,000	12,622,000	26,645,000
Construction Management	NA	37,074,000	49,961,000	73,883,000	921,004,000	7,069,000	69,811,000
Remedial Design							
Remedial Design							
No Action	NA	NA	NA	NA	NA	NA	NA
Surface Barrier	NA	5,850,180	2,682,300	2,682,300	3,173,640	4,405,680	5,850,180
	NA	NA					
Grouting (ISG and Fdn)	NA	11,545,920	26,990,640	8,978,320	8,978,320	NA	11,545,920
ISTD/ISV	NA	4,396,240	2,202,560	62,271,100	2,753,200	NA	4,396,240
PAD A Excavation	NA	8,884,400	11,004,800	8,884,400	NA	NA	8,884,400
Retrieval/Excavation	NA	N/A	NA	NA	94,998,100	NA	NA
Vertical Slurry Wall	NA	N/A	NA	NA	NA	NA	1,462,180
Horizontal Subsurface Barri	NA	N/A	NA	NA	NA	NA	11,990,640
Readiness Assessment	NA	7,817,225	9,860,700	14,582,085	60,083,906	1,393,290	10,620,510
Remedial Action Report	NA	378,350	378,350	667,625	766,700	227,010	667,625
Remedial Action - Construction Subcontract							
Construction Subcontracts							
No Action	NA	NA	NA	NA	NA	NA	NA
Surface Barrier	NA	123,841,295	66,651,825	66,651,825	66,910,910	92,886,000	123,841,295
Grouting (ISG & Foundation	NA	182,669,860	426,789,495	141,969,685	141,969,685	NA	182,669,860
ISTD/ISV	NA	69,515,545	34,827,980	661,229,415	34,827,980	NA	69,515,545
PAD A Excavation	NA	112,987,660	139,210,720	112,987,660	0	NA	112,987,660
Retrieval/Excavation	NA	NA	NA	NA	3,980,034,080	NA	NA
Vertical Slurry Wall	NA	NA	NA	NA	NA	NA	30,616,795
Horizontal Slurry Wall	NA	NA	NA	NA	NA	NA	189,601,995
Treatability Work	NA	8,964,000	18,246,000	84,018,000	102,482,000	NA	14,710,000
TOTAL CAPITAL COST (ROUNDED)	NA	**598,870,000**	**804,351,000**	**1,276,390,000**	**4,889,950,000**	**118,793,000**	**857,507,000**
Remedial Action - Operations (100 Year Duration)							
WAG Post RA Management for 100 Years	3,814,350	4,099,300	4,099,300	3,484,150	3,484,150	3,783,750	4,099,000
Added Institutional Controls - For 100 Years	210,000	270,000	270,000	270,000	270,000	270,000	270,000
Cover Maintenance	NA	7,500,000	7,500,000	7,500,000	7,500,000	2,250,000	7,500,000
Surveillance and Monitoring	28,077,000	26,216,000	26,216,000	13,913,000	13,913,000	25,155,000	26,216,000
TOTAL OPERATIONS COST (100 YEARS) (ROUNDED)	**32,101,000**	**38,085,000**	**38,085,000**	**25,167,000**	**25,167,000**	**31,459,000**	**38,085,000**

PROJECT: WAG 7, FS COST ESTIMATES

OU7-13/14 DRAFT COMPREHENSIVE FS

LOCATION: INEEL - RWMC

DESCRIPTION	NO ACTION	SURFACE BARRIER	IN SITU GROUT (ISG)	IN SITU VITRIFICATION (ISV)	RETRIEVAL/ TREATMENT AND DISPOSAL (RTD)	LIMITED ACTION	FULL ENCAPSULATION
CAPITAL COST SUBTOTAL IN FY02 DOLLARS	NA	598,870,000	804,351,000	1,276,390,000	4,889,950,000	118,793,000	857,507,000
DESIGN/CONSTRUCTION (CONTINGENCY)							
No Action (20%)	NA	NA	NA	NA	NA	NA	NA
Surface Barrier (25%)	NA	32,297,869	14,808,631	14,808,531	17,521,188	24,322,920	32,297,869
ISG (35%)	NA	67,940,523	158,829,047	52,831,602	52,831,802	NA	67,940,523
ISTD/ISV (60%)	NA	36,955,893	18,515,270	355,750,258	18,790,590	NA	36,986,893
PAD A Excavation (45%)	NA	54,572,427	67,696,984	54,572,427	NA	NA	54,572,427
Retrieval/Excavation (45%)	NA	NA	NA	NA	1,833,764,481	NA	NA
Vertical Slurry Wall (25%)	NA	NA	NA	NA	NA	NA	8,017,244
Horizontal Slurry Wall (40%)	NA	NA	NA	NA	NA	NA	80,637,064
RA Report, Readiness Assessment, Treatability (30%)	NA	5,297,873	8,545,515	29,750,283	45,996,782	486,090	7,769,411
TOTAL CAPITAL COST CONTINGENCY	NA	197,060,000	268,290,000	508,710,000	1,968,900,000	24,809,010	288,190,420
Average Contingency	NA	32.9%	33.4%	39.9%	40.3%	20.9%	33.6%
TOTAL CAPITAL COST IN FY02 DOLLARS, w/CONTINGENCY	NA	795,930,000	1,072,640,000	1,785,100,000	6,858,850,000	143,602,010	1,145,697,420
TOTAL CAPITAL COST IN NET PRESENT VALUE, w/CONTINGENCY	NA	609,380,000	814,500,000	1,193,270,000	3,776,380,000	110,930,000	864,070,000
O&M COST SUBTOTAL	32,101,000	38,085,000	38,085,000	25,167,000	25,167,000	31,459,000	38,085,000
CONTINGENCY	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
TOTAL O&M COST IN FY02 DOLLARS, w/CONTINGENCY	38,520,000	45,700,000	45,700,000	30,200,000	30,200,000	37,750,000	45,700,000
TOTAL O&M COST IN NET PRESENT VALUE, w/CONTINGENCY	9,670,000	6,680,000	8,120,000	4,060,000	3,360,000	6,900,000	7,060,000
TOTAL PROJECT COST IN FY02 DOLLARS, w/CONTINGENCY	38,520,000	841,630,000	1,118,340,000	1,816,300,000	6,889,050,000	181,352,010	1,191,397,420
TOTAL PROJECT COST IN NET PRESENT VALUE, w/CONTINGENCY	9,600,000	616,100,000	822,600,000	1,197,300,000	3,779,700,000	117,800,000	871,100,000

Attachment D-1

Operable Unit 7-13/14 Feasibility Study Cost Estimate for the No Action Alternative

The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost estimate are likely to occur as a result of new information and data collected during the engineering design, safety reviews, and remedial alternative. Major changes may be documented in the form of a memorandum in the administrative record file, an explanation of significant differences, or a record of decision amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within –30 to +50 percent of the actual project cost.

I. SCOPE OF WORK:

Under the No Action alternative, no additional remedial action would be taken at the Waste Area Group (WAG) 7 site beyond the current site-wide monitoring of environmental media. The buried waste would remain as they are with no containment or treatment to reduce contaminant mobility, toxicity, and volume. For this alternative, it is assumed that the perimeter fencing would be maintained and a long-term monitoring would be conducted for groundwater, soil, air, and other environmental media.

II. BASIS OF ESTIMATE:

The basis of the estimate was developed from the following sources to provide a defensible and comparative cost of the remedial alternatives. The applicable sources available for the No Action alternatives include the following:

A. EPA, 2000, "A Guide to Developing and Documenting Cost Estimates During Feasibility Study," EPA 540-R-00-002, OSWER 9355.0-75 (EPA Guidance), July 2000.

B. INEEL, 2000, "Idaho National Engineering and Environmental Laboratory Cost Estimating Guide," DOE/ID-10473, Rev. 2, January 2000

C. INEEL, 2002, "Site Craft and Professional Services Labor Rates," February 2002

D. OMB, 2002, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Appendix C, "Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses," OMB Circular A-94, February 2002.

E. R. S. Means, 2002, *Heavy Construction and Industrial Building Unit Costs Data*, 16th edition, Kingston, Massachusetts.

F. INEEL, "Analytical Laboratory Unit Costs."

III. ASSUMPTIONS:

Under the No Action alternative, the following assumptions provide the basis for the cost estimate.

A. Management and oversight

A.1 Project management for the operating and maintenance (O&M) program is 10% of the overall costs.

A.2 Reports will be prepared annually summarizing analytical and field data.

A.3 Reviews will be conducted once every 5 years for 100 years. Five-year reviews will not result in additions or modifications of the remedy. No costs are included in the estimate for remedy additions or modifications.

A.4 The estimate assumes that the INEEL site resources (i.e., Central Facilities Area [CFA], medical facilities, geotechnical lab, fire department, security, utilities at the Subsurface Disposal Area [SDA]) will be available for the duration of the project.

B. Long-Term Operating and Maintenance and Monitoring

B.1 Environmental monitoring will continue for 100 years following issuance of the record of decision (ROD). Estimated monitoring requirements are summarized in Table 1. The projected labor effort for each element of the O&M Program is provided in Table 2. The estimated costs of the required laboratory analyses are provided in Table 3.

B.2 The lysimeter analytical cost assumes that liquid samples will be recovered in 10% of the wells. Therefore, analytical costs are included only for the assumed number of recoverable samples.

B.3 A 10% allocation has been included for replacement parts and equipment for the existing wells and lysimeters.

B.4 The analytical costs are based on unit prices provided by the INEEL and do not include costs for analysis at any commercial laboratories.

B.5 Costs to either install new groundwater monitoring wells or redevelop existing wells have not been included in the cost estimate.

B.6 The No Action alternative does include costs to maintain, operate, or remove the existing organic contamination in the vadose zone (OCVZ) system.

IV. CONTINGENCY COSTS:

The EPA provides guidance for estimating contingency costs in the EPA Guidance (EPA 2000). The EPA Guidance distinguishes between scope contingency and bid contingency costs. Scope contingency costs represent risks associated with incomplete design and include contributing factors such as limited experience with technologies, additional requirements because of regulatory or policy changes, and inaccuracies in defining quantities or characteristics.
Exhibit 5-6 of the EPA Guidance provides examples of scope contingencies. Bid contingency costs are unknown costs at the time of estimate preparation and that become known as remedial action construction or O&M proceeds. Bid contingencies represent reserves for quantity overruns, modifications, change orders, and claims during construction. The EPA Guidance states that bid contingencies may be added to construction and O&M costs and typically range from 10 to 20%. A minimum contingency of 25% is assumed to be representative for the No Action alternative for this project and has been included.

V. SCHEDULE:

The environmental monitoring schedule will be as described under Section III, Assumptions. Environmental monitoring will continue at the site for 100 years.

VI. PRESENT WORTH ANALYSIS:

Present value analysis for this alternative was conducted in accordance with Chapter 4 of the EPA Guidance. The overall period of analysis for the No Action alternative will begin shortly after issuance of a ROD and continue for 100 years. Cash outflows for the No Action alternative will include payments for environmental monitoring at the levels and on the schedules identified above in Section III, Assumptions. In accordance with EPA Guidance requirements, 2002 constant dollars are used for all cash outflows.

For federal facility sites being cleaned up using Superfund authority, EPA Guidance states that it is generally appropriate to apply real discount rates found in Appendix C of OMB Circular A-94. The most current version of Appendix C of OMB Circular A-94 (revised February 2002) proposes a real discount rate of 3.9% for programs with durations longer than 30 years. The 3.9% discount rate and constant dollars are used for the present value analysis of the No Action alternative. The present value of the No Action alternative is calculated using the equations provided in EPA Guidance.

VII. RISK AND UNCERTAINTY:

The primary risk associated with the No Action alternative is that environmental monitoring will detect significant releases from the site and additional remedial actions will be required. The analyses completed for the PERA suggests it is likely that additional remedial actions eventually will be required at the site. Because of the 100-year period for this alternative, it is probable that significant regulatory changes will require additions or modifications to the environmental monitoring program. New or revised regulations might require monitoring of environmental media more frequently, or sampling and testing of environmental media for additional monitoring parameters.

VIII. TABLES

Table 1. Estimated long-term monitoring program.

Media	Monitoring Stations	Monitoring Frequency	Other Assumptions
Groundwater	16 monitoring wells	Quarterly 2 years; semiannually 3 years; annually 95 years	Maximum depth of screened interval 600 ft; four QA/QC samples per event; parameters include characteristic leaching procedure metals, nitrate/nitrite, VOCs, semivolatile organic compounds, gross alpha and beta, Sr-90, Tc-99, Np-237, U-234, U-235/236, U-238, Pu-238, Pu-239/240, Am-241, gamma isotopes, C-14, I-129, tritium, pH, turbidity, total suspended solids, and total dissolved solids.
Vadose zone	37 lysimeters	Annually in late spring for 100 years	Assume 10% of lysimeters yield adequate liquid for analysis. Assume 1 additional QA/QC sample. Samples would be analyzed for groundwater analytes.
	20 vapor ports	Quarterly 5 years; annually 95 years	Vapor port samples would be analyzed for VOCs only.
Surface water	2 locations	Every 5 years for 100 years	Surface water samples would be analyzed for groundwater analytes. Assume one additional QA/QC sample.
Air	Four CAMs	Annually for 100 years	Air samples would be analyzed for groundwater analytes.
	Site perimeter	Annually for 100 years	Radiological monitoring; requires two staff once per year, all-terrain vehicle, global position system; data plots and management for 100 years; purchase new equipment three times over 100 years.
Biological	Animal intrusion	Annually for 100 years	Requires two staff once per year.

CAM = continuous air monitor
QA/QC = quality assurance and quality control
VOC = volatile organic compound

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE NO ACTION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

Table 2. Sampling labor requirements.

Media	Stations	Labor Effort per Event	Estimated Costs for Event
Groundwater	16 wells	2.5 personnel for staff for 8 days	\$55/hour × 200 hours = \$11,000
Vadose zone	37 lysimeters	2.5 personnel for 13 days	\$55/hour × 325 hours = \$17,875
	20 vapor ports	2.5 personnel for 20 days	\$55/hour × 500 hours = \$27,500
Surface water	Two locations	2.5 personnel for 1 day	\$55/hour × 25 hours = \$1,375
Air	Four CAMs	2 personnel for 2 days	\$55/hour × 40 hours = \$2,200
	Site perimeter	2 personnel for 2 day	\$55/hour × 40 hours = \$2,200
Biological	Animal intrusion	2 personnel for 1 day	\$55/hour × 20 hours = \$1,100

CAM = constant air monitor

Table 3. Estimated analytical requirements.

Target Analyte	Unit Cost	Groundwater Event (20 samples)	Lysimeter Event (five samples)	Surface Water Event (three samples)
Volatile organics	\$153	\$3,060	\$765	\$459
Semivolatile organics	\$295	\$5,900	\$1,475	\$885
Metals	\$525	\$10,500	\$2,625	\$1,575
Nitrate/nitrite	\$200	\$4,000	\$1,000	\$600
Gross alpha and beta	\$70.40	\$1,408	\$352	\$211
Sr-90	\$167.20	\$3,344	\$836	\$502
Tc-99	\$170.78	\$3,416	\$854	\$512
Np-237	\$230.18	\$4,604	\$1,151	\$691
U-234, -235/236, -238	\$230.18	\$4,604	\$1,151	\$691
Pu-238, -239/240	\$230.18	\$4,604	\$1,151	\$691
Am-241	\$230.18	\$4,604	\$1,151	\$691
C-14	\$105.60	\$2,112	\$528	\$317
I-129	\$105.60	\$2,112	\$528	\$317
Tritium	\$39.60	\$792	\$198	\$119
Gamma isotopes	\$178.20	\$3,564	\$891	\$535
Analytical subtotal		\$58,624	\$14,656	\$8,796
Procurement (10.42%)		\$6,109	\$1,527	\$917
Project adder[a]		\$39,294	\$9,824	\$5,894
Validation procurement		\$2,840	\$710	\$426
TOTALS		**\$106,867**	**\$26,717**	**\$16,033**

a. Adder costs included task order statement, sampling and analysis plan table, data review, data tracking, data entry (Energy Research Information System) upload, invoicing, and validation.

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE NO ACTION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: NO ACTION ALTERNATIVE
TYPE OF ESTIMATE: PLANNING
LOCATION: INEEL - RWMC

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/24/02

DESCRIPTION	MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
INSTITUTIONAL CONTROLS FOR 100 YEARS										
Replace Perimeter Security Fence	10,000	LF	$ 20	NA				$ 200,000		$ 200,000
Repair and Replace Perimeter Signs	1	LS	$ 10,000	NA				$ 10,000		$ 10,000
Subtotal										$ **210,000**
SURVEILLANCE AND MONITORING										
Groundwater Monitoring: (16-wells)										
Groundwater Monitoring, Quarterly for 2 Years - (8-Sampling Events)	8	EVT	$ 1,000	8	EVT	$ 11,000	$ 88,000	$ 8,000	$ 854,936	$ 950,936
Groundwater Monitoring, Semi -Annually for 3 Years - (6-Sampling Events)	6	EVT	$ 1,000	6	EVT	$ 11,000	$ 66,000	$ 6,000	$ 641,202	$ 713,202
Groundwater Monitoring, Annually for 95 Years (95-Sampling Events)	95	EVT	$ 1,000	95	EVT	$ 11,000	$ 1,045,000	$ 95,000	$ 10,152,365	$ 11,292,365
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)	1	LS	$ 1,295,650					$ 1,295,650		$ 1,295,650
Vadose Zone Monitoring:										
Sample 37 Lysimeters 1 Time per Year in Late Spring	100	EVT	$ 1,000	100	EVT	$ 17,875	$ 1,787,500	$ 100,000	$ 2,671,700	$ 4,559,200
Sample & Analyze 20 Vapor Ports 4 Times per Year for 5 Years	20	EVT	$ 1,000	20	EVT	$ 27,500	$ 550,000	$ 20,000	$ 140,000	$ 710,000
Sample & Analyze 20 Vapor Ports 1 Time per Year thereafter	95	EVT	$ 1,000	95	EVT	$ 27,500	$ 2,612,500	$ 95,000	$ 665,000	$ 3,372,500
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)	1	LS	$ 864,170					$ 864,170		$ 864,170
Surface Water Monitoring:										
Collect Sample from 2 Points 2 Times Every 5 Years (20 Sample Events)	20	EVT	$ 100	20	EVT	$ 1,375	$ 27,500	$ 2,000	320,660	$ 350,160
Air Monitoring (Radiological/Organic):										
Monitor 4 Existing CAMs	100	EVT	$ 1,000	100	EVT	$ 2,200	$ 220,000	$ 100,000	$ 2,671,700	$ 2,991,700
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)	1	LS	$ 299,170					$ 299,170		$ 299,170
Perimeter Radiological Monitoring GPS with NaI Detector										
2 People, 1-Time per Year, 2 Days in Summer with Hummer & GPS	100	EVT	$ 500	100	EVT	$ 2,200	$ 220,000	$ 50,000		$ 270,000
Data Interpretation/Plot Data	100	EVT	$ 750	100	EVT	$ 2,500	$ 250,000	$ 75,000		$ 325,000
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)	1	LS	$ 59,500					$ 59,500		$ 59,500
Biological Monitoring:										
2 People 2-Events, First 5-Years for Intrusion Monitoring	NA			2	EVT	$ 1,100	$ 2,200			$ 2,200
2 People 1-Time, Every 5th Year thereafter for 95 years	NA			19	EVT	$ 1,100	$ 20,900			$ 20,900
Subtotal										$ **28,077,000**
WAG 7 MANAGEMENT										
WAG 7 Management (@ 5% of other post-RA operations costs)							$ 1,414,350			$ 1,414,350
Annual Data Summary Report (100 reports @ 200 hrs/report)				20,000	HR	75.00	$ 1,500,000			$ 1,500,000
WAG-Wide RA 5 Year Reviews for 100 Years (20 reviews @ 600 hrs/review)				12,000	HR	75.00	$ 900,000			$ 900,000
Subtotal										$ **3,814,350**
TOTAL COST - Post-Remedial Action Operations (100 Year Duration)										$ **32,101,350**

Attachment D-2

Operable Unit 7-13/14 Feasibility Study Cost Estimate for the Surface Barrier Alternative

The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost estimate are likely to occur as a result of new information and data collected during the engineering design, safety reviews, and remedial alternative. Major changes may be documented in the form of a memorandum in the administrative record file, an explanation of significant differences, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within –30 to +50 percent of the actual project cost.

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE SURFACE BARRIER ALTERNATIVE

Project Title:	WAG 7 OU 13/14 Feasibility Study
Estimator:	Brian K. Corb
Date:	December 2002
Estimate Type:	Planning
Reviewed/Appr:	Lee Lindig/Bruce L. Stevens

I. SCOPE OF WORK:

A. Remedial Design and Remedial Action

A.1 Construction of the Surface Barrier alternative will be implemented in two phases because a portion of the SDA is currently active and continuing to receive waste material. Phase 1 construction will cover the inactive portion of the site (105 acres) and Phase 2 construction will cover the currently active portion of the site (5 acres) after disposal operations are completed in 2020. Work associated with construction of the Surface Barrier alternative includes preconstruction activities, placement of earth fill, high-pressure in situ grouting (ISG), foundation stabilization grouting, placement of surface barrier layers, and placement of erosion control materials. Preconstruction activities will include investigation of borrow sources, preparation of final design, completion of a readiness assessment, and mobilization.

A.2 The initial construction activity will be placement of a minimum 5-ft-thick layer of earthen fill over the SDA to minimize contact with waste materials during subsequent construction activities. This layer will provide a contouring layering with an average thickness of 5 ft across the site. Before grouting activities, in situ thermal desorption (ISTD) technology will be applied to remove volatile organic compounds (VOCs) in the waste streams in pits containing the highest organic concentrations (approximately 5 acres). Grouting activities will include high-pressure ISG with specialized grout to treat waste in soil vault row (SVR) areas and the activation and fission product waste in the trenches (approximately 1,500 ft of trench). Lower pressure foundation stabilization grouting with cement-based grout will be used to stabilize waste and reduce settlement in other areas of the SDA. Concurrent with the grouting operations, the Pad A waste will be excavated and placed beneath the grading fill without treatment to reduce the vertical profile of the waste pile.

A.3 As grouting is completed, various layers of the surface barrier will be installed, including additional earth fill, gas collection, infiltration barrier, biotic barrier, filter, and topsoil layers. Placement of erosion control materials will include construction of a flood control berm around the perimeter of the surface barrier, placement of armor (riprap and other materials) on surface barrier and berm side slopes, and establishment of vegetation.

B. Long-Term Monitoring and Maintenance

B.1 Once the Remedial Action has been completed, long-term monitoring and maintenance will continue for the 100-year window with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) reviews conducted every 5 years. The long-term environmental monitoring will be conducted for groundwater, vadose zone water, surface water, and air. In addition, the surface barrier itself will be monitored annually during the first 5 years following completion of construction (beginning after the vegetation establishment period). After the completion of annual monitoring, monitoring will be reduced to every 5 years concurrent with the 5-year reviews required under CERCLA. The surface barrier will be monitored for vegetation density, erosion damage, and differential settlement. Areas of erosion damage will be repaired with additional topsoil or earth fill, and reseeded. Areas without established vegetation will be reseeded.

II. BASIS OF ESTIMATE:

The basis of the estimate was developed from the following sources to provide a defensible and comparative cost of the remedial alternatives. The applicable sources available for the Surface Barrier alternatives include:

A. EPA, 2000, "A Guide to Developing and Documenting Cost Estimates During Feasibility Study," EPA 540-R-00-002, OSWER 9355.0-75, (EPA Guidance), July 2000

B. INEEL, "Cost Estimating Guide," DOE/ID-10473, September 2000

C. DOE, 1997, "Environmental Assessment and Plan for New Silt/Clay Source Development and Use at the Idaho National Engineering and Environmental Laboratory," DOE/EA-1083, May 1997

D. Caterpillar, Inc., 2001, "Caterpillar Performance Handbook," 32nd Edition, Peoria, IL

E. The INEEL Site Stabilization Agreement, Union Labor Agreement

F. Facilities Unit Costs—Military Construction, PAX Newsletter No. 3.2.2—10, March 2000

G. INEEL CERCLA Disposal Facility (ICDF) Construction Cost Estimate, Cap Construction Cost (CH2MHILL, December 2000)

H. Subject Matter Experts—M. Jackson, BBWI, and T. Borschel, BBWI, "Availability of Borrow Source Material at the INEEL"

I. BBWI, "INEEL Site Craft and Professional Services Labor Rates," February 2002

J. OMB, 2002, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Appendix C, "Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses," OMB Circular A-94, February 2002.

K. AMEC Earth & Environmental, Inc., ISV Technology Specialist

L. R. S. Means, 2002, *Heavy Construction and Industrial Building Unit Costs Data* 16th edition, Kingston, Massachusetts.

M. INEEL "Analytical Laboratory Unit Costs."

III. ASSUMPTIONS

The primary work associated with the Surface Barrier alternative includes placement of a surface barrier over the SDA. Because some portions of the SDA will continue operating until 2020, the construction effort is divided into two phases. Phase 1 construction includes placing a surface barrier over approximately 105 acres of inactive portions of the SDA. Phase 2 construction includes placing a surface barrier over an estimated 5 acres of the SDA that will remain active until 2020. Specific elements of the work and important assumptions are provided below:

A. Management and Oversight

A.1 Project Management for the BBWI oversight of this alternative has been estimated based on an average classification of job categories using the BBWI rates. The number of full-time equivalents (FTEs) are based on 2,000 MH per person per year.

A.2 The remedial design and remedial action (RD/RA) schedule assumes that the budgetary funding will not be constrained.

A.3 The RD/RA schedule assumes that no unexpected delays will result from changes to the unreviewed safety question and safety assurance review (USQ/SAR) process.

A.4 The estimate assumes that the INEEL site resources (i.e., CFA, medical facilities, geotechnical lab, fire department, security, utilities at the SDA) will be available for the duration of the project.

B. Design and Preconstruction

B.1 Preconstruction activities—Borrow source investigations, cultural resource clearance, and development of an onsite source of basalt rock, final design, readiness assessment completion, road building, and mobilization.

B.2 Treatability testing for ISG sand ISTD will be conducted.

C. Site Preparation and Support Activities and Facilities

C.1 Placement of initial earth fill—Site clearing, grubbing, and leveling will be followed by placement of a 5-ft-thick cover over areas to be grouted.

C.2 All existing wells and lysimeters within the footprint of the SDA will be plugged and abandoned.

C.3 Containment buildings and structures will be constructed (see ISG alternative cost estimate for more information).

C.4 In situ thermal desorption—ISTD will be performed to remove VOCs in the high organic concentration waste streams in the pits before grouting operations. The ISTD technology will be applied over a surface area of 5 acres, to a depth of 14 ft.

C.5 In situ grouting—The SVRs and the activation and fission product waste streams in the trenches will be treated by high-pressure jet grouting.

C.6 Pad A excavation—Approximately 10,000 m^3 of waste at Pad A will be excavated, sorted, and (depending on the integrity of the containers) either overpacked or placed in new containers. The containers will then be placed in a single layer within the central portion of the SDA and covered by the surface barrier.

C.7 Foundation stabilization grouting—Wastes will be stabilized to reduce settlement by low-pressure grouting areas of pits and trenches with cement-based grout. It is assumed that once the foundation grouting has been completed, heavy equipment operation can commence without any ground subsidence. No additional costs for cribbing or temporary road stabilization are included in the estimate.

C.8 Placement of earthen fill and gravel gas collection layers—An initial earthen fill (10-ft-average thickness) will be placed over the SDA to grade the site for surface barrier construction. Six inches of gravel will be placed to collect gas that may be generated beneath the surface barrier.

C.9 During the development of this cost estimate, modular containment buildings were evaluated including Butler and Sprung structures. The cost of a building for the ISG operation considers a Sprung-type containment structure for the operation. The costs for these facilities include fire protection; heating, ventilation, and air conditioning; lighting; communication lines; and power distribution.

D. Borrow Areas

D.1 To use Spreading Area B as a borrow source, the area will need to be drilled and tested for material quality and quantity. For this PERA, it is assumed that an Environmental Assessment Plan will need to be revised; an Army Corps of Engineers Section 404 permit will need to be obtained, and a National Pollutant Discharge Elimination System permit will need to be completed and approved prior to using this area. It is assumed that the permitting process for Spreading Area B will be completed concurrent with other preconstruction activities to avoid extending the construction schedule.

D.2 Spreading Area B will be available and will not be flooded. No additional costs have been provided to dewater Spreading Area B.

D.3 An adequate quantity and quality of borrow source material is available from Spreading Area B, the Borax Pit, and the Basalt Source (for riprap and coarse fractured material). Furthermore, no royalty fee or earthen material costs are provided for in the estimate.

D.4 An adequate water source will be available to support the earthmoving and soil moisture conditioning for placement and compaction based on the equipment productivities developed for this estimate.

D.5 The source of low-permeability soil will meet the hydraulic conductivity requirements of 10^{-7} cm/second and the soil will not require amendment with bentonite.

E. Treatability Testing Assumptions

E.1 Additional characterization of the SDA and treatability testing using both simulated and actual waste locations will be required to establish the design and safety basis for operating ISTD, ISG, and the secondary waste treatment processes for processing waste generated in the ISTD off-gas cleanup systems. This work will verify that waste sites and properties that represent bounding conditions can be safely and effectively treated.

F. Surface Barrier Construction

F.1 Placement of clay, geomembrane, and filter layers—A 2-ft-thick compacted clay layer and a 60-mil high-density polyethylene (HDPE) geomembrane layer will be placed as infiltration barriers. A 1-ft-thick filter section consisting of sand and gravel will be placed over the geomembrane.

F.2 Placement of remaining surface barrier layers—Remaining surface barrier layers will consist of a 2.5-ft-thick layer of coarse fractured basalt (biotic barrier layer), 1-ft-thick filter layer consisting of sand and gravel, 8-ft-thick layer of engineered earth fill, and a 1-ft-thick layer of topsoil.

F.3 Placement of perimeter berm and erosion controls—A 6-ft-high berm will be constructed around the perimeter of the surface barrier to control flooding; filter layers, coarse fractured basalt, and riprap will be placed on the side slopes to minimize erosion.

F.4 Vegetation establishment—The topsoil layer will be seeded with native grasses to provide a vegetative cover. The cover will be monitored and reseeded as necessary to maintain the vegetative layer.

G. Organic Area Treatment with In Situ Thermal Desorbtion

G.1 In situ thermal desorption will be used to treat the high VOC area waste streams in the SDA to minimize future operational requirements on the OCVZ system. ISTD will employ an array of heated stainless steel pipe assemblies inserted into the ground on an 8 × 8-ft spacing to a depth of approximately 3 ft below the buried waste.

G.2 It is assumed that each pipe assembly will include a sealed pipe that contains an electrical-resistance heating element, a vented pipe used to extract gases, and thermocouples. Extraction pipes will be connected to a pipe manifold that conveys the gases to an off-gas treatment system. The average pipe assembly will be inserted to a depth of 24 ft. Pipe assemblies will be inserted into the ground using either nonstandard vibratory or hydraulic techniques.

G.3 It is assumed that heat can be transferred from the heating elements to the pipes and then to the waste at a nominal rate of 350 watts per lineal ft of heated pipe.

G.4 Six ISTD systems will be used. With the 8 × 8-ft spacing of the pipe assemblies, heating will occur over an approximate 90-day period. The six systems are projected to treat approximately 2 acres per year, requiring 2.5 years to complete the projected 5 acres.

G.5 The ISTD systems will require about 330 kW.

G.6 When a subsystem reaches its heating objectives, the pipe manifold that collects off-gases will be isolated from the rest of the off-gas manifold by closing valves. The 12 or 20 extraction pipes in the subsystem will be crimped closed, the manifold section will be disconnected and transported to the front of the advancing ISTD system and reconnected after purging at that location.

H. Pad A Waste Retrieval And Management

H.1 It is assumed that 6 m^3 of transuranic (TRU) waste will be generated during the retrieval actions, which will require off-Site disposal at the Waste Isolation Pilot Plant (WIPP).

H.2 The Pad A retrieval operations will require a primary and secondary containment structure, approximately 230 × 410 ft in plan dimensions, and designed in accordance with the International Building Code (IBC). Frost depth for building foundations is 5 ft (DOE-ID 2001). The ground snow load of at least 35 lb/ft^2 shall be used in American Society of Civil Engineers (ASCE) 7 calculations and a minimum roof snow load of 30 lb/ft^2 shall be used for all buildings (DOE-ID 2001). Retrieval buildings and other structures shall not be designed to tornado loads (DOE-ID 2001). All structures shall be designed to performance category (PC) 2 standards for wind, seismic, and flood design requirements. The Performance Category (PC) 2 seismic return period is 1,000 years (STD-1020). The fastest wind speed for INEEL structures is 70 mph, and 3-second gust wind speed is 90 mph (DOE-ID 2001). The design mean hazard annual probability for floods is 5×10^{-4}, or a 2,000-year return period (STD-1020). Fire protection systems shall meet or exceed the minimum requirements established by the National Fire Protection Association and DOE O 420.1.

H.3 The primary and secondary containment structure is a double-walled structure that would be equipped with radiation alarm systems such as constant air monitors set to alarm when airborne contamination reached unacceptable levels. Criticality alarms would be installed in the primary containment structure. These alarm systems would require periodic testing and calibration.

H.4 It is assumed that the containment building will be dismantled and buried beneath the surface barrier. A cost allowance of 25% of the capital expenditures of the building costs is assumed to be representative of the estimated level of effort to dispose of the buildings and equipment.

H.5 The structure would include a gantry crane that would be used to apply water, foams, and foggers to keep dust and contamination at a minimum during the retrieval operation. The crane would provide support for lifters, detectors, and other equipment.

H.6 Negative pressure would be applied to the digface at all times and directed to high-efficiency particulate air (HEPA) filters to control the contamination and keep it from entering the secondary containment structure. Air exhausted from the retrieval zone would be fully saturated with water vapor by applying mists to control airborne contamination. Some of the water vapor would condense in the ductwork leading to the air treatment system. This condensate would be recycled through the retrieval-face misting system, as would other condensates. The air treatment system consists of chillers, demisters, heaters, and banks of HEPA filters in two parallel systems to provide redundancy if one of the systems failed. The chillers would cool the air and decrease the air's dew point, causing mists to form. The air would then pass through a demister, which would remove moisture from the air. The air would then pass through heating elements to raise the temperature to about 10°C above the dew point. The air would then pass through the HEPA filters.

I. ISG/Foundation Grouting Assumptions

I.1 The ISG equipment and enclosures will be dismantled and disposed of under the Surface Barrier Cap. Twenty-five percent of the capital equipment expenditure is included in the estimate for the deactivation, decontamination, and decommissioning (D&D&D) of the equipment.

I.2 The TRU pits and other trenches will be only low-pressure grouted for foundation stabilization.

I.3 Grouting operations will be conducted within a weather enclosure to facilitate Radiological Control. Two sprung-type structures will be moved to the site. These structures initially will be constructed and then progressively disassembled and reconstructed to accommodate the advancement of the ISG operation. Following completion of the grouting operation within an enclosure and before disassembly of the building, the grouted area will be covered with a minimum of two ft of earth fill.

I.4 The grout production rate of one hole every 4 minutes can be maintained with no subsurface anomalies that would further reduce the assumed efficiency of 70%. ISG will begin after the f initial earthen fill has been placed over a significant portion of grouting areas. ISG for waste treatment will be performed using the same grouting technique and grout types as described for the ISG alternative, however, ISG will be limited to the SVRs and portions of the waste trenches. Specific assumptions related to ISG are provided in the ISG alternative cost estimate.

I.5 The SVRs and other trenches will be treated using the ISG technology and based on a 2-ft center-to-center spacing. The productivity assumption is grouting of one hole every 4 minutes.

I.6 Foundation stabilization grouting will be applied using low-pressure jet grouting technology and based on a 4-ft center-to-center spacing. The productivity assumption is grouting of one hole every 4 minutes.

I.7 Grouting for foundation stabilization will be performed using a modified drill rig to inject grout under high pressures into the waste stream. The grout will fill readily accessible void space and cure into a solid monolith. This technique allows using a relatively low-cost cement-based grout instead of specialized grout types for waste treatment. Unlike the ISG portion of the alternative, the foundation stabilization operation would not be required to completely mix the grout with the waste or soil. It is assumed that voids that could threaten the integrity of the surface barrier are fairly large and would be intersected if the spacing between grout holes were larger than the spacing for ISG. In addition, it is assumed that substantially less grout would be needed for foundation stabilization because the grout would be injected on a less dense spacing, and that an attempt was made to compact waste when it was initially placed in the SDA. Assumptions for foundation stabilization grouting for the Surface Barrier are addressed in the ISG alternative cost estimate.

I.8 The equipment and crew size needed for ISG and foundation stabilization grouting is similar to the crew size and equipment needed for the ISG alternative.

I.9 Remaining earthen fill and the gravel gas collection layer of the surface barrier will be placed during grouting activities.

J. Capital Costs, Unit Rates, and other Pricing Assumptions

J.1 The unit prices have been developed from a crew build-up to process, load, haul, place, and compact basis. The volume of material represented in the cost tables identifies compacted cubic yards (CCY). The appropriate factors convert the estimated unit material weights (e.g., bank, loose, and fill) and are factored into the equipment productivity.

J.2 Crew labor rates were developed based on hourly rates stipulated in the INEEL Site Stabilization Agreement. Labor and equipment spreads were developed to support the project schedule based on the assumed achievable daily productivity. Other factors that influenced the selection of labor and equipment quantities include safety considerations, level of personal protective equipment (PPE) of the work to be performed, haul routes, and availability of resources on the INEEL. Each daily crew cost also includes field oversight personnel such as the health and safety officer (HSO), superintendents, foremen, certified industrial hygienists (CIHs), maintenance personnel, and allocation of supplies (e.g., fuel, oil, grease, and spare parts).

J.3 Mobilization and demobilization charges are based on 2% of the total cost for each phase.

J.4 Capital equipment and pricing were selected from commercially available sources or similar projects allowing a scale factor to be applied to yield an estimated cost of the conceptual equipment and operational requirements. Equipment installation cost is considered to be a significant variable in estimating individual components of a given system. The installation cost of the capital equipment was based on a percentage of the capital costs ranging from 110 to 160% of the estimated capital expenditure based on the unknowns and level-of-complexity.

J.5 Subcontractors bond and insurance rate of 2% of the total subcontractor dollars including overhead and profit has been included based on each alternative.

J.6 The estimate includes an allocation for the INEEL specific work order procedure requirements and safety meetings. Because this estimate includes primarily unit prices, the labor cost is estimated to be 40% of the unit prices and, based on historical data, cost of the INEEL-specific process is approximately 6% of the total labor dollars.

K. Schedule

K.1 The estimate assumes that earthwork operations can be performed for 10 months per year without weather impacts. The work will be performed working two 10-hour shifts, with a back shift performing maintenance 5 days per week.

K.2 The estimate assumes that the field crews will demobilize the equipment during the 2-month winter shutdown period to refurbish and replace the equipment. The estimate includes an allocation to cover these costs in addition to the 2% estimated.

L. Health and Safety

L.1 Once the initial site grading material is placed over the SDA, all earthmoving operations can be performed in Level D PPE.

L.2 Pad A waste will be excavated, sorted, and either overpacked or placed in new containers. The containers then will be tightly stacked in a single layer within the SDA and covered by the cap grade fill. The estimate assumes that this waste will not require any treatment and will be performed in Level B PPE.

M. Long-term Operating and Maintenance and Monitoring

M.1 The monitoring program will be the same as for the No Action alternative (see Section D-1).

M.2 The capital cost for the project includes replacing the groundwater wells and lysimeters that were removed as part of site preparation. The estimate assumes that nested wells and lysimeters will be installed at varying depths of 20 ft, 90 ft, 200 ft, and 600 ft along the interbed surfaces.

M.3 The lysimeter analytical cost assumes that liquid samples will be recovered in 10% of the wells. Therefore, analytical costs are included only for the assumed number of recoverable samples.

M.4 After topsoil has been placed as the final layer on the surface barrier, it will be seeded with native grasses to provide vegetative cover that will reduce erosion. However, because of the arid climate of the INEEL, an extended period of time will be required to establish a permanent vegetative cover. Erosion of the uppermost layers of the surface barrier during snowmelt will occur during the years immediately following construction and repairs, and reseeding will be required.

M.5 Ongoing maintenance of the surface barrier will be required in perpetuity after construction is completed. It is assumed that frequent maintenance will be required during the years immediately following construction, to repair damage from erosion and to establish a permanent vegetative cover. In addition, the added weight of the surface barrier is expected to result in increased settlement during the initial years following construction. Some areas of the surface barrier will require ongoing maintenance to repair damage resulting from settlement. It is expected that annual maintenance and repairs will be required during the first 5 years following construction. Ongoing maintenance and repairs will continue every 5 years concurrent with the 5-year review process.

N. Design Costs

The following discussion provides the basis for the assumed percentage for design, construction, and contingency. The EPA provides guidance for estimating remedial design costs in the EPA Guidance (EPA 2000). Exhibit 5-8 of the EPA Guidance provides examples of remedial design costs as a percentage of total capital costs. The percentages range from 20% for projects with capital costs less than $100,000 to 6% for projects with capital costs greater than $10 million. The EPA Guidance does not provide an example of design costs that vary according to the complexity of technologies.

For the WAG 7 PERA, the alternatives include technologies that have been demonstrated on other sites and have well-developed engineering design criteria (e.g., capping) and technologies that have not been demonstrated on a large scale and require development of engineering design criteria (e.g., ISV). For the WAG 7 PERA alternatives, remedial design costs are expected to vary significantly according to the degree of complexity and the estimated costs for remedial design need to reflect the varying degrees of complexity. Based on the complexity of the technology application, a percentage of the capital and operating cost specific to the technology was assumed.

The proposed cover system has been demonstrated on other sites and design standards have been developed for the various types of materials and construction methods. Some borrow source investigations will be needed to verify material properties and quantities, but the methods for conducting these investigations are not expected to require specialized equipment or personnel. Because capping is a demonstrated technology with established design standards, the cost for remedial design is assumed to be 6% of capital costs.

In situ grouting includes subsurface jet injection of specialized types of grout into waste disposal areas of the SDA to stabilize and treat waste materials. ISG will need to be done inside a modular building to contain possible releases of contaminants. Some waste disposal areas will require pretreatment before grouting. Considerable effort will be needed to design appropriate grout types for the waste disposal areas, design the modular building and grouting equipment, determine areas of the site that will need pretreatment, and field test the various design elements. Because of the additional design effort required for ISG, the cost for remedial design is assumed to be 8% of capital costs.

Foundation stabilization grouting includes using modified grouting equipment to jet grout areas of the SDA to fill voids within the waste and provide a stable foundation for placing and maintaining cover systems. Foundation grouting is somewhat similar to ISG except specialized grout and grouting equipment (including a modular building) will not be needed and the grout holes will be spaced farther apart than for ISG. Cement-based grout and modified grouting equipment will be used for this technology. Some field demonstrations will be conducted to verify the ability of the grouting equipment to penetrate the waste disposal areas and to estimate the approximate quantity of grout that will be needed. Because the design effort will be considerably less for foundation grouting than for ISG, the cost for remedial design is assumed to be 7% of capital costs.

The various technologies and the percentage of capital costs estimated for remedial design are summarized in Table 1. These percentages are applied to individual technologies in the cost estimate to establish estimated design costs for the various alternatives.

O. Construction Management Costs

Cost considerations for BBWI oversight, regulatory agency interaction, and project management were estimated on a representative basis of an assumed level of effort required to implement the selected alternative. Additionally, costs for the remedial design, safety equipment and PPE, construction management, general conditions, and insurance and bonds were included in the estimate to capture a relative basis for cost comparison and to identify other costs associated with implementing a given remedial alternative.

The percentage basis assumed for each category identified was selected considering the complexity of the alternative and risk and uncertainty of the approach. The cost captured in conjunction with the percentage basis identified under the category general conditions includes administration buildings, parking area, utilities, and support infrastructure to facilitate the remedial alternative.

P. Contingency Costs

The EPA provides guidance for estimating contingency costs in the EPA Guidance, which distinguishes between scope contingency and bid contingency costs. Scope contingency costs represent risks associated with incomplete design and include contributing factors (e.g., limited experience with technologies, additional requirements because of regulatory or policy changes, and inaccuracies in defining quantities or characteristics). Exhibit 5-6 of the EPA Guidance provides examples of scope contingencies. Bid contingency costs are unknown costs at the time of estimate preparation, which become known as remedial action construction or O&M proceeds. Bid contingencies represent reserves for quantity overruns, modifications, change orders, and claims during construction. The EPA Guidance states that bid contingencies may be added to construction and O&M costs and typically range from 10 to 20%.

Because EPA Guidance suggests that contingency costs will vary according to the alternative technologies, it is necessary to estimate varying contingency costs for the technologies included in the alternatives of the WAG 7 PERA. Technologies have been evaluated separately to determine appropriate contingency costs. Scope and bid contingencies for each technology associated with this alternative are discussed below and are shown only in the summary cost estimate that lists the comparative cost of each alternative.

The cover system includes using several types of materials in addition to those planned for biotic barrier technology, constructing of infiltration barriers, and using synthetic materials. One significant assumption for this technology is that available native materials will be capable of meeting infiltration barrier layer permeability requirements without using additives (e.g., bentonite). Capping technology is assumed to require a scope contingency within the range of 10 to 20% as shown in Table 2. Because of the risk associated with the need for additional borrow sources for materials, using synthetic materials, and the possible need to use additives for infiltration barrier layer construction, the cost for the scope contingency is assumed to be 15%. Most risks associated with capping technology will be significantly reduced during remedial design, therefore, the cost for the bid contingency is assumed to be 10%. The total contingency for capping technology is assumed to be 25% of capital costs.

ISG includes jet injection of various types of grout into waste materials in the SDA to stabilize and treat waste materials. ISG technology will require consideration of appropriate grout design, design of specialized grouting equipment and a modular containment building, and field demonstrations. ISG technology is assumed to require a scope contingency within the range of 15 to 35% as shown in Table 3. Because of the specialized design efforts required for this technology, the cost for the scope contingency is assumed to be 20%. Some significant construction risks still will be associated with this technology because of unanticipated subsurface conditions, therefore the cost for the bid contingency is assumed to be 15%. The total contingency for ISG technology is assumed to be 35% of capital costs.

Foundation stabilization grouting includes lower-pressure grouting areas of the SDA with cement-based grout to fill voids within the waste and provide a stable foundation for placing and maintaining cover systems. While foundation stabilization grouting is somewhat similar to ISG, design of specialized types of grout and a modular containment building will not be required. Scope and bid contingencies for foundation stabilization grouting are the same as those for ISG (20% and 15%, respectively) with a total contingency for foundation grouting assumed to be 35% of capital costs.

The scope and bid contingency percentages associated with this alternative are identified in Table 3. These percentages are applied to individual technologies in the cost estimate to establish a representative aggregate cost contingency.

Considering the cost contingency guidance provided in Table 2 for each of the technologies, a representative contingency was selected within the range provided, factoring in complexity and size of the project, and inherent uncertainties related to the remedial technology. However, the guidance document does not address all of the remedial technologies identified in this alternative. Specifically, the foundation stabilization grouting and ISG technologieswould be within a cost contingency range of 20 to 35% and are considered representative for this work and project scope.

IV. SCHEDULE:

The following activities comprise the RD/RA portion of the Surface Barrier alternative. The corresponding durations are based on the estimated crew productivity, regulatory reviews and approvals, and weather constraints inherent to the INEEL site. Tables 4 and 5 show this information.

V. PRESENT WORTH ANALYSIS:

Guidance for present value analysis is provided in Chapter 4 of the EPA Guidance (EPA 2000). EPA Guidance states that the present value analysis of a remedial alternative involves four basic steps:

1. Define the period of analysis
2. Calculate the cash outflows (payments) for each year of the project
3. Select a discount rate to use in the present value calculation
4. Calculate the present value.

Periods of analysis for the Surface Barrier alternative include Phase 1 design and construction, Phase 2 design and construction, and O&M. The Phase 1 design and construction period is estimated to occur during a 12.5-year period beginning shortly after issuance of a ROD for the site. Phase 2 design and construction is estimated to occur during a 5.5-year period beginning shortly after currently active areas of the site are closed in 2020. The O&M period will begin toward the end of the vegetation establishment period for Phase 1 construction and will continue for 100 years.

Cash outflows for the Surface Barrier alternative will include payments for design and construction, periodic payments for major repairs, and annual O&M costs. The EPA Guidance suggests that most capital costs should be assumed to occur in the first year of remedial action when funds are committed for remedial action. While this suggestion might be a realistic assumption for short-duration remedial actions, it is not a realistic assumption for the Surface Barrier alternative because of time required for design and construction. Cash outflows for the surface barrierwould be paid on an annual basis as costs are incurred, beginning with the borrow source investigation/remedial design and ending with the end of the vegetation establishment periods for Phase 1 and Phase 2 construction.

Annual capital cost payments vary with the level of activity, with relatively low annual payments during the borrow source investigation, remedial design, readiness assessment, and vegetation establishment periods, and relatively high annual payments during heavy construction periods (grouting and material excavation, processing, stockpiling, and placement). Periodic costs for major repairs would occur every 5 years concurrent with the 5-year reviews required by CERCLA. Periodic costs would begin 5 years after Phase 1 construction and continue through the O&M period. Annual O&M costs would begin the first year after completion of Phase 1 construction and continue for 100 years. In accordance with EPA Guidance requirements, 2002 constant dollars are used for all annual and periodic cash outflows.

EPA Guidance requires using a real discount rate that approximates the marginal pretax rate of return on an average investment and has been adjusted to eliminate the effect of expected inflation. The real discount rate must be used with constant or real dollars that have not been adjusted for inflation. EPA Guidance recommends using a 7% real discount rate for present value analysis in most remedial action cost estimates. However, for federal facility sites being cleaned up using Superfund authority, EPA Guidance states that it is generally appropriate to apply the real discount rates found in Appendix C of OMB Circular A-94. The suggested rates for federal facility sites are based on interest rates from Treasury notes and bonds and are appropriate because the federal government has a different cost of capital than the private sector. The most current version of Appendix C of OMB Circular A-94 (revised February 2002) proposes a real discount rate of 3.9% for programs with durations longer than 30 years. The 3.9% discount rate and constant dollars are used for the present value analysis of the Surface Barrier alternative. The present value of the Surface Barrier alternative is calculated using equations provided in EPA Guidance.

VI. RISK AND UNCERTAINTY:

Because the primary construction activity associated with the Surface Barrier alternative is excavation, hauling, and placing of very large quantities of borrow material, the highest risk for this alternative is any other situation that results in losing using a primary borrow source located close to the site. The largest quantity of material needed for the surface barrier is silt loam. For this alternative, it is assumed that sufficient quantities of silt loam will be available from Spreading Areas A and B, located near the site. If these sources are lacking in capacity or otherwise unavailable, the nearest alternative sources are the Ryegrass Flats and the Water Reactor Research Test Facility (WRRTF) borrow areas, located 12 and 34 mi from the site, respectively. Haul distances from the spreading areas are 1.5 mi from Spreading Area A and 1 mi from Spreading Area B. Increased haul distances could significantly increase the cost of materials and delay construction.

Another significant risk is the general assumptions that have been made concerning the areas of the site that will need to be grouted, the estimated grout uptake by the waste, and the grouting production and the foundation stabilization rates. None of these assumptions have been verified by tests using the proposed grouting equipment in onsite waste pits, trenches, or soil vaults. Quantities of materials and the schedule for grouting could deviate significantly from the quantities and production rates assumed for this PERA.

Assumptions regarding the quality of material available for the surface barrier may be found invalid during borrow source investigations. Compacted clay from Spreading Area B is assumed to be capable of meeting project specifications without the need for additives. If low-permeability requirements cannot be met by using the native material, bentonite will need to be added to the material to reduce permeability. However, the quantity of bentonite needed would probably be low (approximately 5%) and the addition of bentonite would reduce the compactive effort needed during placement to achieve the specified permeability. The additional time required for adding bentonite to the material could extend the project schedule.

VII. ESTIMATED MATERIAL VOLUME:

Tables 6 and 7 summarize the required materials for the Surface Barrier alternative and related design layers, thickness, and volume.

VIII. TABLES:

Table 1. Summary of remedial design costs as percentages of capital and operating costs.

Technology	Percentage of Capital and Operating Costs
Capping (Surface Barrier)	6
In situ thermal desorption	8
In situ grouting	8
Pad A Retrieval	10

Table 2. Example feasibility study-level scope contingency percentages.

Remedial Technology	Scope Contingency (%)
Soil excavation	15 to 55
Synthetic cap	10 to 20
Clay cap	5 to 10
Surface grading and diking	5 to 10
Revegetation	5 to 10

Table 3. Summary of contingency costs as percentages of capital costs.

	Percent of Capital Cost		
Remedial Technology	Scope Contingency	Bid Contingency	Total Contingency
Capping	15	10	25
In situ thermal desorption	25	25	50
In situ grouting	20	15	35
Foundation stabilization grouting	20	15	35

Table 4. Phase 1—Design and construction.

Activity Description	Estimated Duration
Borrow source investigation	1 year
Remedial design and procurement	1.5 years (overlaps borrow source inv. by 0.5 year)
Readiness assessment	1 year (no overlap with design)
Mobilization	0.5 year (no overlap with readiness assessment)
Initial earthen fill placement	1 year (no overlap with mobilization)
Foundation and in situ grouting	6 years (overlaps earth-fill placement by 1.0 year)
In situ thermal desorption	2.5 years (overlaps with grouting operation)
Pad A waste excavation and placement	2 years (overlaps with grouting operations)
Grading fill and gravel placement	1 year (overlaps grouting by 1.0 year)
Clay, geomembrane, and filter layers	1 year (overlaps grading fill placement by 0.5 year)
Placement of remaining layers	1 year (overlaps clay, geomembrane, and filter by 0.5 year)
Vegetation establishment	2 years (no overlap with placement of remaining layers)

Table 5. Phase 2—Design and construction.

Activity Description	Estimated Duration
Remedial design and procurement	1 year assumed
Readiness assessment	1 year (no overlap with design)
Mobilization	0.5 year (no overlap with readiness)
Grouting and cover system construction	1 year (no overlap with mobilization)
Vegetation establishment	2 years (no overlap with grouting and cover system)

Table 6. Distances and sources of borrow materials for the modified Resource Conservation and Recovery Act Subtitle C cover system.

Material	Issue	One-Way Haul Distance	Source
Topsoil	This material would consist of organic silt loam and would be used to construct a topsoil layer to support vegetation on top of the surface barrier.	1.5 mi	This material is assumed to be unprocessed organic silt loam derived from Spreading Area A.
Silt loam	This material would be used to construct a number of the layers within the cap including the general site grading fill, perimeter berm, and engineered earth fill.	1.5 mi	The majority of this material is expected to be unprocessed silt loam derived from Spreading Area B. Additional material is available from Ryegrass Flats (haul distance = 12 mi) and the WRRTF borrow area (haul distance = 34 mi).
Silt loam	This material would be used to construct the compacted clay layer within the caps.	1 mi	If necessary permits and approvals can be obtained, the majority of this material is expected to be unprocessed silt loam derived from Spreading Area B. Similar material might be available from Spreading Area A (haul distance = 1.5 mi), Ryegrass Flats (haul distance = 12 mi), and the WRRTF borrow area (haul distance = 34 mi).
Gravel	This material would be used for the coarse filter layers within the cap. Sufficient quantities of good structural gravel and fines materials are available.	2.5 mi	This material is assumed to be processed gravel derived from the Borax Gravel Pit.
Sand	This material would be used for the fine filter layers within the cap. No identified bank run borrow areas are available within the INEEL boundary.	45 mi	This material is assumed to be imported from off-Site source.
Riprap	Riprap would be used for erosion control. The majority of the mined riprap material at the INEEL has been used for other remedial actions at the INEEL.	5 mi	This material is assumed to be processed material mined from a basalt outcropping identified 5 mi from the site, directly west of the RWMC and just outside the Big Lost River System.
Coarse fractured basalt	This material would be used as bio-barrier material within the cap. The majority of the mined coarse fractured basalt material at the INEEL has been used for other remedial actions at the INEEL.	5 mi	This material is assumed to be processed material mined from a basalt outcropping identified 5 mi from the site, directly west of the RWMC and just outside the Big Lost River System.

Table 6. (continued).

Material	Issue	One-Way Haul Distance	Source
Cobbles	This material would be used as biobarrier material if coarse fractured basalt is not available or is not allowed for such use. There are no identified borrow areas within the INEEL boundary.	45 mi	This material is assumed to be processed material transported to the INEEL from Idaho Falls.

INEEL = Idaho National Engineering and Environmental Laboratory
RWMC = Radioactive Waste Management Complex
WRRTF = Water Reactor Research Test Facility

Table 7. Surface barrier design layers, thickness, and volume.

Layer	Thickness	Approximate Volume[a]	Material Description
Phase 1 Construction (105 acres with initial grading fill for grouting plus perimeter berm and side slope protection)			
Topsoil	12 in.	169,400 CCY	Unprocessed organic silt loam from Spreading Area B.
Engineered earth fill	96 in.	1,355,200 CCY	Unprocessed silt loam from Spreading Area B.
Fine filter	12 in.	169,400 CCY	Processed sand from off-Site source.
Coarse filter	12 in.	169,400 CCY	Processed gravel from the Borax Gravel Pit.
Coarse fractured basalt (biotic barrier)	30 in.	423,500 CCY	Processed basalt mined from an INEEL site.
Coarse filter	12 in.	169,400 CCY	Processed gravel from the Borax Gravel Pit.
Fine filter	12 in.	169,400 CCY	Processed sand from off-Site source.
Geomembrane	60 mil	508,200 SY	HDPE from off-Site sources.
Compacted clay	24 in.	338,800 CCY	Unprocessed silt loam from Spreading Area B.
Gravel gas collection layer	6 in.	84,700 CCY	Processed gravel from the Borax Gravel Pit.
Final grading fill	60 in.	847,000 CCY	Unprocessed silt loam from Spreading Area B.
Initial grading fill	60 in.	847,000 CCY	Unprocessed silt loam from Spreading Area B for initial 5-ft layer before grouting.
Fine filter	12 in.	15,200 CCY	Processed sand from off-Site source for surface barrier side slope protection; 41-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V side slopes.
Coarse filter	12 in.	15,200 CCY	Processed gravel from the Borax Gravel Pit for surface barrier side slope protection; 41-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V side slopes.

Table 7. (continued).

Layer	Thickness	Approximate Volume[a]	Material Description
Coarse fractured basalt	12 in.	15,200 CCY	Processed basalt mined from an INEEL site for surface barrier side slope protection; 41-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V side slopes.
Riprap	36 in.	45,600 CCY	Processed basalt mined from an INEEL site for surface barrier side slope protection; 41-ft long; 3-ft thick; 10,000-ft perimeter; 2.5H:1V side slopes.
Riprap	36 in.	15,600 CCY	Processed basalt mined from an INEEL site for berm side slope protection; 14-ft long; 3-ft thick; 10,000-ft perimeter; 2H:1V side slopes.
Perimeter berm	NA	244,200 CCY	Unprocessed silt loam from Spreading Area B; berm average 6-ft high, 100-ft wide, 10,000-ft perimeter; 2H:1V side slopes.
Phase 2 Construction (5 acres with no grouting, berm construction, or side slope protection)			
Topsoil	12 in.	8,100 CCY	Unprocessed organic silt loam from Spreading Area A.
Engineered earth fill	96 in.	64,500 CCY	Unprocessed silt loam from Spreading Area B.
Fine filter	12 in.	8,100 CCY	Processed sand from off-Site source.
Coarse filter	12 in.	8,100 CCY	Processed gravel from the Borax Gravel Pit.
Coarse fractured basalt (biotic barrier)	30 in.	20,200 CCY	Processed basalt mined from an INEEL site.
Coarse filter	12 in.	8,100 CCY	Processed gravel from the Borax Gravel Pit.
Fine filter	12 in.	8,100 CCY	Processed sand from off-Site source.
Geomembrane	60 mil	24,200 SY	HDPE from off-Site sources.
Compacted clay	24 in.	16,100 CCY	Unprocessed silt loam from Spreading Area B.
Gravel gas collection layer	6 in.	4,000 CCY	Processed gravel from the Borax Gravel Pit.
Grading fill	120 in.	80,700 CCY	Unprocessed silt loam from Spreading Area B.

a. This table provides estimated in-place volumes rounded to the nearest 100 CCY. To convert in-place volumes to loose volumes (truck measure), multiply in-place volumes by a factor of 1.5.

INEEL = Idaho National Engineering and Environmental Laboratory
CCY = compacted cubic yards
HDPE = high-density polyethylene
SY = square yards

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE SURFACE BARRIER ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: SURFACE BARRIER ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/24/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
FFA/CO MANAGEMENT AND OVERSIGHT											
WAG 7 Management (16-Years)											
Coordination/Oversight Tech Support (E28) - 1.0 FTE/YR		NA			32,000	HR	$ 93	$ 2,967,040			$ 2,967,040
Coordination with Agency Participants (E28) - 0.5 FTE/YR		NA			16,000	HR	$ 93	$ 1,483,520			$ 1,483,520
Environmental Engineering (E08) - 1.0 FTE/YR		NA			32,000	HR	$ 76	$ 2,421,440			$ 2,421,440
Cost and Schedule Control (F10) - 2.0 FTE/YR		NA			64,000	HR	$ 59	$ 3,768,960			$ 3,768,960
Regulatory Compliance (S11) - 1.0 FTE/YR		NA			32,000	HR	$ 79	$ 2,528,320			$ 2,528,320
Quarterly and Annual Reviews (S21) - 1.0 FTE/YR		NA			32,000	HR	$ 73	$ 2,325,760			$ 2,325,760
Audit Preparation and Coordination (S11) - 0.5 FTE/YR		NA			16,000	HR	$ 79	$ 1,264,160			$ 1,264,160
Health and Safety Coordination/Training (S08) - 2.0 FTE/YR		NA			64,000	HR	$ 62	$ 3,988,480			$ 3,988,480
Annual O&M Reports (S15) - 0.5 FTE/YR		NA			16,000	HR	$ 79	$ 1,256,640			$ 1,256,640
Attorney/Legal Fees, 0.3 FTE/YR		NA			9,600		$ 150	$ 1,440,000			$ 1,440,000
Allocation for Other Direct Costs (ODCs) - 10% of Total Labor					NA					$ 2,200,432	$ 2,200,432
TOTAL COST - FFA/CO Management and Oversight											$ 25,645,000
Construction Management											
Construction Management (@ 6% of Phase 1 & 2 RA Costs)	6.0%	NA			NA			$ 29,268,900			$ 29,268,900
General Conditions (@ 1.25% of Phase 1 & 2 RA Costs)	1.3%	NA			NA			$ 6,097,688			$ 6,097,688
Health and Safety Equipment Allocation (@ 0.25% of Phase 1 & 2 RA Costs)	0.3%	NA			NA			$ 1,219,538			$ 1,219,538
Medical Monitoring/Surveillance/Air Monitoring (@ 0.10% of Phase 1 & 2 RA Costs)	0.1%	NA			NA			$ 487,815			$ 487,815
TOTAL COST - Construction Management											$ 37,074,000
TREATABILITY STUDIES											
Treatment Treatability Studies, ISG/ISTD (@ 5% of Phase 1 Grouting, ISTD)	5.0%	NA			NA			$ 9,963,850			$ 9,963,850
TOTAL COST - Treatability Studies											$ 9,964,000
REMEDIAL DESIGN AND REMEDIAL ACTION PLANS/REPORTS											
ISTD RD/RA Workplan (@ 8% of ISTD Capital/Operation)	8.0%	NA			NA			$ 4,396,240			$ 4,396,240
PAD (A) Excavation RD/RA Workplan (@ 10% of PAD A Capital/Operations)	10.0%	NA			NA			$ 8,884,400			$ 8,884,400
GROUTING RD/RA Workplan (@ 8% of Grouting Capital/Operations)	8.0%	NA			NA			$ 11,545,920			$ 11,545,920
Surface Barrier RD/RA Workplan (@ 6% of Phase 1 & 2 Surface Barrier Operations)	6.0%	NA			NA			$ 5,850,180			$ 5,850,180
Readiness Assessment (@ 1.5% of Construction)	1.5%	NA			NA			$ 7,317,225			$ 7,317,225
Remedial Action Report		NA			5,000	HR	75.67	$ 378,350			$ 378,350
TOTAL COST - Remedial Design											$ 38,372,000

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE SURFACE BARRIER ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: SURFACE BARRIER ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/24/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
REMEDIAL ACTION - PHASE 1											
ISTD APPLICATION FOR VOC REMOVAL (5 acres)											
Capital Equipment Costs											
ISTD Control Trailer		6	EA	$ 325,000	NA				$ 1,950,000		$ 1,950,000
ISTD Off-Gas Treatment		6	EA	$ 250,000	NA				$ 1,500,000		$ 1,500,000
ISTD Off-Gas Treatment Support (Chillers)		6	EA	$ 725,000	NA				$ 4,350,000		$ 4,350,000
ISTD Capital Costs (Assume 6-ISTD Systems Are Required)		1	LS	$ 5,256,620	NA				$ 5,256,620		$ 5,256,620
Electrical Power Supply/Overhead Powerline H-Frame		3	MI	$ 375,000	NA				$ 1,125,000		$ 1,125,000
Electrical Substation/Transformers for Site Distribution		2	EA	$ 125,000	NA				$ 250,000		$ 250,000
Operation											
ISTD Operational Costs (per acre)		5	AC	$ 153,103	5	AC	$ 4,030,658	$ 20,153,290	$ 765,515		$ 20,918,805
Power Consumption/Utilities		NA			NA					$ 2,285,000	$ 2,285,000
ISTD Secondary Waste Disposal		NA			NA					$ 5,000,000	$ 5,000,000
Installation/Pre-Operational Set-up/Testing (Percentage of Total Capital Costs)	10.0%	NA			1	LS	$ 1,519,714	$ 1,519,714			$ 1,519,714
Back-up Generators (Diesel Powered)		2	EA	137,500	NA				$ 275,000		$ 275,000
Repair/Maintenance/Spare Parts (Percentage of Operating/Treatment Costs)	25.0%	NA			1	LS	$ 5,038,323	$ 5,038,323			$ 5,038,323
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 989,369	NA				$ 989,369		$ 989,369
D&D Cost for Equipment (Percentage of Capital Equipment)	10.0%	NA			NA					$ 1,443,162	$ 1,443,162
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	1,974,011	$ 1,974,011			$ 1,974,011
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 1,077,500	$ 1,077,500
Subtotal											54,953,000
PAD A EXCAVATION											
Capital Equipment/Disposal Bins		1	LS	$ 7,620,000	NA				$ 7,620,000		$ 7,620,000
Building; RCS Materials and Erection		94,300	SF	$ 350	NA				$ 33,005,000		$ 33,005,000
Building; Radiological, Fire Protection, CCTV, HVAC		94,300	SF	$ 250	NA				$ 23,575,000		$ 23,575,000
Weather Enclosure (Assume 10% Larger Footprint)		103,730	SF	$ 65	NA				$ 6,742,450		$ 6,742,450
Over head Crane, Monitors, Misters		1	LS	$ 350,000	NA				$ 350,000		$ 350,000
Building Operations Costs		20	MO	$ 130,208	NA				$ 2,604,160		$ 2,604,160
Overburden Soil Removal/Stockpile		12,110	CY	$ 5	NA				$ 57,765		$ 57,765
PAD A Excavation and Waste Handling (2-years)		300	CD	$ 3,217	300	CD	$ 9,115	$ 2,734,500	$ 965,100		$ 3,699,600
Equipment Repair and Maintenance (10%)		1	LS	$ 96,510					$ 96,510		$ 96,510
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 227,547	NA				$ 227,547		$ 227,547
D&D Cost for Equipment	10.0%	NA			NA					$ 7,129,245	$ 7,129,245
Characterize TRU wastes for WIPP disposal (per drum)		20	EA	$ 1,500					$ 30,000		$ 30,000
INEEL Site-Specific Training/Work Order Requirements	6.0%	NA			1	LS	$1,964,454	$ 1,964,454			$ 1,964,454
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 1,742,035	$ 1,742,035
Subtotal											$ 88,844,000

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE SURFACE BARRIER ALTERNATIVE
(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: SURFACE BARRIER ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/24/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
GROUTING											
EQUIPMENT											
Capital Cost - Batch Plant, Vehicles, Drill Rigs		1	LS	$ 8,326,000	NA				$ 8,326,000		$ 8,326,000
Mobilize/Erect Weather Structure Grouting Operations		2	EA	$ 750,198	NA				$ 1,500,396		$ 1,500,396
HEPA Filtration System/Lighting/Redundant Systems		2	EA	$ 2,147,448	NA				$ 4,294,896		$ 4,294,896
Back-up Generators (Diesel Powered)		2	EA	$ 375,000	NA				$ 750,000		$ 750,000
Building Foundation Construction		30,277	LF	$ 561	NA				$ 16,985,397		$ 16,985,397
Bridge Crane/Control System		3	EA	$ 670,000	NA				$ 2,010,000		$ 2,010,000
Bridge Crane/Control System/Modify and Install		NA			1	LS	$ 1,005,000	$ 1,005,000			$ 1,005,000
D&D Cost for Equipment/Enclosures	10.0%	NA			NA					$ 3,386,669	$ 3,386,669
INEEL Site-Specific Training/Work Order Requirements	6.0%				1	LS	$ 873,101	$ 873,101			$ 873,101
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 782,629	$ 782,629
Subtotal											**$ 39,914,000**
PRE-CONSTRUCTION ACTIVITIES											
Plug and Abandon (P&A) Existing GW Wells		NA			71	EA	$ 15,000	$ 1,065,000		$ 1,775,000	$ 2,840,000
Install New Nested GW Wells Outside Perimeter of Cap (Drilling Sub and Equipment)		NA			24	EA	$ 50,000	$ 1,200,000		$ 3,000,000	$ 4,200,000
Construct Rail Spur for Bulk Grout Delivery/Storage		1	LS	$ 1,200,000	NA				$ 1,200,000		$ 1,200,000
INEEL Site-Specific Training/PRD/Work Order	6.0%	NA			1	LS	$ 164,700	$ 164,700			$ 164,700
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 168,094	$ 168,094
Subtotal											**$ 8,573,000**
OPERATIONS (ISG and FDN GROUTING)											
2-Foot Thick Cover Material (Post ISG Decon)		130,000	CCY	$ 10	NA				$ 1,300,000		$ 1,300,000
Grout Trench Areas Crew/Additives		79	CD	$ 181,314	79	CD	$ 40,902	$ 3,231,258	$ 14,323,806		$ 17,555,064
Grout SVRs Crew/Additives		34	CD	$ 181,314	34	CD	$ 40,902	$ 1,390,668	$ 6,164,676		$ 7,555,344
Repair/Maintenance/Spare Parts (Percentage of Operating/Treatment Costs)	10.0%				1	LS	$ 5,460,743	$ 5,460,743			$ 5,460,743
Grout Rig Decontamination		3	EA	$ 2,125,800	NA				$ 6,377,400		$ 6,377,400
HEPA Filtration System Operation		2	YR	$ 2,000,000	NA				$ 4,000,000		$ 4,000,000
Verification Testing Geophysical Survey		4	MO	$ 40,000	2,500	HR	$ 76	$ 189,175	$ 160,000		$ 349,175
Foundation Stabilization Grouting (TRU Pits, Other Trenches)		342	CD	$ 99,763	286	CD	$ 40,902	$ 11,697,972	$ 34,118,946		$ 45,816,918
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 2,630,527	NA				$ 2,630,527		$ 2,630,527
INEEL Site-Specific Training/Work Order Requirements	6.0%	NA			1	LS	2,912,865	$ 2,912,865			$ 2,912,865
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 1,879,161	$ 1,879,161
Subtotal											**$ 95,837,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE SURFACE BARRIER ALTERNATIVE
(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: SURFACE BARRIER ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/24/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
SURFACE BARRIER - PHASE 1											
PRE-CONSTRUCTION ACTIVITIES											
Borrow Source Site Investigation		1	LS	$ 250,000	NA				$ 250,000		$ 250,000
Spreading Area "B" 404 Permit Application (6-months)		1	LS	$ 200,000	NA				$ 200,000		$ 200,000
Surface Water Controls/Soil Erosion Sediment Control Features		1	LS	$ 250,000	NA				$ 250,000		$ 250,000
Site Preparation: Clear, Grub & Grade		125	AC	$ 3,800	NA				$ 475,000		$ 475,000
Construct 2-mile Haul Road from Borrow to Site (Stone Road)		2	MI	$ 500,000	NA				$ 1,000,000		$ 1,000,000
Install/Develop GW Wells for Compaction Water		3	EA	$ 250,000	NA				$ 750,000		$ 750,000
BUILDINGS AND EQUIPMENT											
Administrative Buildings (Lunch Room and Change Room)		10,000	SF	$ 95	NA				$ 950,000		$ 950,000
Equipment Maintenance/Storage Area		10,000	SF	$ 175	NA				$ 1,750,000		$ 1,750,000
Decontamintation Area		5,000	SF	$ 150	NA				$ 750,000		$ 750,000
Subtotal											$ 6,375,000
CONSTRUCTION											
Topsoil Layer - 1-ft Thick		169,400	CCY	$ 6	NA				$ 1,014,706		$ 1,014,706
Rip-Rap Layer - Perimeter Berm		15,600	CCY	$ 40	NA				$ 624,000		$ 624,000
Rip-Rap Layer - Sideslopes of Surface Barrier		45,600	CCY	$ 40	NA				$ 1,824,000		$ 1,824,000
Gravel Filter Layer, 1-ft Thick		169,400	CCY	$ 10	NA				$ 1,694,000		$ 1,694,000
Sand Filter Layer, 1-ft Thick		169,400	CCY	$ 25	NA				$ 4,235,000		$ 4,235,000
Gravel Filter Layer - Sideslopes of Surface Barrier, 1-ft Thick		15,200	CCY	$ 10	NA				$ 152,000		$ 152,000
Sand Filter Layer, - Sideslopes of Surface Barrier, 1-ft Thick		15,200	CCY	$ 25	NA				$ 380,000		$ 380,000
Gravel Gas Collection Layer - 0.5-ft Thick		84,700	CCY	$ 10	NA				$ 847,000		$ 847,000
Sand Filter Layer, 1-ft Thick		169,400	CCY	$ 25	NA				$ 4,235,000		$ 4,235,000
Gravel Filter Layer, 1-ft Thick		169,400	CCY	$ 10	NA				$ 1,694,000		$ 1,694,000
HDPE Geomembrane, 60-mil		508,200	SY	$ 6	NA				$ 2,795,100		$ 2,795,100
Compacted Clay Liner, 2-ft Thick		338,800	CCY	$ 12	NA				$ 4,068,988		$ 4,068,988
Biotic Barrier Layer - 2.5-ft		423,500	CCY	$ 50	NA				$ 21,175,000		$ 21,175,000
Coarse Fractured Basalt Layer - Sideslope of Surface Barrier, 1-ft		15,200	CCY	$ 50	NA				$ 760,000		$ 760,000
Engineered Earth Fill - 8-ft Thick		1,355,200	CCY	$ 5	NA				$ 6,464,304		$ 6,464,304
Grading Fill, 10-ft Thick Average (Less post ISG decon fill)		1,564,000	CCY	$ 5	NA				$ 7,460,280		$ 7,460,280
Perimeter Berm		244,200	CCY	$ 5	NA				$ 1,164,834		$ 1,164,834
					NA						
Install (37) New Lysimeters and Cap Penetrations		37	EA	$ 131,756	NA				$ 4,874,972		$ 4,874,972
OCVZ System Relocation/Well Extension		1	LS	$ 300,000	NA				$ 300,000		$ 300,000
Lab Geotechnical Testing/Compaction		40	MO	$ 50,000	NA				$ 2,000,000		$ 2,000,000
Filed Geotechnical Testing/Compaction		40	MO	$ 90,000	NA				$ 3,600,000		$ 3,600,000
Surveying/Grade Control		40	MO	$ 65,000	NA				$ 2,600,000		$ 2,600,000
Third-Party Independent CQA Testing/Certification		40	MO	$ 75,000	NA				$ 3,000,000		$ 3,000,000
Hydroseeding/Mulching (Re-seeding Included)		125	AC	$ 2,750	NA				$ 343,750		$ 343,750
					NA						
Seasonal Shutdown/Re-Mobilization		3	EA	$ 500,000	NA				$ 1,500,000		$ 1,500,000
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 1,673,639	NA				$ 1,673,639		$ 1,673,639
INEEL Site-Specific Training/Work Order Requirements	6.0%	NA			1	LS	$ 2,084,534	$ 2,084,533.74			$ 2,084,534
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 1,778,802	$ 1,778,802
Pre-Final Inspection Report, Phase I		1	LS		1	LS	$ 250,000	$ 250,000.00			$ 250,000
Subtotal											$ 84,594,000
Subtotal Subcontractor Directs - Phase 1 Remedial Action											$ 379,090,000
Subcontractor Overhead	15.0%										$ 56,863,500
Subcontractor Profit	10.0%										$ 43,595,350
TOTAL COST - Phase 1 Remedial Action			Prepared by CH2MHILL 12/20/2002								$ 479,549,000

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE SURFACE BARRIER ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: SURFACE BARRIER ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/24/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
SURFACE BARRIER - PHASE 2											
SITE PREPARATION											
Site Preparation: Clear, Grub & Grade		5	AC	$ 5,400	NA				$ 27,000		$ 27,000
Subtotal											$ 27,000
CONSTRUCTION											
Topsoil, 1-ft		8,100	CCY	$ 6	NA				$ 48,519		$ 48,519
Sand Filter Layer, 1-ft Thick		8,100	CCY	$ 25	NA				$ 202,500		$ 202,500
Gravel Filter Layer, 1-ft Thick		8,100	CCY	$ 10	NA				$ 81,000		$ 81,000
Biotic Barrier Layer - 2.5-ft Thick		20,200	CCY	$ 50	NA				$ 1,010,000		$ 1,010,000
Gravel Gas Collection, 0.5-ft Thick		4,000	CCY	$ 10	NA				$ 40,000		$ 40,000
Compacted Clay Liner		16,100	CCY	$ 12	NA				$ 193,361		$ 193,361
Gravel Filter Layer, 1-ft Thick		8,100	CCY	$ 10	NA				$ 81,000		$ 81,000
Sand Filter Layer, 1-ft Thick		8,100	CCY	$ 25	NA				$ 202,500		$ 202,500
HDPE Geomembrane		24,200	SY	$ 6	NA				$ 133,100		$ 133,100
Engineered Earth Fill, 8-ft Thick		64,500	CCY	$ 5	NA				$ 307,665		$ 307,665
Earth Grading Fill, 10-ft Thick		80,700	CCY	$ 5	NA				$ 384,939		$ 384,939
Hydroseeding/Mulching (Re-seeding Included)		5	AC	$ 2,750	NA				$ 13,750		$ 13,750
Lab Geotechnical Testing/Compaction		10	MO	$ 50,000	NA				$ 500,000		$ 500,000
Filed Geotechnical Testing/Compaction		10	MO	$ 90,000	NA				$ 900,000		$ 900,000
Surveying/Grade Control		10	MO	$ 65,000	NA				$ 650,000		$ 650,000
Third-Party Independent CQA Testing/Certification		10	MO	$ 75,000	NA				$ 750,000		$ 750,000
					NA						
Seasonal Shutdown/Re-Mobilization		1	EA	$ 500,000	NA				$ 500,000		$ 500,000
Mobilization and Demobilization	2.0%	1	LS	$ 110,507	NA				$ 110,507		$ 110,507
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 147,260	$ 147,260			$ 147,260
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 125,662	$ 125,662
Pre-Final Inspection Report, Phase 2					1	LS	$ 125,000	$ 125,000			$ 125,000
Subtotal											6,507,000
Subtotal Subcontractor Directs - Phase 2 Remedial Action											$ 6,534,000
Subcontractor Overhead	15.0%										$ 980,100
Subcontractor Profit	10.0%										$ 751,410
Subtotal Subcontractor Directs and Indirects											$ 8,266,000
TOTAL COST - Phase 2 Remedial Action											$ 8,266,000.0
TOTAL COST - Phase 1 & 2 Remedial Action Contracts											$ 487,815,000
TOTAL CAPITAL COSTS											$ 598,870,000

Attachment D-3

Operable Unit 7-13/14 Feasibility Study Cost Estimate for the In Situ Grout Alternative

The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost estimate are likely to occur as a result of new information and data collected during the engineering design, safety reviews, and remedial alternative. Major changes may be documented in the form of a memorandum in the administrative record file, an explanation of significant differences, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within –30 to +50 percent of the actual project cost.

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE IN SITU GROUTING ALTERNATIVE

Project Title:	WAG 7 OU 13/14 Feasibility Study
Estimator:	Brian K. Corb
Date:	December 2002
Estimate Type:	Planning
Reviewed/Appr:	Lee Lindbig/Bruce L. Stevens

I. SCOPE OF WORK:

A. Remedial Design and Remedial Action

The ISG alternative provides for the encapsulation of the buried waste in a stable monolith designed to reduce contaminant migration from the site to acceptable levels. The grouted waste materials will be further isolated from potential future human or ecological receptors through constructing a low-permeability biotic barrier cover system. Preconstruction activities will include field-scale testing of the grouting method, grout formulations with surrogate and actual waste, investigating borrow sources for the cover system, preparing of final design, completing a readiness assessment, and mobilization.

Certain areas of the site may require pretreatment before grouting. It is estimated that those areas with high concentrations of organic oils comprise a total area less than 1 acre. For these areas, ISTD will be applied to pretreat the oils. The presence of high concentrations of nitrate salts in Pad A precludes effective ISG. Pad A waste will be retrieved and stabilized in an ex situ treatment process.

Initial site activities will include setting up a grout batch plant and material delivery system and leveling some areas of the site. A modular building and crane system will be erected over areas to receive ISG. An injection lance will be driven into waste and various grout formulations will be jetted into waste as the lance is advanced. The injection lance will be retracted and the process repeated at a close spacing over the waste areas within the SDA. As ISG is completed, a modified RCRA Subtitle C cover system will be constructed over the surface of the SDA. The various layers of the cover system will include earth fill, gas collection, infiltration barrier, biotic barrier, filter, and topsoil layers. Erosion control will include constructing of a flood control berm around the perimeter of the cover system, placement of armor (riprap and other materials) on cover system and berm side slopes, and establishing vegetation.

B. Long-Term Monitoring and Maintenance

Once the RA has been completed, long-term monitoring and maintenance will continue for the 100-year window with CERCLA reviews conducted every 5 years. The long-term environmental monitoring will be conducted for groundwater, vadose zone water, surface water, and air. In addition, the cover system itself will be monitored annually during the first 5 years following completion of construction (beginning after the vegetation establishment period). After the completion of annual monitoring, the monitoring frequency will be reduced to every 5 years concurrent with the 5-year reviews required under CERCLA. The cover system will be monitored for vegetation density, erosion damage, and differential settlement. Areas of erosion damage will be repaired with additional topsoil or earthen fill and reseeded, and areas without established vegetation will be reseeded.

II. BASIS OF ESTIMATE:

The basis of the estimate was developed from the following sources to provide a defensible and comparative cost of the remedial alternatives. The applicable sources available for the ISG alternative include:

A. EPA 540-R-00-002, "A Guide to Developing and Documenting Cost Estimates During Feasibility Study," July 2000

B. INEEL, "Cost Estimating Guide," DOE/ID-10473, September 2000

C. "Environmental Assessment and Plan for New Silt/Clay Source Development and Use at the Idaho National Engineering and Environmental Laboratory," DOE/EA-1083, May 1997

D. *Caterpillar Equipment Performance Handbook*, 31st edition

E. The INEEL Site Stabilization Agreement, Union Labor Agreement, URL: http://home.inel.gov/labor/ineelcba.html.

F. Facilities Unit Costs—Military Construction, PAX Newsletter No. 3.2.2—10, March 2000

G. ICDF Construction Cost Estimate, Cap Construction Cost (CH2MHILL) December 2000.

H. Subject Matter Experts—M. Jackson, BBWI and T. Borschel, BBWI, "Availability of Borrow Source Material at the INEEL"

I. BBWI, "INEEL Site Craft and Professional Services Labor Rates," February 2002

J. OMB, 2002, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Appendix C, "Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses," OMB Circular A-94, February 2002.

K. R. S. Means, 2002, *Heavy Construction and Industrial Building Unit Costs Data* 16th edition, Kingston, Massachusetts.

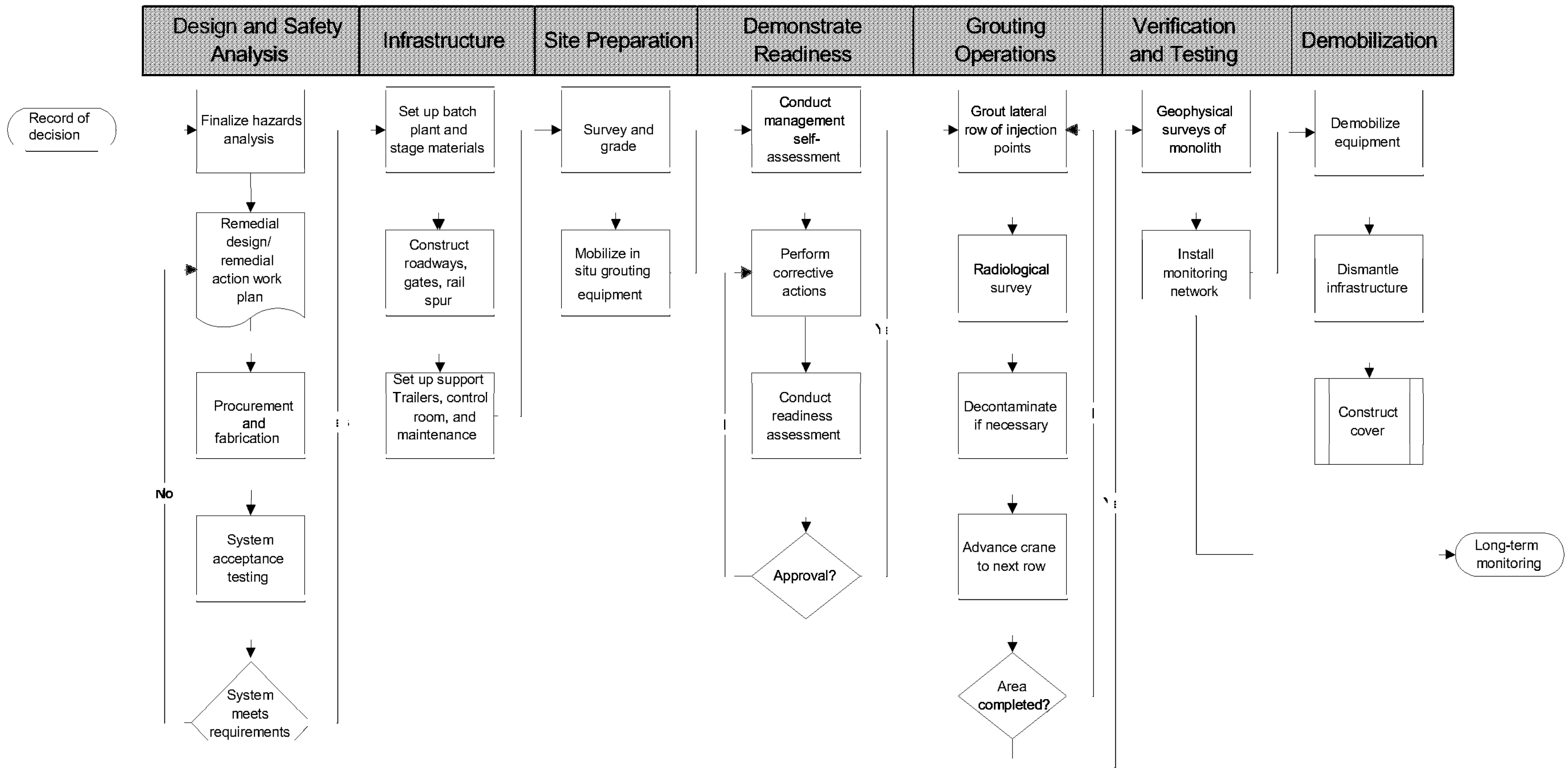
L. INEEL "Analytical Laboratory Unit Costs."

III. ASSUMPTIONS:

The primary work associated with the ISG alternative includes jet injection of various grout formulations into waste areas within the SDA. The following schematic presents a conceptual process flow describing the implementation of the ISG alternative. Specific elements of the work and important assumptions are provided below:

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE IN SITU GROUTING ALTERNATIVE
(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study



A. Management and Oversight

A.1 Project Management for the BBWI oversight of this alternative has been estimated based on an average classification of job categories using the BBWI rates. The number of FTEs are based on 2,000 MH per person per year.

A.2 The RD/RA schedule assumes that the budgetary funding will not be constrained.

A.3 The RD/RA schedule assumes that no unexpected delays resulting from changes to the USQ/SAR process will occur.

A.4 The estimate assumes that the INEEL site resources (i.e., CFA, medical facilities, geotechnical lab, fire department, security, and utilities at the SDA) will be available for the duration of the project.

B. Design and Preconstruction

B.1 Preconstruction activities—Borrow source investigations, cultural resource clearance, developing an onsite source of basalt rock, field-scale testing of jet grouting into waste, testing of grout formulation, final design, readiness assessment completion, and mobilization.

B.2 Design activities will include integrating the drill mast and hydraulic head of the grouting equipment onto a mobile gantry crane and designing and specifying lights, camera systems, and radiation monitors.

B.3 Grout formulations will be tested with surrogate and actual waste on bench scale to optimize formulations.

C. Site Preparation and Support Activities and Facilities

C.1 A grout batch plant will be set up near the SDA capable of producing a maximum of 500 yd^3 of grout per day.

C.2 Materials to formulate the grout will be shipped in from vendors by rail car. Access and transfer roads will be constructed to deliver materials to the site.

C.3 Administrative and equipment buildings or trailers will be installed in the SDA to support operational controls, radiation controls, and personnel facilities.

C.4 Minimal site grading and filling will ensure level terrain to operate the crane grouting system.

C.5 Thorough geophysical surveys of the SDA will be conducted to verify dimensions and determine pretreatment conditions of waste zones.

C.6 ISTD will be applied to areas of the SDA to pretreat waste with high concentrations of oils. It is assumed that these areas will comprise approximately 1 acre of the SDA.

C.7 Pad A waste will be retrieved and stabilized in an ex situ treatment process.

C.8 During development of this cost estimate, modular containment buildings were evaluated including Butler and Sprung structures. The cost provided for the ISG alternative considers a Sprung-type containment structure for the treatment grouting operation; no containment structure is assumed to be required for foundation stabilization grouting operations. Costs for these facilities include fire protection, HVAC, lighting, communication lines, and power distribution.

D. General Grouting Assumptions

D.1 Grouting equipment, enclosures, and Pad A excavation and placement equipment will be dismantled and disposed of under the cover system. Twenty-five percent of the operational and no additional cost for D&D&D is included in the estimate.

D.2 Grouting operations will be conducted in a large modular building that provides defense in depth for remediation workers. The building is maintained under negative pressure and ventilated through a HEPA filtration system. Because of the structure over grouting operations, no thrust blocks will be necessary. The building is approximately 80-ft wide and has several long modular sections connected end-to-end to provide a long strip. The modular sections will be disassembled and reassembled to facilitate continuous advancement of the grouting operation.

D.3 Grouting operations will commence with positioning the injection crane system over the first grout area. It is envisioned that the injection lance will be moved in short increments laterally across the span of the crane and that the crane will be incrementally advanced forward across long strips of ground. The actual positioning, spacing, and sequencing of drilling will be optimized during the remedial design. It is assumed that the grout will be injected on a triangular pitch grid at approximately 20-in. centers to ensure every 55-gal drum is grouted on the inside.

D.4 Grout will be mixed at the batch plant adjacent to the SDA and delivered by truck to the ISG operational area. The grout truck will be received at the pump house and grout will be fed into high-pressure positive displacement pumps. The grout will be delivered to the injection lance by a system of high-pressure lines.

D.5 The injection lance will be driven with rotary percussion action into the soil and waste to a depth of 20 ft or until refusal. Once the maximum depth is reached, grout will be pumped down the center of the injection lance, and out two jet nozzles at the tip. The injection lance will be rotated and slowly retracted as the grout is jetted into the formation. Grouting will be stopped at the waste/overburden interface.

D.6 The injection lance will be fully retracted and the lance assembly will be surveyed remotely for radiological contamination. High-volume air monitors mounted on the crane near the injection lance also will be used to detect any airborne contamination. If contamination is detected, the equipment will be decontaminated.

Any inadvertent grout returns will be covered periodically with clean soil. The injection lance will be moved laterally one increment and the injection process will be repeated. When all the points under the span of the crane have been grouted, the crane will be walked forward an increment and the process repeated.

D.7 Verification and Testing—Following the injection of grout, posttreatment geophysical surveys will be conducted to verify the extent of the grout monolith. High contrast in moisture content and density will be used as indicators of the vertical and horizontal extent of the monolith. Operational data including the pressures and volume of grout injected over each area will be evaluated to verify the thoroughness of each grouting campaign.

D.8 Process Areas—Based on preliminary information in the PERA, the remediation will focus on several areas within the SDA that contribute to the future potential risk. Areas will include the TRU pits, TRU trenches, activation and fission product waste in the non-TRU trench areas, SVRs, and foundation stabilization. Each area will require a slightly different approach. The actions taken at each area and the size of each area is a critical factor in the basis for the cost estimate. Area sizes and production rates are provided in Table 1.

E. Grouting Large Areas

E.1 For grouting large areas (pits, trenches), it is assumed that each hole will take 4 minutes to drill and grout before moving to the adjacent point (low of 2 minutes, high of 6 minutes). (Past experience on simulated waste pits showed 6 to 7 minutes, including time to move drill rig between holes [Loomis, Zdinak, and Bishop 1997]. The crane-positioning system is expected to significantly reduce time required to move between holes.)

E.2 Wheel-mounted gantry cranes are commercially available with 60-ft spans and up to 80-ton capacity from commercial vendors (e.g., Shuttlelift). (It is expected that the injection apparatus, including hydraulic pump will weigh less than 20 tons [the weight of the entire sonic probing rig currently used at the SDA]). Assuming 2 ft on either side are unreachable by the injection point, the grouting span is 56 ft. Using 20-in. spacing, 33 holes can be drilled in one row. Time to move the crane approximately 20 in. forward to the next row is estimated at 5 minutes, including time for radiation monitoring.

E.3 Each row of 33 holes is estimated as 4 min/hole × 33 holes + 5 min = 137 minutes.

E.4 A rectangular area similar to Pits 4, 6, or 10 will be grouted in two to three passes. It is assumed that turning the crane and setting up on a new swath will take one shift.

E.5 To estimate the time required per acre, assume three moves (three shifts) and three 56-ft-wide swaths 260-ft long (3 × 56 ft × 260 ft = 43,680 ft^2). Each swath will require 156 rows. At 137 minutes per row, and a total of 468 rows (156 × 3), each acre will require 1,069 hours plus 30 hours for moves, or about 1,100 hours.

E.6 The basic production rate for grouting the pits and trenches will be 1,100 hours per acre per rig, not accounting for any inefficiencies.

E.7 A 70% factor will be applied to account for inefficiencies caused by routine and nonroutine delays (e.g., radiation surveys, instrument calibration, breakdowns, donning and doffing PPE). It is assumed that in every 10-hour shift, only 7 hours will be spent grouting. The adjusted production rate is 1,571 hours per acre, per rig.

E.8 The grouting operation will be controlled from an operations control room (a trailer or building as described in Assumption J). It is assumed that a crew of 10 will be required to operate one injection system (one manager, one supervisor, one crane operator, one pump operator, two radiological control technician [RCTs], one HSO, one quality assurance [QA] specialist, and two maintenance).

F. Grouting Soil Vault Rows

F.1 Treating the soil vaults with grout to immobilize radioactive fission products and other contaminants is estimated to take less than 100 days (10 hours) of work for the actual grouting operations and will require approximately 2,000 yd^3 of cementitious grout.

F.2 The soil vaults are small holes augured into the SDA soil where high activity debris waste was disposed of to prevent personnel exposure. The holes were augured in linear arrays called SVRs. The auger holes were either 18 or 54 in. in diameter. Each of the 20 soil vaults has a large number of individual soil vaults of varying size. By observing the soil vaults represented on an INEEL geographical information system map of the SDA (INEEL map trench_shipments-dlv-31.mxd, 12/31/01), it is estimated that there are 344 individual vaults of 27 in. radius, and 298 individual vaults with 8 in. radius.

F.3 Grout injection lances will be driven down along the perimeter of each soil vault. It is assumed that two injections will be required for every 9-in. radius hole, and that four injections will be required for every 27-in. radius hole. Because all the vaults are arranged in a linear array, each less than 50 ft wide, it is assumed each row can be grouted in a single pass of the grout injection crane. Crane moves will be required between SVRs (20 in all).

F.4 The time to drill and grout each borehole and move to an adjacent borehole is estimated at 4 minutes (the same time estimated in a large pit configuration). With a total of 1984 boreholes, total time to drill grout is (4 × 1984 ÷ 60) 132 hours.

F.5 The time to walk the crane forward to the next position is estimated to take 5 minutes for each move (the same time required to move between rows in a large pit configuration), times the number of moves required. The number of moves required is estimated by dividing the total length of the SVRs (3,600 ft) by 20-in. increments (3,600 ft × 12 in. ÷ 20 in. = 2,160). Therefore, the time required to walk the crane forward from vault to vault is 180 hours. The total length of the soil vaults from INEEL geographical information system data is 7,141 ft, excluding Row 21. However, this length includes large areas that have no vaults (presumably the soil was too shallow). Therefore, the length of the vault areas to be grouted, as estimated from manual measurements taken from the map of the SDA, is 3,600 ft.

F.6 The time to move the apparatus between SVRs is estimated as two days because the rows are spread out across the SDA. As there are 20 SVRs, it is estimated that 40 days will be required to move the apparatus between SVRs. (The soil vaults are grouped together in areas with deep soils, therefore it is likely that fewer moves will actually be required.)

F.7 The basic production rate for grouting the soil vault rows is 712 hours for all soil vaults using one rig, not accounting for any inefficiencies.

F.8 To account for inefficiencies caused by routine and nonroutine delays (e.g., radiation surveys, instrument calibration, breakdowns, donning and doffing PPE) a 70% factor will be applied. It is assumed that of every 10-hour shift, only 7 hours will be spent grouting. The adjusted production rate is 102 days for all soil vaults using one rig.

G. Low Level Waste Trenches

G.1 The production rate for grouting the activation and fission product waste areas within the low-level trenches is assumed to be the same production rate as for the TRU pit and trench areas. Assuming 1.5 acres will require grouting, and applying the 70% efficiency factor, grouting the activation and fission product waste areas will take 238 days.

H. Grouting for Cover System Foundation Stabilization

H.1 The grouting technique used for foundation stabilization will be nonreplacement in situ jet grouting as developed for the INEEL. This technique employs a modified drill rig to inject grout under high pressures into the waste seam. The grout will fill all readily accessible void space and will cure into a solid monolith. Because the waste and grout monolith will be supported on five sides and void space will be filled, subsidence will be eliminated regardless of the final compressive strength of the waste, soil, and concrete product. This will permit using widely available, inexpensive grouts (e.g., Portland cement).

H.2 Unlike grouting for waste treatment, it will not be required that the grout be intimately mixed with the waste or soil, nor will it be required that the grout fill soil pore space or other small void spaces inside individual waste drums. Because actual data regarding void space in the SDA is not available at this time, it is assumed for purposes of the PERA evaluation that voids threatening the integrity of the cap are fairly large and will be intersected if the grout is injected on a 4-ft center-to-center spacing across the areas requiring stabilization. Although this spacing does not ensure that every container is intersected, it is assumed to be adequate to support the cap. During the remedial design, a records review and geophysical program will be performed in an attempt to characterize the size and extent of the large void areas.

H.3 The production rate for foundation stabilization grouting will be substantially greater than that required for waste treatment because of the increased spacing and fewer number of grout holes required. The time required to grout for stabilization is estimated to be a factor of four less than the basic production rate.

H.4 The basic production rate for grouting the remaining pit and trench areas (9.8 acres) is estimated as (1/4) (1,100 hours/acre) (9.8 acres), 2695 hours. Applying 70% efficiency yields 3,850 hours, or 385 10-hour days.

I. Grout Batch Plant Production Rate

I.1 The grout will be produced at a batch plant located adjacent to the SDA. The batch plant will be sized to feed three injection systems simultaneously. Each acre of waste will require 13,552 yd^3 of grout (60% of the volume assuming 14-ft depth). Each rig will grout an acre in 157 days. Therefore, each rig will consume an average 86 yd^3 of grout per day. (Note: Using an inefficiency factor extends the duration of the grouting operation, but the volume of grout remains constant.)

I.2 The batch plant will be operated the same number of days as the injection system. The batch plant will require an additional crew of 10 (one manager, one supervisor, three operators, two QA inspectors, and three drivers).

J. Grout Volume

J.1 Large areas (pits and trenches)—Each acre of waste is assumed to be ($43{,}560\ ft^2 \times 14\ ft \div 27\ ft^3/yd^3$) 22,587 yd^3 of volume to be treated. It is assumed from past testing and a cursory review of waste stream disposal information (Armstrong, Arrenholz, and Weidner 2002) that grout take can be estimated as 60% of treatment area volume. Therefore, each acre will require 13,552 yd^3 of grout. Grout volume for large areas are estimated in Table 2.

J.2 Soil vaults—Total grout required is estimated as 60% of the volume of the soil vaults (the same assumption of 60% void space as used in the large pits). The soil vaults would be 14-ft deep (not counting overburden, which will not be grouted), the volume of the large soil vaults are 224 ft^3 each ($pi \times r^2 \times h = pi \times (27\ in. \div 12\ in./ft^2) \times 14\ ft = 224\ ft^3$). Similarly, the volume of the small vaults is 25 ft^3 ($pi \times (9\ in. \div 12\ in./ft)^2 \times 14\ ft = 25\ ft^3$). The total volume to be treated is estimated as approximately 300 small vaults $\times$ 25 ft^3 each, (7,500 ft^3) plus approximately 350 large vaults $\times$ 224 ft^3 each (78,400 ft^3), 85,900 ft^3, or ($8{,}500\ ft^3 \times .03704\ yd^3/ft^3$) 3,182 yd^3; 60% will equal 1,909 yd^3 of grout.

K. Grout Costs

K.1 Based on previous experience with ISG at the INEEL, the cost for grouts have ranged from \$1/gal (\$202/yd^3) for Portland Type H to \$5/gal (1,010/yd^3) for proprietary grouts (e.g., TECT or Waxfix) based on vendor data in the *Innovative Subsurface Stabilization Project* (Loomis, Zdinak, and Bishop 1997). However, the prices experienced during this and other field tests were escalated because of the small quantities of grout involved. These prices also reflected total delivered costs. Bringing ingredients in bulk and mixing large quantities onsite will result in significantly lower production costs. One vendor has estimated that production costs will be half of those cited in the *Innovative Subsurface Stabilization Project* (Loomis, Zdinak, and Bishop 1997). Recent vendor estimates for specialized grout, tested for application at the SDA, are \$505/yd^3 material costs.

L. Organic Area Treatment with In Situ Thermal Desorbtion

L.1 The ISTD will be used to treat the high organic waste streams within the SDA. ISTD will employ an array of heated stainless steel pipe assemblies inserted into the ground on an 8 × 8-ft spacing to a depth of approximately 3 ft below the buried waste.

L.2 It is assumed that each pipe assembly will include a sealed pipe that contains an electrical-resistance heating element, a vented pipe used to extract gases, and thermocouples. Extraction pipes will be connected to a pipe manifold that conveys the gases to an off-gas treatment system. The average pipe assembly will be inserted to a depth of 24 ft. Pipe assemblies will be inserted into the ground using either nonstandard vibratory or hydraulic techniques.

L.3 It is assumed that heat can be transferred from the heating elements to the pipes and then to the waste at a nominal rate of 350 W per linear foot of heated pipe.

L.4 Six ISTD systems will be used. With the 8 × 8 ft spacing of the pipe assemblies, heating will occur during an approximate 90-day period. The six systems are projected to treat approximately 0.5 acre/year, requiring 1 year to complete the projected 1 acre.

L.5 The ISTD systems will require about 330 kW.

L.6 When a subsystem reaches its heating objectives, the pipe manifold that collects off-gases will be isolated from the rest of the off-gas manifold by closing valves. The 12 or 20 extraction pipes in the subsystem will be crimped closed, the manifold section will be disconnected and transported to the front of the advancing ISTD system, and reconnected after purging at that location.

M. Pad A waste retrieval and management.

M.1 Retrieved non-TRU waste and soil will be treated onsite and fixated through an ex situ grouting technology (pugmill). Large metal waste will be sized, placed in containers, and the containers filled with a grout matrix. The grouted materials will be placed in a central portion of the SDA and covered with the surface barrier.

M.2 It is assumed that 20 drums of TRU waste and soil will be generated during the retrieval actions, which will require off-Site disposal at WIPP.

M.3 The Pad A retrieval operations will require a primary and secondary containment structure, approximately 230 × 410 ft in plan dimensions and designed in accordance with the IBC. Frost depth for building foundations is 5 ft (DOE-ID 2001). The ground snow load of at least 35 lb/ft^2 shall be used in (ASCE) 7 calculations and a minimum roof snow load of 30 lb/ft^2 shall be used for all buildings (DOE-ID 2001). Retrieval buildings and other structures shall not be designed for tornado loads (DOE-ID 2001). All structures shall be designed for PC 2 standards for wind, seismic, and flood design requirements. The PC 2 seismic return period is 1,000 years (STD-1020). The fastest wind speed for INEEL structures is 70 mph, and the 3-second gust wind speed is 90 mph (DOE-ID 2001). The design mean hazard annual probability for floods is 5E-04, or a 2,000-year return period (STD-1020). Fire protection systems shall meet or exceed the minimum requirements established by the NFPA and DOE O 420.1.

M.4 The primary and secondary containment structure is a double-walled structure that would be equipped with radiation alarm systems such as constant air monitors set to alarm when airborne contamination reached unacceptable levels. Criticality alarms would be installed in the primary containment structure. These alarm systems would require periodic testing and calibration.

M.5 It is assumed that the containment building will be dismantled and buried beneath the surface barrier. A cost allowance of 25% of the capital expenditures of the building costs is assumed to be representative of the estimated level of effort to dispose of the buildings and equipment.

M.6 The structure would include a gantry crane that would be used to apply water, foams, and foggers to keep dust and contamination at a minimum within the retrieval operation. The crane would provide support for lifters, detectors, and other equipment.

M.7 Negative pressure would be applied to the digface at all times and directed to HEPA filters to control the contamination and keep it from entering the secondary containment structure. The air exhausted from the retrieval zone would be fully saturated with water vapor because of the application of mists to control airborne contamination. Some of the water vapor would condense in the ductwork leading to the air treatment system. This condensate would be recycled through the retrieval-face misting system, as would other condensates. The air treatment system consists of chillers, demisters, heaters, and banks of HEPA filters in two parallel systems to provide redundancy in the event one systems failed. The chillers would cool the air, which would decrease the dew point of the air and cause mists to form. The air would then pass through a demister, which would remove moisture from the air. The air would pass through heating elements to raise the temperature to about 10°C above the dewpoint. The air would then pass through the HEPA filters.

N. Borrow Areas

N.1 It is assumed that Spreading Area B will be available and will not be flooded. No additional costs have been provided to dewater Spreading Area B.

N.2 It is assumed that there an adequate quantity and quality of borrow source material is available from Spreading Area B, the Borax Pit, and the Basalt Source (for riprap and coarse fractured basalt). Furthermore, no royalty fee and earthen material costs are provided for in the estimate.

N.3 It is assumed that an adequate water source will be available to support the earthmoving and soil moisture conditioning for placement and compaction based on the equipment productivities developed for this estimate.

O. Cover System Construction

O.1 Placement of earth fill—An average 10-ft-thick layer of earthen fill will be placed over the surface of the SDA to grade the surface and to prepare for placement of the cover system.

O.2 Placement of gravel gas collection layer—A 6-in.-thick layer of processed gravel will be placed over the earthen fill to vent any gases that might build up beneath the cover system.

O.3 Earthen fill and the gravel gas collection layers of the cover system will be placed during grouting.

O.4 Placement of asphalt, lateral drainage, and filter layers—A 4-in. asphalt base course and a 6-in. low-permeability asphalt layer will be placed over the gas collection layer to function as infiltration barriers. A 6-in. lateral drainage layer consisting of processed sand will be placed over the asphalt to remove infiltration from the surface of the barrier layer. A 1-ft-thick filter section consisting of sand and gravel will be placed over the lateral drainage layer.

O.5 Placement of remaining cover system layers—Remaining cover system layers will consist of a 20-in. compacted topsoil layer and a 20-in. layer of topsoil with gravel.

O.6 Placement of perimeter berm and erosion controls—A 6-ft-high berm will be constructed around the perimeter of the cover system to control flooding; filter layers, coarse fractured basalt, and riprap will be placed on the side slopes to minimize erosion.

O.7 Vegetation establishment—The topsoil layer will be seeded with a specialized seed mix to provide a vegetative cover. The cover will be monitored and reseeded as necessary to maintain the vegetative layer.

P. Capital Costs, Unit Rates, and Other Pricing Assumptions

P.1 The unit prices were developed from a crew build-up to process, load, haul, place, and compact. The volume of material represented in the cost tables identifies CCY. The appropriate factors convert the estimated unit material weights (bank, loose, and fill) and are factored into the equipment productivity.

P.2 Crew labor rates were developed based on hourly rates stipulated in the INEEL Site Stabilization Agreement. Labor and equipment spreads were developed based on the assumed achievable daily productivity to support the project schedule. Other factors that influenced the selection of labor and equipment quantities included safety considerations, level of PPE of the work to be performed, haul routes, and availability of resources on the INEEL. Each daily crew cost also includes field oversight personnel such as the HSO, superintendents, foremen, CIHs, maintenance personnel, and allocation of supplies (e.g., fuel, oil, grease, and spare parts).

P.3 In general, all capital equipment and pricing were selected from commercially available sources or similar projects. A scale factor will be applied to estimate cost of equipment and operational requirements. Equipment installation cost is considered to be a significant variable in estimating individual components of a given system. For the basis of cost, the installation cost of the capital equipment was based on a percentage of the capital costs ranging from 110 to 160% of the estimated capital expenditure based on the unknowns and level-of-complexity.

P.4 Subcontractors bond and insurance rate of 2% of the total subcontractor dollars includes overhead, and profit has been included based on each alternative.

P.5 The estimate includes an allocation for the INEEL specific work order program, requirements document (PRD) requirements, and safety meetings. Because this estimate includes primarily unit prices, the labor cost is estimated to be 40% of the unit prices and, based on historical data, cost of the INEEL-specific process is approximately 6% of total labor dollars.

Q. Schedule

Q.1 The estimate assumes that construction operations can be performed for 10 months year without weather impacts. Grouting construction will be performed during this time working one 10-hour shift per day. Cover system construction is scheduled for two 10-hour shifts, with a back shift that performs maintenance. Employees will work 5 days per week.

Q.2 The estimate assumes that field crews will demobilize the equipment during the 2-month winter shutdown period to refurbish and replace equipment. The estimate includes an allocation to cover these costs in addition to the 2% estimated.

R. Health and Safety

R.1 For the ISG operation, a preliminary hazards analysis indicates that the ISG operation will be classified as other than a nuclear low hazard radiological operation. A safety analysis report will not be required. The remedial design, however, will include a final hazards analysis, a criticality evaluation, and a comprehensive health and safety plan.

R.2 It is assumed that once the earthen fill material is placed over the SDA, all earthmoving operations for the cover system can be performed in Level D.

S. Long-term Operating and Maintenance and Monitoring

S.1 The monitoring program will be the same as for the No Action alternative (see Section D-1).

S.2 The capital cost for the project includes replacing the groundwater wells and lysimeters removed as part of site preparation activities. The estimate assumes that nested wells and lysimeters will be installed at varying depths of 20, 90, 200, and 600 ft along the interbed surfaces.

S.3 The lysimeter analytical cost assumes that liquid samples will be recovered in 10% of the wells. Therefore, analytical costs are included only for the assumed number of recoverable samples.

S.4 It is assumed that after topsoil has been placed as the final layer on the cover system, it will be seeded with native grasses to provide vegetative cover for reducing erosion. However, because of the arid climate of the INEEL, an extended period will be required to establish a permanent vegetative cover. Erosion of the uppermost layers of the cover system during snowmelt will occur during years immediately following construction, and repairs and reseeding will be required.

S.5 It is assumed that ongoing maintenance of the cover system will be required in perpetuity after construction is completed. It is assumed that frequent maintenance will be required during the years immediately following construction to repair damage from erosion and to establish a permanent vegetative cover. In addition, the added weight of the cover system is expected to result in increased settlement during the initial years following construction. Some areas of the cover system will require ongoing maintenance to repair damage resulting from settlement. It is expected that annual maintenance and repairs will be required during the first 5 years following construction. Ongoing maintenance and repairs will continue every 5 years concurrent with the 5-year review process.

T. Design Costs

The following discussion provides the basis for the assumed percentage for design, construction, and contingency. EPA provides guidance for estimating remedial design costs in the EPA Guidance. Exhibit 5-8 of the EPA Guidance provides examples of remedial design costs as a percentage of total capital costs. The percentages range from 20% for projects with capital costs less than $100,000 to 6% for projects with capital costs greater than $10 million. The EPA Guidance does not provide an example of design costs that vary according to the complexity of technologies.

For the WAG 7 PERA, the alternatives include technologies that have been demonstrated on other sites and have well developed engineering design criteria (such as capping), and technologies that have not been demonstrated on a large scale and require development of engineering design criteria (e.g., ISV). For the WAG 7 PERA alternatives, remedial design costs are expected to vary significantly according to the degree of complexity. The estimated costs for remedial design need to reflect the varying degrees of complexity. Based on the complexity of the technology application, a percentage of the capital and operating cost specific to the technology was assumed.

The modified RCRA Subtitle C cap has been demonstrated on other sites and design standards have been developed for the various types of materials and construction methods. Some borrow source investigations will be needed to verify material properties and quantities, but methods for conducting these investigations are not expected to require specialized equipment or personnel. Because capping is a demonstrated technology with established design standards, the cost for remedial design is assumed to be 6% of capital costs.

ISG includes subsurface jet injection of specialized types of grout into waste disposal areas of the SDA to stabilize and treat waste materials. ISG will need to be done inside a modular building to contain possible releases of contaminants. Some waste disposal areas will require pretreatment before grouting. Considerable effort will be needed to design appropriate grout types for the waste disposal areas, design the modular building and grouting equipment, determine areas of the site that will need pretreatment, and field test the various design elements. Because of the additional design effort required for ISG, the cost for remedial design is assumed to be 8% of capital costs.

Foundation stabilization grouting includes using modified grouting equipment to jet grout areas of the SDA to fill voids within the waste and provide a stable foundation for placing and maintaining cover systems. Foundation stabilization grouting is similar to ISG, except specialized grout and grouting equipment (including a modular building) will not be needed and grout holes will be spaced further apart. Cement-based grout and modified grouting equipment will be used for this technology. Some field demonstrations will be conducted to verify the ability of the grouting equipment to penetrate the waste disposal areas and to estimate the approximate quantity of grout that will be needed. Because the design effort will be considerably less for foundation stabilization grouting than for ISG, the cost for remedial design is assumed to be 7% of capital costs.

Retrieval and disposal includes excavating waste from Pad A; characterization and ex situ treatment of waste materials; packaging, shipment, and off-Site disposal of treated TRU waste; and disposal of treated non-TRU waste in an onsite, engineered waste disposal facility. A large containment structure will be needed to prevent releases of contaminants during waste retrieval activities. A very high level of effort will be necessary to design methods to safely retrieve waste from disposal areas, characterize waste for treatment and disposal, design treatment methods and facilities, and plan for safe handling and transport of waste to an off-Site disposal facility. Because of the very intense design effort required for this technology, the cost for remedial design is assumed to be 10% of capital costs.

The various technologies and percentages of capital costs estimated for remedial design are summarized in Table 3. These percentages are applied to individual technologies in the cost estimate to establish estimated design costs for the various alternatives.

U. Construction Management Costs

Cost considerations for BBWI oversight, regulatory agency interaction, and project management were estimated on an assumed level of effort required to implement the selected alternative. Additionally, costs for the remedial design, safety equipment and PPE, construction management, general conditions, and insurance and bonds were included in the estimate to capture a relative basis for cost comparison and to identify other costs associated with implementing a given remedial alternative.

The percentage is based on the total capital construction cost to implement the alternative. The percentage basis assumed for each category identified was selected considering the complexity of the alternative and risk and uncertainty of the approach. The cost conjunction with the percentage basis identified under the general conditions category includes administration buildings, parking area, utilities, and support infrastructure to facilitate the remedial alternative.

V. Contingency Costs

The EPA provides guidance for estimating contingency costs in the EPA (EPA 2000), which distinguishes between scope contingency and bid contingency costs. Scope contingency costs represent risks associated with incomplete design and include contributing factors such as limited experience with technologies, additional requirements because of regulatory or policy changes, and inaccuracies in defining quantities or characteristics. Exhibit 5-6 of the EPA Guidance provides examples of scope contingencies. Bid contingency costs are unknown costs at the time of estimate preparation that become known as remedial action construction or O&M proceeds. Bid contingencies represent reserves for quantity overruns, modifications, change orders, and claims during construction. The EPA Guidance states that bid contingencies may be added to construction and O&M costs and typically range from 10 to 20%.

Because EPA Guidance suggests that contingency costs will vary according to the alternative technologies, it is necessary to estimate contingency costs for the PERA alternatives. Technologies have been evaluated separately to determine appropriate contingency costs. Scope and bid contingencies for each technology are discussed below.

Capping technology includes placement of the modified RCRA Subtitle C cap. This cover system include using several types of materials in addition to those planned for biotic barrier technology, constructing of infiltration barriers, and using synthetic materials. One significant assumption for this technology is that available native materials will be capable of meeting infiltration barrier layer permeability requirements without using additives (e.g., bentonite). Capping technology is assumed to require a scope contingency within the range of 10 to 20% as shown in Table 2. Because of the risk associated with needing additional borrow sources for materials, using synthetic materials, and the possible need to use additives for infiltration barrier layer construction, the cost for the scope contingency is assumed to be 15%. Most risks associated with capping technology will be significantly reduced during remedial design, therefore the cost for the bid contingency is assumed to be 10%. The total contingency for capping technology is assumed to be 25% of capital costs.

In situ grouting includes jet injection of various types of grout into waste materials in the SDA to stabilize and treat waste materials. ISG technology will require consideration of pretreatment for some waste disposal areas, grout design for different types of waste, design of specialized grouting equipment and a modular containment building, and field demonstrations. ISG technology is assumed to require a scope contingency within the range of 15 to 35% as shown in Table 3. Because of the specialized design efforts required for this technology, cost for the scope contingency is assumed to be 20%. Some significant construction risks still will be associated with this technology because of unanticipated subsurface conditions, therefore the cost for the bid contingency is assumed to be 15%. The total contingency for ISG technology is assumed to be 35% of capital costs.

Foundation stabilization grouting includes jet-grouting areas of the SDA with cement-based grout to fill voids in the waste and provide a stable foundation for placing and maintaining cover systems. While foundation stabilization grouting is similar to ISG, design of specialized types of grout and a modular containment building will not be required. Scope and bid contingencies for foundation stabilization grouting are the same as those for ISG (20 and 15%, respectively) with a total contingency for foundation stabilization grouting assumed to be 35% of capital costs.

Retrieval and disposal involves excavating and removing waste from Pad A followed by treatment and disposal. An intensive design effort will be required to determine methods to characterize and treat waste, to package and ship TRU waste for off-Site disposal, to handle and dispose of non-TRU waste at an onsite disposal facility, and to design and construct onsite treatment and disposal facilities. Each of these design efforts could result in significant changes in project scope. Retrieval and disposal technology is assumed to require a scope contingency within the range for soil excavation in Table 2 (15 to 35%). Because of the high potential for scope changes associated with this technology, the cost for the scope contingency is assumed to be 25%. Considerable construction risks will be associated with this technology because of the uncertainties associated with excavating buried waste materials. Because of the considerable construction risks, the cost for the bid contingency is assumed to be 20%. The total contingency for retrieval and disposal technology is assumed to be 45% of capital costs.

The scope and bid contingency percentages associated with this alternative are identified in Table 4. These percentages are applied to individual technologies in the cost estimate to establish a representative aggregate cost contingency.

Following the cost contingency guidance provided in Table 5 for each of the technologies, a representative contingency was selected within the range provided, based on the complexity and size of the project and inherent uncertainties related to the remedial technology. However, the guidance document does not address all of the remedial technologies identified in this alternative. Specifically, the foundation stabilization grouting and ISG technology would be within a cost contingency range of 20 to 35% and are considered representative for this work and project scope.

IV. SCHEDULE:

The following activities comprise the RD/RA portion of the ISG alternative. The corresponding durations are based on the estimated crew productivity, regulatory reviews and approvals, and weather constraints inherent to the INEEL site. They are presented in Table 6.

V. PRESENT WORTH ANALYSIS:

Guidance for present value analysis is provided in Chapter 4 of the EPA Guidance, which states that the present value analysis of a remedial alternative involves four basic steps:

1. Define the period of analysis
2. Calculate the cash outflows (payments) for each project year
3. Select a discount rate to use in the present value calculation
4. Calculate the present value.

Periods of analysis for the ISG alternative include design and construction, and O&M. The design and construction period is estimated to 14 years, beginning shortly after issuance of a ROD for the site. The O&M period will begin toward the end of the vegetation establishment period and will continue for 100 years.

Cash outflows for the ISG alternative will include payments for design and construction, periodic payments for major repairs, and annual O&M costs. EPA Guidance suggests that most capital costs should be assumed to occur in the first year of remedial action, when funds are committed. While this suggestion might be a realistic assumption for short-duration remedial actions, it is not realistic for the ISG alternative because of the time required for design and construction. Cash outflows for the ISG alternative will be paid on an annual basis as costs are incurred, beginning with the grout testing and remedial design, and ending with vegetation establishment.

Annual capital cost payments vary with the level of activity, with relatively low annual payments during the borrow source and grout investigations, remedial design, readiness assessment, and vegetation establishment periods, and relatively high annual payments during heavy construction periods (grouting and material excavation, processing, stockpiling, and placement). Periodic costs for major repairs would occur every 5 years concurrent with the 5-year reviews conducted in accordance with CERCLA requirements. Periodic costs would begin 5 years after Phase 1 construction and continue through the O&M period. Annual O&M costs would begin the first year after completion of construction and continue for 100 years. In accordance with EPA Guidance requirements, 2002 constant dollars are used for all annual and periodic cash outflows.

EPA Guidance requires using a real discount rate that approximates the marginal pretax rate of return on an average investment and has been adjusted to eliminate the effect of expected inflation. The real discount rate must be used with constant or real dollars that have not been adjusted for inflation. EPA Guidance recommends using a 7% real discount rate for present value analysis in most remedial action cost estimates. However, for federal facility sites being cleaned up using Superfund authority, EPA Guidance states that it is generally appropriate to apply the real discount rates found in Appendix C of OMB Circular A-94. The suggested rates for federal facility sites are based on interest rates from Treasury notes and bonds and are appropriate because the federal government has a different cost of capital than the private sector. The most current version of Appendix C of OMB Circular A-94 (revised February 2002) proposes a real discount rate of 3.9% for programs with durations longer than 30 years. The 3.9% discount rate and constant dollars are used for the present value analysis of the ISG alternative. The present value of the ISG alternative is calculated using the equations provided in EPA Guidance.

VI. RISK AND UNCERTAINTY:

A significant uncertainty in this evaluation is the time and effort required to design and implement remediation systems for Pad A and the organics areas. Although the total areas are relatively small, they could have a significant impact on the cost of this alternative. A hazard classification is not currently available for retrieving waste from Pad A and the ISTD treatment of the organics areas. It is unclear what level of safety analysis and design will be required for these components. It is unclear whether safety significant systems will be required.

The time required to drill and grout each hole is estimated at 4 minutes. Actual times could be significantly less or greater depending on soil type and waste type encountered. An uncertainty of up to 50% could be applied to the 4-minute estimate.

Another issue is that volume and surface area estimates are inconsistent. Assuming a 14-ft depth to be treated, and using the surface area of pits, trenches, and vaults yields a higher volume to be treated than if the total volume were used. To be conservative, the ISG cost estimates were based on the surface area and assumed a constant 14-ft depth for the volume to be treated. The actual volume may be 50% less.

The production rate for operations (retrieving waste from Pad A and grouting the SDA) is dependent largely on the waste types encountered. Unexpected hazards (e.g., explosives, reactives, pressurized containers) or simply impenetrable layers of waste could cause significant delay in the schedule. It is unlikely that the feasibility study cost estimate guidelines of +50%/–30% could be met without a much more rigorous analysis.

The schedule is highly uncertain. The estimates included here are intended to be high-level examples and are not an adequate basis for establishing the actual remediation schedule. At this time, there are too many uncertainties regarding all aspects of the alternative (i.e., design, construction times, retrieval, ISTD treatment, grouting production rates) to estimate a schedule. Past experience demonstrated that years could be needed to obtain approval of a design or safety analysis for operations as simple as probing. Delays caused by obtaining approval internally, from DOE, or the regulatory agencies cannot be estimated at this time.

A risk associated with the cover system is any situation that results in losing using a primary borrow source located close to the site. The largest quantity of material needed for the cover system is silt loam. For this alternative, it is assumed that sufficient quantities of silt loam will be available from Spreading Area B, located near the site. If this source is lacking in capacity or otherwise unavailable, the nearest alternative sources are the Ryegrass Flats and the WRRTF borrow areas. Ryegrass Flats is 12 mi from the site and the WRRTF borrow area is 34 mi. The haul distance from Spreading Area A is 1.5 mi. Increased haul distances could result in a significant increase in the construction schedule and cost of materials.

VII. TABLES:

Table 1. Estimated production rates for in situ grouting.

Area	Size	Production Rate	Rig Machine Days
TRU pits	14.5 acres	1,571 hours/acre	2,279
TRU trenches	1.8 acres	1,571 hours/acre	283
Other COC trench areas	1.5 acre	1,571 hours/acre	236
Soil vault rows	650 vaults	1.9 hours/vault	102
Foundation stabilization	9.8 acres	390 hours/acre	128

COC = contaminant of concern

Table 2. Estimated grout volume.

Large Areas	Surface Area (ft^2)	Acres	Grout (yd^3)
TRU pits	663,974	15	203,280
TRU trenches	86,555	2	27,104

TRU = transuranic

Table 3. Summary of remedial design costs as percentages of capital and operating costs.

Technology	Percentage of Capital and Operating Costs
Capping (cover systems)	6
In situ thermal desorption	8
In situ grouting	8
Pad A retrieval and disposal	10

Table 4. Example feasibility study-level scope contingency percentages.

Remedial Technology	Scope Contingency (%)
Soil excavation	15 to 55
Synthetic cap	10 to 20
Clay cap	5 to 10
Surface grading and diking	5 to 10
Revegetation	5 to 10

Table 5. Summary of contingency costs as percentages of capital costs.

	Percent of Capital Cost		
Remedial Technology	Scope Contingency	Bid Contingency	Total Contingency
Capping	15	10	25
In situ grouting	20	15	35
In situ thermal desorption	25	25	50
Pad A retrieval and disposal	25	20	45

Table 6. In situ grouting—design and construction.

Activity Description	Estimated Duration
Borrow source investigation	1 year
Grout formulation and field testing	1 year (overlaps borrow source inv. by 1 year)
Remedial design and procurement	1.5 years (overlaps testing by 0.5 year)
Readiness assessment	1 year (no overlap with design)
Mobilization	0.5 year (no overlap with readiness assessment)
TRU pit grouting	152 weeks (no overlap with mobilization)
TRU trench grouting	19 weeks (no overlap with pit grouting)
Activation and fission trench area grouting	16 weeks (no overlap with trench grouting)
Soil vault row grouting	7 weeks (no overlap with trench grouting)
Foundation stabilization grouting	26 weeks (overlaps with C-14 area grouting)
Pad A retrieval and disposal	2 years (overlaps with grouting activities)
In situ thermal desorption	1 year (overlaps with grouting activities)
Earthen fill placement	2 years (overlaps with grouting activities)
Gas gravel, asphalt, drainage, and filter layers	2 years (overlaps grading fill placement by 1 year)
Placement of remaining layers	1 year (overlaps asphalt and other layers by 0.5 year)
Vegetation establishment	2 years (no overlap with placement of remaining layers)

TRU = transuranic

Table 7. Identification of in situ grouting process areas and necessary pretreatment, treatment, and posttreatment implementation steps.

Process Area	Pretreatment	Treatment	Posttreatment
TRU pits	Pretreat areas with organic oil content >12 wt% (approximately 1 acre) using low-temperature vapor extraction or oxidizing grout solutions.	ISG of waste zone to mix grout, waste, and interstitial soil into large monoliths. Grout designed to be low permeability and chemically reactive to immobilize COCs.	Construct low-permeability cap to minimize infiltration and to be consistent with other SDA areas.
TRU trenches		ISG of waste zone to mix grout, waste, and interstitial soil into large monoliths. Grout designed to be low permeability and chemically reactive to immobilize COCs.	Construct low-permeability cap to minimize infiltration and to be consistent with other SDA areas.
Activation and fission product waste areas		ISG of waste zone to mix grout, waste, and interstitial soil into large monoliths. Grout designed to be low permeability and chemically reactive to immobilize C-14.	Construct low-permeability cap to minimize infiltration and to be consistent with other SDA areas.
Soil vaults 344 large vaults (27-in. radius) 298 small vaults (9-in. radius)		ISG around and in soil vaults to encapsulate waste objects. Use cementitious grouts to minimize the corrosion of activated metal waste and bind radioactive fission products into the grout matrix.	Construct low-permeability cap to minimize infiltration and for consistency with other SDA areas.
Pad A	Retrieve waste containers from Pad A and segregate nitrate salt drums from other waste streams.	Stabilize nitrate salts ex situ with polyethylene or polysiloxane grout. Stabilize uranium waste ex situ with cementitious grout. Macroencapsulate debris waste with polyethylene.	Dispose of stabilized nitrate and uranium waste onsite. Dispose of macroencapsulated debris waste onsite.
Remaining pits and trench areas		ISG using low-permeability grout to fill void space and minimize subsidence.	Construct low-permeability cap to minimize infiltration and to be consistent with other SDA areas.

COC = contaminant of concern
ISG = in situ grouting
SDA = Subsurface Disposal Area

Table 8. Distances and sources of borrow materials for the modified Resource Conservation and Recovery Act Subtitle C cover system.

Material	Issue	One-Way Haul Distance	Source
Top soil	This material will consist of organic silt loam and will be used to construct a topsoil layer to support vegetation on top of the cover system.	1.5 mi	This material is assumed to be unprocessed organic silt loam derived from Spreading Area B.
Silt loam	This material will be used to construct a number of the layers within the cover system including the general site grading fill, perimeter berm, and topsoil.	1.5 mi	The majority of this material is expected to be unprocessed silt loam derived from Spreading Area B. Additional material is available from Ryegrass Flats (haul distance = 12 mi) and the WRRTF borrow area (haul distance = 34 mi). If permitted, some of this material could be excavated from Spreading Area B (haul distance = 1 mi).
Gravel	This material will be used for the gravel gas collection, drainage, and coarse filter layers within the cover system. Sufficient quantities of good structural gravel and fines materials are available.	2.5 mi	This material is assumed to be processed gravel derived from the Borax Gravel Pit.
Sand	This material will be used for the fine filter layers within the cover system. There are no identified bank run borrow areas available within the INEEL boundary.	45 mi	This material is assumed to be processed sand derived from an off=site borrow source.
Riprap	Riprap will be used for erosion control. The majority of the mined riprap material at the INEEL has been used for other remedial actions at the INEEL.	5 mi	This material is assumed to be processed material mined from a basalt outcropping identified 5 mi from the site, directly west of the RWMC and just outside the Big Lost River System.
Coarse fractured basalt	This material will be used for erosion control. The majority of the mined coarse fractured basalt material at the INEEL has been used for other remedial actions at the INEEL.	5 mi	This material is assumed to be processed material mined from a basalt outcropping identified 5 mi from the site, directly west of the RWMC and just outside the Big Lost River System.

RWMC = Radioactive Waste Management Complex
WRRTF = Water Reactor Research Test Facility

Table 9. Modified Resource Conservation and Recovery Act Subtitle C cover system design layers, thickness, and volume.

Layer	Thickness	Approximate Volume[a]	Material Description
Topsoil with gravel	20 in.	296,000 CCY	Processed silt loam topsoil with pea gravel admixture from Spreading Area B.
Compacted topsoil	20 in.	296,000 CCY	Unprocessed silt loam topsoil from Spreading Area B.
Sand filter layer	6 in.	89,000 CCY	Processed sand from off-Site borrow source.
Gravel filter layer	6 in.	89,000 CCY	Unprocessed gravel from the Borax Gravel Pit.
Lateral drainage layer	6 in.	89,000 CCY	Processed gravel from the Borax Gravel Pit.
Low permeability asphalt layer	6 in.	89,000 CCY	Asphalt from an off-Site source in Idaho Falls.
Asphalt base course	4 in.	59,000 CCY	Asphalt base course from an off-Site source in Idaho Falls.
Gravel gas collection layer	6 in.	89,000 CCY	Processed gravel from the Borax Gravel Pit.
Grading fill	120 in.	1,694,000 CCY	Unprocessed silt loam from Spreading Area B.
Fine filter	12 in.	6,000 CCY	Processed sand from off-Site borrow source for cover system toe armor; 16-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V side slopes.
Coarse filter	12 in.	6,000 CCY	Processed gravel from Borax Pit for cover system toe armor; 16-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V side slopes.
Coarse fractured basalt	12 in.	6,000 CCY	Processed basalt mined from an INEEL site for cover system toe armor; 16-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1.V
Riprap	36 in.	18,000 CCY	Processed basalt mined from an INEEL site for cover system toe armor; 16-ft long; 3-ft thick; 10,000-ft perimeter; 2.5H:1V.
Perimeter berm	NA	244,200 CCY	Unprocessed silt loam from Spreading Area A; berm average 6.5-ft high; 100-ft wide; 10,000-ft perimeter; 2H:1V.

a. This table provides estimated in-place volumes rounded to the nearest 100 CCY.
CCY = compacted cubic yard

VIII. REFERENCES:

Armstrong, Aran T., Daniel A. Arrenholz, and Jerry R. Weidner, 2002, *Evaluation of In Situ Grouting for Operable Unit 7-13/14*, INEEL/EXT-01-00278, Rev. 0, Idaho National Engineering and Environmental Laboratory, CH2MHILL and North Wind Environmental for Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho.

Loomis, Guy G., Andrew P. Zdinak, and Carolyn W. Bishop, 1997, *Innovative Subsurface Stabilization Project—Final Report (Revision 1)*, INEL-96/0439, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE IN SITU GROUTING ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
FFA/CO MANAGEMENT AND OVERSIGHT											
WAG 7 Management (16-Years)											
Coordination/Oversight Tech Support - 1.0 FTE/YR		NA			32,000	HR	$ 93	$ 2,967,040			$ 2,967,040
Coordination with Agency Participants - 0.5 FTE/YR		NA			16,000	HR	$ 93	$ 1,483,520			$ 1,483,520
Environmental Engineering - 1.0 FTE/YR		NA			32,000	HR	$ 76	$ 2,421,440			$ 2,421,440
Cost and Schedule Control - 2.0 FTE/YR		NA			64,000	HR	$ 59	$ 3,768,960			$ 3,768,960
Regulatory Compliance - 1.0 FTE/YR		NA			32,000	HR	$ 79	$ 2,528,320			$ 2,528,320
Quarterly and Annual Reviews - 1.0 FTE/YR		NA			32,000	HR	$ 73	$ 2,325,760			$ 2,325,760
Audit Preparation and Coordination - 0.5 FTE/YR		NA			16,000	HR	$ 79	$ 1,264,160			$ 1,264,160
Health and Safety Coordination/Training - 2.0 FTE/YR		NA			64,000	HR	$ 62	$ 3,988,480			$ 3,988,480
Annual O&M Reports - 0.5 FTE/YR		NA			16,000	HR	$ 79	$ 1,256,640			$ 1,256,640
Attorney/Legal Fees. 0.3 FTE/YR		NA			9,600	HR	$ 150	$ 1,440,000			$ 1,440,000
Allocation for Other Direct Costs (ODCs) - 10% of Total Labor		NA								$ 2,200,432	$ 2,200,432
TOTAL COST - FFA/CO Management and Oversight											**$ 25,845,000**
Construction Management											
Construction Management (@ 6% of RA Costs)	6%	NA			1	LS	$ 39,442,800	$ 39,442,800			$ 39,442,800
General Conditions (@ 1.25% of RA Costs)	1.25%	NA			1	LS	$ 8,217,250	$ 8,217,250			$ 8,217,250
Health and Safety Equipment Allocation (@ 0.25% of RA Costs)	0.25%	NA			1	LS	$ 1,643,450	$ 1,643,450			$ 1,643,450
Medical Monitoring/Surveillance/Air Monitoring (@ 0.10% of RA Costs)	0.10%	NA			1	LS	$ 657,380	$ 657,380			$ 657,380
TOTAL COST - Construction Management											**$ 49,961,000**
TREATABILITY STUDIES											
Treatment Treatability Studies, ISG/ISTD (@ 5% of Phase 1 ISG and ISTD)	5%	NA			1	LS	$ 18,245,750	$ 18,245,750			$ 18,245,750
TOTAL COST - Treatability Studies											**$ 18,246,000**
REMEDIAL DESIGN AND REMEDIAL ACTION PLANS/REPORTS											
ISTD RD/RA Workplan (@ 8% of ISTD Capital/Operation)	8%	NA			1	LS	$ 2,202,560	$ 2,202,560			$ 2,202,560
PAD (A) Excavation RD/RA Workplan (@ 10% of PAD A Capital/Operations)	10%	NA			1	LS	$ 11,004,800	$ 11,004,800			$ 11,004,800
GROUTING RD/RA Workplan (@ 8% of ISG AND FDN GROUTINGCapital/Operations)	8%	NA			1	LS	$ 26,990,640	$ 26,990,640			$ 26,990,640
Surface Barrier RD/RA Workplan (@ 6% of Barrier Construction)	6%	NA			1	LS	$ 2,682,300	$ 2,682,300			$ 2,682,300
Readiness Assessment (@ 1.5% of RA)	1.5%	NA			1	LS	$ 9,860,700	$ 9,860,700			$ 9,860,700
Remedial Action Report					5,000	HR	$ 76	$ 378,350			$ 378,350
TOTAL COST - Remedial Design											**53,119,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE IN SITU GROUTING ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: IN SITU GROUTING (ISG) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
REMEDIAL ACTION											
ISTD APPLICATION FOR VOC REMOVAL (1 acre)											
Capital Equipment Costs											
ISTD Control Trailer		6	EA	$ 325,000	NA				$ 1,950,000		$ 1,950,000
ISTD Off-Gas Treatment		6	EA	$ 250,000	NA				$ 1,500,000		$ 1,500,000
ISTD Off-Gas Treatment Support (Chillers)		6	EA	$ 725,000	NA				$ 4,350,000		$ 4,350,000
ISTD Capital Costs (Assume 6-ISTD Systems Are Required)		1	LS	$ 5,256,620	NA				$ 5,256,620		$ 5,256,620
Electrical Power Supply/Overhead Powerline H-Frame		3	MI	$ 375,000	NA				$ 1,125,000		$ 1,125,000
Electrical Substation/Transformers for Site Distribution		2	EA	$ 125,000	NA				$ 250,000		$ 250,000
Operation Treatment/Deposal Costs											
ISTD Operational Costs (per acre)		1	AC	$ 153,103	1	AC	$ 4,030,658	$ 4,030,658	$ 153,103		$ 4,183,761
Power Consumption/Utilities										$ 460,000	$ 460,000
ISTD Secondary Waste Disposal										$ 2,500,000	$ 2,500,000
Installation/Pre-Operational Set-up/Testing (Percentage of Total Capital Costs)	10.0%	NA			1	LS	$ 1,458,472	$ 1,458,472			$ 1,458,472
Back-up Generators (Diesel Powered)		2	EA	$ 137,500					$ 275,000		$ 275,000
Repair/Maintenance/Spare Parts (Percentage of Operating/Treatment Costs)	25.0%	NA			1	LS	1,007,665	$ 1,007,665			$ 1,007,665
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 486,330	NA				$ 486,330		$ 486,330
D&D Cost for Equipment (Percentage of Capital Equipment)	10.0%	NA			NA					$ 1,443,162	$ 1,443,162
INEEL Site-Specific Training/Work Order Requirements	6.0%				1	LS	746,441.04	$ 746,441			$ 746,441
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 539,849	$ 539,849
Subtotal											**$ 27,532,000**
PAD A EXCAVATION											
Capital Equipment/Disposal Bins		1	LS	$ 7,620,000	NA				$ 7,620,000		$ 7,620,000
Containment Building											
Building; RCS Materials and Erection		94,300	SF	$ 350	NA				$ 33,005,000		$ 33,005,000
Building; Radiological, Fire Protection, CCTV, HVAC		94,300	SF	$ 250	NA				$ 23,575,000		$ 23,575,000
Weather Enclosure (Assume 10% Larger Footprint)		103,730	SF	$ 65	NA				$ 6,742,450		$ 6,742,450
Over head Crane, Monitors, Misters		1	LS	$ 350,000	NA				$ 350,000		$ 350,000
Building Operations Costs		20	MO	$ 130,208	NA				$ 2,604,160		$ 2,604,160
Treatment Building											
Building Construction		10,000	SF	$ 225	NA				$ 2,250,000		$ 2,250,000
Solidfication System (100 drums/day) (Pugmill)		1	EA	$ 11,900,000					$ 11,900,000		$ 11,900,000
Overburden Soil Removal/Stockpile		12,110	CY	$ 5	NA				$ 57,765		$ 57,765
PAD A Excavation and Waste Handling (2-years)		300	CD	$ 15,368	300	CD	$ 10,920	$ 3,276,000	$ 4,610,400		$ 7,886,400
Equipment Repair and Maintenance (10%)	10%	1	LS	$ 461,040					$ 461,040		$ 461,040
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 549,283	NA				$ 549,283		$ 549,283
D&D Cost for Equipment	10.0%	NA			NA					$ 8,544,245	$ 8,544,245
Characterize TRU wastes for WIPP disposal (per drum)		20	EA	$ 1,500					$ 30,000		$ 30,000
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$2,314,844	$ 2,314,844			$ 2,314,844
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 2,157,804	$ 2,157,804
Subtotal											**$ 110,048,000**

Prepared by CH2M HILL

3/21/2002

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE IN SITU GROUTING ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: IN SITU GROUTING (ISG) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
GROUTING											
BUILDINGS AND EQUIPMENT											
Administrative Buildings (Lunch Room and Change Room)		10,000	SF	$ 95	NA				$ 950,000		$ 950,000
Equipment Maintenance/Storage Area		10,000	SF	$ 175	NA				$ 1,750,000		$ 1,750,000
Decontamintation Area		5,000	SF	$ 150	NA				$ 750,000		$ 750,000
EQUIPMENT COST											
Capital Cost - Batch Plant, Vehicles, Drill Rigs		1	LS	$ 8,326,000.0	NA				$ 8,326,000		$ 8,326,000
Mobilize/Erect Weather Structure Grouting Operations		2	EA	$ 750,198.0	NA				$ 1,500,396		$ 1,500,396
HEPA Filtration System/Lighting/Redundant Systems		2	EA	$ 2,147,448.0	NA				$ 4,294,896		$ 4,294,896
Back-up Generators (Diesel Powered)		2	EA	$ 375,000.0	NA				$ 750,000		$ 750,000
Building Foundation Construction		30,277	LF	$ 561.0	NA				$ 16,985,397		$ 16,985,397
Bridge Crane/Control System		3	EA	$ 670,000.0	NA				$ 2,010,000		$ 2,010,000
Bridge Crane/Control System/Modify and Install		NA			1	LS	$ 1,005,000	$ 1,005,000			$ 1,005,000
D&D Cost for Equipment/Enclosures	10.0%	NA			NA					$ 3,386,669	$ 3,386,669
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 873,100.5	$ 873,101			$ 873,101
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 782,629	$ 782,629
Subtotal											$ 43,364,000
PRE-CONSTRUCTION ACTIVITIES											
Plug and Abandon (P&A) Existing GW Wells		NA			71	EA	$ 15,000	$ 1,065,000		$ 1,775,000	$ 2,840,000
Install New Nested GW Wells Outside Perimeter of Cap (Drilling Sub and Equipment)		NA			24	EA	$ 50,000	$ 1,200,000		$ 3,000,000	$ 4,200,000
Construct Rail Spur for Bulk Grout Delivery/Storage		1	LS	$ 1,200,000					$ 1,200,000		$ 1,200,000
INEEL Site-Specific Training/Work Order Requirements					1	LS	$ 164,700	$ 164,700			$ 164,700
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 168,094	$ 168,094
Subtotal											$ 8,573,000
OPERATIONS											
5-Foot Thick Cover Material (Initial Site Grading)		130,000	CCY	$ 10	NA				$ 1,300,000		$ 1,300,000
Grout Activation/Fission Product Trench Areas		79	CD	$ 181,314	79	CD	$ 40,902	$ 3,231,258	$ 14,323,806		$ 17,555,064
Grout TRU Trenches		94	CD	$ 181,314	94	CD	$ 40,902	$ 3,858,422	$ 17,103,954		$ 20,962,376
Grout TRU Pits		760	CD	$ 181,314	760	CD	$ 40,902	$ 31,071,886	$ 137,738,202		$ 168,810,088
Grout SVRs		34	CD	$ 181,314	34	CD	$ 40,902	$ 1,390,668	$ 6,164,676		$ 7,555,344
Grout Rig Decontamination		3	EA	$ 2,125,800	NA				$ 6,377,400		$ 6,377,400
HEPA Filtration System Operation		2	YR	$ 2,000,000	NA				$ 4,000,000		$ 4,000,000
Repair/Maintenance/Spare Parts (Percentage of Operating/Treatment Costs)	10.0%	1	LS	$ 19,977,770	NA				$ 19,977,770		$ 19,977,770
Verification Testing Geophysical Survey		10	MO	$ 94,588	2,500	HR	$ 76	$ 189,175	$ 945,875		$ 1,135,050
Foundation Stabilization Grouting (Other Trenches, 98-MD)		128	CD	$ 99,763	128	CD	$ 40,902	$ 5,235,456	$ 12,769,664		$ 18,005,120
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 6,175,798	NA				$ 6,175,798		$ 6,175,798
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 7,995,444	$ 7,995,444			$ 7,995,444
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 5,596,989	$ 5,596,989
Subtotal											$ 285,446,000
SURFACE BARRIER											
PRECONSTRUCTION ACTIVITIES											
Borrow Source Site Investigation		1	LS	$ 250,000	NA				$ 250,000		$ 250,000
Spreading Area "B" 404 Permit Application (6-months)		1	LS	$ 200,000	NA				$ 200,000		$ 200,000
Surface Water Controls/Soil Erosion Sediment Control Features		1	LS	$ 250,000	NA				$ 250,000		$ 250,000
Site Preparation: Clear, Grub & Grade		125	AC	$ 3,800	NA				$ 475,000		$ 475,000
Construct 2-mile Haul Road from Borrow to Site (Stone Road)		2	MI	$ 500,000	NA				$ 1,000,000		$ 1,000,000
Install/Develop GW Wells for Compaction Water		3	EA	$ 250,000	NA				$ 750,000		$ 750,000
Subtotal											$ 2,925,000

Prepared by CH2M HILL

3/21/2002

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE IN SITU GROUTING ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: IN SITU GROUTING (ISG) ALTERNATIVE
LOCATION: INEEL - RWMC
TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
CONSTRUCTION - MODIFIED RCRA SUBTITLE "C" CAP											
Pea Gravel Admixture with Topsoil 20-inches		296,000	CCY	$ 6	NA				$ 1,773,040		$ 1,773,040
Compacted Silt Loam (Topsoil) 20-inches		296,000	CCY	$ 5	NA				$ 1,411,920		$ 1,411,920
Sand Filter Layer 6-inches		89,000	CCY	$ 25	NA				$ 2,225,000		$ 2,225,000
Gravel Filter Layer 6-inches		89,000	CCY	$ 10	NA				$ 890,000		$ 890,000
Lateral Drainage Layer 6-inches		89,000	CCY	$ 10	NA				$ 890,000		$ 890,000
Low-Perm Asphalt 6-inches		89,000	CCY	$ 19	NA				$ 1,646,500		$ 1,646,500
Asphalt Base Course 4-inches		59,000	CCY	$ 19	NA				$ 1,091,500		$ 1,091,500
Gravel Gas Collection Layer, 6-inches		89,000	CCY	$ 10	NA				$ 890,000		$ 890,000
Fine Filter - Sideslopes, 12-inches		6,000	CCY	$ 25	NA				$ 150,000		$ 150,000
Coarse Filter - Sideslopes, 12-inches		6,000	CCY	$ 10	NA				$ 60,000		$ 60,000
Sideslope Rip-Rap 12-inches		6,000	CCY	$ 40	NA				$ 240,000		$ 240,000
Rip-Rap, Sideslope , 36-inches		18,000	CCY	$ 40	NA				$ 720,000		$ 720,000
Grading Fill, 10-ft Thick Average (Less post ISG decon fill)		1,564,000	CCY	$ 5	NA				$ 7,460,280		$ 7,460,280
Perimeter Berm		244,200	CCY	$ 5	NA				$ 1,164,834		$ 1,164,834
					NA						
Install (37) New Lysimeters and Cap Penetrations		37	EA	$ 131,756	NA				$ 4,874,972		$ 4,874,972
OCVZ System Relocation/Well Extension		1	LS	$ 300,000	NA				$ 300,000		$ 300,000
Lab Geotechnical Testing/Compaction		40	MO	$ 50,000	NA				$ 2,000,000		$ 2,000,000
Filed Geotechnical Testing/Compaction		40	MO	$ 90,000	NA				$ 3,600,000		$ 3,600,000
Surveying/Grade Control		40	MO	$ 65,000	NA				$ 2,600,000		$ 2,600,000
Third-Party Independent CQA Testing/Certification		40	MO	$ 75,000	NA				$ 3,000,000		$ 3,000,000
Hydroseeding/Mulching (Re-seeding Included)		125	AC	$ 2,750	NA				$ 343,750		$ 343,750
											$ -
Seasonal Shutdown/Re-Mobilization		3	EA	$ 500,000	NA				$ 1,500,000		$ 1,500,000
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 805,136	NA				$ 805,136		$ 805,136
INEEL Site-Specific Training/Work Order Requirements					1	LS	$ 1,021,486.4	$ 1,021,486.4			$ 1,021,486
Subcontractor Insurance/Bonds	2.0%				NA					$ 871,668	$ 871,668
Pre-Final Inspection Report, Phase I					1	LS	$ 250,000.0	$ 250,000.0			$ 250,000
Subtotal											**$ 41,780,000**
Subtotal Subcontractor Directs - Remedial Action											**$ 519,668,000**
Subcontractor Overhead	15.0%										$ 77,950,200
Subcontractor Profit	10.0%										$ 59,761,820
TOTAL COST OF REMEDIAL ACTION											**$ 657,380,000**
TOTAL CAPITAL COST - Remedial Action Contracts											**$ 804,351,000**
POST-REMEDIAL ACTION OPERATIONS (100 YEAR DURATION)											
INSTITUTIONAL CONTROLS FOR 100 YEARS											
Install Permanent Markers/Survey		12	EA	$ 5,000	NA				$ 60,000		$ 60,000
Replace Perimeter Security Fence		10,000	LF	$ 20	NA				$ 200,000		$ 200,000
Repair and Replace Perimeter Signs		1	LS	$ 10,000	NA				$ 10,000		$ 10,000
Subtotal											**$ 270,000**

Prepared by CH2M HILL 3/21/2002

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE IN SITU GROUTING ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: IN SITU GROUTING (ISG) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
COVER MAINTENANCE											
Cover Maintenance Cost - 100 Year Duration Annual Cap Maintenance Costs		100	YR	$ 75,000	NA				$ 7,500,000		$ 7,500,000
Subtotal											**$ 7,500,000**
SURVEILLANCE AND MONITORING											
Groundwater Monitoring: (16-wells)											
Groundwater Monitoring, Quarterly for 2 Years - (8-Sampling Events)		8	EVT	$ 1,000	8	EVT	$ 11,000	$ 88,000	$ 8,000	$ 854,936	$ 950,936
Groundwater Monitoring, Semi -Annually for 3 Years - (6-Sampling Events)		6	EVT	$ 1,000	6	EVT	$ 11,000	$ 66,000	$ 6,000	$ 641,202	$ 713,202
Groundwater Monitoring, Annually for 95 Years (95-Sampling Events)		95	EVT	$ 1,000	95	EVT	$ 11,000	$ 1,045,000	$ 95,000	$ 10,152,365	$ 11,292,365
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 1,295,650	NA				$ 1,295,650		$ 1,295,650
Vadose Zone Monitoring:											
Sample 37 Lysimeters 1 Time per Year in Late Spring		100	EVT	$ 1,000	100	EVT	$ 17,875	$ 1,787,500	$ 100,000	$ 2,671,700	$ 4,559,200
Sample & Analyze 20 Vapor Ports 4 Times per Year for 5 Years		20	EVT	$ 1,000	20	EVT	$ 27,500	$ 550,000	$ 20,000	$ 140,000	$ 710,000
Sample & Analyze 20 Vapor Ports 1 Time per Year thereafter		95	EVT	$ 1,000	95	EVT	$ 27,500	$ 2,612,500	$ 95,000	$ 665,000	$ 3,372,500
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 864,170	NA				$ 864,170		$ 864,170
Surface Water Monitoring:											
Collect Sample from 2 Points 2 Times Every 5 Years (20 Sample Events)		20	EVT	100	20	EVT	$ 1,375.00	$ 27,500.00	$ 2,000	$ 320,660	$ 350,160
Vegetation Monitoring:											
1 Inspection per Year in Early Fall for 5 years		NA			5	EVT	$ 1,100	$ 5,500			$ 5,500
Re-seed 10 Acres Each Year for 5 Years (50 Acres Total)		50	AC	$ 15,000	NA				$ 750,000		$ 750,000
1 Inspection Every 5th Year in Early Fall Thereafter for 95 Years		NA			19	EVT	$ 1,100	$ 20,900			$ 20,900
Re-seed 10 Acres Every 5 Years		19	EVT	$ 15,000	NA				$ 285,000		$ 285,000
Air Monitoring (Radiological/Organic):											
Monitor 4 Existing CAMs		100	EVT	$ 1,000	1	LS	$ 2,200	$ 220,000	$ 100,000	$ 15,300	$ 335,300
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 33,530					$ 33,530		$ 33,530
Perimeter Radiological Monitoring GPS with NaI Detector											
2 People, 1-Time per Year, 2 Days in Summer with Hummer & GPS		100	YR	$ 500	100	YR	$ 2,200	$ 220,000	$ 50,000		$ 270,000
Data Interpretation/Plot Data		100	YR	$ 750	100	YR	$ 2,500	$ 250,000	$ 75,000		$ 325,000
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 59,500	NA				$ 59,500		$ 59,500
Biological Monitoring:											
2 People 2-Times, First 5-Years for Intrusion Monitoring					2	EVT	$ 1,100	$ 2,200			$ 2,200
2 People 1-Time, Every 5th Year thereafter for 95 years					19	EVT	$ 1,100	$ 20,900			$ 20,900
Subtotal											**$ 26,216,000**
Subtotal Surveillance and Monitoring (Sampling & Monitoring Activities)											**$ 33,986,000**
WAG 7 MANAGEMENT											
WAG 7 Management (@ 5% of other post-RA operations costs)	5%				1	LS	$ 1,699,300	$ 1,699,300			$ 1,699,300
Annual Data Summary Report (100 reports @ 200 hrs/report)					20,000	HR	75.00	$ 1,500,000			$ 1,500,000
WAG-Wide RA 5 Year Reviews for 100 Years @ 600 hrs/review					12,000	HR	$ 75	$ 900,000			$ 900,000
Subtotal											**$ 4,099,300**
TOTAL COST - Post-Remedial Action Operations (100 Year Duration)											**$ 38,085,300**

Attachment D-4

Operable Unit 7-13/14 Feasibility Study Cost Estimate for the In Situ Vitrification Alternative

The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost estimate are likely to occur as a result of new information and data collected during the engineering design, safety reviews, and remedial alternative. Major changes may be documented in the form of a memorandum in the administrative record file, an explanation of significant differences, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within –30 to +50 percent of the actual project cost.

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE IN SITU VITRIFICATION ALTERNATIVE

Project Title:	WAG 7 OU 13/14 Feasibility Study
Estimator:	Brian K. Corb
Date:	December 2002
Estimate Type:	Planning
Reviewed/Appr.:	Lee Lindig/Bruce L. Stevens

I. SCOPE OF WORK:

A. Remedial Design and Remedial Action

The ISV alternative will remove and destroy the organic constituents of the waste and encapsulate most of the inorganic constituents within a durable glass-like monolith. This stable waste form will reduce the potential for the migration of hazardous constituents to adjacent media. Work associated with construction of the ISV alternative includes preconstruction activities, restaging Pad A waste, placing additional soil over areas to reduce the potential for melt expulsion events, preconditioning waste by ISTD, ISV of selected waste disposal areas, collecting and treating off-gases, conducting ISG of selected waste disposal areas, and constructing a Modified RCRA Subtitle C cover system over the SDA. Preconstruction activities will include investigating borrow sources; testing ISTD, ISV, and ISG technology; remedial design; personnel training; completion of a readiness assessment; and mobilization. Waste materials will be removed from Pad A and relocated into an adjacent pit for treatment by the ISV process. Additional soil will be added to areas of the SDA to provide a minimum soil thickness of 10 ft over areas before ISTD and ISV.

ISTD will be completed on waste areas before beginning treatment with ISV. ISTD will dry out the soil and waste sludge, vaporize volatile materials, and safely breach most remaining sealed containers. Underburden soil also will be heated using ISTD to remove interstitial water and any water perched on the underlying basalt. A starter path for ISV will be installed beneath the soil cover and a large massive hood will be placed over the melt area to contain off-gases. Electrical current will be passed through the starter path to begin melting waste and soil. The melt will sink into the waste materials and create a melt zone from the surface of the waste to the basalt layer. An off-gas treatment system will collect and treat gases generated during the ISTD and ISV process.

The ISG will be performed on areas that cannot be treated with ISV. These areas will include the SVRs and other areas of waste that contain elevated levels of activated metals. Other areas of the SDA not treated with ISV or ISG will undergo foundation stabilization grouting to minimize subsidence. Following completion of ISTD and ISV and grouting activities, the SDA surface will be graded and a modified RCRA Subtitle C cover system will be installed. The cover system will include an infiltration barrier and erosion controls to minimize seepage into the treated waste and prevent intrusion by burrowing animals and plant roots.

B. Long-Term Monitoring and Maintenance

After the Remedial Action has been completed, long-term monitoring and maintenance will continue for a 100-year window. The long-term environmental monitoring will be conducted for groundwater, vadose zone water, surface water, and air. CERCLA reviews will be conducted every 5 years. The cover system will be monitored annually during the first 5 years following completion of construction (beginning after the vegetation establishment period). After the completion of annual monitoring, the monitoring frequency will be reduced to every 5 years concurrent with the 5-year reviews required under CERCLA. The cover system will be monitored for vegetation density, erosion damage, and differential settlement. Areas of erosion damage will be repaired with additional topsoil or earth fill, and reseeded. Areas without vegetation will be reseeded.

II. BASIS OF ESTIMATE:

The basis of the estimate was developed from the following sources to provide a defensible and comparative cost of the remedial alternatives. The applicable sources available for the ISV alternative include:

A.

A.1 EPA 540-R-00-002, "A Guide to Developing and Documenting Cost Estimates During Feasibility Study," July 2000

A.2 INEEL, "Cost Estimating Guide," DOE/ID-10473, September 2000

A.3 "Environmental Assessment and Plan for New Silt/Clay Source Development and Use at the Idaho National Engineering and Environmental Laboratory, DOE/EA-1083," May 1997

A.4 *Caterpillar Equipment Performance Handbook*, 31st Edition

A.5 The INEEL Site Stabilization Agreement, Union Labor Agreement

A.6 Facilities Unit Costs—Military Construction, PAX Newsletter No. 3.2.2—10, 2000

A.7 ICDF Construction Cost Estimate, Cap Construction Cost (CH2MHILL, December 2000)

A.8 Subject Matter Experts—M. Jackson, BBWI, and T. Borsches. BBWI, "Availability of Borrow Source Material at the INEEL"

A.9 BBWI, "INEEL Site Craft and Professional Services Labor Rates," February 2002

A.10 OMB, 2002, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Appendix C, "Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses," OMB Circular A-94, February 2002.

A.11 AMEC Earth & Environmental, Inc., ISV Technology Specialist

A.12 R. S. Means, 2002, *Heavy Construction and Industrial Building Unit Costs Data* 16th edition, Kingston, Massachusetts.

A.13 INEEL, "Analytical Laboratory Unit Costs."

III. ASSUMPTIONS:

The primary work associated with the ISV alternative includes ISTD and ISV and grouting of waste materials, and placing a Modified RCRA Subtitle C cover system over the SDA. Specific elements of the work and important assumptions are provided below:

A. Management and Oversight

A.1 Project Management for the BBWI oversight of this alternative has been estimated based on an average classification of job categories using the BBWI rates. The number of FTEs are based on 2,000 MH per person per year.

A.2 The RD/RA schedule assumes that the budgetary funding will not be constrained.

A.3 The RD/RA schedule assumes that no unexpected delays will result from changes to the USQ/SAR process.

A.4 The estimate assumes that the INEEL site resources (i.e., CFA, medical facilities, geotechnical lab, fire department, security, utilities at the SDA) will be available for the duration of the project.

B. Design and Preconstruction

B.1 Site review—Additional site characterization and analysis of records will be completed to identify waste disposal areas of the SDA that might contain excessive levels of combustible and alkaline materials and inadequate soil. Records also will be reviewed for the possible presence of spent fuel and high radiation sources within waste disposal areas.

B.2 Treatability testing—Because this alternative employs ISV and ISTD technologies in unproven applications, a significant amount of testing of the technologies will be needed. Testing will include cold ISV and ISTD testing, cold integrated ISTD and ISV testing, and hot integrated ISTD and ISV testing. Cold testing also will be needed for ISG and foundation stabilization grouting.

B.3 Preconstruction activities—Preconstruction activities will include borrow source investigations, cultural resource clearance, developing an onsite source of basalt rock, final design, readiness assessment completion, and mobilization.

C. Pad A Waste Restaging

C.1 Pad A waste will be restaged by moving waste to a new pit adjacent to the pad while adding more soil to ensure a mixture suitable for vitrification. The waste will be restaged with an equal volume of soil in a 150- × 240- × 25-ft deep pit (900,000 ft^3) constructed adjacent to Pad A. Contaminated overburden, underburden, and berm soil will be used as the source of soil to mix with the waste.

C.2 A restaging building will be constructed that encompasses Pad A and the new disposal pit. The building will be approximately 300 × 300 ft with heights of 35 ft above Pad A and 25 ft above the new disposal pit. Remotely operated bridge cranes equipped with clam shovels will be installed in the building and used to move waste and soil from Pad A to the pit. Transfer carts will be used to move waste in bins from Pad A to the pit area. The building will be constructed to Seismic Category II requirements, to provide seismic stability during restaging activities. Water fogs will be employed to minimize airborne particulates. The building will be maintained under a negative pressure of about -4-in.water gauge to ensure containment of airborne contamination. The air in the building will be exhausted through HEPA filters and a stack after heating the air to above its dew point temperature. Two 100% blowers will provide the motive force for exhausting the facility. A separate diesel-powered blower will provide ventilation in case line power is lost.

C.3 A waste and soil mixture will fill the pit to within 5 ft of the top of the pit. A 5-ft layer of clean soil will be placed on top of the waste and soil mixture before decontaminating and removing the building in which restaging activities are conducted.

D. Placement of Additional Soil

D.1 Additional soil will be placed on top of all designated pits and trenches designated for ISTD and ISV to meet the objective of 10 ft of soil covering zones undergoing vitrification. Specific groupings of pits and trenches under the same soil and ballast cover will include all designated trenches and Pits 1 and 2; Pit 3; Pits 4, 6, 10, 11, and 12; Pit 5; Pit 9; and the new Pad A pit.

D.2 It is assumed that approximately 5 ft of soil covers the waste sites at present. A total of 12 ft of soil will be needed to allow for safe emplacement of ISV starter path material between electrodes at a depth of 10 ft. This will ensure a 2-ft buffer of clean soil above the waste level.

D.3 It is assumed that the surface area for Pits 1, 2, 3, 4, 5, 6, 9, 10, 11, and 12 totals 663,974 ft^3 and the surface area for Trenches 1 through 10 totals 86,555 ft^3.

D.4 Soil must support the heavy equipment used during ISV. Local soils contain sufficient clay to render the soil unsuitable for road use under rainy conditions. Therefore 7 ft of additional soil cover will be required. The upper 3 ft of soil will consist of a suitable road ballast material, compacted to meet vehicle load-bearing requirements. This fresh ballast material will need to be transported from an off-Site location, with an average transport distance of 30 to 40 mi. Total volume of off-Site ballast material needed is 170,000 yd^3.

D.5 A 4-ft soil layer placed below the ballast will provide the remaining soil height to satisfy the 12-ft cover objective. This 4-ft soil layer will consist of onsite soil with a total volume of 160,000 yd^3.

D.6 The soil and ballast cover will be flat and extend 20 ft beyond the footprints of the trenches and pits. The soil/ballast cover will span the entire area that contains the designated trenches because the spacing between trenches averages only 20 ft. Contiguous pits will be combined under the same soil and ballast cover to facilitate movement of ISTD and ISV equipment.

D.7 Soil and ballast cover on waste area groupings will be encircled by bermed soil installed at a 3:1 slope. Berms will be 7 ft high with bases extending 21 ft beyond the edge of the cover.

D.8 The total quantity of soil to be used in the cover and berm is approximately 250,000 yd^3. Soil and ballast will cover a total area of about 32 acres, not including the area covered by the berms.

E. Other Site Preparation and Support Activities/Facilities

E.1 Personnel training—Before beginning construction operations, site personnel will be trained in the startup and operation of equipment related to ISTD, ISV, ISG, and foundation stabilization grouting technologies.

E.2 A 10,000 ft^2 secondary waste treatment building will be installed that includes an activated carbon recycling system, a mercury recovery and treatment system, a grout mixing and pumping system, a sludge filtration and thermal treatment system, and a treated secondary waste packaging system.

E.3 A tank system will be installed that includes a sodium hydroxide receipt tank, a diluted sodium hydroxide storage tank, a spent scrubber solution receipt tank, two treated scrubber solution storage tanks, an anhydrous ammonia storage tank, and a grout solids hopper.

E.4 A maintenance building and decontamination pad will be installed for servicing vehicles.

E.5 Two trailers will be installed. One trailer will contain offices and a lunchroom, and the other trailer will contain a change room and personnel survey and decontamination capability.

E.6 A 2,000,000-gal capacity grout disposal basin lined and covered with HDPE geomembrane will be provided.

E.7 During development of this cost estimate, modular containment buildings were evaluated including Butler and Sprung structures. Typically, the Sprung structure erected on a perimeter foundation is not designed for double-containment and live loads such as a bridge crane. Therefore, the cost provided for those sites to be treated by ISG considers a Sprung-type containment structure for waste grouting operations; no containment structure is assumed to be required for foundation stabilization grouting operations. The costs for these facilities include fire protection, HVAC, lighting, communication lines, and power distribution.

F. Preconditioning Waste with ISTD

F.1 ISTD will be used to precondition the waste and underburden before the application of ISV. ISTD will employ an array of heated stainless steel pipe assemblies inserted into the ground on an 8 × 8-ft spacing to a depth of approximately 3 ft below the buried waste.

F.2 It is assumed that each pipe assembly will include a sealed pipe that contains an electrical-resistance heating element, a vented pipe used to extract gases, and thermocouples. Extraction pipes will be connected to a pipe manifold that conveys gases to an off-gas treatment system. The average pipe assembly will be inserted to a depth of 24 ft. Pipe assemblies will be inserted into the ground using either nonstandard vibratory or hydraulic techniques.

F.3 It is assumed that heat can be transferred from the heating elements to the pipes and then to the waste at a nominal rate of 350 watts per lineal ft of heated pipe.

F.4 Six ISTD systems will be used; each paired with an ISV system. Four larger systems will be used when processing pits, and two smaller systems will be used when processing trenches.

F.5 With the 8 × 8-ft spacing of the pipe assemblies, heating will occur over about a 90-day period. This is in contrast to the 18-day period estimated to complete an ISV cycle. Thus, each ISTD system must cover an area approximately five times larger than the area being vitrified, to match the ISV procession rate.

F.6 In pits where the largest glass melts will be created, a total of 100 pipe assemblies will be employed in each ISTD system. The smallest melts will be created when vitrifying trenches; these will require about 60 assemblies per ISTD system. Each of the larger ISTD systems will require about 330 kW. The smaller systems will require about 160 kW. About 15 MW of installed power capability will be needed to support all power needs in this alternative, including those necessary to support ISV and secondary waste treatment operations. The power will be distributed to the combined ISTD and ISV systems via a power grid that will allow each system to draw a maximum of 4 kW during nonroutine operations when high off-gas cooling demands are encountered.

F.7 Each ISTD system will be operated as a single system or divided into five subsystems, each covering somewhat more than the area of a single melt. When a subsystem reaches its heating objectives, the pipe manifold that collects off-gases will be isolated from the rest of the off-gas manifold by closing valves. The 12 or 20 extraction pipes in the subsystem will be crimped closed, the manifold section will be disconnected and transported to the front of the advancing ISTD system, and reconnected after purging at that location. ISTD processing at a given melt setting will be completed about 1 month before ISV will begin. This approach will allow sufficient room for both ISV and ISTD operations while allowing both operations to be monitored and controlled from a single control trailer.

G. ISV Assumptions

G.1 ISV will be used to raise the temperature of the ISTD-treated waste further to about 1,500°C to convert it to a glassy monolith. ISV will complete the pyrolysis and decomposition of the waste constituents initiated by ISTD, and then vitrify the waste and associated soils. The ISV process will heat soil and waste in the designated pits and trenches by passing current through the materials using four, 12-in. diameter graphite electrodes inserted into the ground.

G.2 Electrodes used to vitrify pit waste will be installed in a square array on about an 11-ft spacing. This configuration will create generally circular melts averaging 35 ft in diameter. Electrodes used to vitrify trench waste will be installed in a line 11 ft apart. This configuration will create rectangular-shaped melts averaging approximately 35-ft long × 15-ft wide. If necessary, power will be applied between the center electrodes to achieve the desired melt width between the two planar melts.

G.3 When first applying voltage to the electrodes in the ISV process, a flow of electrical current will be established through an electrically conductive, buried starter path containing powdered graphite and glass frit. The resultant discharge of joule heat in the starter path will raise the starter-path temperatures to as high as 2,000°C. This temperature is well above the temperature required to melt soil (about 1,100°C to 1,400°C). As the starter path melts, soil immediately adjacent to the starter path will begin to melt and mix with the molten frit.

G.4 The starter path will be created using a backhoe to excavate trenches 2-ft wide × 10-ft deep (i.e., 2 ft above the buried waste level). A 1-ft deep layer of the starter path material will be placed in each trench, followed by four, 2-ft diameter × 10-ft long steel tubes inserted vertically on 11-ft centers. The trenches will be backfilled with the excavated soil. The tubes will provide holes for guiding the electrodes to the desired starting elevation. Approximately 6 in. of electrically conductive grease will be added to the base of each tube if necessary to ensure adequate electrode-to-starter path conductivity. Thermocouples embedded in the waste at varying diameters will provide the capability to monitor the progression of the melt.

G.5 Densification of the waste and soils will occur because the glass usually contains few voids, and because the oxidation and pyrolysis that occur during melting largely eliminate organic materials. A 60% volume reduction is expected in the designated pits and trenches at the SDA. The melts will average about 6 ft in height. The average depth of the base of a completed melt below the soil-cover surface will be about 24 ft.

G.6 Each melt setting will consume on average about 100,000 kW-h based on an estimated power consumption rate of 300 kW-h per ton of glass produced. The estimated time to provide power to a melt is 8 days, requiring the delivery of 700 kW power to the pit electrodes and 350 kW to the trench electrodes.

G.7 Surface area of the melts will overlap each other by 15%, and the melts will overlap to the soil that bounds the trenches and pits by 6 ft on average to ensure effective vitrification of contaminated areas. A total of 1,300 melts will be required over a 15-year operating period, requiring four pit-ISV systems and two trench-ISV systems operating on an 18-day melt-to-melt cycle at 70% total operating efficiency.

G.8 Gases produced at each ISV setting will be vented to a 70-ft-diameter off-gas hood centered over each melt zone. The hood will be substantially more robust than hoods used in earlier ISV applications to resist the highly corrosive effects of the melt off-gases and ensure effective containment of respirable TRU contaminants that may be emitted into the hood. The hood will be hydraulically jacked 1 ft above the ground using an external frame and then driven 32 ft to the next melt setting where it will be lowered to the ground. A 60-ft boom crane with a 5-ton capacity will be used to raise and move a hopper of dry sand around the boundary of the hood.

G.9 The hood will be equipped with remote grapples to accept new electrode segments, screw them into position on the electrodes, and then lower the electrodes into the tube guides installed on the starter paths. The crane must lift and transfer 12 to 16 electrode segments to the grapple positions during each 8-day ISV power-on cycle. A crane will be dedicated to each of the six ISTD and ISV systems.

G.10 Each hood will be equipped with nine hydraulic rams capable of breaking down bridges of soil that may form over the melts as the waste undergoes volume reduction during melting. The rams will be equipped with a cyclone and star valve to aid in the receipt and delivery of washed, dry sand to the hood. Dry sand will be pneumatically delivered from a 20-yd^3 hopper truck each day to the cyclones and fed down the hollow center of the rams into the enclosed space of the hood. The addition of sand to the hood will compensate for the average 10 ft of subsidence expected during vitrification and ensure that the waste area will not become exposed to air. Approximately 7 ft of sand will be added to the subsidence zone, leaving 3 ft to be filled with road ballast after the hood is moved to the next location. Approximately 300,000 yd^3 of sand will be delivered and placed to seal hoods to the ground and compensate for subsidence. Approximately 100,000 yd^3 of ballast will be delivered and placed to restore the load-bearing capability of the site to support future traffic. Approximately five 20-yd^3 truckloads of sand and ballast will be delivered each day to the six locations undergoing ISV.

H. Treatment of Off-Gases Generated During In situ Thermal Desorbtion and In Situ Vitrification

H.1 Separate off-gas treatment systems will be used to treat off-gases generated by the paired ISTD and ISV systems. The conceptual ISTD off-gas system will include traps to condense and collect elemental mercury as the off-gas exits the gas extraction pipes. Other trap locations also may be needed in the off-gas collection manifold to minimize corrosive damage to the piping. The gas will then pass through a roughing filter and a metal HEPA filter designed to stop further entrainment of any TRU-contaminated particles that may be present. After filtration, the still hot gases will be chilled to about 50°C to condense and collect both water and mercury in a wet scrubber and demister. Elemental mercury will be collected in traps and the condensed water will be passed through two activated carbon filters in series to remove organics and mercury in the +2 valence state.

H.2 The water then will be neutralized with sodium hydroxide and evaporated to a salt concentration of about three molar using primarily waste heat generated by the off-gas system. The concentrated salt solution will be transported in 1,000 gal tanker trucks to a secondary waste treatment facility for further processing. One tanker truck will be transported every 5 days to the secondary waste treatment facility. Approximately 200,000 gal of 19-molar sodium hydroxide will be needed in ISTD and ISV off-gas neutralization processes during the 15 years of operation. Two 5,000-gal steel tanks will be needed; one a heated tank for receipt of 19-molar sodium hydroxide and one for dilute neutralization feed makeup. Both tanks will be installed in a lined, bermed basin for protection in the event of a leak.

H.3 The acidic off-gases will be treated in a thermal oxidation unit using natural gas as the heat source (when required) and controlled air feed as the oxygen source. The resulting gas will be cooled and then passed through two activated carbon adsorbers in series to remove mercury +2 and residual organic carbon. The acidic gases then will be passed through a bag house or two static lime-based dry scrubbers in series to remove acid halogens, sulfuric acid, and residual carbon monoxide before being drawn into a blower. The blower will impel the gas forward to a selective catalyzed reactor where anhydrous ammonia will be injected to chemically reduce the nitrogen oxides to nitrogen gas. Approximately 200,000 gal of anhydrous ammonia will be consumed over the 15-year processing period. A tanker truck will deliver ammonia to each of the six systems every few weeks. The fully treated gases will be discharged to the atmosphere via a stack.

H.4 The ISTD off-gas system will include two identical trains; both designed for 100% capacity at about 100 ft^3/minute. Adsorber vessels will be mounted on skids. Both trains will operate simultaneously, but one in a standby mode to ensure readiness of the other train failed. The off-gas treatment process will be controlled from the same trailer used to control thermal desorption, ISV, and the ISV off-gas treatment process. Two diesel generators designed to withstand the design-basis earthquake will provide emergency power to the blowers to ensure continued ventilation of the off-gas system if line power were lost.

H.5 The ISV off-gas system will be similar to the ISTD system. The major exception is its much larger size, nearly 100 times the capacity of the ISTD system to accommodate the dilution air added at the hood.

H.6 The ISV off-gas train will begin with a roughing filter and HEPA filter, followed by quencher and wet scrubber with a mercury trap and solids filter. Water recirculated through the scrubber will be neutralized with sodium hydroxide to scrub acids from the off-gases. The scrub solution will be evaporated using primarily waste heat and then trucked to the secondary waste treatment facility for further processing. The scrubbed off-gases will be heated to about 110°C and passed through banks of activated carbon adsorbers to remove trace organics and mercury. The fully treated gas will be drawn through two 100%-capacity blowers and discharged to the atmosphere via a stack.

H.7 Like the ISTD system, the ISV system will include two identical trains that will fit onto a single trailer (with the exception of the adsorber vessels). The redundant ventilation systems provided for each ISV system will be necessary to ensure effective containment of airborne contaminants while diluting the gas under the hood with air to prevent potential buildup of explosive concentrations. Each of the redundant off-gas treatment trains will be capable of drawing and treating about 3,000 ft^3/min of gas. An emergency backup ventilation system powered with emergency diesel generators would be necessary if a large earthquake were to sever the duct connections between the hoods and off-gas trailers.

I. Secondary Waste Treatment

I.1 Secondary waste generated during ISTD and ISV operations will include flasks of elemental mercury, vessels containing saturated activated carbon and spent acid sorber materials, concentrated neutralized scrubber solutions, and failed equipment. Failed equipment will include spent roughing filters and HEPA filters, and corroded or plugged pipes and off-gas processing vessels. Failed equipment that may be contaminated with TRU materials will be treated and disposed of by placing it on top of one of the trenches purposely left uncovered. The failed equipment will then be covered with soil and ballast, and vitrified with the waste beneath it. A small fraction of the failed equipment, in particular the filters, may be classified as TRU waste. All remaining secondary waste will be classified as either low-level waste (LLW) or mixed low-level waste (MLLW).

I.2 Concentrated scrubber solutions will be transported in 1,000-gal batches and pumped into an agitated 10,000-gal steel tank. The solution will then be filtered or centrifuged to remove sludge, which will likely contain mercury and other heavy metals requiring treatment. The sludge will be dried and retorted to drive off mercury, which will be condensed and further treated. The filtered scrubber solution will be collected in one of two other 10,000-gal tanks in preparation for grouting to immobilize the solution and heavy metals it may contain.

I.3 Grouting of the treated secondary liquid waste will be accomplished on an 8,000-gal batch basis once every 40 days. A dry grout blend consisting of Portland cement and clay will be mixed in a ratio of about 10 lbs of blend per gal of solution. The volume of the resulting grout slurry will be about 50% greater than the volume of the solution. The grout slurry will be pumped approximately 300 ft to a basin where it will flow to a low point and harden. The basin will be approximately 200-ft square at the surface, double-lined with HDPE, and be covered with floating HDPE. It will be designed to contain about 2 million gal of grout. The grout blend will be purchased premixed from a vendor, transported in 20-yd^3 hopper trucks, and unloaded using pneumatics into a 50-yd^3 grout-feed silo.

Approximately 6,000 tons of dry grout blend will be required over the 15-year-operating period.

I.4 Saturated activated carbon will be regenerated under elevated temperatures and chemically reducing conditions. This step will enable its reuse about 10 times by removing adsorbed mercury and organic compounds. The estimated quantity of spent activated carbon disposed of will be 1,000 55-gal drums. The spent carbon will be disposed of at the ICDF. The organic materials desorbed from the carbon will be destroyed in the vapor form in a small thermal oxidation unit. The desorbed mercury will be condensed and then amalgamated along with mercury collected in flasks during ISTD and ISV processing and with mercury condensed during retorting of scrubber sludge.

I.5 Mercury amalgamation will occur by combining and mixing the mercury with elemental sulfur, heating it, and then vigorously agitating the mixture to create the amalgam. Some of the scrubber sludge that resists retorting will be ground to a fine powder and amalgamated as well. Approximately 100 tons of sulfur will be needed in the amalgamation process. The estimated total quantity of amalgamated waste produced is 2,000 5-gal containers. Amalgamated waste will be disposed of at the ICDF.

I.6 Spent acid sorber material will be disposed of directly in its processing vessels at the ICDF. Approximately 500 500-gal vessels of spent acid sorber material will be disposed of.

I.7 The secondary waste disposal facility will be of metal-frame construction and also house a small laboratory for analyzing secondary waste and treated products. The maintenance and stores building will be located nearby, as will the office trailer and a worker change room trailer.

J. In Situ Grouting and Foundation Stabilization Grouting Assumptions

J.1 The ISG technology will be used to grout SVRs and other areas of the site containing activation and fission product waste. Foundation stabilization grouting technology will be used to grout remaining untreated areas of the SDA to provide a stable foundation for the Modified RCRA Subtitle C cover system.

J.2 The grouting equipment and enclosures will be dismantled and disposed of under the cover system. Cost for dismantling and disposing of the grouting equipment is 25% of the operational costs of grouting.

J.3 Waste in SVRs and portions of waste trenches will be treated by ISG using jet grouting with specialized grout.

J.4 Wastes will be stabilized to reduce settlement (foundation stabilization grouting) by jet grouting areas of pits and trenches with cement-based grout. It is assumed that once the foundation stabilization grouting has been completed, heavy equipment operations can commence without any ground subsidence. No additional costs for cribbing or temporary road stabilization are included in the estimate.

J.5 Grouting operations will be conducted within a weather enclosure to facilitate RadCon control. Two sprung-type structures will be mobilized to the site. These structures will be initially constructed and progressively disassembled and reconstructed as required to accommodate advancement of the ISG operation. Following completion of the grouting operation within an enclosure and before disassembly of the building, the grouted area will be covered with a minimum of two ft of earth fill.

J.6 The grout production rate can be maintained and no subsurface anomalies will adversely impact the assumed total operating efficiency of 70%. ISG will be performed using the same grouting technique and grout types as described for the ISG alternative; however, ISG will be limited to the SVRs and portions of the waste trenches. Detailed assumptions related to ISG are provided in the ISG alternative cost estimate.

J.7 The SVRs and non-TRU trench areas containing high activation and fission product concentrations will be treated using the ISG technology with grout injected on a 2-ft center-to-center spacing. One hole will be grouted every 4 minutes.

J.8 Foundation stabilization grouting will be achieved using low-pressure ISG technology with grout injected on a 4-ft center-to-center spacing. One hole will be grouted every 4 minutes.

J.9 Grouting for foundation stabilization will be performed using a modified drill rig to inject grout into the waste stream. The grout will fill readily accessible void spaces and cure into a solid monolith. This technique allows using a relatively low-cost, cement-based grout instead of the specialized grout types used for waste treatment. Unlike grouting for waste treatment, completely mixing grout with the waste or soil will not be required. Voids that could degrade integrity of the cover system are fairly large and will be filled sufficiently with grout to ensure adequate cover support. Substantially less grout will be needed for foundation stabilization because the grout will be injected on a less frequent spacing and because the waste was partially compacted when initially placed in the SDA. Detailed assumptions for foundation stabilization grouting for the cover system are addressed in the ISG alternative cost estimate.

J.10 The equipment and crew sizes needed for ISG and foundation stabilization grouting are similar to those needed for the ISG alternative.

K. Borrow Areas for the Cover System

K.1 Spreading Area B will be available and will not be flooded. No additional costs have been provided to dewater Spreading Area B.

K.2 The quantity and quality of borrow source material available from Spreading Area B, the Borax Pit, and the Basalt Source (for riprap and coarse fractured material) will be adequate. No royalty fees and special earthen material costs will apply.

K.3 An adequate water source will be available to support the requirements for earthmoving and soil moisture conditioning for placement and compaction.

L. Modified Resource Conservation and Recovery Act Subtitle C Cover System Construction

L.1 Placement of earthen fill—An average 10-ft-thick layer of earthen fill will be placed over the surface of the SDA following ISTD and ISV and ISG. This will grade the surface to the top of the mounded soil covers placed over areas subjected to ISTD and ISV in preparation for placing the cover system.

L.2 A 6-in.-thick layer of processed gravel will be placed over the earthen fill to allow gases to safely vent that might build up beneath the cover system.

L.3 The earthen fill and the gravel gas venting layers of the cover system will be placed during grouting activities.

L.4 A 4-in. asphalt base course and a 6-in. low-permeability asphalt layer will be placed over the gas collection layer to function as infiltration barriers. A 6-in. lateral drainage layer consisting of processed sand will be placed over the asphalt to enable drainage of infiltration from the surface of the barrier layer. A 1-ft-thick filter section consisting of sand and gravel will be placed over the lateral drainage layer.

L.5 Remaining cover system layers will consist of a 20-in. compacted topsoil layer and a 20-in. layer of mixed topsoil and gravel.

L.6 A 6-ft-high berm will be constructed around the perimeter of the cover system to control flooding; filter layers, coarse fractured basalt, and riprap will be placed on the side slopes to minimize erosion.

L.7 The topsoil layer will be seeded with a specialized seed mix to provide a vegetative cover. The cover will be monitored and reseeded as necessary to maintain the vegetative layer.

M. Treatability Testing Assumptions

M.1 Additional characterization of the SDA and treatability testing using both simulated and actual waste locations will be required to establish the design and safety basis for operating ISV, ISTD, ISG, and the secondary waste treatment processes for processing waste generated in the ISV and ISTD off-gas cleanup systems. This work will verify that waste sites and properties that represent bounding conditions can be safely and effectively treated.

N. Capital Costs, Unit Rates, and Other Pricing Assumptions

N.1 The unit prices have been developed from crew build-ups to load, haul, place, compact, and conduct treatment O&M. The volume of materials represented in the cost tables are identified as CCY. The appropriate factors convert the estimated unit material weights (Bank, Loose, and Fill) and are factored into the equipment productivity estimates.

N.2 Crew labor rates were developed based on hourly rates stipulated in the INEEL Site Stabilization Agreement. Labor and equipment spreads were developed based on the assumed achievable daily productivity to support the project schedule. Other factors that influenced the selection of labor and equipment quantities include safety considerations, levels of PPE for the work activities to be performed, haul routes, and availability of resources on the INEEL site. Each daily crew cost also includes field oversight personnel such as the HSO, superintendents, foremen, CIHs, maintenance personnel, and allocation of supplies (e.g., fuel, oil, grease, and spare parts).

N.3 Capital equipment and pricing were selected from commercially available sources or similar projects, allowing a scale factor to be applied to yield an estimated cost of the conceptual equipment. Equipment installation cost is considered to be a significant variable. The installation costs were based on percentages of the capital costs, ranging from 110 to 160% of the estimated capital expenditure based on the unknowns and level of complexity.

N.4 A subcontractor's bond and insurance rate of 2% of the total subcontractor costs including overhead and profit is included.

N.5 An allocation for the INEEL-specific work order PRD requirements and safety meetings is included. Because this estimate includes primarily unit prices, the labor cost is estimated to be 40% of the unit prices and, based on historical data, cost of the INEEL-specific work order PRD requirements and safety meetings is approximately 6% of the total labor dollars.

O. Schedule

O.1 Earthwork operations can be performed for 10 months of the year without weather impacts. The work will be performed during this time working two 10-hour shifts. A back shift performing maintenance would work a 5-day week.

O.2 Field crews will demobilize the equipment during the 2-month winter shutdown period to refurbish and replace the equipment. The estimate includes an allocation to cover these costs in addition to the 2% estimated.

O.3 ISTD and ISV activities will be conducted over a 15-year period, but workers will be scheduled for 17.5 years of work to account for training, startup, and demobilization.

O.4 Pad A retrieval and restaging activities will occur over a two-year period, but workers will be scheduled for 4.5 years of work to account for training, startup, and demobilization.

P. Health and Safety

P.1 After the initial site grading material is placed over the SDA, all earthmoving operations can be performed in Level D PPE.

P.2 Work within primary treatment process confinement areas will require respirators or fresh air breathing supply. Other routine O&M will be conducted in Level D PPE, except where radiation monitoring shows a need for higher levels of protection.

Q. Long-Term Operating and Maintenance and Monitoring

Q.1 The initial postRA monitoring program probably will be similar to that proposed for the Surface Barrier and No Action alternatives (see Section D-1). However, because of the robust nature of the RA, it is assumed that following 5 years of monitoring, the groundwater well and lysimeter monitoring programs can be reduced by 50% and the vapor port program can be eliminated.

Q.2 The capital cost for the project includes replacing of the groundwater wells and lysimeters removed as part of site preparation activities. The estimate assumes that nested wells and lysimeters will be installed at varying depths of 20 ft, 90 ft, 200 ft, and 600 ft along the interbed surfaces.

Q.3 Liquid samples will be recovered in 10% of the wells. Therefore, analytical costs are included only for recoverable samples.

Q.4 Erosion of the uppermost layers of the cover system during snowmelts will occur during the years immediately following construction, and repairs and reseeding will be required.

Q.5 Ongoing maintenance of the cover system barrier will be required in perpetuity after construction is completed. The added weight of the cover system is expected to result in settlement during the initial years following construction, requiring ongoing maintenance to repair damage. Annual maintenance and repairs will be required during the first 5 years following construction. Subsequent maintenance and repairs will continue every 5 years concurrent with the 5-year review process.

R. Design Costs

The following discussion provides the basis for the assumed percentage for design, construction, and contingency. EPA provides guidance for estimating remedial design costs in the EPA Guidance (EPA 2000). Exhibit 5-8 of the EPA Guidance provides examples of remedial design costs as a percentage of total capital costs. The percentages range from 20% for projects with capital costs less than $100,000 to 6% for projects with capital costs greater than $10 million. The EPA Guidance does not provide an example of design costs that vary according to the complexity of technologies.

For the WAG 7 PERA, the alternatives include technologies that have been demonstrated on other sites and that have well-developed engineering design criteria (such as capping) and technologies that have not been demonstrated successfully on a large scale in TRU-waste applications and require development of engineering design criteria (e.g., ISV). For the WAG 7 PERA alternatives, remedial design costs are expected to vary significantly according to the degree of complexity, and estimates need to reflect this. Based on the complexity of the technology application, a percentage of the capital and operating cost specific to the technology was assumed.

The modified RCRA Subtitle C cap has been demonstrated on other sites and design standards have been developed for the various types of materials and construction methods that will be needed. Some borrow source investigations will be needed to verify material properties and quantities, but the methods for conducting these investigations are not expected to require specialized equipment or personnel. Because capping is a demonstrated technology with established design standards, the cost for remedial design is assumed to be 6% of capital costs.

In situ grouting includes subsurface jet injection of specialized types of grout into waste disposal areas to stabilize and treat waste materials. ISG must be done inside a modular building to contain possible release of contaminants. Some waste disposal areas will require pretreatment before to grouting. Considerable effort will be needed to design appropriate grout types for the waste disposal areas, design the modular building and grouting equipment, determine areas of the site that will need pretreatment, and field test various design elements. Because of the additional design effort required for ISG, cost for remedial design is assumed to be 8% of capital costs.

Foundation stabilization grouting includes using modified grouting equipment to jet grout areas to fill voids in the waste and provide a stable foundation for placing and maintaining cover systems. Foundation stabilization grouting is somewhat similar to ISG except specialized grout and grouting equipment (including a modular building) will not be needed and the grout holes will be spaced further apart than for ISG. Cement-based grout and modified grouting equipment will be used for this technology. Some field demonstrations will be conducted to verify the ability of the grouting equipment to penetrate the waste disposal areas and to estimate the approximate quantity of grout that will be needed. Because the design effort will be considerably less for foundation stabilization grouting than for ISG, the cost for remedial design is assumed to be 7% of capital costs.

In situ vitrification includes using an electrical current to heat waste disposal areas to about 1500^{O}C to create a glass monolith. Before melting, waste disposal areas will need to be pretreated by ISTD to remove water, VOCs, and expandable gases from the waste. Melting of waste will be carried out beneath a large hood that will contain off-gases emitted from the molten materials. Off-gases from ISTD and vitrification will be collected and treated during the operation. ISV has not been implemented over as large an area as will be required at the SDA. Considerable design effort and field testing will be necessary to ensure that this technology can be implemented successfully and safely. Because ISV has not been demonstrated on sites similar to the SDA, and because of elevated safety requirements and associated design reviews for this alternative, the cost for remedial design is assumed to be 10% of capital costs.

The various technologies and the percentages of capital costs estimated for remedial design are summarized in Table 1. These percentages are applied to individual technologies in the cost estimate to establish estimated design costs for the various alternatives.

S. Construction Management Costs

Cost considerations for BBWI oversight, regulatory agency interaction, and project management were estimated on a representative basis of an assumed level of effort to implement the selected alternative. Additionally, costs for the remedial design, safety equipment and PPE, construction management, general conditions, and insurance and bonds were included in the estimate to provide a relative basis for comparing costs associated with implementing a given remedial alternative.

The construction management cost percentage is based on the total capital construction cost to implement the alternative. The percentage basis for each category identified was selected considering the complexity of the technology and the risk and uncertainty of the approach. The cost identified under the category General Conditions includes administration buildings, parking area, utilities, and support infrastructure.

T. Contingency Costs

The EPA provides guidance for estimating contingency costs in the EPA Guidance (EPA 2000). EPA Guidance distinguishes between scope contingency and bid contingency costs. Scope contingency costs represent risks associated with incomplete design and include contributing factors such as limited experience with technologies, additional requirements because of regulatory or policy changes, and inaccuracies in defining quantities or characteristics. Exhibit 5-6 of the EPA Guidance provides examples of scope contingencies. Bid contingency costs are unknown costs at the time of estimate preparation that become known as remedial action construction or O&M proceeds. Bid contingencies represent reserves for quantity overruns, modifications, change orders, or claims during construction. The EPA Guidance states that bid contingencies may be added to construction and O&M costs and typically range from 10 to 20%.

Because EPA Guidance suggests that contingency costs will vary according to the alternative technologies, it is necessary to estimate these costs for technologies included in the alternatives of the PERA. Technologies have been evaluated separately to determine appropriate contingency costs. Scope and bid contingencies for each technology associated with this alternative are discussed below.

Capping technology includes placing the RCRA Subtitle C cap. These cover system include using several types of materials in addition to those planned for biotic barrier technology, constructing infiltration barriers, and using synthetic materials. One significant assumption for this technology is that native materials capable of meeting infiltration barrier layer permeability requirements without using additives such as bentonite will be available. Capping technology is assumed to require a scope contingency within the range of 10 to 20% as shown in Table 2. Because of the risk associated with the need for additional borrow sources for materials, using synthetic materials, and the possible need to use additives for infiltration barrier layer construction, cost for the scope contingency is assumed to be 15%. Most risks associated with capping technology will be significantly reduced during remedial design, therefore, the cost for the bid contingency is assumed to be 10%. The total contingency for capping technology is assumed to be 25% of capital costs.

In situ grouting includes jet injection of various types of grout into waste materials in the SDA to stabilize and treat waste materials. ISG technology will require consideration of pretreatment for some waste disposal areas, grout design for different types of waste, design of specialized grouting equipment and a modular containment building, and field demonstrations. ISG technology is assumed to require a scope contingency within the range of 15 to 35% as shown in Table 3. Because of the specialized design efforts required for this technology, the cost for the scope contingency is assumed to be 20%. There will still be some significant construction risks associated with this technology because of unanticipated subsurface conditions, therefore the cost for the bid contingency is assumed to be 15%. The total contingency for ISG technology is assumed to be 35% of capital costs.

Foundation stabilization grouting includes jet grouting areas of the SDA with cement-based grout to fill voids in the waste and provide a stable foundation for placing and maintaining cover systems. While foundation stabilization grouting is somewhat similar to ISG, design of specialized types of grout and a modular containment building will not be required. Scope and bid contingencies for foundation stabilization grouting are the same as those for ISG (20 and 15%, respectively) with a total contingency for foundation stabilization grouting assumed to be 35% of capital costs.

The ISV alternative also includes pretreating waste areas with ISTD to remove VOCs, water, and expandable gases followed by melting waste disposal areas using an electrical current to create a glass monolith. ISTD and ISV technology has not been demonstrated successfully on sites of comparable size. Considerable design efforts will be needed to ensure that this technology can be implemented successfully and safely. There is a high risk for scope changes during design of the various components of this technology (ISTD, melt containment, off-gas collection and treatment). ISV technology is assumed to require a scope contingency within the range of 15 to 35%. Because of the high potential for scope changes associated with this technology, the cost for the scope contingency is assumed to be 25%. Because this technology has not been demonstrated in the field on a scale similar to that required for the SDA, some major construction risks (e.g., melt control and containment, possible exposure to contaminants, off-gas treatment difficulties) will remain after design and testing has been completed. Construction risks will be highest during the first melt and will decrease with subsequent melts, because of additional design and implementation expertise. Bid contingency will be highest for initial melts and will decrease for subsequent melts. Because of the major construction risks associated with this technology, an average bid contingency of 25% is assumed for this technology. The total contingency for ISV technology is assumed to be 50% of capital costs.

The scope and bid contingency percentages associated with this alternative are identified in Table 3. These percentages are applied to individual technologies in the cost estimate to establish a representative aggregate cost contingency.

Following the cost contingency guidance provided in Table 2 for each of the technologies, a representative contingency was selected within the range provided based on engineering judgment and the complexity, and size of the project, and inherent uncertainties related to the remedial technology. However, the guidance document does not address all of the remedial technologies identified in this alternative. Specifically, the foundation stabilization grouting, ISG, and ISTD and ISV technologies would be within a scope contingency range of 20 to 35% and are considered representative for this work and project scope.

IV. SCHEDULE:

The following activities that comprise the RD/RA portion of the ISV alternative are provided. Table 4 shows the corresponding durations based on estimated crew productivity, regulatory reviews and approvals, and weather constraints inherent to the INEEL site.

V. PRESENT WORTH ANALYSIS:

Chapter 4 of the EPA Guidance provides guidance for present value analysis, The EPA Guidance states that the present value analysis of a remedial alternative involves four basic steps:

1. Define the period of analysis
2. Calculate the cash outflows (payments) for each year of the project
3. Select a discount rate to use in the present value calculation
4. Calculate the present value.

Periods of analysis for the ISV alternative include design and construction and O&M. The design and construction period for ISG, foundation stabilization grouting, and ISTD and ISV will occur over an estimated 4 years beginning shortly after issuance of a ROD for the site. Design, construction, and O&M costs for retrieving and restaging Pad A waste will be deferred until near the end of the project to reduce cost peaks and minimize the present value. The long-term monitoring will begin toward the end of the vegetation establishment period and will continue for 100 years.

Cash outflows for the ISV alternative will include payments for design and construction, periodic payments for major repairs, and annual O&M costs. EPA Guidance suggests that most capital costs should occur in the first year of remedial action when funds are committed for remedial action. While this suggestion might be a realistic assumption for short-duration remedial actions, it is not realistic for the ISV alternative because of the time required for design and construction. Cash outflows for the ISV alternative barrier would be paid on an annual basis as costs are incurred, beginning with the borrow source investigation, technology testing, and remedial design, and end with completion of the vegetation establishment period.

Annual capital cost payments vary with the level of activity, with relatively low annual payments during the borrow source investigation, technology testing, remedial design, readiness assessment, and vegetation establishment periods and relatively high annual payments during heavy construction periods (ISTD, ISV, grouting, and material excavation, processing, stockpiling, and placement). Periodic costs for major repairs would occur every 5 years concurrent with the 5-year reviews required by CERCLA. Periodic costs would begin 5 years after Phase 1 construction and continue through the O&M period. Annual O&M costs would begin the first year after completion of Phase 1 construction and continue for 100 years. In accordance with EPA Guidance requirements, 2002 constant dollars are used for all annual and periodic cash outflows.

The EPA Guidance requires using a real discount rate that approximates the marginal pretax rate of return on an average investment and has been adjusted to eliminate the effect of expected inflation. The real discount rate must be used with constant or real dollars that have not been adjusted for inflation. EPA Guidance recommends using a 7% real discount rate for present value analysis in most remedial action cost estimates. However, for federal facility sites being cleaned up using Superfund authority, EPA Guidance states that it is generally appropriate to apply real discount rates found in Appendix C of OMB Circular A-94. Suggested rates for federal facility sites are based on interest rates from Treasury notes and bonds and are appropriate because the federal government has a different cost of capital than the private sector. The most current version of Appendix C of OMB Circular A-94 (revised February 2002) proposes a real discount rate of 3.9% for programs with durations longer than 30 years. The 3.9% discount rate and constant dollars are used for the present value analysis of the ISV alternative. The present value of the ISV alternative is calculated using the equations provided in EPA Guidance.

VI. RISK AND UNCERTAINTY:

Further characterization and analysis of records are needed to better establish bounding conditions for safe and effective operations at individual melt settings. A preliminary review of the data shows a potential for excessive levels of combustible and alkaline materials, and perhaps inadequate soil at some melt settings. Spent fuel and sources with high ionizing radiation levels also may be encountered. A significant level of nonradioactive and radioactive treatability testing will be required in this alternative. This alternative will employ ISV and ISTD in unproven applications. Unique conditions for these technologies include high concentrations of potentially respirable plutonium powders in some waste containers, possible presence of spent fuel, high-gamma-energy sources, and gas cylinders. As previously discussed, a significant ISTD and ISV treatability test program has been assumed necessary to provide an adequate design and safety basis for implementing the alternative. Nevertheless, the total contingency for ISTD and ISV is assumed to be 50%.

Significant cost and schedule risks are associated with some of the materials proposed for additional soil coverage and the layers of the Modified RCRA Subtitle C cap. Increased haul distances also could increase by 50% the project schedule involving placing cover materials, depending on availability of additional trucks and the ability to manage them on the haul routes and on the site.

Processes and quantities for grouting activities have not been verified under actual site conditions. Because of the high level of uncertainty associated with grouting activities, the cost and schedule for these construction activities could increase by more than the 35% contingency applied to this technology.

VII. ESTIMATED MATERIAL VOLUME TABLES:

Tables 5 and 6 summarize the required materials for the Modified RCRA Subtitle C cover system and related design layers, thickness, and volume. Required materials for establishing and maintaining a minimum 10-ft soil cover during ISV, quantities of process materials consumed during ISTD and ISV, and quantities of treated secondary waste produced were defined earlier in the assumptions.

VIII. TABLES:

Table 1. Summary of remedial design costs as percentages of capital and operating costs.

Technology	Percentage of Capital and Operating Costs
Capping (Cover System)	6
In situ grouting	8
Foundation stabilization grouting	7
In situ vitrification	10

Table 2. Example feasibility study-level scope contingency percentages.

Remedial Technology	Scope Contingency (%)
Soil excavation	15 – 55
Synthetic cap	10 – 20
Clay cap	5 – 10
Surface grading and diking	5 – 10
Revegetation	5 – 10

Table 3. Summary of contingency costs as percentages of capital costs.

	Percent of Capital Cost		
Remedial Technology	Scope Contingency	Bid Contingency	Total Contingency
Capping	15	10	25
In-situ grouting	20	15	35
Foundation stabilization grouting	20	15	35
ISTD and ISV	25	25	50

ISTD = in situ thermal desorption
ISV = in situ vitrification

Table 4. Remedial Action/Remedial Design testing, design, and construction.

Activity Description	Estimated Duration
Waste records analysis	1.5 years
Site sampling and analysis	2 years (overlaps records analysis by 1 year)
Borrow source investigation	1 year (overlaps sampling and analysis by 1 year)
Technology testing	5 years
Remedial design and procurement	1.5 years (overlaps testing by 2 year)
Readiness assessment	1 year (no overlap with design)
Mobilization	0.5 year (no overlap with readiness assessment)
Pad A restaging	2 years (overlap with ISTD and ISV operations)
ISTD and ISV operations	15 years
Foundation and soil vault grouting	2 years (overlap with ISTD and ISV operations)
Grading fill and gravel placement	1 year (overlaps grouting by 1 year)
Asphalt, drainage, and filter layers	1 year (overlaps grading fill placement by 0.5 year)
Placement of remaining layers	1 year (overlaps clay, geomembrane, and filter by 0.5 year)
Vegetation establishment	2 years (no overlap with placement of cap layers)

ISTD = in situ thermal desorption
ISV = in situ vitrification

Table 5. Distances and sources of borrow materials for the modified Resource Conservation and Recovery Act Subtitle C cover system.

Material	Issue	One-way Haul Distance	Source
Topsoil	This material will consist of organic silt loam and will be used to construct a topsoil layer to support vegetation on top of the cover system.	1.5 mi	This material is assumed to be unprocessed organic silt loam derived from Spreading Area B.
Silt Loam	This material will be used to construct a number of the layers in the cover system including the general site grading fill, perimeter berm, and topsoil.	1.5 mi	The majority of this material is expected to be unprocessed silt loam derived from Spreading Area B. Additional material is available from Ryegrass Flats (haul distance = 12 mi) and the WRRTF borrow area (haul distance = 34 mi). If permitted, some of this material could be excavated from Spreading Area B (haul distance = 1 mi).
Gravel	This material will be used for the gravel gas collection, drainage, and coarse filter layers in the cover system. Sufficient quantities of good structural gravel and fines materials are available.	2.5 mi	This material is assumed to be processed gravel derived from the Borax Gravel Pit.
Sand	This material will be used for the fine filter layers in the cover system. No identified bank run borrow areas are available within the INEEL boundary.	45 mi	This material is assumed to be processed sand derived from an off-Site borrow source.
Riprap	Riprap will be used for erosion control. The majority of the mined riprap material at the INEEL has been used for other remedial actions.	5 mi	This material is assumed to be processed material mined from a basalt outcropping identified 5 mi from the site, directly west of the RWMC and just outside the Big Lost River System.
Coarse Fractured Basalt	This material will be used for erosion control. The majority of the mined coarse fractured basalt material at the INEEL has been used for other remedial actions.	5 mi	This material is assumed to be processed material mined from a basalt outcropping identified 5 mi from the site, directly west of the RWMC and just outside the Big Lost River System.

RWMC = Radioactive Waste Management Complex
WRRTF = Water Reactor Research Test Facility

Table 6. Modified Resource Conservation and Recovery Act Subtitle C cover system design layers, thickness, and volume.

Layer	Thickness	Approximate Volume[a]	Material Description
Topsoil with gravel	20 in.	296,000 CCY	Processed silt loam topsoil with pea gravel admixture from Spreading Area B
Compacted topsoil	20 in.	296,000 CCY	Unprocessed silt loam topsoil from Spreading Area B
Sand filter layer	6 in.	89,000 CCY	Processed sand from off-Site borrow source.
Gravel filter layer	6 in.	89,000 CCY	Unprocessed gravel from the Borax Gravel Pit
Lateral drainage layer	6 in.	89,000 CCY	Processed gravel from the Borax Gravel Pit
Low permeability asphalt layer	6 in.	89,000 CCY	Asphalt from an off-Site source in Idaho Falls
Asphalt base course	4 in.	59,000 CCY	Asphalt base course from an off-Site source in Idaho Falls
Gravel gas collection layer	6 in.	89,000 CCY	Processed gravel from the Borax Gravel Pit
Grading fill	120 in.	1,694,000 CCY	Unprocessed silt loam from Spreading Area B
Fine filter	12 in.	6,000 CCY	Processed sand from off-Site borrow source for cover system toe armor; 16-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V sideslopes
Coarse filter	12 in.	6,000 CCY	Processed gravel from Borax Pit for cover system toe armor; 16-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V sideslopes
Coarse fractured basalt	12 in.	6,000 CCY	Processed basalt mined from an INEEL site for cover system toe armor; 16-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V
Riprap	36 in.	18,000 CCY	Processed basalt mined from an INEEL site for cover system toe armor; 16-ft long; 3-ft thick; 10,000-ft perimeter; 2.5H:1V
Perimeter berm	NA	244,200 CCY	Unprocessed silt loam from Spreading Area A; berm average 6.5-ft high; 100-ft wide; 10,000-ft perimeter; 2H:1V

a. This table provides estimated in-place volumes rounded to the nearest 100 CCY.
CCY = compacted cubic yards

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE IN SITU VITRIFICATION ALTERNATIVE
(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: IN SITU VITRIFICATION (ISV) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/23/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
FFA/CO MANAGEMENT AND OVERSIGHT											
WAG 7 Management (23-Years)											
Coordination/Oversight Tech Support - 1.0 FTE/YR		NA			46,000	HR	$ 93	$ 4,265,120			$ 4,265,120
Coordination with Agency Participants - 0.5 FTE/YR		NA			234,000	HR	$ 93	$ 21,696,480			$ 21,696,480
Environmental Engineering - 1.0 FTE/YR		NA			46,000	HR	$ 76	$ 3,480,820			$ 3,480,820
Cost and Schedule Control - 2.0 FTE/YR		NA			92,000	HR	$ 59	$ 5,417,880			$ 5,417,880
Regulatory Compliance - 1.0 FTE/YR		NA			46,000	HR	$ 79	$ 3,634,460			$ 3,634,460
Quarterly and Annual Reviews - 1.0 FTE/YR		NA			46,000	HR	$ 73	$ 3,343,280			$ 3,343,280
Audit Preparation and Coordination - 0.5 FTE/YR		NA			23,000	HR	$ 79	$ 1,817,230			$ 1,817,230
Health and Safety Coordination/Training - 2.0 FTE/YR		NA			92,000	HR	$ 62	$ 5,733,440			$ 5,733,440
Annual O&M Reports - 0.5 FTE/YR		NA			23,000	HR	$ 79	$ 1,806,420			$ 1,806,420
Attorney/Legal Fees, 0.3 FTE/YR		NA			13,800	HR	$ 150	$ 2,070,000			$ 2,070,000
Allocation for Other Direct Costs (ODCs) - 10% of Total Labor		NA			NA					$ 5,119,513	$ 5,119,513
TOTAL COST - FFA/CO Management and Oversight											**$ 58,385,000**
Construction Management											
Construction Management (@ 6% of RA Costs)	6%	NA			1	LS	$ 58,328,340	$ 58,328,340			$ 58,328,340
General Conditions (@ 1.25% of RA Costs)	1.25%	NA			1	LS	$ 12,151,738	$ 12,151,738			$ 12,151,738
Health and Safety Equipment Allocation (@ 0.25% of RA Costs)	0.25%	NA			1	LS	$ 2,430,348	$ 2,430,348			$ 2,430,348
Medical Monitoring/Surveillance/Air Monitoring (@ 0.10% of Phase RA Costs)	0.10%	NA			1	LS	$ 972,139	$ 972,139			$ 972,139
TOTAL COST - Construction Management											**$ 73,883,000**
TREATABILITY STUDIES											
Treatment Treatability Studies, GROUTING (@ 5% of Grouting)	5%	NA			1	LS	$ 5,611,450	$ 5,611,450			$ 5,611,450
Treatment Treatability Studies, ISV & ISTD @ 15% of ISV/ISTD Costs	15%	NA			1	LS	$ 78,406,650	$ 78,406,650			$ 78,406,650
TOTAL COST - Treatability Studies											**$ 84,018,000**
REMEDIAL DESIGN AND REMEDIAL ACTION PLANS/REPORTS											
ISTD RD/RA Workplan (@ 10% of ISTD Capital/Operation)	10%	NA			1	LS	$ 12,319,000	$ 12,319,000			$ 12,319,000
ISV RD/RA Workplan (@ 10% of ISV Capital/Operation)	10%	NA			1	LS	$ 39,952,100	$ 39,952,100			$ 39,952,100
PAD (A) Excavation RD/RA Workplan (@ 10% of PAD A Capital/Operations)	10%	NA			1	LS	$ 8,884,400	$ 8,884,400			$ 8,884,400
GROUTING RD/RA Workplan (@ 8% of Grouting Capital/Operations)	8%	NA			1	LS	$ 8,978,320	$ 8,978,320			$ 8,978,320
Surface Barrier RD/RA Workplan (@ 6% of Surface Barrier Construction)	6%	NA			1	LS	$ 2,682,300	$ 2,682,300			$ 2,682,300
Readiness Assessment (@ 1.5% of Construction)	1.5%	NA			1	LS	$ 14,582,085	$ 14,582,085			$ 14,582,085
Remedial Action Report					7,500	HR	$ 76	$ 567,525			$ 567,525
TOTAL COST - Remedial Design											**$ 87,966,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE IN SITU VITRIFICATION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: IN SITU VITRIFICATION (ISV) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/23/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
REMEDIAL ACTION											
ISTD APPLICATION (17 acres)											
Capital Equipment Costs											
ISTD Off-Gas Treatment		6	EA	$ 725,000	NA				$ 4,350,000		$ 4,350,000
ISTD Off-Gas Treatment Support Trailers (Chillers)		6	EA	$ 250,000	NA				$ 1,500,000		$ 1,500,000
ISTD Equipment Capital Costs		1	EA	$ 5,256,620	NA				$ 5,256,620		$ 5,256,620
Electrical Power Supply/Overhead Powerline H-Frame		3	MI	$ 375,000	NA				$ 1,125,000		$ 1,125,000
Electrical Substation/Transformers for Site Distribution		2	EA	$ 125,000	NA				$ 250,000		$ 250,000
Operation Treatment/Disposal Costs											
ISTD Operational Costs (per acre)		17	AC	153103	17	AC	$ 4,030,658	$ 68,521,186	$ 2,602,751		$ 71,123,937
Power Consumption/Utilities		NA			NA					$ 7,768,000	$ 7,768,000
Installation/Pre-Operational Set-up/Testing (Percentage of Total Capital Costs)	10.0%	NA			1	LS	$ 1,508,437	$ 1,508,437			$ 1,508,437
Back-up Generators (Diesel Powered)		6	EA	$ 275,000	NA				$ 1,650,000		$ 1,650,000
Repair/Maintenance/Spare Parts (Percentage of Operating/Treatment Costs)	25.0%	NA			1	LS	$ 17,130,297	$ 17,130,297			$ 17,130,297
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 2,233,246	NA				$ 2,233,246		$ 2,233,246
D&D Cost for Equipment (Percentage of Capital Equipment)	10.0%	NA			NA					$ 1,248,162	$ 1,248,162
INEEL Site-Specific Training/Work Order Requirements		NA	NA		1	LS	5,631,220.08	$ 5,631,220			$ 5,631,220
Subcontractor Insurance/Bonds	2.0%	NA	NA		NA					$ 2,415,498	$ 2,415,498
Subtotal											**$ 123,190,000**
ISV APPLICATION											
Capital Equipment Costs											
ISV Off-Gas Treatment		6	EA	$ 315,000	NA				$ 1,890,000		$ 1,890,000
ISV Off-Gas Treatment Support (Chillers)		6	EA	$ 1,200,000	NA				$ 7,200,000		$ 7,200,000
ISTD Control Trailer		6	EA	$ 325,000	NA				$ 1,950,000		$ 1,950,000
ISV Equipment Capital Costs		1	LS	$ 33,997,476	NA				$ 33,997,476		$ 33,997,476
Electrical Substation/Transformers for Site Distribution		1	LS	$ 2,500,000	NA				$ 2,500,000		$ 2,500,000
ISV Operational Costs (MELTS)		1300	MT	$ 31,856	1,300	MT	$ 102,118	$ 132,753,400	$ 41,412,800		$ 174,166,200
Power Consumption/Utilities		1	LS	$ 32,600,000	NA				$ 32,600,000		$ 32,600,000
ISV Installation/Pre ops testing (% of capital costs)	10.0%			$ -	1	LS	$ 14,192,528	$ 14,192,528			$ 14,192,528
Back-up Generators (Diesel Powered)		6	EA	$ 45,833	NA				$ 275,000		$ 275,000
Repair/Maintenance/Spare Parts (Percentage of Operating/Treatment Costs)	25.0%	NA			1	LS	$ 33,188,350	$ 33,188,350			$ 33,188,350

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE IN SITU VITRIFICATION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: IN SITU VITRIFICATION (ISV) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
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BUILDINGS AND EQUIPMENT											
Administrative Buildings (Lunch Room and Change Room)		10,000	SF	$ 95	NA				$ 950,000		$ 950,000
Equipment Maintenance/Storage Area		10,000	SF	$ 175	NA				$ 1,750,000		$ 1,750,000
Decontamintation Area		5,000	SF	$ 150	NA				$ 750,000		$ 750,000
Treatment Facility		10,000	SF	$ 225	NA				$ 2,250,000		$ 2,250,000
Water and Chemical Storage Tanks		2	EA	$ 475,000	NA				$ 950,000		$ 950,000
Utility Piping/Gas Line		1	LS	$ 3,500,000	NA				$ 3,500,000		$ 3,500,000
GROUT STORAGE/DISPOSAL POND											
Subgrade Prep		3	AC	$ 2,500	NA				$ 7,500		$ 7,500
Berm Construction for Evap Pond		5,000	CY	$ 5	NA				$ 23,850		$ 23,850
HDPE Secondary Geomembrane		4,500	SY	$ 6	NA				$ 28,350		$ 28,350
HDPE Primary Geomembrane		4,500	SY	$ 6	NA				$ 28,350		$ 28,350
Geotextile Cushion		4,500	SY	$ 2	NA				$ 8,325		$ 8,325
SECONDARY WASTE TREATMENT											
Scrubber Solution/Storage Tanks (10,000-gal)		3	EA	$ 50,000	NA				$ 150,000		$ 150,000
Grout Storage Silo		1	EA	$ 275,000	NA				$ 275,000		$ 275,000
Pugmill Grouting		6,000	TN	$ 200	NA				$ 1,200,000		$ 1,200,000
Spent Activated Carbon/Disposal (55-gallon Drums)		1,000	EA	$ 250	NA				$ 250,000		$ 250,000
Secondary Waste Treatment System		1	LS	$ 8,900,000	NA				$ 8,900,000		$ 8,900,000
Secondary Waste Treatment System Operations Costs		15	YR	$ 2,300,000	NA				$ 34,500,000		$ 34,500,000
Scrubber Sludges/Amalgamation/Disposal Process (5-gal)		2,000	EA	$ 350	NA				$ 700,000		$ 700,000
Spent Acid Sorber Material (500-gal)		500	EA	$ 1,000	NA				$ 500,000		$ 500,000
Chemical Delivery/Storage		1	LS	$ 6,500,000	NA				$ 6,500,000		$ 6,500,000
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 6,350,501	NA				$ 6,350,501		$ 6,350,501
D&D Cost for Equipment (Percentage of Capital Equipment)	10.0%	NA			NA					$ 4,753,748	$ 4,753,748
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 15,401,588	$ 15,401,588			$ 15,401,588
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 7,833,735	$ 7,833,735
Subtotal											**$ 399,521,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE IN SITU VITRIFICATION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: IN SITU VITRIFICATION (ISV) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
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PAD A EXCAVATION											
Capital Equipment/Disposal Bins		1	LS	$ 7,620,000	NA				$ 7,620,000		$ 7,620,000
Building; RCS Materials and Erection		94,300	SF	$ 350	NA				$ 33,005,000		$ 33,005,000
Building; Radiological, Fire Protection, CCTV, HVAC		94,300	SF	$ 250	NA				$ 23,575,000		$ 23,575,000
Weather Enclosure (Assume 10% Larger Footprint)		103,730	SF	$ 65	NA				$ 6,742,450		$ 6,742,450
Over head Crane, Monitors, Misters		1	LS	$ 350,000	NA				$ 350,000		$ 350,000
Building Operations Costs		20	MO	$ 130,208	NA				$ 2,604,160		$ 2,604,160
Overburden Soil Removal/Stockpile		12,110	CY	$ 5	NA				$ 57,765		$ 57,765
PAD A Excavation and Waste Handling (2-years)		300	CD	$ 3,217	300	CD	$ 9,115	$ 2,734,500	$ 965,100		$ 3,699,600
Equipment Repair and Maintenance (10%)		1	LS	$ 96,510					$ 96,510		$ 96,510
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 227,547	NA				$ 227,547		$ 227,547
D&D Cost for Equipment	10.0%	NA			NA					$ 7,129,245	$ 7,129,245
Characterize TRU wastes for WIPP disposal (per drum)		20	EA	$ 1,500					$ 30,000		$ 30,000
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$1,964,454	$ 1,964,454			$ 1,964,454
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 1,742,035	$ 1,742,035
Subtotal											**$ 88,844,000**
GROUTING											
EQUIPMENT COST											
Capital Cost - Batch Plant, Vehicles, Drill Rigs		1	LS	$ 8,326,000.0	NA				$ 8,326,000		$ 8,326,000
Mobilize/Erect Weather Structure Grouting Operations		2	EA	$ 750,198.0	NA				$ 1,500,396		$ 1,500,396
HEPA Filtration System/Lighting/Redundant Systems		2	EA	$ 2,147,448.0	NA				$ 4,294,896		$ 4,294,896
Back-up Generators (Diesel Powered)		2	EA	$ 375,000.0	NA				$ 750,000		$ 750,000
Building Foundation Construction		30,277	LF	$ 561.0	NA				$ 16,985,397		$ 16,985,397
Bridge Crane/Control System		3	EA	$ 670,000.0	NA				$ 2,010,000		$ 2,010,000
Bridge Crane/Control System/Modify and Install		NA			1	LS	$ 1,005,000	$ 1,005,000			$ 1,005,000
D&D Cost for Equipment/Enclosures	10.0%	NA			NA					$ 3,386,669	$ 3,386,669
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 873,101	$ 873,101			$ 873,101
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 782,629	$ 782,629
Subtotal											**$ 39,914,000**
PRE-CONSTRUCTION ACTIVITIES											
Plug and Abandon (P&A) Existing GW Wells		NA			71	EA	$ 15,000	$ 1,065,000		$ 1,775,000	$ 2,840,000
Install New Nested GW Wells Outside Perimeter of Cap (Drilling Sub and Equipment)		NA			24	EA	$ 50,000	$ 1,200,000		$ 3,000,000	$ 4,200,000
Construct Rail Spur for Bulk Grout Delivery/Storage		1	LS	$ 1,200,000					$ 1,200,000		$ 1,200,000
INEEL Site-Specific Training/Work Order Requirements					1	LS	$ 164,700	$ 164,700			$ 164,700
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 168,094	$ 168,094
Subtotal											**$ 8,573,000**
OPERATIONS											
5-Foot Thick Cover Material (Initial Site Grading)		130,000	CCY	$ 10	NA				$ 1,300,000		$ 1,300,000
Grout SVRs		34	CD	$ 181,314	34	CD	40,902	$ 1,390,668	$ 6,164,676		$ 7,555,344
Grout Trenches Containing Activation/Fission Product Wastes		79	CD	$ 181,314	79	CD	40,902	$ 3,231,258	$ 14,323,806		$ 17,555,064
Foundation Stabilization Grouting (Remaining Non TRU Trenches)		128	CD	$ 99,763	128	CD	40,902	$ 5,235,456	$ 12,769,664		$ 18,005,120
Repair/Maintenance/Spare Parts (Percentage of Operating/Treatment Costs)	10.0%	1	LS	$ 3,325,815	NA				$ 3,325,815		$ 3,325,815
Grout Rig Decontamination		3	EA	$ 2,125,800	NA				$ 6,377,400		$ 6,377,400
HEPA Filtration System Operation		2	YR	$ 2,000,000	NA				$ 4,000,000		$ 4,000,000
Verification Testing Geophysical Survey		4	MO	$ 94,588	2,500	HR	$ 76	$ 189,175	$ 378,350		$ 567,525
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 2,035,959	NA				$ 2,035,959		$ 2,035,959
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 1,770,146	$ 1,770,146			$ 1,770,146
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 1,249,847	$ 3/21/2002 1,249,847
Subtotal											**$ 63,742,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE IN SITU VITRIFICATION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: IN SITU VITRIFICATION (ISV) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/23/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
SURFACE BARRIER											
PRE-CONSTRUCTION ACTIVITIES											
Borrow Source Site Investigation		1	LS	$ 250,000	NA				$ 250,000		$ 250,000
Spreading Area "B" 404 Permit Application (6-months)		1	LS	$ 200,000	NA				$ 200,000		$ 200,000
Surface Water Controls/Soil Erosion Sediment Control Features		1	LS	$ 250,000	NA				$ 250,000		$ 250,000
Site Preparation: Clear, Grub & Grade		125	AC	$ 3,800	NA				$ 475,000		$ 475,000
Construct 2-mile Haul Road from Borrow to Site (Stone Road)		2	MI	$ 500,000	NA				$ 1,000,000		$ 1,000,000
Install/Develop GW Wells for Compaction Water		3	EA	$ 250,000	NA				$ 750,000		$ 750,000
Subtotal											**$ 2,925,000**
CONSTRUCTION - MODIFIED RCRA SUBTITLE "C" CAP											
Pea Gravel Admixture with Topsoil 20-inches		296,000	CCY	$ 6	NA				$ 1,773,040		$ 1,773,040
Compacted Silt Loam (Topsoil) 20-inches		296,000	CCY	$ 5	NA				$ 1,411,920		$ 1,411,920
Sand Filter Layer 6-inches		89,000	CCY	$ 25	NA				$ 2,225,000		$ 2,225,000
Gravel Filter Layer 6-inches		89,000	CCY	$ 10	NA				$ 890,000		$ 890,000
Lateral Drainage Layer 6-inches		89,000	CCY	$ 10	NA				$ 890,000		$ 890,000
Low-Perm Asphalt 6-inches		89,000	CCY	$ 19	NA				$ 1,646,500		$ 1,646,500
Asphalt Base Course 4-inches		59,000	CCY	$ 19	NA				$ 1,091,500		$ 1,091,500
Gravel Gas Collection Layer, 6-inches		89,000	CCY	$ 10	NA				$ 890,000		$ 890,000
Fine Filter - Sideslopes, 12-inches		6,000	CCY	$ 25	NA				$ 150,000		$ 150,000
Coarse Filter - Sideslopes, 12-inches		6,000	CCY	$ 10	NA				$ 60,000		$ 60,000
Sideslope Rip-Rap 12-inches		6,000	CCY	$ 40	NA				$ 240,000		$ 240,000
Rip-Rap, Sideslope , 36-inches		18,000	CCY	$ 40	NA				$ 720,000		$ 720,000
Grading Fill, 10-ft Thick Average (Less post ISG decon fill)		1,564,000	CCY	$ 5	NA				$ 7,460,280		$ 7,460,280
Perimeter Berm		244,200	CCY	$ 5	NA				$ 1,164,834		$ 1,164,834
Install (37) New Lysimeters and Cap Penetrations		37	EA	$ 131,756	NA				$ 4,874,972		$ 4,874,972
OCVZ System Relocation/Well Exrension		1	LS	$ 300,000	NA				$ 300,000		$ 300,000
Lab Geotechnical Testing/Compaction		40	MO	$ 50,000	NA				$ 2,000,000		$ 2,000,000
Filed Geotechnical Testing/Compaction		40	MO	$ 90,000	NA				$ 3,600,000		$ 3,600,000
Surveying/Grade Control		40	MO	$ 65,000	NA				$ 2,600,000		$ 2,600,000
Third-Party Independent CQA Testing/Certification		40	MO	$ 75,000	NA				$ 3,000,000		$ 3,000,000
Hydroseeding/Mulching (Re-seeding Included)		125	AC	$ 2,750	NA				$ 343,750		$ 343,750
Seasonal Shutdown/Re-Mobilization		3	EA	$ 500,000	NA				$ 1,500,000		$ 1,500,000
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 805,136	NA				$ 805,136		$ 805,136
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	1,021,486	$ 1,021,486			$ 1,021,486
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 871,668	$ 871,668
Pre-Final Inspection Report, Phase I		NA			1	LS	$ 250,000	$ 250,000			$ 250,000
Subtotal											**$ 41,780,000**
Subtotal Subcontractor Directs - Remedial Action											**$ 768,489,000**
Subcontractor Overhead	15.0%										$ 115,273,350
Subcontractor Profit	10.0%										$ 88,376,235
TOTAL REMEDIAL ACTION COSTS											**$ 972,139,000**
TOTAL CAPITAL COSTS											**1,276,391,000**

Prepared by CH2M HILL

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE IN SITU VITRIFICATION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: IN SITU VITRIFICATION (ISV) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/23/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
POST-REMEDIAL ACTION OPERATIONS (100 YEAR DURATION)											
INSTITUTIONAL CONTROLS FOR 100 YEARS											
Install Permanent Markers/Survey		12	EA	$ 5,000	NA				$ 60,000		$ 60,000.0
Replace Perimeter Security Fence		10,000	LF	$ 20	NA				$ 200,000		$ 200,000.0
Repair and Replace Perimeter Signs		1	LS	$ 10,000	NA				$ 10,000		$ 10,000.0
Subtotal											$ 270,000.0
COVER MAINTENANCE											
Cover Maintenance Cost - 100 Year Duration Annual Cap Maintenance Costs		100	YR	$ 75,000	NA				$ 7,500,000		$ 7,500,000
Subtotal											$ 7,500,000.00
SURVEILLANCE AND MONITORING											
Groundwater Monitoring: (16-wells)											
Groundwater Monitoring, Quarterly for 2 Years - (8-Sampling Events)		8	EVT	$ 1,000	8	EVT	$ 11,000	$ 88,000	$ 8,000	$ 854,936	$ 950,936
Groundwater Monitoring, Semi-Annually for 3 Years - (6-Sampling Events)		6	EVT	$ 1,000	6	EVT	$ 11,000	$ 66,000	$ 6,000	$ 641,202	$ 713,202
Groundwater Monitoring, Annually for 95 Years (95-Sampling Events)		95	EVT	$ 500	95	EVT	$ 5,500	$ 522,500	$ 47,500	$ 5,076,183	$ 5,646,183
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 731,032	NA				$ 731,032		$ 731,032
Vadose Zone Monitoring:											
Sample 37 Lysimeters 1 Time per Year in Late Spring (Initial 5 years)		5	EVT	$ 1,000	100	EVT	$ 17,875	$ 89,375	$ 5,000	$ 133,585	$ 227,960
Sample 37 Lysimeters 1 Time per Year in Late Spring (95 years)		95	EVT	$ 500	100	EVT	$ 8,938	$ 849,063	$ 47,500	$ 1,269,058	$ 2,165,620
Sample & Analyze 20 Vapor Ports 4 Times per Year for 5 Years		20	EVT	$ 1,000	20	EVT	$ 27,500	$ 550,000	$ 20,000	$ 140,000	$ 710,000
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 310,358	NA				$ 310,358		$ 310,358
Surface Water Monitoring:											
Collect Sample from 2 Points 2 Times Every 5 Years (20 Sample Events)		20	EVT	100	20	EVT	$ 1,375.00	$ 27,500.00	$ 2,000	$ 320,660	$ 350,160
Vegetation Monitoring:											
1 Inspection per Year in Early Fall for 5 years		NA			5	EVT	$ 1,100	$ 5,500			$ 5,500
Re-seed 10 Acres Each Year for 5 Years (50 Acres Total)		50	AC	$ 15,000	NA				$ 750,000		$ 750,000
1 Inspection Every 5th Year in Early Fall Thereafter for 95 Years		NA			19	EVT	$ 1,100	$ 20,900			$ 20,900
Re-seed 10 Acres Every 5 Years		19	EVT	$ 15,000	NA				$ 285,000		$ 285,000
Air Monitoring (Radiological/Organic):											
Monitor 4 Existing CAMs		100	EVT	$ 1,000	1	LS	$ 2,200	$ 220,000	$ 100,000	$ 15,300	$ 335,300
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 33,530					$ 33,530		$ 33,530
Perimeter Radiological Monitoring GPS with NaI Detector											
2 People, 1-Time per Year, 2 Days in Summer with Hummer & GPS		100	YR	$ 500	100	YR	$ 2,200	$ 220,000	$ 50,000		$ 270,000
Data Interpretation/Plot Data		100	YR	$ 750	100	YR	$ 2,500	$ 250,000	$ 75,000		$ 325,000
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 59,500	NA				$ 59,500		$ 59,500
Biological Monitoring:											
2 People 2-Times, First 5-Years for Intrusion Monitoring		NA			2	EVT	$ 1,100	$ 2,200			$ 2,200
2 People 1-Time, Every 5th Year thereafter for 95 years		NA			19	EVT	$ 1,100	$ 20,900			$ 20,900
Subtotal											$ 13,913,000
Subtotal Surveillance and Monitoring (Sampling & Monitoring Activities)											$ 21,683,000
WAG 7 MANAGEMENT											
WAG 7 Management (@ 5% of other post-RA operations costs)	5%				1	LS	$ 1,084,150	$ 1,084,150			$ 1,084,150
Annual Data Summary Report (100 reports @ 200 hrs/report)					20,000	HR	75.00	$ 1,500,000			$ 1,500,000
WAG-Wide RA 5 Year Reviews for 100 Years (20 5-year reviews @ 600 hrs/review)					12,000	HR	$ 75	$ 900,000			$ 900,000
Subtotal											3,484,150
TOTAL COST - Post-Remedial Action Operations (100 Year Duration)											25,167,150

Prepared by CH2M HILL

3/21/2002

Attachment D-5

Operable Unit 7-13/14 Feasibility Study Cost Estimate for Retrieval, Treatment, and Disposal Alternative

The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost estimate are likely to occur as a result of new information and data collected during the engineering design, safety reviews, and remedial alternative. Major changes may be documented in the form of a memorandum in the administrative record file, an explanation of significant differences, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within –30 to +50 percent of the actual project cost.

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE RETRIEVAL, TREATMENT, AND DISPOSAL ALTERNATIVE

Project Title:	WAG 7 OU 13/14 Feasibility Study
Estimator	Brian K. Corb
Date:	December 2002
Estimate Type:	Planning
Reviewed/Appr:	Lee Lindig/Bruce L. Stevens

I. SCOPE OF WORK:

A. Remedial Design and Remedial Action

The RTD alternative involves the retrieval, ex situ treatment, and disposal of the onsite buried waste within the SDA. The scope of this alternative is similar to the in situ treatment alternatives, primarily encompassing burial sites containing the TRU waste from the RFP and MLLW (Pits 1 through 6 and 9 through 12, Trenches 1 through 10, and Pad A). Area and volume data for the TRU pits, trenches, and Pad A are provided in Table 1. The premise of this alternative is that TRU waste and soil retrieved would be characterized, treated as required to meet waste acceptance criteria (WAC), packaged, and transported to the WIPP for disposal. All other retrieved materials, including LLW and MLLW would be treated onsite to meet regulatory and risk-based requirements and placed in an onsite engineered disposal facility. The excavated pits and trenches would be backfilled as the retrieval action proceeds and systematically capped with a low-permeability modified RCRA Subtitle C cover. The onsite engineered disposal facility would be capped with an ICDF type cover that would be incorporated into the final Subtitle C cover over the entire SDA. Ancillary facilities and programs then would be established to maintain the covers and provide for the long-term monitoring.

As part of the RTD alternative, as with the ISG and ISV alternatives, the SVRs will be grouted in place before final capping. Additionally, remaining LLW trenches where activation and fission products (and other groundwater COCs) have been disposed of will be grouted to immobilize contamination before the cap is placed. The remaining pit and trench areas in the SDA (Trenches 12 through 58) will be foundation grouted to provide additional stability and prevent subsidence for the final cap.

The retrieval, treatment, and disposal of waste involve a relatively complex process. After the major paperwork portion of the alternative is complete (ROD, design and safety analyses, and procurement), the retrieval action will start, which includes the following main steps: site-preparation, in situ VOC extraction using ISTD, predesign characterization for soil stability and other design characteristics, constructing support buildings, removing clean overburden, constructing primary and secondary containment, establishing contamination controls and curtains, retrieving waste, segregating TRU and non-TRU waste and soil, treatment, characterization to meet waste acceptance criteria for disposal site, repacking material for disposal, transporting material to disposal site, constructing the onsite disposal facility, grouting SVRs and remaining LLW trenches containing groundwater COCs, constructing caps over SDA and onsite engineered disposal facility, installing controls, implementing institutional controls, groundwater monitoring, and cap maintenance.

B. Long-Term Monitoring and Maintenance

After the Remedial Action has been completed, long-term monitoring and maintenance will continue for 100 years, with CERCLA reviews conducted every 5 years. Long-term environmental monitoring will be conducted for groundwater, vadose zone water, surface water, and air. In addition, the cover system itself will be monitored annually during the first 5 years following completion of construction (beginning after the vegetation establishment period). With stabilized waste remaining onsite, a long-term groundwater-monitoring program would be required to verify the protectiveness of the remedial action. The evaluation assumes that this program would include several perimeter wells, which would be monitored on a quarterly basis for the first two years following completion of the remedial action. For the next 3 years, the wells would be monitored on a semiannual basis. Following completion of the 5-year review, the program presumably could be reduced to annual monitoring. After the completion of annual monitoring, the monitoring frequency will be reduced to every 5 years concurrent with the 5-year reviews required under CERCLA. The cover system will be monitored for vegetation density, erosion damage, and differential settlement. Areas of erosion damage will be repaired with additional topsoil and earth fill, and reseeded. Areas without established vegetation will be reseeded.

II. BASIS OF ESTIMATE:

The basis of the estimate was developed from the following sources to provide a defensible and comparative cost of the remedial alternatives. The applicable sources available for the ISG alternative include:

A. EPA 540-R-00-002, "A Guide to Developing and Documenting Cost Estimates During Feasibility Study," July 2000

B. INEEL, "Cost Estimating Guide," DOE/ID-10473 September 2000

C. "Environmental Assessment and Plan for New Silt/Clay Source Development and Use at the Idaho National Engineering and Environmental Laboratory," DOE/EA-1083, May 1997

D. Caterpillar Equipment Performance Handbook, 31st Edition

E. The INEEL Site Stabilization Agreement, Union Labor Agreement

F. Facilities Unit Costs—Military Construction, PAX Newsletter No. 3.2.2—10, March 2000

G. ICDF Construction Cost Estimate, Cap Construction Cost (CH2MHILL, December 2000)

H. Subject Matter Expert, R. Smith, WIPP Transportation Manager

I. Subject Matter Expert, J. Bradford, RFETS, Waste Management Department

J. Subject Matter Experts—M. Jackson, BBWI, and T. Borschel, BBWI, "Availability of Borrow Source Material at the INEEL"

K. Pit 9, RWMC, Cost Estimate (Building Data)

L. 710 Building Demonstration Project

M. BBWI INEEL Site Craft and Professional Services Labor Rates, February 2002

N. Advanced Mixed Waste Treatment Project (AMWTP) Construction and Operational Cost Estimate.

O. OMB, 2002, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Appendix C, "Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses," OMB Circular A-94, February 2002.

P. R. S. Means, 2002, *Heavy Construction and Industrial Building Unit Costs Data* 16th edition, Kingston, Massachusetts.

Q. INEEL Analytical Laboratory Unit Cost

R. Win Porter, Waste Policy Center conversation with Kira Sykes, CH2MHILL regarding the "Top-To-Bottom Review of the Carlsbad Field Office". Dr. Ines Triay, Carlsbad Field Office, August 29, 2001

S. DOE-ID, 2001, "Architectural Engineering Standards," Rev. 28, U.S. Department of Energy Idaho Operations Office, Idaho Falls, Idaho

T. DOE-STD-1020-96, "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities," U.S. Department of Energy, January 1996.

U. DOE O 420.1, "Facility Safety," U.S. Department of Energy, November 22, 2000

V. Loomis, G. G., A. P. Zdinak, and C. W. Bishop, 1997, *Innovative Subsurface Stabilization Project - Final Report,* Rev. 1. INEL-96/0439, Idaho National Engineering Laboratory, Idaho Falls, Idaho

W. Armstrong 2002, *Draft Operable Unit 7-13/14 Evaluation of In Situ Grouting*, Idaho National Engineering Laboratory, Idaho Office Operations, Idaho Falls, Idaho.

III. ASSUMPTIONS:

The primary work associated with the RTD alternative involves the retrieval, ex situ treatment, and disposal of onsite buried waste in the SDA. Additionally, grouting, capping, and monitoring are main components of this alternative. The following section includes the primary assumptions that identify and quantify technical and cost parameters to provide a basis for the cost estimate and bound the information based on available data.

A. Management and Oversight

A.1 Project Management for the BBWI oversight of this alternative has been estimated based on an average classification of job categories using the BBWI rates. The numbers of FTE are based on 2,000 MH per person per year.

A.2 The RD/RA schedule assumes that the budgetary funding will not be constrained.

A.3 The RD/RA schedule assumes no unexpected delays will result from changes to the USQ/SAR process.

A.4 The estimate assumes that the INEEL site resources (i.e., CFA, medical facilities, geotechnical laboratory, fire department, security, utilities at the SDA) will be available during the project.

B. Design and Preconstruction

B.1 The design will be developed in several initial phases to support early activities necessary for the remedial action—in situ VOC extraction and predesign characterization. These activities, once planned and designed, will be conducted in the field during the remedial design phase and in parallel with the remedial design and safety analysis documentation preparation.

B.2 Preconstruction activities—Borrow source investigations, cultural resource clearance, developing an onsite source of basalt rock, field-scale testing of jet grouting into waste, testing grout formulation, final design, readiness assessment completion, and mobilization.

B.3 For grouting, design activities will include integrating the drill mast and hydraulic head of the grouting equipment onto a mobile gantry crane and designing and specifying lights, camera systems, and radiation monitors. Grout formulations will be tested with surrogate and actual waste on bench scale to optimize formulations.

C. Capital Costs, Unit Rates, and other Pricing Assumptions

C.1 The unit prices have been developed from a crew build-up to process, load, haul, place, and compact. The volume of material represented in the cost tables identifies CCY. The appropriate factors convert the estimated unit material weights (bank, loose, and fill) and are factored into the equipment productivity.

C.2 Crew labor rates were developed based on hourly rates stipulated in the INEEL Site Stabilization Agreement. Labor and equipment spreads were developed based on the assumed achievable daily productivity to support the project schedule. Other factors that influenced the selection of labor and equipment quantities include safety, level of PPE of the work to be performed, haul routes, and availability of resources on the INEEL. Each daily crew cost also includes field oversight personnel such as the HSO, superintendents, foremen, CIHs, maintenance personnel, and allocation of supplies (e.g., fuel, oil, grease, and spare parts).

C.3 Primarily all capital equipment and pricing were selected from commercially available sources or similar projects allowing a scale factor to be applied to yield an estimated cost of the conceptual equipment and operational requirements. Equipment installation cost is considered to be a significant variable in estimating individual components of a given system. For the basis of cost, the installation cost of the capital equipment was based on a percentage of the capital costs ranging from 110 to 160% of the estimated capital expenditure based on the unknowns and level-of-complexity.

C.4 Subcontractors bond and insurance rate of 2% of the total subcontractor dollars includes overhead and profit based on each alternative.

C.5 The estimate includes an allocation for the INEEL specific work order PRD requirements and safety meetings. Because this estimate includes primarily unit prices, the labor cost is estimated to be 40% of the unit prices and, based on historical data, INEEL-specific process cost is approximately 6% of the total labor dollars.

D. Site Preparation and Support Activities and Facilities

The following assumptions have been made:

D.1 The Treatment Facility, Lag Storage, and the TRUPACT loading Facility likely will be constructed at a centralized location adjacent to the SDA.

D.2 The allowable soil-bearing capacity for the planned facilities will not impact the costs.

D.3 The existing utilities at or adjacent to the SDA are sufficient to support the planned facilities.

D.4 The estimate includes cost to construct local off-road haul routes for delivery of soil material for the cap construction. Costs for road maintenance on the INEEL and off-Site costs associated with the transporting the containerized waste to WIPP are not included in the estimate.

D.5 A grout batch plant will be set up near the SDA sized to produce a maximum of 500 yd^3 of grout per day.

D.6 Materials to formulate the grout will be shipped in from vendors by rail car. Access and transfer roads will be constructed to deliver the materials to the site.

D.7 Administrative and equipment buildings or trailers will be installed in the SDA to support operational controls, radiation controls, and personnel facilities.

D.8 In situ thermal desorption will be applied to areas of the SDA to pretreat waste with high concentrations of oils. These areas likely will comprise less than 1 acre of the SDA.

D.9 As described in the PERA, it is believed that for health and safety, as well as waste handling, it is advantageous to remove the VOCs before excavation. Approximately 1,000 tons of CCl_4 are known to have been disposed of within the SDA. The necessary VOC treatment would be accomplished through characterization and in situ VOC extraction using ISTD and off-gas collection. Early design efforts would be focused on preparing the necessary design documentation to perform the VOC extraction.

D.10 For the PERA estimate, it is assumed that in situ VOC extraction would require approximately two years for installation and operation to remove the mass of VOCs. This duration has been established to allow both the VOC extraction and predesign characterization to occur during the remedial design phase.

D.11 Predesign characterization will be conducted early in the remedial design phase to provide necessary data to complete the design. Soil stability and other physical design characteristics will be determined in this phase. Probing may be used to determine the thickness of clean overburden and general chemical and radiological concentrations to decide the amount of soil that may be used as clean backfill. Early design efforts would be focused on preparing the necessary design documentation to perform the characterization.

D.12 For the PERA estimate, it is assumed that the predesign characterization will require two years to acquire all the data necessary to support the design. For cost purposes, it is assumed that noninvasive probing and geoprobe equipment will be used.

E. Health and Safety

E.1 Presumably, all excavation work will be performed in Level B PPE. Productivities and crew labor have been adjusted to be representative of the expected level of effort. It is assumed that after the earthen fill is placed over the SDA, all earthmoving operations for the cover system can be performed in Level D.

F. Constructing Supporting Structures and Facilities

F.1 General Requirements—All buildings will be designed and constructed to the IBC. Frost depth for building foundations is 5 ft (DOE-ID 2001). The ground snow load of at least 35 lb/ft^2 shall be used in ASCE calculations and a minimum roof snow load of 30 lb/ft^2 shall be used for all buildings (DOE-ID 2001). Retrieval buildings and other structures shall not be designed for tornado loads (DOE-ID 2001). All structures shall be designed for PC 2 standards for wind, seismic, and flood design requirements. The PC 2 seismic return period is 1,000 years (STD-1020). The fastest wind speed for INEEL structures is 70 mph, and the 3-second gust wind speed is 90 mph (DOE-ID 2001). The design mean hazard annual probability for floods is 5E-04, or a 2,000-year return period (STD-1020). Fire protection systems shall meet or exceed the minimum requirements established by the NFPA and DOE O 420.1. Heating, lighting, and ventilation systems are required for all supporting structures, as human occupancy will occur in each of the buildings.

G. On-Site Engineered Landfill

G.1 The onsite engineered landfill is assumed to be similar to the design for the ICDF, and the landfill necessary for the RTD alternative will require two waste cells, one of which would be constructed before the retrieving any waste. The second cell is assumed to be located in an area that previously had waste disposal, and will be constructed following retrieving waste from that area. Both cells are to be constructed within the SDA. The necessary total capacity of the landfill is 250,000 yd^3, which would accommodate all MLLW and LLW and include volume increase to account for waste treatment and cover soil.

G.2 Construction of the disposal facility would require excavating the landfill cells, installing lining and leachate collection systems, and constructing leachate transmission, storage, and treatment systems. Table 2 provides the components and quantities assumed necessary for the bottom lining system, and for the side slope lining system.

G.3 Borrow sources for materials would be Spreading Areas B for the silt loam, which would require using a bentonite additive. Drainage gravel and the gravel operations layer will consist of processed gravel from the Borax Gravel Pit. Twenty 20-yd^3 trucks will be used to haul material; each truck will deliver 10 loads per day to the site.

G.4 The leachate collection, transmission, treatment, and disposal system will consist of perforated collection piping on the bottom of the landfill, a leachate collection sump and evaporation pond outside of the landfill, and transmission piping to the sump and pond. An estimated 1,200 ft of perforated 12-in. pipe and 500 ft of nonperforated 12-in. pipe are assumed for the disposal facility. The leachate collection sump would have a pumping system to transfer leachate to the evaporation ponds.

G.5 For this PERA, it is assumed that two ponds would be constructed with approximate surface dimensions of 200×350 ft, and average depths of 8 ft each. Table 3 provides the components and quantities for the evaporation pond liner systems. Borrow sources for the evaporation pond liner systems would be the same as described for the landfill.

H. Buildings and Structures

H.1 Administrative Buildings

Administrative building(s) are to be constructed for the RTD alternative. Existing administrative buildings at the RWMC will not be used because of their distance from the SDA, and the extended duration of the alternative. The administrative building(s) would be approximately 10,000 ft^2 to provide office space, meeting rooms, shift worker lockers with change rooms and showers, radiological control offices, and lunchroom space. With the large number of personnel, this size administrative building(s) is believed necessary. Project management, engineering, project controls, and other management/administrative personnel would be located in the administrative buildings. It is assumed that these personnel would not require significant medical monitoring.

H.2 Equipment Maintenance and Storage Area

The equipment maintenance and storage area is necessary for the RTD alternative. This building or buildings would be approximately 10,000 ft^2 and would house equipment such as fire trucks, forklifts, trucks, spare waste bins, PPE, and other equipment and supplies that will be used during the course of the remedial action. This building would have separate space for performing maintenance on the various pieces of equipment used by the RTD alternative, including, but not limited to, treatment facility equipment, retrieval facility equipment, and excavation. Based on the substantial amount of equipment, materials, and supplies required for this alternative, this size maintenance and storage area is necessary. Because equipment would be decontaminated before entry in this building, it is assumed that personnel would not require significant medical monitoring.

H.3 Decontamination Area

A building will be provided where equipment can be decontaminated. Because of the large equipment that would be used by the RTD alternative, several large decontamination areas would be necessary. For the this PERA, it is assumed that the decontamination building would be 5,000 ft^2 and that two large equipment doors would allow movement of heavy equipment into the building. Only standard decontamination equipment is needed. Personnel that work in the decontamination building would be included in the medical monitoring program, specifically for radionuclides.

H.4 Lag Storage Building

The lag storage building will be constructed to initially separate and store TRU and non-TRU waste before transfer to the treatment facility. Nondestructive assay (NDA) of the waste bins will be used to separate the TRU and non-TRU waste.

The lag storage facility should be sized with sufficient storage area to accommodate 16 weeks worth of retrieval (16 weeks $\times$ 4 days/week $\times$ 100 yd^3/day = 6,400 yd^3) in storage. Therefore, the lag storage facility, based on assumed waste packing fractions and waste bin sizes, is 70,000-ft^2. Optimally, the lag storage facility would be kept half full to ensure adequate volume for treatment should the retrieval operation be stopped, and sufficient storage space is available for retrieval waste should the treatment operation be stopped. The square footage allows for the equipment and shielding between the NDA equipment and the waste storage area, and allows for efficient movement of waste bins through the storage facility.

The lag storage facility will have a reinforced-concrete floor capable of withstanding loads of 2,000 lb/ft^2. Waste will be moved within the lag storage facility using forklifts; therefore, no overhead crane is necessary. It is assumed that ceiling heights of 15 ft would be adequate. Two large doors would allow entry and exit.

H.5 Treatment Facility

It is assumed that the existing AMWTP is representative of requirements for the TRU and non-TRU treatment facility with the addition of the steam-reforming component of the LLW treatment train. The construction and operational costs have been scaled based on the expected waste material feed rates.

The treatment facility will be separated into separate TRU and non-TRU processing areas. Based on expected waste volume and mass in comparison to those that will be processed by the AMWTP, it is estimated that the treatment facility required for the RTD alternative will be 130,000 ft^2, and two stories approximately 44 ft high. Table 4 lists the treatment equipment components and feed rates needed.

The off-gas system listed in Table 4 consists of the following components: quencher, venturi scrubber, packed bed scrubber, demister, reheater, catalytic oxidation, parallel HEPA filters, carbon filters, and parallel off-gas fans. The off-gas would then exit the stack of the treatment facility. The secondary liquid waste system listed in Table 4 is an evaporator that would evaporate the scrubber solution into a brine. The brine would require disposal.

The treatment facility would be designed and constructed as a Category 2 Nuclear facility and include negative pressure process areas, airlocks, multiple contamination control zones, cascading ventilation systems, multiple HEPA filtration on building and process exhaust streams, and continuous monitoring of emissions.

In addition to the treatment facility components, waste opening and sorting will be conducted remotely by facility operators. Gloveboxes, large and small manipulators, and sizing equipment will be necessary to handle the waste as part of the process. Personnel entry would be possible using Level A PPE but would not be part of routine operations.

Safety issues in the processing facility include: preventing and suppressing fire, preventing and mitigating explosion hazards, contamination controlling, radiation shielding, and normal industrial hazards. The facility would be designed and constructed to mitigate these hazards. Criticality control is not anticipated to be a concern in this facility (though it would be monitored) but would be investigated further in the design phase.

The cost estimate includes allowances for operational start up and testing for regulatory approval and provides a cost allowance to decommission the facility after use.

H.6 WIPP Transportation Storage

A secondary storage building must be constructed for the RTD alternative to provide storage space for waste shipments before transport to WIPP. Each drum of waste requires a 225-day wait following final packaging before it can be certified for transport to WIPP. Based on the expected TRU production rate, the WIPP Transportation Storage facility requires approximately 75,000 ft^2 and waste drums will be stacked three high. Waste stacking shelves are included in the cost estimate. This storage building is equipped with two large doors to allow for easy waste entry and exit.

The cost estimate includes capital cost to construct a TRUPACT loading facility and the necessary crew labor cost to load and assemble waste containers for transport to WIPP.

I. Retrieval, Ex Situ Treatment, and Disposal Assumptions

I.1 Overburden Soil Removal

Clean overburden, assumed to be the top 5 ft over all the TRU pits, trenches, and Pad A, would be removed. Table 1 lists the total volume of clean overburden as 113,000 m^3. The retrieval schedule indicates that the clean overburden would be removed in approximately 1 year. The overburden would be stockpiled, further characterized, and later used as backfill. No containment would be required for removal of this soil, as it is assumed clean. The stockpile location could be located outside the area of contamination if necessary. Stockpile management would occur during the entire RTD alternative duration, and would include run-on and run-off control, and wind control.

J. Construction of Primary and Secondary Containment Structures

J.1 The same general criteria for constructing the support facilities apply to the constructing of the primary and secondary containment structure. All buildings will be designed and constructed in accordance with the IBC. Frost depth for building foundations is 5 ft (DOE-ID 2001). The ground snow load of at least 35 lb/ft^2 shall be used in ASCE 7 calculations and a minimum roof snow load of 30 lb/ft^2 shall be used for all buildings (DOE-ID 2001). Retrieval buildings and other structures shall not be designed for tornado loads (DOE-ID 2001). All structures shall be designed for PC 2 standards for wind, seismic, and flood design requirements. The PC 2 seismic return period is 1,000 years (STD-1020). The fastest wind speed for INEEL structures is 70 mph, and the 3-second gust wind speed is 90 mph (DOE-ID 2001). The design mean hazard annual probability for floods is 5E-04, or a 2,000-year return period (STD-1020). Fire protection systems shall meet or exceed the minimum requirements established by the NFPA and DOE O 420.1.

J.2 The primary and secondary containment structure is a double-walled structure that would be erected over a pit or trench area. Pits that have an extremely wide span, such as Pit 5, would require using H-piles to construct a wall down the center of the pit on one side of the structure. The H-piles would be driven into the bedrock. The primary and secondary containment structure will be constructed to Nuclear Facility Category 2 standards.

J.3 The primary and secondary containment structure would be equipped with radiation alarm systems such as constant air monitors that would alarm when airborne contamination reached unacceptable levels. Criticality alarms would be installed in the primary containment structure. These alarm systems would require periodic testing and calibration.

J.4 The following is a listing of the number, size, and encompassed waste areas for each primary and secondary containment structure:

J.4.a Building 1 (Trenches 1, 5, 7, and 9): 1,180 × 176 ft

J.4.b Building 2 (Pits 1 and 2, divided down the middle, part 1): 115 × 950 ft

J.4.c Building 3 (Pits 1 and 2, divided down the middle, part 2): 115 × 950 ft

J.4.d Building 4 (Trenches 3, 4, 6, and 10): 1,140 × 140 ft

J.4.e Building 5 (Trench 2): 1,140 × 90 ft

J.4.f Building 6 (Pits 4 and 6): 1,430 × 140 ft

J.4.g Building 7 (Pits 10 and 11): 1,410 × 140 ft

J.4.h Building 8 (Pit 12): 115 × 300 ft

J.4.i Building 9 (Pit 3): 140 × 500 ft

J.4.j Building 10 (Pad A): 230 × 410 ft

J.4.k Building 11 (Pit 5, divided down the middle, part 1): 180 × 430 ft

J.4.l Building 12 (Pit 5, divided down the middle, part 2): 205 × 340 ft

J.4.m Building 14 (Pit 9): 140 × 390 ft.

J.5 It is assumed that as the remedial action is completed in a phased manner the containment buildings will be dismantled and collapsed into the excavated trenches and backfilled. A cost allowance of 25% of the capital expenditures of the building costs is assumed to be representative of the estimated level of effort to dispose of buildings and equipment.

K. Contamination Control at the Digface

K.1 Contamination control at the digface would consist of a series of moveable flame-retardant plastic and metals curtains similar to those used in the INEEL TSA to protect against leaking boxes. The curtains would be hung from a gantry crane from the ceiling of the primary and secondary containment structure. The gantry crane would also apply water, foams, and foggers to keep dust and contamination at a minimum within the retrieval operation. The crane would provide support for lifters, detectors, metal curtains, and other equipment.

K.2 The curtain system would incorporate a ventilation system and is assumed to provide adequate contamination control to allow the work to proceed. Negative pressure would be applied to the digface at all times and directed to HEPA filters to control contamination and keep it from entering the secondary containment structure.

K.3 The air exhausted from the retrieval zone would be fully saturated with water vapor because mist will be applied to control airborne contamination. Some water vapor would condense in the ductwork leading to the air treatment system. This condensate would be recycled through the retrieval-face misting system, as would other condensates. The air treatment system consists of chillers, demisters, heaters, and banks of HEPA filters in two parallel systems to provide redundancy if one system failed. The chillers would cool the air, which would decrease the dew point and cause mists to form. The air would then pass through a demister, which would remove moisture from the air. The air would then pass through heating elements to raise the temperature to about 10°C above dew point. The air would then pass through the HEPA filters.

K.4 Water will be used to control dust within the containment structure, however, this may have an impact on moderator control with respect to criticality. Another substance may be required and is not included in this cost estimate.

K.5 The cost estimate includes stand-by excavation and sizing equipment that can be rotated out for maintenance and equipment difficulties to minimize productivity loss.

K.6 The curtains also would be equipped with an air lock system to move drums and waste out of containment. The design of the air lock systems would be similar to those used in nuclear facilities.

K.7 Dust suppression would be accomplished by keeping the soil relatively moist and operating the retrieval equipment carefully to minimize waste disturbance. Aerosol foggers, sprays, and foams would be available in case additional contamination control is needed during excavation.

K.8 The moveable metal curtains hung from the gantry crane would move with the excavation to provide for a contained environment. The curtains would be decontaminated by fixation or by using strippable coatings. Personnel entry would be through the airlock system and by using water, misters, foggers, and venting.

K.9 The need for foggers, sprays, foams, and demisters is not known for this type of operation. Estimates are based on the amount of water required for construction dust control practices.

K.10 The curtain contamination control system can accommodate any potential variability of the depth excavation resulting from waste depth or depth to the basalt interface.

K.11 The excavation and sizing equipment operating within the containment structures will be diesel powered and the exhaust from equipment will be captured as part of the building HEPA filtration system.

L. Soil and Waste Excavation from Pits, Trenches, and Pad A.

The following are assumptions for the PERA:

L.1 An excavator and an operator would be used to retrieve waste from the pits and trenches by benching down and then removing the waste from an at-grade position. The sidewalls of the excavation would be sloped to Occupational Safety and Health Administration regulations.

L.2 A modified manually operated excavator would be used to retrieve waste and impacted soil. Modifications would include a hermetically sealed cabin (sealed and positive pressure) with either a HEPA filtration system that would supply filtered air to the cabin and the engine compartment or a complete supplied-air system. Anticipated airborne concentrations and other safety factors would dictate which air supply system to use. In some instances, shielding would be required on the equipment to protect the worker from radiation being emitted from the source. The operator would be in PPE with a facemask and supplied air. The excavator may have air supply tanks attached to the inside of the cabin with an emergency escape pack also in the cab. The operator would move into the cab through a control area with a door. Contamination control would be available if an emergency exit was warranted and the operator had to leave the excavator when inside the containment.

L.3 For pits and trenches the thin soil layer over the waste (approximately 1 ft thick) and the waste itself (approximately 20 to 30 ft thick) would be retrieved as one waste matrix. Although this thin soil layer is potentially clean, the amount of time and money required to characterize this moist and silty soil to determine how to handle it makes it more cost effective to deal with as waste.

L.4 As the digface progressed, the excavator carefully would pick at the digface using a small bucket (or other end-effectors) and would put the waste and the potentially clean overburden into soil bags or waste bins (lined with a poly-sack). Fire suppression systems, water misters, fogging material, and other contamination control devices would be hung from a gantry crane running the length of the containment. As waste is removed, the digger would keep the contents of each bin as homogeneous as possible (presorting), while trying to minimize actions that might increase the risk of contaminating the primary containment.

L.5 Wastes that would require cutting or sizing to fit in the bins would be temporarily set aside for another piece of equipment to handle. The second piece of equipment would also be manned and would use the necessary end-effectors to size the waste. This additional piece of equipment would be operated at the same time and for the same duration as the excavator.

L.6 If an item were not sizeable (e.g., tanks, trucks, reactor vessels, and heavy machinery) by using the second piece of equipment, it would be removed from the digface and relocated to a nearby location (out of the way) until a treatment method (or some other remedial action) could be identified.

L.7 Binned waste would have a lid placed on the top and would be sprayed down to decontaminate the outside of the container (another gantry crane would have end-effectors used for decontamination). All of the water would be collected and recycled through the system. Once the bin was decontaminated, it would be transferred out of the digface area through an airlock. Containers would be swabbed to ensure they were appropriately decontaminated. Bins would be sent to lag storage where they would await further segregation and treatment.

L.8 For the trenches, the same approach would be taken as for the pits described above. Several of the trenches are in a line about 8 ft from each other. The containments would be built over several trenches at one waste site and the excavation would systematically remove the waste and leave the clean soil between the trenches for use as backfill. The waste face would be advanced approximately 15 ft and the clean soil between the trenches would be excavated and used as backfill in the trenches behind the equipment. The containment structures and supporting equipment are the same as described above for the pits. In some instances, SVRs or other obstacles would be located in between trenches. To avoid excavation of these areas, sheet piling may be used to isolate the area.

L.9 Pad A would be excavated using a slightly different approach than would be used in the pits and trenches because it is an aboveground site with relatively intact drums and deteriorated boxes. Equipment would include standard excavation equipment such as a backhoe and front-end loader. Also, curtains would not be used to isolate the digface because of the physical layout of the pad (it is an aboveground structure with sufficient height to almost reach the containment roof in some locations). Based on previous remedial actions and evaluations of waste container integrity, the waste containers (plywood boxes and 55-gal drums) may not be structurally intact.

L.10 A production rate of 100 yd^3 per day has been determined to be feasible for the RTD alternative. This production rate would be the annual average, assuming that work was conducted for 200 days each year. The crew necessary for the retrieval operation is assumed to be approximately 25 workers working 4 days per week, 10 hours per day. The number of working days per year (200) allows for downtime in the retrieval zone for equipment maintenance. The number of hours required for annual maintenance is estimated to be 20% of the total required for active retrieval. Waste retrieval is expected to take 16 years, assuming that as one pit or trench area is complete, work can begin within the next primary and secondary containment structure almost immediately.

L.11 Personnel that work in the primary and secondary containment structures would be enrolled in an extensive medical monitoring program, particularly for radionuclides. Whole body counting and fecal assay programs for these employees would be necessary.

L.12 The TRU and non-TRU waste streams can be segregated by appearance at the excavation work face, and will not impede the assumed production and estimated waste volume.

L.13 Based on information from the OU 7-10 Glovebox Excavator Method Project, there would be no free water and criticality concerns in the waste matrix.

L.14 Waste boxes/bins, poly liners, and overpacks will be used to package waste and move it from the primary and secondary containment structure to lag storage, and ultimately, to the treatment facility. The total volume of waste and soil that will be retrieved is approximately 230,000 m^3 and the waste box/bin size is 4 × 4 × 7 ft. A 0.9 loading factor is used for the waste bins. The total number of poly liners needed is 84,400. The total estimated number of waste boxes and bins that are needed is 20,000; it is assumed that 10,000 will become too contaminated to reuse and 10,000 will be able to be reused throughout the project. The cost estimate assumes that 25% of these waste bins are fitted with shielding to protect against high gamma-emitting waste. One waste box/bin will be placed into an 8 × 6- × 5-ft overpack. The number of overpacks required is 2,150, which allows for 20 weeks of operation before the overpack is returned to the retrieval area. These waste bin sizes and estimated quantities are based on assumed operations and would be refined during the remedial design.

L.15 The number of overpacks required is 2,150, which allows for 20 weeks of operation before the overpack is returned to the retrieval area. These waste bin sizes and estimated quantities are based on assumed operations and would be refined during the remedial design.

M. Digface Monitoring

M.1 Monitoring at the digface would include gamma-radiation, simple chemical testing, and health and safety monitoring only because earlier characterization results, availability of shipping records, and using the observational approach during excavation should prove adequate for safe and productive retrieval. Therefore, the only characterization that would be performed at the digface would be for protection from gamma radiation. This would require a gamma detector near the digface to detect excessive radiation levels. The gamma detector would be hung from the gantry crane or other similar support structure. This would help determine whether the waste containers needed to be shielded or unshielded for safe handling. Safety monitoring would include VOC, visual, fire, explosion, and criticality monitoring.

M.2 The equipment operators also would have to wear a thermoluminescent dosimetry/ dosimeter and pocket dosimeter with criticality monitor. VOC monitoring at the digface will be performed only for maintenance-requiring manned entry into the area. Samples of the waste or soil would only be collected at the digface in event-driven situations (i.e., visual occurrence of chemical reaction or other unusual behavior that would be considered nonroutine).

N. Lag Storage

N.1 Operations in the lag storage facility would consist of receiving waste from the retrieval operations in waste bins. Initial NDA of the waste bins would occur in the lag storage facility to provide a coarse separation of the TRU and non-TRU waste streams. Once separated, the TRU and non-TRU bins would be stored in the lag storage facility until they are taken to the treatment facility. It is estimated that a crew of 10 would be necessary in the lag storage facility to operate the NDA equipment, perform waste inspections, and perform waste movement within the facility following the NDA. Operation of the lag storage facility would last 16 years, based on receiving 100 yd^3 of waste every day for 200 working days of each year. Lag storage would operate using the first in, first out inventory process to keep waste moving through the facility. Employees working in the lag storage facility would be part of the medical monitoring program but may have diminished frequency of testing because of the reduced radiological hazard of this building.

O. Ex Situ Treatment, Processing, and Repackaging

O.1 Common facility components—All retrieved waste and soil would be transferred from lag storage to the treatment facility. There, the waste would be removed from the containers and would undergo a more accurate assay and be separated into TRU and non-TRU waste streams. Each waste stream would undergo different examination and treatment.

O.2 The treatment facility has a common area with the remainder divided into two major process areas—one for the TRU waste (TRU processing facility) and the other for the non-TRU (non-TRU processing facility). These two completely separate facilities each have process equipment, ventilation systems, and contamination control zones. The common area would provide for the following functions: initial presorting, TRU and non-TRU waste separation, utilities, control rooms, data processing, and administration.

O.3 All processing of exposed waste would be performed using remotely operated equipment. Manipulators, conveyors, and gloveboxes would be employed as necessary. Although provisions would be made for manned entry into processing cells using Level A PPE, this only would be used for nonroutine O&M. In some non-TRU processing areas, personnel entry using lesser protection may be allowed if the surface and airborne contamination levels are sufficiently low.

O.4 The treatment facility is assumed to operate 330 days per year on a 24-hour/day, 7-day/week basis. One month is allowed annually for scheduled maintenance and a 75% availability factor (that is, the system is down 25% of the time) has been applied to take into consideration unexpected problems. With this schedule, the facility would process approximately 60 yd^3 per day. It is assumed the waste would be transported to the processing facility in 4 × 4 × 7-ft bins that have been overpacked in 8 × 6 × 5-ft containers. Approximately 16 overpacks with their inner boxes and bins of waste would arrive at the facility daily. Table 5 provides the estimated quantity of waste and soil and associated treatment rates to process waste in the treatment facility.

O.5 Estimated capital and treatment operations costs associated with the TRU and non-TRU treatment process considered under the RTD alternative have been scaled upward from the AMWTP. This similar process treatment facility provides a knowledgeable source of information assumed to be appropriate for this estimate. Cost uncertainties associated with further safety and hazard analyses, which will be conducted as part of the design progression, may identify other unknowns that may impact the cost. The potential for a cost variance associated with unknowns is considered for both the remedial action and long-term O&M by applying an assumed contingency based on the complexity of the given alternative.

O.6 Because of the volume of waste being shipped to the treatment facility, multiple parallel process lines, each with its own loading dock, would be required. Two options exist for transferring waste into the waste processing facility. In the first option, overpacks would pass directly through an air lock and into a presorting cell. At this location, the lid would be removed remotely from the waste overpack and the 4 × 4 × 7-ft bin containing the waste would be removed from the overpack onto a presort table. The empty 4 × 4 × 7-ft bin would be placed back in the overpack and the lid reattached. The overpack then would be moved to a decontamination cell where the exterior surface of the overpack would be decontaminated. After a final survey, the overpack would pass back out through another airlock to a receiving truck that would return the overpack containing the 4 × 4 × 7-ft bin/box to the retrieval site for reuse.

O.7 In the second option, the waste overpack would be mated to a transfer port and the lid would be removed. Remotely operated equipment would be used to transfer the 4 × 4 × 7-ft box or bin containing the waste to the presort table. After the box or bin was emptied, it would be returned to the overpack. The lid would be reattached to the overpack and disconnected from the mating port and returned to the retrieval site via truck.

O.8 The waste would now be in the presort cell, which puts the waste into a condition for assay and for subsequent division into TRU and non-TRU waste fractions. This may include a rough further separation of soil from the larger waste materials. It also could include opening selected drums or other containers to accommodate specific assay equipment requirements. It also could include limited sizing. The degree of size reduction necessary to allow for accurate assay would be determined during design.

O.9 From the presort cell, the waste would pass into the separation and assay cell. In this cell, assay equipment would further separate the waste and soil into two streams. Material containing greater than 100 nCi per gram (TRU) would be sent to the TRU processing area of the facility. Material containing less than 100 nCi per gram would be sent to the non-TRU processing area. Radioassay equipment would include segmented gate conveyor systems for the soil and smaller waste sizes that can be placed on conveyors at approximately 2 in. deep. This system is capable of assaying at a 100 nCi/g level at a rate of 22 tons per hour, and diverting the waste into two streams. The large-size waste would be placed into a favorable configuration for counting and assayed with equipment similar to the box and drum counter currently being used in other DOE facilities.

P. Transuranic Processing Facility

P.1 Estimated capital and treatment operations costs associated with the TRU and non-TRU treatment process considered under the RTD alternative have been scaled upward from the AMWTP. This similar process treatment facility provides a knowledgeable source of information assumed to be appropriate for this estimate. Cost uncertainties associated with further safety and hazard analyses, which will be conducted as part of the design progression may identify other unknowns that may impact the cost. The potential for a cost variance associated with unknowns is considered for both the remedial action and long-term O&M by applying an assumed contingency based on the complexity of the given alternative.

P.2 The treatment facility required for this alternative is roughly two to five times larger than the AMWTP, depending on whether the comparison is made on a by-volume or by-mass basis. Twenty-four hour, daily operation of the treatment facility, which is necessary for the RTD alternative, still requires 16 years for project completion. The waste retrieval has been developed to keep pace with the treatment facility because significant storage capacity between retrieval and treatment would be extremely costly.

P.3 The purpose of the TRU processing area will size, treat, characterize, and package the TRU fraction of the waste to meet transportation requirements and the WIPP WAC. Minimal treatment is expected to be required for the TRU waste compared to the non-TRU waste. The waste and soil sent to the TRU processing area would first enter opening and sorting cells. The waste would be in numerous physical and chemical forms. In the opening and sorting cells, waste would be removed from any container (most retrieved drums and boxes are expected to be in a state of deterioration), visually inspected, sampled for chemical composition as necessary, and sorted for downstream processing. The inspection process would identify and remove or treat prohibited items including liquids, pyrophoric materials, explosives, pressurized cylinders, material requiring neutralization, and flammable materials.

P.4 Real-time radiography would be used to provide information to assist in opening any intact waste containers that might contain prohibited items. Prohibited items that could be detected by the radiography include liquid waste and gas cylinders. Downstream processing would include adding absorbents for any free liquids, chemical neutralization of acids and caustics, and super compaction of selected waste to reduce the waste volume. Size reduction would be performed as necessary to allow efficient repackaging of waste in 55-gal drums. Other containers may be approved for disposal at WIPP when this project is started. It is envisioned that much of the TRU processing area would be of similar configuration and use process lines and equipment similar to that found in the AMWTP.

P.5 Based on the number of operations personnel required for operations at the AMWTP (approximately 200), and the increase in size for the treatment facility for the RTD alternative, it is estimated that a 500 employees will be needed to operate all aspects of the AMWTP operations, which include loading TRUPACT II containers for shipment to WIPP. These employees would be split into four shifts so that 24-hour, 7-day-per-week operation could be attained. Employees would work 40 hours per week and the treatment facility would operate for 330 days per year. The remaining time during the year would be spent performing routine maintenance on the equipment.

P.6 Treatment operations will require a significant amount of infrastructure development to support either of these alternatives in supplying an adequate amount of power, water, and gas to implement these remedial alternatives. Estimated power costs have been included, however, peak demand surcharges have not been considered at this time. The treatment facility proposed for the RTD alternative would require additional infrastructure development costs to support the treatment facilities, TRU, and LLW, and these have not been included.

Q. Non-Transuranic Processing

Q.1 The purpose of the non-TRU processing area will process, characterize, and package the non-TRU fraction to meet the WAC for disposal in an onsite engineered disposal facility, designed in to the RCRA Subtitle C standards. Because the retrieved waste and soil is known to contain RCRA-regulated hazardous chemical contaminants, it must be treated before disposal and meet regulatory and risk-based levels. These treatments would include chemical, physical, and thermal processes to remove hazardous organics and provide stabilization for fixation of regulated metals and radionuclides. It is assumed that a large fraction of the total non-TRU waste would require thermal processing.

Q.2 In a similar fashion to the TRU processing area, the waste and soil sent to the non-TRU processing area would first enter an opening and sorting cell where it would be segregated into additional streams for processing. The waste would be screened to separate soil and smaller debris from larger pieces of waste. Some minor crushing and drying may occur at this point to reduce soil clumps so they would pass through the screen or grizzly separator. The larger fraction would be separated using remote equipment into categories based on their shredability. The degree of separation and sizing required would be a function of the final selection of thermal treatment equipment used. Large industrial shredders would be employed to size the material as necessary.

Q.3 This PERA assumes that steam reforming or another thermal treatment process would be used to address the organic constituents within the waste stream. Estimated costs are based on costs for incineration. It is assumed that a wet scrubbing system with some heat recovery is used. The scrubbing system would consist of quencher, venturi and packed bed scrubbers, and a mist eliminator followed by a reheater.

Q.4 The off-gas stream would finally pass through HEPA and carbon filter trains, induced draft fans, and be discharged to a stack. The off-gas volume would be considerably less than that from a comparable incinerator. The off-gas emissions would be monitored continuously. A destruction efficiency of 99.99% is achievable for organic materials using thermal treatment.

Q.5 All of the non-TRU would need to be thermally processed caused by the wide dispersal of RCRA-regulated organic materials disposed of in the SDA.

Q.6 After processing the waste via thermal treatment, the resulting residue is similar to ash from an incinerator. This residue would be stabilized using either Portland cement grout or sulfur polymer cement. Both agents have been found to be effective in stabilization and can meet applicable land disposal restrictions for waste disposal of ash and soil containing RCRA-regulated metals and radionuclides. Exact formulation and quantities of agent to be used would be determined during the design phase of the project. The stabilized waste would be placed in 55-gal drums, or other larger specially designed containers for oversized waste, and transported to the onsite disposal facility.

Q.7 Secondary waste generated from non-TRU treatment would include scrubber blowdown solution, filters, and waste generated during routine O&M activities. The scrubber solution would be evaporated and the resulting salts and residue would be stabilized and solidified and sent to the engineered storage facility with the other processed non-TRU waste. All other material would be processed through the facility with the exception of carbon filters containing low vapor point metals that might continue to recycle through the process. These filters would be packaged to meet the onsite disposal facility acceptance criteria and would be disposed of at this facility.

Q.8 The operational costs for the non-TRU treatment have been included in the TRU treatment operational costs scaled from AMWTP costs.

R. On-Site Transportation and Disposal Operation

R.1 The disposal facility will accept LLW and MLLW from the treatment facility that meets the WAC of the landfill. It is assumed that the majority of the waste requiring disposal will be treated and stabilized with cement. Stabilized waste will be delivered to the site primarily in 55-gal drums, 4 × 4 × 4-ft boxes, or 4 × 4 × 8-ft boxes. Some bulk disposal of contaminated soils and other waste may occur if these untreated waste meet the WAC. The disposal facility will also accept solid residues from the evaporation ponds.

R.2 Wastes will be placed in the landfill in 5- to 10-ft lifts. Large, bulky materials or containers will be placed carefully in the disposal area to minimize the potential for damage to the bottom or side slope lining systems. Clean soil will be used periodically to cover waste or to stabilize containers as they are placed in the disposal area. Approximately 250,000 yd^3 would be disposed of at the landfill. It is assumed that the waste treatment and disposal operation will continue for 16 years, after which time the disposal facility will be closed.

R.3 The disposal facility would be closed by grading the surface with earthen fill and constructing a cap similar to the one proposed for the Surface Barrier alternative. It is estimated that closure of the onsite disposal facility would be completed in two years. An additional two years would be required to sufficiently establish the necessary vegetation on the topsoil layer. The surface barrier cap for the disposal facility would consist of the components and approximate quantities provided in Table 6.

R.4 Earthmoving, placement, compaction operations, and facility operations costs for the landfill are structured by assuming a standard crew to implement the identified task. Additional costs have been considered for compaction water well installation and development, surveying, and third-party independent construction quality assurance for the surface barrier and Modified RCRA cap. Unit rates for each earthen material source were developed considering the identified borrow source on the INEEL including Spreading Areas A and B. If either of these borrow sites is not available as a result of insufficient quantity or quality of material because of material variability or availability, the unit cost could increase significantly as a result of a longer haul route. Furthermore, the unit rates for all the surface barrier construction would be conducted in Level D PPE, with no surface radiological concerns. All of the natural borrow source material is assumed to be mined from the INEEL.

R.5 Closure would also involve decommissioning one of the evaporation ponds. Decommissioning would include removing lining materials and filling the pond to grade with earthen fill. Approximately 8,000 yd^3 of liner material would be removed from the pond and placed in the disposal facility before closure. Approximately 28,500 yd^3 of earthen fill would be placed in the evaporation pond area to fill the depression left by the pond. One of the ponds would remain operational to collect and evaporate any leachate that accumulates in the disposal area after closure. after the second pond stops receiving leachate, it also would require decommissioning. The second pond's liner material would require off-Site disposal. The volumes for closure of the second pond would be the same as the volumes of the first pond. It is assumed that the waste would be considered MLLW.

S. Off-Site Transportation and Disposal

S.1 Waste that meets the WIPP WAC would be disposed of at WIPP, near Carlsbad, New Mexico. It is estimated that approximately of 73,000 yd^3 of retrieved waste and soil would be shipped to WIPP for disposal. The following assumptions apply to WIPP transportation for the RTD alternative:

S.2 Based on the total number of drums and anticipated transportation weight restrictions and compaction, the number of WIPP shipments is estimated to be approximately 7,400. The overall schedule for WIPP shipments is 16 years, which assumes that waste transportation will occur for 240 days each year. Therefore, approximately two daily shipments to WIPP are necessary.

S.3 Each waste shipment will transport three TRUPACT II containers with a maximum of 36 drums to address vehicle loads limits.

S.4 Costs for TRUPACT II containers and transportation to WIPP and waste disposal are not included in this PERA cost estimate. It is assumed that these costs are covered by the WIPP facility, including the TRUPACT containers and transportation costs from the INEEL.

S.5 The generalized WIPP certification process is described in the PERA text. The time required to implement an acceptable program and be granted certification authority is largely dependent on the complexity of the program being implemented, the funding for site activities and the scope of the certification audits. The cost estimate does not include a certification allowance of SDA waste for transport and disposal at WIPP.

S.6 Three characterization activities must be available to ensure that TRU waste has been adequately characterized so that it can be certified for transportation and disposal in the WIPP. These characterization techniques are further described in the PERA text and include:

S.6.a. Visual Examination

S.6.b. Nondestructive Assay

S.6.c. Headspace Gas Sampling

S.7 It is assumed that the cost for WIPP characterization of TRU drums is \$1,500/drum, based on the 3100 m^3 Project at the INEEL.

T. In Situ Grouting

T.1 Grouting will be performed for the SVRs and the groundwater COC disposal locations in the LLW trenches, and for the remainder of the SDA to provide a foundation for the final cover. Grouting would be performed in the same manner as that described in the ISG alternative. The grouting operation would be performed concurrent with waste retrieval so that the entire SDA would be ready for capping when retrieval is complete. Grouting of the SVRs and the COC disposal locations in the LLW trenches would be performed to immobilize contaminants, whereas grouting of the remainder of the SDA is needed only to provide an adequate foundation for the cap to prevent subsidence. The foundation grouting will have approximately 75% fewer grout holes than what is required for immobilization grouting.

T.2 Grouting operations will be conducted within a weather enclosure to facilitate Radiological Control. Two sprung-type structures will be mobilized to the site. These structures initially will be constructed and then progressively disassembled and reconstructed as required to accommodate the advancement of the ISG operation. Following completion of the grouting operation within an enclosure and before disassembly of building, the grouted area will be covered with a minimum of 2 ft of earthen fill.

T.3 It is estimated that those areas with high concentrations of organic oils comprise a total area less than 1 acre. For these areas, ISTD will be applied to pretreat the oils. The cost basis for ISTD is presented in previous sections. The presence of high concentrations of nitrate salts in Pad A precludes effective ISG.

T.4 It is assumed that the grouting equipment, enclosures, and excavation and placement equipment will be dismantled and disposed of under the cover system. Twenty-five percent of the operational and no additional cost for D&D&D is included in the estimate.

T.5 To account for inefficiencies caused by routine and nonroutine delays (e.g., radiation surveys, instrument calibration, breakdowns, and donning and doffing PPE) a 70% factor will be applied. It is assumed that in every 10-hour shift, only 7 hours will be spent grouting (i.e., the adjusted production rate is 102 days for all soil vaults using one rig).

U. Grouting for Cover System Foundation Stabilization

U.1 The grouting technique used for foundation stabilization will be nonreplacement in situ jet grouting as developed for the INEEL. This technique employs a modified drill rig to inject grout under high pressures into the waste seam. The grout will fill all readily accessible void space and will cure into a solid monolith. Because the waste and grout monolith will be supported on five sides and void space will be filled, subsidence will be eliminated regardless of the final compressive strength of the waste, soil, and concrete product. This principle will permit using widely available, inexpensive grouts such as Portland cement as the solidifying agent.

U.2 Unlike grouting for waste treatment, it will not be required that the grout be intimately mixed with the waste or soil, nor will it be required that the grout fill soil pore space or other small voids space inside individual waste drums. Because actual data regarding void space in the SDA are not available at this time, it is assumed that voids threatening the integrity of the cap are fairly large and will be intersected if the grout is injected on a 4-ft center-to-center spacing across areas requiring stabilization. Although this spacing does not ensure that every container is intersected, it is assumed adequate to support the cap. During the remedial design, a records review and geophysical program will be performed in an attempt to characterize the size and extent of the large void areas.

U.3 It is estimated that the production rate will be substantially greater than that required for ISG waste treatment because of the increased spacing and smaller number of grout holes required. The time required to grout for stabilization is estimated to be a factor of four less than the basic production rate.

V. Borrow Areas for the Cover System

The following has been assumed for the PERA:

V.1 Spreading Area A will be available and will not be flooded. No additional costs have been provided to dewater Spreading Area A.

V.2 The quantity and quality of borrow source material available from Spreading Area B, the Borax Pit, and the Basalt Source (for riprap and coarse fractured material) will be adequate. No royalty fees and special earthen material costs will apply.

V.3 An adequate water source will be available to support the requirements for earthmoving and soil moisture conditioning for placement and compaction.

W. Final Cover and Cap Construction

W.1 Following the grouting operation, the final cover would be placed over the SDA. For the PERA RTD alternative, it is assumed that capping would occur in several phases so that final capping would be completed within 1 year of the final waste retrieval. Wells currently located within the SDA would need to be pulled and abandoned. The estimated number of wells that require removal is 71. The entire SDA (excluding the onsite engineered disposal facility which will be covered with an ICDF type cover) will be capped with the Modified RCRA Subtitle C cap. The materials and their approximate quantities are in Table 7. The cover placed over the onsite engineered disposal facility is somewhat thicker than the RCRA Subtitle C cap; therefore, a transition zone is needed around the disposal area to connect the two caps. The transition materials have been factored into the disposal facility cover.

W.2 Placement of earth fill—An initial layer of earthen fill (10-foot thick average) will be placed over the surface of the SDA for grading and to prepare for placement of the cover system.

W.3 Placement of gravel gas collection layer—A 6-in.-thick layer of processed gravel will be placed over the earthen fill to vent any gases that might build up beneath the cover system.

W.4 Earthen fill and the gravel gas collection layers of the cover system will be placed during grouting activities.

W.5 Placement of asphalt, lateral drainage, and filter layers—A 4-in. asphalt base course and a 6-in. low-permeability asphalt layer will be placed over the gas collection layer to function as infiltration barriers. A 6-in. lateral drainage layer consisting of processed sand will be placed over the asphalt to remove infiltration from the surface of the barrier layer. A 1-ft-thick filter section consisting of sand and gravel will be placed over the lateral drainage layer.

W.6 Placement of remaining cover system layers—Remaining cover system layers will consist of a 20-in. compacted topsoil layer and a 20-in. layer of topsoil with gravel.

W.7 Placement of perimeter berm and erosion controls—A 6-ft-high berm will be constructed around the perimeter of the cover system to control flooding; filter layers, coarse fractured basalt, and riprap will be placed on the side slopes to minimize erosion.

W.8 Vegetation establishment—The topsoil layer will be seeded with a specialized seed mix to provide a vegetative cover. The cover will be monitored and reseeded as necessary to maintain the vegetative layer.

X. Treatability Testing Assumptions

X.1 Treatability testing using both simulated and actual waste locations will be required to establish the design and safety basis for operating ISTD, ISG, and the secondary waste treatment processes for processing waste generated in the ISTD off-gas cleanup systems. This work will verify properties that represent bounding conditions that can be safely and effectively treated.

Y. Capital Costs, Unit Rates, and Other Pricing Assumptions

Y.1 Unit prices have been developed from a crew build-up to process, load, haul, place, and compact. The volume of material represented in the cost tables identifies CCY. The appropriate factors convert the estimated unit material weights (bank, loose, and fill) and are factored into the equipment productivity.

Y.2 Crew labor rates were developed based on hourly rates stipulated in the INEEL Site Stabilization Agreement. Labor and equipment spreads were developed based on the assumed achievable daily productivity. Other factors that influenced the selection of labor and equipment quantities include safety, level of PPE of the work to be performed, haul routes, and availability of resources on the INEEL. Each daily crew cost also includes field oversight personnel such as the HSO, superintendents, foremen, CIH, maintenance personnel, and allocation of supplies (e.g., fuel, oil, grease, and spare parts).

Y.3 Primarily all capital equipment and pricing were selected from commercially available sources or similar projects allowing a scale factor to be applied to yield an estimated cost of the conceptual equipment and operational requirements. Equipment installation cost is considered to be a significant variable in estimating individual components of a given system. The installation cost of the capital equipment was based on a percentage of the capital costs ranging from 110 to 160% of the estimated capital expenditure based on the unknowns and level-of-complexity.

Y.4 Subcontractors' bond and insurance rate of 2% of the total subcontractor dollars includes overhead, and profit has been included based on each alternative.

Y.5 The estimate includes an allocation for the INEEL specific work order PRD requirements and safety meetings. Because this estimate includes primarily unit prices, the labor cost is estimated to be 40% of the unit prices and, based on historical data, cost of the INEEL-specific process is approximately 6% of the total labor dollars.

Z. Health and Safety

Z.1 All of the excavation work will be performed in Level B PPE. Productivities and crew labor have been adjusted to be representative of the expected level of effort.

Z.2 Safety monitoring would include VOC, visual, fire, explosion, and criticality monitoring.

Z.3 Chemical and radiological hazards to the public and employees would be mitigated by a double containment structure built around the area to be excavated, which would minimize the potential release of contaminants off-Site. A negative pressure ventilation system would be installed in the containment structures to ensure that contaminants would not escape. Ex situ treatment will occur in a similar type containment structure with ventilation system.

Z.4 Work within primary treatment process confinement areas will require respirators or a fresh air breathing supply. Other routine O&M will be conducted in Level D PPE, except where radiation monitoring indicates a need for higher levels of protection.

Z.5 Earth moving equipment, modified with positive-pressure ventilation system cabs and HEPA filters, could be used to minimize exposure to radioactively contaminated airborne hazards.

AA. Long-term O & M and Monitoring

The following has been assumed for the PERA:

AA.1 O&M activities will continue following completion of the remedial action, and will include such activities as placement of institutional controls, surveillance monitoring, and maintenance.

AA.2 It is assumed that placement of institutional controls will include installing permanent markers surrounding the SDA to delineate the contamination. The permanent markers are to be made of concrete and would contain information regarding the type of contamination. The number of permanent markers is assumed to be 12 based on the large size of the SDA. A perimeter fence would be installed around the SDA (10,000 ft) and would be replaced once in 100 years.

AA.3 Subsidence and erosion monitoring and maintenance would be conducted every 5 years to identify and repair any areas of the cover that have eroded, subsided, or been affected by other intruders.

AA.4 Vegetation monitoring would be conducted annually for the first 5 years until the vegetation is established. It is assumed that 10 acres would require reseeding during each of the first 5 years. After the first 5 years, vegetation monitoring would be conducted every 5 years, and 10 acres likely would require reseeding every 5 years.

AA.5 The initial postRA monitoring program will be similar to that proposed for the Surface Barrier and No Action alternatives (see Section D-1). However, because of the robust nature of the RA, after 5 years of monitoring, the groundwater well and lysimeter monitoring programs can be reduced by 50% and the vapor port program can be eliminated.

AA.6 The ultimate disposition of the equipment, weather enclosure, containment buildings, and treatment facilities should be considered as part of the total life cycle cost analysis. In general, these costs are not included at this time; however, further consideration should be made as to the end-use, D&D&D, dismantlement or disposal of equipment and material.

AA.7 The lysimeter analytical cost assumes that liquid samples will be recovered in 10% of the wells. Therefore analytical costs are included only for the assumed number of recoverable samples.

AA.8 After topsoil has been placed as the final layer on the cover system, it will be seeded with native grasses to provide vegetative cover that will reduce erosion. However, because of the arid climate of the INEEL, an extended period will be required to establish a permanent vegetative cover. Erosion of the uppermost layers of the cover system during snowmelt will occur during the years immediately following construction and repairs, and reseeding will be required.

AA.9 Ongoing maintenance of the cover system will be required in perpetuity after construction is completed. Frequent maintenance will be required during the years immediately following construction to repair damage from erosion and to establish a permanent vegetative cover. In addition, the added weight of the cover system is expected to result in increased settlement during the initial years following construction. Some areas of the cover system will require ongoing maintenance to repair damage resulting from settlement. It is expected that annual maintenance and repairs will be required during the first 5 years following construction.

BB. Design Costs

BB.1 The following discussion provides the basis for the assumed percentage for design, construction, and contingency. EPA provides guidance for estimating remedial design costs in the EPA Guidance. Exhibit 5-8 of the EPA Guidance provides examples of remedial design costs as a percentage of total capital costs. The percentages range from 20% for projects with capital costs less than $100,000 to 6% for projects with capital costs greater than $10 million. The EPA Guidance does not provide an example of design costs that vary according to the complexity of technologies.

BB.2 The alternatives include technologies that have been demonstrated on other sites and have well developed engineering design criteria (such as capping) and technologies that have not been successfully demonstrated on a large scale in TRU-waste applications and require development of engineering design criteria (such as ISV). For the alternatives, remedial design costs are expected to vary significantly according to the degree of complexity, and estimated costs for remedial design need to reflect the varying degrees of complexity. Based on the complexity of the technology application, a percentage of the capital and operating cost specific to the technology was assumed.

BB.3 The proposed cover system has been demonstrated on other sites and design standards have been developed for the various types of materials and construction methods. Some borrow source investigations will be needed to verify material properties and quantities, but the methods for conducting these investigations are not expected to require specialized equipment or personnel. Because capping is a demonstrated technology with established design standards, the cost for remedial design is assumed to be 6% of capital costs.

BB.4 ISG includes subsurface jet injection of specialized types of grout into waste disposal areas to stabilize and treat waste materials. ISG will be done inside a modular building to contain possible releases of contaminants. Some waste disposal areas will require pretreatment before grouting. Considerable effort will be needed to design appropriate grout types for the waste disposal areas, design the modular building and grouting equipment, determine areas of the site that will need pretreatment, and field test the various design elements. Because of the additional design effort required for ISG, the cost for remedial design is assumed to be 8% of capital costs.

BB.5 Foundation stabilization grouting includes using modified grouting equipment to jet grout areas of the SDA to fill voids within the waste and provide a stable foundation for placing and maintaining cover systems. Foundation stabilization grouting is somewhat similar to ISG except specialized grout and grouting equipment (including a modular building) will not be needed and the grout holes will be spaced farther apart than for ISG. Cement-based grout and modified grouting equipment will be used for this technology. Some field demonstrations will be conducted to verify the ability of the grouting equipment to penetrate the waste disposal areas and to estimate the approximate quantity of grout needed. Because the design effort will be considerably less for foundation stabilization grouting than for ISG, the cost for remedial design is assumed to be 7% of capital costs.

BB.6 Retrieval and disposal includes excavating and removing waste from Pad A and pits and trenches within the SDA; characterization and ex situ treatment of waste materials; packaging, shipment, and off-Site disposal of treated TRU waste; and disposal of treated non-TRU waste in an onsite, engineered waste disposal facility. Large containment structures will be needed to prevent releases of contaminants during waste retrieval. A high level of effort will be necessary to design methods to safely retrieve waste from disposal areas, characterize waste for treatment and disposal, design treatment methods and facilities, and plan for safe handling and transport of waste to an off-Site disposal facility. Because of the very intense design effort required for this technology, the cost for remedial design is assumed to be 10% of capital costs.

BB.7 Table 8 summarizes the various technologies and the percentages of capital costs estimated for remedial design. These percentages are applied to individual technologies in the cost estimate to establish estimated design costs for the various alternatives.

CC. Construction Management Costs

CC.1 Cost considerations for BBWI oversight, regulatory agency interaction, and project management were estimated on a representative basis of an assumed level of effort to implement the selected alternative. Additionally, costs for the remedial design, safety equipment and PPE, construction management, general conditions, and insurance and bonds were included in the estimate to provide a relative basis for comparing costs associated with implementing a given remedial alternative.

CC.2 The construction management cost percentage is based on the total capital construction cost to implement the alternative. The percentage basis for each category was selected considering the complexity of the technology and the risk and uncertainty of the approach. The cost identified under general conditions includes administration buildings, parking area, utilities, and support infrastructure to facilitate the alternative.

DD. Contingency Costs

DD.1 EPA provides guidance for estimating contingency costs in the EPA Guidance, which distinguishes between scope contingency and bid contingency costs. Scope contingency costs represent risks associated with incomplete design and include contributing factors such as limited experience with technologies, additional requirements because of regulatory or policy changes, and inaccuracies in defining quantities or characteristics. Exhibit 5-6 of the EPA Guidance provides examples of scope contingencies. Bid contingency costs are unknown costs at the time of estimate preparation that become known as remedial action construction or O&M proceeds. Bid contingencies represent reserves for quantity overruns, modifications, change orders, and claims during construction. The EPA Guidance states that bid contingencies may be added to construction and O&M costs and typically range from 10 to 20%.

DD.2 Because EPA Guidance suggests that contingency costs will vary according to the alternative technologies, it is necessary to estimate varying contingency costs for the technologies included in the alternatives of the WAG 7 PERA. Technologies have been evaluated separately to determine appropriate contingency costs. Scope and bid contingencies for each technology associated with this alternative are discussed below.

DD.3 The proposed cover systems include using several types of materials in addition to those planned for biotic barrier technology, constructing infiltration barriers, and using synthetic materials. One significant assumption for this technology is that available native materials will be capable of meeting infiltration barrier layer permeability requirements without using additives such as bentonite. Capping technology is assumed to require a scope contingency within the range of 10 to 20% as shown in Table 8. Because of the risk associated with the need for additional borrow sources for materials, using synthetic materials, and the possible need to use additives for infiltration barrier layer construction, the cost for the scope contingency is assumed to be 15%. Most risks associated with capping technology will be significantly reduced during remedial design; therefore, the cost for the bid contingency is assumed to be 10%. The total contingency for capping technology is assumed to be 25% of capital costs.

DD.4 In situ grouting includes jet injection of various types of grout into waste materials in the SDA to stabilize and treat waste materials. ISG technology will require consideration of pretreatment for some waste disposal areas, grout design for different types of waste, design of specialized grouting equipment and a modular containment building, and field demonstrations. ISG technology is assumed to require a scope contingency within the range of 15 to 55% as shown in Table 8. Because specialized design efforts are required for this technology, the cost for the scope contingency is assumed to be 20%. Some significant construction risks still will be associated with this technology because of unanticipated subsurface conditions, therefore, cost for the bid contingency is assumed to be 15%. The total contingency for ISG technology is assumed to be 35% of capital costs.

DD.5 Foundation stabilization grouting includes jet-grouting areas of the SDA with cement-based grout to fill voids within the waste and provide a stable foundation for placing and maintaining cover systems. While foundation stabilization grouting is somewhat similar to ISG, design of specialized types of grout and a modular containment building will not be required. Scope and bid contingencies for foundation stabilization grouting are the same as those for ISG (20 and 15%, respectively) with a total contingency for foundation stabilization grouting assumed to be 35% of capital costs.

DD.6 Retrieval and disposal involves excavating and removing waste from Pad A and pits and trenches within the SDA, followed by treatment and disposal. An intensive design effort will be required to determine methods to characterize and treat waste, to package and ship TRU waste for off-Site disposal, to handle and dispose of non-TRU waste at an onsite disposal facility, and to design and construct onsite treatment and disposal facilities. Each of these design efforts could result in significant changes in project scope. Retrieval and disposal technology is assumed to require a scope contingency within the range of the scope contingency for soil excavation in Table 9 (15 to 55%). Because high potential for scope changes are associated with this technology, cost for the scope contingency is assumed to be 25%. Considerable construction risks still will be associated with this technology because of the uncertainties associated with excavating buried waste materials. Because of the considerable construction risks, the cost for the bid contingency is assumed to be 20%. The total contingency for retrieval and disposal technology is assumed to be 45% of capital costs.

DD.7 The scope and bid contingency percentages associated with this alternative are identified in Table 9. These percentages are applied to individual technologies in the cost estimate to establish a representative aggregate cost contingency.

DD.8 Considering the cost contingency guidance in Table 10 for each of the technologies, a representative contingency was selected within the range provided based on the complexity and size of the project and the inherent uncertainties related to the remedial technology. However, the EPA Guidance document does not address all remedial technologies identified in this alternative. Specifically, the foundation grouting and ISG technology would be within a cost contingency range of 20 to 35% and are considered representative for this work and project scope.

IV. SCHEDULE:

The following activities comprise the RD/RA portion of the ISG alternative. The corresponding durations are based on estimated crew productivity, regulatory reviews and approvals, and weather constraints inherent to the INEEL site, and are presented in Table 11.

V. PRESENT WORTH ANALYSIS:

Guidance for present value analysis is provided in Chapter 4 of the EPA Guidance, which states that the present value analysis of a remedial alternative involves four basic steps:

1. Define the period of analysis

2. Calculate the cash outflows (payments) for each year of the project

3. Select a discount rate to use in the present value calculation

4. Calculate the present value.

Periods of analysis for the ISG alternative include design and construction and O&M. The design and construction period is estimated to be 30 years beginning shortly after issuance of a ROD for the site. The O&M period will begin at the end of the vegetation establishment and will continue for 100 years.

Cash flow for the RTD alternative will include payments for design and construction, periodic payments for major repairs, and annual O&M costs. EPA Guidance suggests that most capital costs should be assumed to occur in the first year of remedial action. While this suggestion might be for short-duration remedial actions, it is not a realistic assumption for the RTD alternative because of the time required for design and construction. Cash outflows for the RTD alternative will be paid on an annual basis as costs are incurred, beginning with the grout testing and remedial design and ending with the end of the vegetation establishment period.

Annual capital cost payments vary with the level of activity, with relatively low payments during the borrow source and grout investigations, remedial design, readiness assessment, and vegetation establishment periods and relatively high payments during heavy construction periods (grouting and material excavation, processing, stockpiling, and placement). Periodic costs for major repairs would occur every 5 years concurrent with the 5-year reviews required by CERCLA. Periodic costs would begin 5 years after Phase 1 construction and continue through the O&M period. Annual O&M costs would begin the first year after construction ends and continue for 100 years. In accordance with EPA Guidance requirements, 2002 constant dollars are used for all annual and periodic cash outflows.

EPA Guidance requires using a real discount rate that approximates the marginal pretax rate of return on an average investment and has been adjusted to eliminate the effect of expected inflation. The real discount rate must be used with constant or real dollars that have not been adjusted for inflation. EPA Guidance recommends using a 7% real discount rate for present value analysis in most remedial action cost estimates. However, for federal facility sites being cleaned up using Superfund authority, EPA Guidance states that it is generally appropriate to apply the real discount rates found in Appendix C of OMB Circular A-94.

The suggested rates for federal facility sites are based on interest rates from Treasury notes and bonds and are appropriate because the federal government has a different cost of capital than the private sector. The most current version of Appendix C of OMB Circular A-94 (revised February 2002) proposes a real discount rate of 3.9% for programs lasting longer than 30 years. The 3.9% discount rate and constant dollars are used for the present value analysis of the ISG alternative. The present value of the ISG alternative is calculated using equations provided in EPA Guidance.

VI. RISK AND UNCERTAINTY:

Several areas of risk and uncertainty have been identified for the RTD alternative cost estimate. Uncertainties exist with relation to the exact volume that will be retrieved from the SDA and the characterization of that waste, especially the quantity that will require special handling or that cannot be disposed of (e.g., spent fuel). Primary areas of risk and uncertainty lie in the ability to perform the retrieval and treatment as described in the PERA, and whether production rates can be achieved for the duration.

The containment structures required for the RTD alternative are extremely large and the requirement to provide radiological controls is uncertain as it relates to costs and should be considered a variable. The design requirements for these containment structures are not fully known, because a safety analysis for this activity has not been performed. Costs for the actual structures could be substantially higher than estimated.

Alternatively, designing a modular structure might result in design that is modular, cost savings. Non-destructive assay techniques to separate TRU from non-TRU are not fully developed and require additional research and development. Further research and development is required for the thermal treatment, and may have deployment issues for waste treatment of the scale needed for this alternative. The production rates of the treatment facility are several times higher than the production rates for the AMWTP, and require round-the-clock operations to achieve, with very limited annual downtime for maintenance.

Considerable schedule risk is associated with the off-Site transportation of TRU waste to WIPP. The total number of shipments is extremely large; the public and political perception of this volume being transported on public roads could severely impact the schedule.

A significant uncertainty is the time and effort required to design and implement remediation systems for Pad A and the organics areas. Although the total areas are relatively small, they could have a significant impact on the cost. A hazard classification is not currently available for retrieving waste from Pad A and the ISTD treatment of the organics areas. It is unclear what level of safety analysis and design will be required for these components. It is unclear whether safety significant systems will be required.

The production rate for operations (for retrieval and grouting of the SDA) is dependent largely on the waste types encountered. Unexpected hazards (e.g., explosives, reactives, and pressurized containers) or simply impenetrable layers of waste could cause significant schedule delays.

The schedule is highly uncertain. Estimates included here are intended to be high-level examples and are not adequate for establishing the actual remediation schedule. At this time, many uncertainties regarding all aspects of the alternative (i.e., design, construction times, retrieval, ISTD treatment, grouting production rates) remain to estimate a schedule. Past experience demonstrated that years could be needed to obtain approval of a design or safety analysis for operations as simple as probing. Delays caused by obtaining approval internally, from DOE, or the regulatory agencies cannot be estimated at this time.

A risk associated with the cover system is any situation that results in losing using a primary borrow source located close to the site. The largest quantity of material needed for the cover system is silt loam. For this alternative, it is assumed that sufficient quantities of silt loam will be available from Spreading Area B, located near the site. If this source is lacking in capacity or otherwise unavailable, the nearest alternative sources are the Ryegrass Flats and the WRRTF borrow areas. Ryegrass Flats is 12 mi from the site and the WRRTF borrow area is 34 mi. The haul distance from Spreading Area B is 1.5 mi. Increased haul distances could result in a significant increase in the construction schedule and the cost of materials.

VII. ADDITIONAL TABLES:

Table 1. Transuranic pits, trenches, and Pad A with associated waste and soil volume for the retrieval, treatment, and disposal alternative.

Pit/Trench Number	(1) Volume of Non-TRU Waste (m^3)	(2) Volume of TRU Waste (m^3)	(3) Total Waste Volume[a] (m^3)	(4) Volume Contaminated Soil[b] (m^3)	(5) Volume of TRU-Contaminated Soil[c] (m^3)	(6) Volume of NonTRU-Contaminated Soil[d] (m^3)	(7) Volume TRU Waste and Soil[e] (m^3)	(8) Volume Non-TRU Waste and Soil[f] (m^3)	(9) Volume Clean Overburden (m^3)
1	3,650	2,190	5,840	1,410	705	705	2,895	4,355	3,520
2	6,070	3,250	9,320	13,550	3,250	10,300	6,500	16,370	11,110
3	1,305	685	2,000	10,200	685	9,515	1,370	10,820	5,930
4	6,240	4,660	10,900	21,670	4,660	17,010	9,320	23,250	15,820
5	4,280	3,500	7,780	23,930	3,500	20,430	7,000	24,710	15,390
6	3,755	3,105	6,860	9,180	3,105	6,075	6,210	9,830	7,790
9	2,320	1,700	4,020	9,260	1,700	7,560	3,400	9,880	6,450
10	9,260	6,650	15,910	16,660	6,650	10,010	13,300	19,270	15,820
11	213	210	420	6,820	210	6,610	420	6,823	3,520
12	1,005	885	1,890	6,830	885	5,945	1,770	6,950	4,240
Pits Total	**38,100**	**26,835**	**64,940**	**119,510**	**25,350**	**94,160**	**52,200**	**132,300**	**89,590**
PAD A	10,200	6	10,210	11,740	6	11,734	12	21,930	12,120
Pad A Total	**10,200**	**6**	**10,210**	**11,740**	**6**	**11,734**	**12**	**21,930**	**12,120**
T1	325	195	520	1,830	195	1,635	390	1,960	1,140
T2	170	100	270	2,050	100	1,950	200	2,120	1,140
T3	370	220	590	1,680	220	1,460	440	1,830	1,100
T4	400	240	640	1,650	240	1,410	480	1,810	1,110
T5	425	255	680	1,700	255	1,445	510	1,870	1,160
T6	400	240	640	1,650	240	1,410	480	1,810	1,110
T7	270	160	430	1,940	160	1,780	320	2,050	1,140
T8	405	245	650	1,640	245	1,395	490	1,800	1,110
T9	25	15	40	2,460	15	2,445	30	2,470	1,220
T10	205	125	330	2,030	125	1,905	250	2,110	1,140
Trenches Total	**3,000**	**1,795**	**4,790**	**18,630**	**1,800**	**16,840**	**3,590**	**19,830**	**11,370**
Volumes Total	**51,300**	**28,600**	**79,900**	**149,900**	**27,200**	**122,700**	**55,800**	**174,100**	**113,000**

a. Total Waste Volume equals the sum of Volume of Non-TRU Waste (1) and Volume of TRU Waste (2)
b. Total Volume Contaminated Soil equals insterstitial soil plus 1 ft contaminated underburden plus 1 ft contaminated overburden
c. Volume TRU Contaminated Soil equals the volume of contaminated TRU Waste
d. Volume Non-TRU contaminated Soil equals the total Volume of contaminated soil (column 4) minus the volume of TRU contaminated soil (column 5)
e. Total Volume of TRU Waste and Soil equals sum of columns 2 and 5
f. Total Volume of Non-TRU Waste and Soil equals sum of columns 1 and 6

Table 2. Necessary components and quantities for the onsite engineered landfill.

Liner System	Component	Quantity
Bottom liner	3-ft bentonite liner (low-perm soil layer)	33,750 yd^3
	Secondary geomembrane	22,500 yd^2
	Geocomposite drainage layer	22,500 yd^2
	Primary geosynthetic clay liner	22,500 yd^2
	Primary geomembrane	22,500 yd^2
	Geotextile cushion	22,500 yd^2
	1-ft drainage gravel	7,500 yd^3
	3-ft gravel operations layer	22,500 yd^3
	Geotextile separation	22,500 yd^2
Side slope liner	3-ft soil bentonite liner (low-perm soil layer)	21,420 yd^3
	Secondary geomembrane	14,280 yd^2
	Geocomposite drainage layer	14,280 yd^2
	Primary geosynthetic clay liner	14,280 yd^2
	Primary geomembrane	14,280 yd^2
	Geotextile cushion	14,280 yd^2
	Geotextile separation	14,280 yd^2
	3-ft gravel operations layer	14,280 yd^3

Table 3. Necessary components and quantities for the evaporation pond liner systems.

Liner System	Component	Quantity (yd^2)
Evaporation pond liner	Low-perm soil layer (3 ft)	41,500
	Secondary geomembrane	8,000
	Geocomposite	8,000
	Geosynthetic clay layer	8,000
	High-density polyethylene primary geomembrane	8,000
	Drainage gravel (1 ft)	2,000
	Geotextile separation	8,000
	Operation layer (3 ft)	8,000

Table 4. Treatment facility components and feed rates.

Treatment Facility Component	Feed Rate
Assay equipment—segmented gate conveyor systems	2.1 yd^3/hour
Assay equipment—box and drum counter	1.2 yd^3/hour
Waste separation system	3.3 yd^3/hour
Shredder system	550 lb/hour
Thermal treatment system	2,000 lb/hour
Off-gas system	2,500 ft^3/minute
Secondary liquid waste system	10 gal/minute
Solidification system	100 drums/day
Drum assay system (assume three)	100 drums/day
Super compactor	23.6 ft^3/hour
Drum assay system (assume five)	209 drums/day

Table 5. Estimated quantities of waste and soil to be treated and treatment rates.

	Transuranic (waste)	Transuranic (soil)	Transuranic (total)	Non-Transuranic (LLW) (waste)	Non-Transuranic (LLW) (soil)	Non-Transuranic (LLW) (total)	Total Waste Plus Soil
yd^3 per year	2,400	2,200	4,600	4,200	10,000	14,200	18,800
lb per hour (design)	500	1,000	1,500	900	4,500	5,400	6,900
Total volume (yd^3)	37,900	35,500	73,400	66,600	160,200	226,800	300,200

LLW = low-level waste

Table 6. Necessary components and quantities for the onsite engineered disposal facility cap.

Component	Quantity
1-ft topsoil layer	19,400 yd^3
8-ft engineered earth layer	154,800 yd^3
1-ft fine filter layer	19,400 yd^3
1-ft coarse filter layer	19,400 yd^3
2.5-ft coarse fractured basalt layer	48,400 yd^3
1-ft coarse filter layer	19,400 yd^3
1-ft fine filter layer	19,400 yd^3
60-mi high-density polyethylene geomembrane	58,100 yd^2
2-ft compacted clay layer	38,800 yd^3
Gas collection	9,700 yd^3

Table 7. Modified Resource Conservation and Recovery Act Subtitle C cover system, design layers, thickness, and volume.

Layer	Thickness	Approximate Volume[a]	Material Description
Topsoil with gravel	20 in.	296,000 CCY	Processed silt loam topsoil with pea gravel admixture from spreading Area B
Compacted topsoil	20 in.	296,000 CCY	Unprocessed silt from Spreading Area B
Sand filter layer	6 in.	89,000 CCY	Processed sand from the Borax Gravel Pit
Gravel filter layer	6 in.	89,000 CCY	Unprocessed gravel from the Borax Gravel Pit
Lateral drainage layer	6 in.	89,000 CCY	Processed gravel from the Borax Gravel Pit
Asphalt layer	6 in.	89,000 CCY	Asphalt from an off-Site source in Idaho Falls
Asphalt base course	4 in.	59,000 CCY	Base course from off-Site source in Idaho Falls
Gas collection layer	6 in.	89,000 CCY	Processed gravel from the Borax Gravel Pit
Grading fill	120 in.	1,775,000 CCY	Unprocessed silt loam from Spreading Area A
Fine filter	12 in.	6,000 CCY	Processed sand from Borax Pit for cover system toe armor; 16-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V sideslopes
Coarse filter	12 in.	6,000 CCY	Processed gravel from Borax Pit for cover system toe armor; 16-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V sideslopes
Coarse fractured basalt	12 in.	6,000 CCY	Processed basalt mined from an INEEL site for cover system toe armor; 16-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V
Riprap	36 in.	18,000 CCY	Processed basalt mined from an INEEL site for cover system toe armor; 16-ft long; 3-ft thick; 10,000-ft perimeter; 2.5H:1V
Riprap	36 in.	15,600 CCY	Processed basalt mined from an INEEL site for berm toe armor; 14-ft long; 3-ft thick; 10,000-ft perimeter; 2H:1V
Perimeter berm	NA	244,200 CCY	Unprocessed silt loam from Spreading Area A; berm average 6.5-ft high; 100-ft wide; 10,000-ft perimeter; 2H:1V

a. This table provides estimated in-place volume rounded to the nearest 100 CCY.
CCY = compacted cubic yards

Table 8. Summary of remedial design costs as percentages of capital and operating costs.

Technology	Percentage of Capital and Operating Costs
Capping (cover systems)	6
In situ grouting at Pad A	8
In situ thermal desorption	10
Foundation grouting	7
Retrieval and disposal	10

Table 9. Example feasibility study-level scope contingency percentages.

Remedial Technology	Scope Contingency (%)
Soil excavation	15 to 55
Synthetic cap	10 to 20
Clay cap	5 to 10
Surface grading and diking	5 to 10
Revegetation	5 to 10

Table 10. Summary of contingency costs as percentages of capital costs.

	Percent of Capital Cost		
Remedial Technology	Scope Contingency	Bid Contingency	Total Contingency
Capping	15	10	25
In situ grouting	20	15	35
Foundation grouting	20	15	35
In situ thermal desorption	25	25	50
Retrieval disposal	25	20	45

Table 11. Retrieval, treatment, and disposal—design and construction.

Activity Description	Estimated Duration
Borrow source investigation	1 year
Grout formulation and field testing	1 year (overlaps borrow source inv. by 1 year)
Remedial design and procurement	1.5 years (overlaps testing by 0.5 year)
Operational readiness review	1 year (no overlap with design)
Mobilization	0.5 year (no overlap with readiness assessment)
C-14 trench area grouting	0.5 year (no overlap with trench grouting)
Soil vault row grouting	1 year (no overlap with C-14 area grouting)
Foundation stabilization grouting	1 year (overlaps with C-14 area grouting)
Pad A retrieval and disposal	2 years (overlaps with grouting activities)
In situ thermal desorption	2 years (overlaps with grouting activities)
Waste treatment and support facility construction	Assumed 3 years
Preoperational testing and regulatory approval	1 year, predecessor to waste treatment
Waste retrieval and excavation	16 years (overlaps with waste treatment)
TRU and non-TRU waste segregation and treatment	16 years (overlaps with waste retrieval)
Earthen fill placement	2 years (overlaps with retrieval activities)
Gas gravel, asphalt, drainage, and filter layers	2 years (overlaps grading fill placement by 1 year)
Placement of remaining layers	1 year (overlaps asphalt and other layers by 0.5 year)
Vegetation establishment	2 years (no overlap with placement of remaining layers)

TRU = transuranic

Table 12. Required borrow materials for the modified Resource Conservation and Recovery Act Subtitle C Cover System

Material	Issue	One-way Haul Distance	Source
Topsoil	This material will consist of organic silt loam and will be used to construct a topsoil layer to support vegetation on top of the cover system.	1.5 mi	This material is assumed to be unprocessed organic silt loam derived from Spreading Area B.
Silt loam	This material will be used to construct a number of the layers within the cover system including the general site grading fill, perimeter berm, and topsoil.	1.5 mi	The majority of this material is expected to be unprocessed silt loam derived from Spreading Area B. Additional material is available from Ryegrass Flats (haul distance = 12 mi) and the WRRTF borrow area (haul distance = 34 mi). If permitted, some of this material could be excavated from Spreading Area B (haul distance = 1 mi).
Gravel	This material will be used for the gravel gas collection, drainage, and coarse filter layers within the cover system. Sufficient quantities of good structural gravel and fines materials are available.	2.5 mi	This material is assumed to be processed gravel derived from the Borax Gravel Pit.
Sand	This material will be used for the fine filter layers within the cover system. No identified bank run borrow areas are available within the INEEL boundary.	45 mi	This material is assumed to be processed sand derived from an off-Site borrow source.
Riprap	Riprap will be used for erosion control. The majority of the mined riprap material at the INEEL has been used for other remedial actions at the INEEL.	5 mi	This material is assumed to be processed material mined from a basalt outcropping identified 5 mi from the site, directly west of the RWMC and just outside the Big Lost River System.
Coarse fractured basalt	This material will be used for erosion control. The majority of the mined coarse fractured basalt material at the INEEL has been used for other remedial actions at the INEEL.	5 mi	This material is assumed to be processed material mined from a basalt outcropping identified 5 mi from the site, directly west of the RWMC and just outside the Big Lost River System.

INEEL = Idaho National Engineering and Environmental Laboratory
RWMC = Radioactive Waste Management Complex
WRRTF = Water Reactor Research Test Facility

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE RETRIEVAL, TREATMENT, AND DISPOSAL ALTERNATIVE
(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: RETRIEVAL/TREATMENT/DISPOSAL (RTD) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
FFA/CO MANAGEMENT AND OVERSIGHT											
WAG 7 Management (30-Years)											
Coordination/Oversight Tech Support - 1.0 FTE/YR		NA			60,000	HR	$ 93	$ 5,563,200			$ 5,563,200
Coordination with Agency Participants - 0.5 FTE/YR		NA			120,000	HR	$ 93	$ 11,126,400			$ 11,126,400
Environmental Engineering - 1.0 FTE/YR		NA			60,000	HR	$ 76	$ 4,540,200			$ 4,540,200
Cost and Schedule Control - 2.0 FTE/YR		NA			180,000	HR	$ 59	$ 10,600,200			$ 10,600,200
Regulatory Compliance - 1.0 FTE/YR		NA			120,000	HR	$ 79	$ 9,481,200			$ 9,481,200
Quarterly and Annual Reviews - 1.0 FTE/YR		NA			60,000	HR	$ 73	$ 4,360,800			$ 4,360,800
Audit Preparation and Coordination - 0.5 FTE/YR		NA			60,000	HR	$ 79	$ 4,740,600			$ 4,740,600
Health and Safety Coordination/Training - 2.0 FTE/YR		NA			180,000	HR	$ 62	$ 11,217,600			$ 11,217,600
Annual O&M Reports - 0.5 FTE/YR		NA			60,000	HR	$ 79	$ 4,712,400			$ 4,712,400
Attorney/Legal Fees, 0.3 FTE/YR		NA			60,000	HR	$ 150	$ 9,000,000			$ 9,000,000
Allocation for Other Direct Costs (ODCs) - 10% of Total Labor		NA			1	LS	$ 6,634,260	$ 6,634,260			$ 6,634,260
TOTAL COST - FFA/CO Management and Oversight											$ 81,977,000
Construction Management											
Construction Management (@ 6% of RA Costs)	6%	NA			1	LS	$ 253,424,580	$ 253,424,580			$ 253,424,580
General Conditions (@ 1.25% of RA Costs)	1.25%	NA			1	LS	$ 52,796,788	$ 52,796,788			$ 52,796,788
Health and Safety Equipment Allocation (@ 0.25% of RA Costs)	0.25%	NA			1	LS	$ 10,559,358	$ 10,559,358			$ 10,559,358
Medical Monitoring/Surveillance/Air Monitoring (@ 0.10% of RA Costs)	0.10%	NA			1	LS	$ 4,223,743	$ 4,223,743			$ 4,223,743
TOTAL COST - Construction Management											$ 321,004,000
TREATABILITY STUDIES											
Treatment Treatability Studies, Ex Situ Treatment (@ 10% of Treatment)	10%	NA			1	LS	$ 95,494,300	$ 95,494,300			$ 95,494,300
Treatment Treatability Studies, ISG/ISTD (@ 5% of ISG, ISTD)	5%	NA			1	LS	$ 6,988,050	$ 6,988,050			$ 6,988,050
TOTAL COST - Treatability Studies											$ 102,482,000
REMEDIAL DESIGN AND REMEDIAL ACTION PLANS/REPORTS											
ISTD RD/RA Workplan (@ 8% of ISTD Capital/Operation)	10%	NA			1	LS	$ 2,753,200	$ 2,753,200			$ 2,753,200
GROUTING RD/RA Workplan (@ 8% of Grouting Capital/Operations)	8%	NA			1	LS	$ 8,978,320	$ 8,978,320			$ 8,978,320
Excavation/Retrieval/Disposal RD/RA Workplan (@ 10% of Capital Costs)	10%	NA			1	LS	$ 94,998,100	$ 94,998,100			$ 94,998,100
Surface Barrier RD/RA Workplan (@ 6% of Barrier Construction)	6%	NA			1	LS	$ 3,173,640	$ 3,173,640			$ 3,173,640
Readiness Assessment (@ 1.5% of RA)	1.5%	NA			1	LS	$ 50,083,905	$ 50,083,905			$ 50,083,905
Remedial Action Report		NA			10,000	HR	$ 76	$ 756,700			$ 756,700
TOTAL COST - Remedial Design											$ 160,744,000

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE RETRIEVAL, TREATMENT, AND DISPOSAL ALTERNATIVE

(continued).

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OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: RETRIEVAL/TREATMENT/DISPOSAL (RTD) ALTERNATIVE
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TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
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REMEDIAL ACTION											
ISTD APPLICATION FOR VOC REMOVAL (1 acre)											
Capital Equipment Costs											
ISTD Control Trailer		6	EA	$ 325,000.00	NA				$ 1,950,000		$ 1,950,000
ISTD Off-Gas Treatment		6	EA	$ 250,000.00	NA				$ 1,500,000		$ 1,500,000
ISTD Off-Gas Treatment Support (Chillers)		6	EA	$ 725,000.00	NA				$ 4,350,000		$ 4,350,000
ISTD Capital Costs (Assume 6-ISTD Systems Are Required)		1	EA	$ 5,256,620.00	NA				$ 5,256,620		$ 5,256,620
Electrical Power Supply/Overhead Powerline H-Frame		3	MI	$ 375,000.00	NA				$ 1,125,000		$ 1,125,000
Electrical Substation/Transformers for Site Distribution		2	EA	$ 125,000.00	NA				$ 250,000		$ 250,000
Operation Treatment/Disposal Costs											
ISTD Operational Costs (acreage)		1	AC	$ 153,103.00	1	AC	$ 4,030,658	$ 4,030,658	$ 153,103		$ 4,183,761
Power Consumption/Utilities		NA			NA					$ 460,000	$ 460,000
ISTD Secondary Waste Disposal		NA			NA					$ 2,500,000	$ 2,500,000
Installation/Pre-Operational Set-up/Testing (Percentage of Total Capital Costs)	10.0%				1	LS	$ 1,458,472	$ 1,458,472			$ 1,458,472
Back-up Generators (Diesel Powered)		2	EA	$ 137,500	NA				$ 275,000		$ 275,000
Repair/Maintenance/Spare Parts (Percentage of Operating/Treatment Costs)	25.0%				1	LS	$ 1,007,665	$ 1,007,665			$ 1,007,665
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 486,330	NA				$ 486,330		$ 486,330
D&D Cost for Equipment (Percentage of Capital Equipment)	10.0%	NA			NA					$ 1,443,162	$ 1,443,162
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	746,441.04	$ 746,441			$ 746,441
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 539,849	$ 539,849
Subtotal											**$ 27,532,000**
PAD A EXCAVATION (Addressed elsewhere)											
Subtotal											$ -

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE RETRIEVAL, TREATMENT, AND DISPOSAL ALTERNATIVE

(continued).

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GROUTING											
EQUIPMENT COST											
Capital Cost - Batch Plant, Vehicles, Drill Rigs		1	LS	$ 8,326,000.0	NA				$ 8,326,000		$ 8,326,000
Mobilize/Erect Weather Structure Grouting Operations		2	EA	$ 750,198.0	NA				$ 1,500,396		$ 1,500,396
HEPA Filtration System/Lighting/Redundant Systems		2	EA	$ 2,147,448.0	NA				$ 4,294,896		$ 4,294,896
Back-up Generators (Diesel Powered)		2	EA	$ 375,000.0	NA				$ 750,000		$ 750,000
Building Foundation Construction		30,277	LF	$ 561.0	NA				$ 16,985,397		$ 16,985,397
Bridge Crane/Control System		3	EA	$ 670,000.0	NA				$ 2,010,000		$ 2,010,000
Bridge Crane/Control System/Modify and Install		NA			1	LS	$ 1,005,000	$ 1,005,000			$ 1,005,000
D&D Cost for Equipment/Enclosures	10.0%									$ 3,386,669	$ 3,386,669
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 873,101	$ 873,101			$ 873,101
Subcontractor Insurance/Bonds	2.0%				NA					$ 782,629	$ 782,629
Subtotal											**$ 39,914,000**
PRE-CONSTRUCTION ACTIVITIES											
Plug and Abandon (P&A) Existing GW Wells		NA			71	EA	$ 15,000	$ 1,065,000		$ 1,775,000	$ 2,840,000
Install New Nested GW Wells Outside Perimeter of Cap (Drilling Sub and Equipment)		NA			24	EA	$ 50,000	$ 1,200,000		$ 3,000,000	$ 4,200,000
Construct Rail Spur for Bulk Grout Delivery/Storage		1	LS	$ 1,200,000					$ 1,200,000		$ 1,200,000
INEEL Site-Specific Training/Work Order Requirements					1	LS	$ 164,700	$ 164,700			$ 164,700
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 168,094	$ 168,094
Subtotal											**8,573,000**
OPERATIONS											
5-Foot Thick Cover Material (Initial Site Grading)		130,000	CCY	$ 10	NA				$ 1,300,000		$ 1,300,000
Grout Activation/Fission Product Trench Areas		79	CD	$ 181,314	79	CD	$ 40,902	$ 3,231,258	$ 14,323,806		$ 17,555,064
Grout SVRs		34	CD	$ 181,314	34	CD	$ 40,902	$ 1,390,668	$ 6,164,676		$ 7,555,344
Grout Rig Decontamination		3	EA	$ 2,125,800	NA				$ 6,377,400		$ 6,377,400
HEPA Filtration System Operation		2	YR	$ 2,000,000	NA				$ 4,000,000		$ 4,000,000
Repair/Maintenance/Spare Parts (Percentage of Operating/Treatment Costs)	10.0%	1	LS	$ 3,325,815	NA				$ 3,325,815		$ 3,325,815
Verification Testing Geophysical Survey		4	MO	$ 94,588	2,500	HR	$ 76	$ 189,175	$ 378,350		$ 567,525
Foundation Stabilization Grouting (Other Trenches, 98-MD)		128	CD	$ 99,763	128	CD	$ 40,902	$ 5,235,456	$ 12,769,664		$ 18,005,120
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 2,035,959	NA				$ 2,035,959		$ 2,035,959
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 1,770,146	$ 1,770,146			$ 1,770,146
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 1,249,847	$ 1,249,847
Subtotal											**$ 63,742,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE RETRIEVAL, TREATMENT, AND DISPOSAL ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7. FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: RETRIEVAL/TREATMENT/DISPOSAL (RTD) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
ON-SITE ENGINEERED LANDFILL CONSTRUCTION											
Capital Equipment Costs											
Dozer D8 - Landfill Waste Placement		1	EA	$ 525,000	NA				$ 525,000		$ 525,000
825B - Landfill Compaction		1	EA	$ 675,000	NA				$ 675,000		$ 675,000
Water Truck for Landfill Dust Suppression		1	EA	$ 325,000	NA				$ 325,000		$ 325,000
Lining/Leachate Collection for Landfill											
Subgrade Prep/Grading to install lining and collection system		12	AC	$ 3,800	NA				$ 45,600		$ 45,600
Excavate and Grade Disposal Cell		110,000	CY	$ 8	NA				$ 880,000		$ 880,000
Low-Perm Soil Layer - 3-ft		55,170	CY	$ 12	NA				$ 662,592		$ 662,592
Secondary Geomembrane		36,780	SY	$ 6	NA				$ 231,714		$ 231,714
Geocomposite		36,780	SY	$ 2	NA				$ 82,755		$ 82,755
Geosynthetic Clay Liner		36,780	SY	$ 5	NA				$ 196,773		$ 196,773
Primary Geomembrane		36,780	SY	$ 6	NA				$ 231,714		$ 231,714
Geotextile Cushion		36,780	SY	$ 2	NA				$ 68,043		$ 68,043
1-ft Drainage Gravel		7,500	CY	$ 10	NA				$ 75,000		$ 75,000
Geotextile Separation		36,780	SY	$ 2	NA				$ 64,365		$ 64,365
Operation Layer - 3-ft		55,170	CY	$ 5	NA				$ 263,161		$ 263,161
Leachate Controls/Building		1	LS	$ 450,000	NA				$ 450,000		$ 450,000
Construct Leachate System/Transmission/Controls		1	LS	$ 325,000	NA				$ 325,000		$ 325,000
Equipment/Materials - Evaporation Pond											
Subgrade Prep		3	AC	$ 2,500	NA				$ 7,500		$ 7,500
Berm Construction for Evap Pond		41,500	CY	$ 5	NA				$ 197,955		$ 197,955
Low-Perm Soil Layer - 3-ft		8,000	CY	$ 12	NA				$ 96,080		$ 96,080
HDPE Secondary Geomembrane		8,000	SY	$ 6	NA				$ 50,400		$ 50,400
Geocomposite		8,000	SY	$ 2	NA				$ 18,000		$ 18,000
Geosynthetic Clay Liner		8,000	SY	$ 5	NA				$ 42,800		$ 42,800
HDPE Primary Geomembrane		8,000	SY	$ 6	NA				$ 50,400		$ 50,400
Geotextile Cushion		8,000	SY	$ 2	NA				$ 14,800		$ 14,800
1-ft Drainage Gravel		2,000	CY	$ 10	NA				$ 20,000		$ 20,000
Geotextile Separation		8,000	SY	$ 2	NA				$ 14,000		$ 14,000
Operation Layer - 3-ft		8,000	CY	$ 5	NA				$ 38,160		$ 38,160
Leachate Controls/Building		1	LS	$ 125,000	NA				$ 125,000		$ 125,000
Construct Leachate System/Transmission/Controls		1	LS	$ 225,000	NA				$ 225,000		$ 225,000
Construction/Operations											
Lab Geotechnical Testing/Compaction		16	MO	$ 125,000	NA				$ 2,000,000		$ 2,000,000
Field Geotechnical Testing/Compaction		16	MO	$ 90,000	NA				$ 1,440,000		$ 1,440,000
Surveying/Grade Control		16	MO	$ 65,000	NA				$ 1,040,000		$ 1,040,000
Third-Party Independent CQA Testing/Certification		16	MO	$ 75,000	NA				$ 1,200,000		$ 1,200,000
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 120,036	NA				$ 120,036		$ 120,036
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 280,363	$ 280,363			$ 280,363
Subcontractor Insurance/Bonds	2.0%	NA			NA					241,644	$ 241,644
Subtotal											$ 12,324,000

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE RETRIEVAL, TREATMENT, AND DISPOSAL ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: RETRIEVAL/TREATMENT/DISPOSAL (RTD) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
STRUCTURES											
General Administrative (Includes Equipment)		10,000	SF	$ 95	NA				$ 950,000		$ 950,000
Water and Chemical Storage Tanks		3	EA	$ 475,000	NA				$ 1,425,000		$ 1,425,000
Utility Piping/Gas Line		1	LS	$ 7,500,000	NA				$ 7,500,000		$ 7,500,000
Equipment Maint./Storage (Includes Equipment)		10,000	SF	$ 175	NA				$ 1,750,000		$ 1,750,000
Decontamination Area (Includes Equipment)		5,000	SF	$ 150	NA				$ 750,000		$ 750,000
Lag Storage Building (Includes Equipment)		70,000	SF	$ 250	NA				$ 17,500,000		$ 17,500,000
Treatment Facility (No Equipment)											
Materials and Erection		130,000	SF	$ 350	NA				$ 45,500,000		$ 45,500,000
Fire Protection, Radiological, CCTV, HVAC		130,000	SF	$ 250	NA				$ 35,750,000		$ 35,750,000
Weather Enclosure (WES) (Assume Bldg Footprint 10% Larger)		143,000	SF	$ 65	NA				$ 4,875,000		$ 4,875,000
WIPP Transportation Storage (Includes Equipment)		75,000	SF	$ 160	NA				$ 12,000,000		$ 12,000,000
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 3,072,000	$ 3,072,000			$ 3,072,000
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 2,621,440	$ 2,621,440
Subtotal											**$ 133,693,000**
PRIMARY/SECONDARY CONTAINMENT BUILDINGS											
Building No. 1, RCS Materials and Erection		208,075	SF	$ 350	NA				$ 72,826,250		$ 72,826,250
Building No. 1, RCS, Fire Protection, Radiological, CCTV, HVAC		208,075	SF	$ 250	NA				$ 52,018,750		$ 52,018,750
Weather Enclosure (WES) Building No. 1 (Assume Bldg Footprint 10% Larger)		228,883	SF	$ 65	NA				$ 14,877,363		$ 14,877,363
Building No. 2, RCS Materials and Erection		109,250	SF	$ 350	NA				$ 38,237,500		$ 38,237,500
Building No. 2, RCS, Fire Protection, Radiological, CCTV, HVAC		109,250	SF	$ 250	NA				$ 27,312,500		$ 27,312,500
Weather Enclosure (WES) Building No. 2 (Assume Bldg Footprint 10% Larger)		120,175	SF	$ 65	NA				$ 7,811,375		$ 7,811,375
Building No. 3, RCS Materials and Erection		109,250	SF	$ 350	NA				$ 38,237,500		$ 38,237,500
Building No. 3, RCS, Fire Protection, Radiological, CCTV, HVAC		109,250	SF	$ 250	NA				$ 27,312,500		$ 27,312,500
Weather Enclosure (WES) Building No. 3 (Assume Bldg Footprint 10% Larger)		120,175	SF	$ 65	NA				$ 7,811,375		$ 7,811,375
Building No. 4, RCS Materials and Erection		159,600	SF	$ 350	NA				$ 55,860,000		$ 55,860,000
Building No. 4, RCS, Fire Protection, Radiological, CCTV, HVAC		159,600	SF	$ 250	NA				$ 39,900,000		$ 39,900,000
Weather Enclosure (WES) Building No. 4 (Assume Bldg Footprint 10% Larger)		175,560	SF	$ 65	NA				$ 11,411,400		$ 11,411,400
Building No. 5, RCS Materials and Erection		102,600	SF	$ 350	NA				$ 35,910,000		$ 35,910,000
Building No. 5, RCS, Fire Protection, Radiological, CCTV, HVAC		102,600	SF	$ 250	NA				$ 25,650,000		$ 25,650,000
Weather Enclosure (WES) Building No. 5 (Assume Bldg Footprint 10% Larger)		112,860	SF	$ 65	NA				$ 7,335,900		$ 7,335,900
Building No. 6, RCS Materials and Erection		200,200	SF	$ 350	NA				$ 70,070,000		$ 70,070,000
Building No. 6, RCS, Fire Protection, Radiological, CCTV, HVAC		200,200	SF	$ 250	NA				$ 50,050,000		$ 50,050,000
Weather Enclosure (WES) Building No. 6 (Assume Bldg Footprint 10% Larger)		220,220	SF	$ 65	NA				$ 14,314,300		$ 14,314,300

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE RETRIEVAL, TREATMENT, AND DISPOSAL ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: RETRIEVAL/TREATMENT/DISPOSAL (RTD) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
Building No. 7, RCS Materials and Erection		197,400	SF	$ 350	NA				$ 69,090,000		$ 69,090,000
Building No. 7, RCS, Fire Protection, Radiological, CCTV, HVAC		208,075	SF	$ 250	NA				$ 52,018,750		$ 52,018,750
Weather Enclosure (WES) Building No. 7 (Assume Bldg Footprint 10% Larger)		217,140	SF	$ 65	NA				$ 14,114,100		$ 14,114,100
Building No. 8, RCS Materials and Erection		34,500	SF	$ 350	NA				$ 12,075,000		$ 12,075,000
Building No. 8, RCS, Fire Protection, Radiological, CCTV, HVAC		34,500	SF	$ 250	NA				$ 8,625,000		$ 8,625,000
Weather Enclosure (WES) Building No. 8 (Assume Bldg Footprint 10% Larger)		37,950	SF	$ 65	NA				$ 2,466,750		$ 2,466,750
Building No. 9, RCS Materials and Erection		70,000	SF	$ 350	NA				$ 24,500,000		$ 24,500,000
Building No. 9, RCS, Fire Protection, Radiological, CCTV, HVAC		70,000	SF	$ 250	NA				$ 17,500,000		$ 17,500,000
Weather Enclosure (WES) Building No. 9 (Assume Bldg Footprint 10% Larger)		77,000	SF	$ 65	NA				$ 5,005,000		$ 5,005,000
Building No. 10, RCS Materials and Erection		94,300	SF	$ 350	NA				$ 33,005,000		$ 33,005,000
Building No. 10, RCS, Fire Protection, Radiological, CCTV, HVAC		94,300	SF	$ 250	NA				$ 23,575,000		$ 23,575,000
Weather Enclosure (WES) Building No. 10 (Assume Bldg Footprint 10% Larger)		103,730	SF	$ 65	NA				$ 6,742,450		$ 6,742,450
Building No. 11, RCS Materials and Erection		77,400	SF	$ 350	NA				$ 27,090,000		$ 27,090,000
Building No. 11, RCS, Fire Protection, Radiological, CCTV, HVAC		77,400	SF	$ 250	NA				$ 19,350,000		$ 19,350,000
Weather Enclosure (WES) Building No. 11 (Assume Bldg Footprint 10% Larger)		85,140	SF	$ 65	NA				$ 5,534,100		$ 5,534,100
Building No. 12, RCS Materials and Erection		69,700	SF	$ 350	NA				$ 24,395,000		$ 24,395,000
Building No. 12, RCS, Fire Protection, Radiological, CCTV, HVAC		69,700	SF	$ 250	NA				$ 17,425,000		$ 17,425,000
Weather Enclosure (WES) Building No. 12 (Assume Bldg Footprint 10% Larger)		76,670	SF	$ 65	NA				$ 4,983,550		$ 4,983,550
Building No. 13, RCS Materials and Erection		35,100	SF	$ 350	NA				$ 12,285,000		$ 12,285,000
Building No. 13 RCS, Fire Protection, Radiological, CCTV, HVAC		35,100	SF	$ 250	NA				$ 8,775,000		$ 8,775,000
Weather Enclosure (WES) Building No. 13 (Assume Bldg Footprint 10% Larger)		38,610	SF	$ 65	NA				$ 2,509,650		$ 2,509,650
Building No. 14, RCS Materials and Erection		54,600	SF	$ 350	NA				$ 19,110,000		$ 19,110,000
Building No. 14, RCS, Fire Protection, Radiological, CCTV, HVAC		54,600	SF	$ 250	NA				$ 13,650,000		$ 13,650,000
Weather Enclosure (WES) Building No. 14 (Assume Bldg Footprint 10% Larger)		60,060	SF	$ 65	NA				$ 3,903,900		$ 3,903,900
Remote Crane System/Curtains/Water Misters		14	EA	$ 375,000	NA				$ 5,250,000		$ 5,250,000
Airlocks for Curtains		28	EA	$ 100,000	NA				$ 2,800,000		$ 2,800,000
Sheet Piles for Trenches or other Stabilization		1	LS	$ 2,500,000	NA				$ 2,500,000		$ 2,500,000
D&D Cost for Buildings/Equipment	25.0%	NA			NA					258,181,240.63	$ 258,181,241
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 24,845,399	$ 24,845,399			$ 24,845,399
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 26,365,032	$ 26,365,032
Subtotal											**$ 1,344,617,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE RETRIEVAL, TREATMENT, AND DISPOSAL ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: RETRIEVAL/TREATMENT/DISPOSAL (RTD) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
CLEAN SOIL OVERBURDEN REMOVAL/MANAGEMENT											
Overburden Soil Removal/Stockpile		113,000	CY	$ 5	NA				$ 539,010		$ 539,010
Soil Characterization of Stockpile (total CY/1000)		155	CY	$ 500	NA				$ 77,500		$ 77,500
Stockpile Management/Soil Erosion		16	YR	$ 30,000	NA				$ 480,000		$ 480,000
SOIL AND WASTE EXCAVATION											
Capital Equipment Costs											
Equipment/Containers		1	EA	$ 42,351,776	NA				$ 42,351,776		$ 42,351,776
Construction/Operations											
Excavate Waste/Segregate/Size Material (200 days/yr)		3,200	DAY	$ 6,768	3,200	DAY	30,383	$ 97,225,600	$ 21,657,600		$ 118,883,200
Excavate Waste/Segregate/Size Material Down Time (50 days/yr)		800	DAY		800	DAY	30,383	$ 24,306,400	$ -		$ 24,306,400
Operations Costs of Retrieval Process-Buildings		192	MO	$ 130,208	NA				$ 24,999,936		$ 24,999,936
Building Maintenance/Repairs (10-percent of Operations)		16	YR	$ 156,250	NA				$ 2,499,994		$ 2,499,994
Equipment Maintenance/Repairs (10-percent of Operations)		3,200	DAY	$ 3,715	NA				$ 11,888,320		$ 11,888,320
Backfill Excavations w/Clean Soil in Trenches		507,000	CY	$ 9	NA				$ 4,309,500		$ 4,309,500
LAG STORAGE OPERATIONS											
NDA for TRU Separation Instrumentation		1	LS	$ 750,000	NA				$ 750,000		$ 750,000
Facility operation		3,200	DAY	$ 3,000	3,200	DAY	5,300	$ 16,960,000	$ 9,600,000		$ 26,560,000
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	10,920,807	$ 10,920,807			$ 10,920,807
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 5,371,329	$ 5,371,329
Subtotal											**$ 273,938,000**
EX SITU TREATMENT, PROCESSING, REPACKAGING											
Equipment/Materials - Common Area											
Assay Equipment - SGCS (2.1 CY/HR)		1	EA	$ 1,500,000	NA				$ 1,500,000		$ 1,500,000
Assay Equipment - Box/Drum Counter (1.2 CY/HR)		1	EA	$ 4,500,000	NA				$ 4,500,000		$ 4,500,000
Waste Separation System (3.3 CY/HR)		1	EA	$ 3,500,000	NA				$ 3,500,000		$ 3,500,000
Construction/Operations											
Capital Equipment Delivery/Erection/Installation		1	LS	$ 4,700,000	NA				$ 4,700,000		$ 4,700,000
Pre-Operational Testing/Technology Verification		1	LS	$ 6,374,806	NA				$ 6,374,806		$ 6,374,806
TRU Processing Facility											
Equipment/Materials											
Stainless Steel Drums for TRUPACT		265,000	EA	$ 275	NA				$ 72,875,000		$ 72,875,000
Super Compactor		1	EA	$ 1,000,000	NA				$ 1,000,000		$ 1,000,000

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE RETRIEVAL, TREATMENT, AND DISPOSAL ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7. FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: RETRIEVAL/TREATMENT/DISPOSAL (RTD) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
Non-TRU (LLW) Processing											
Equipment/Materials											
Shredder System (550 LB/HR)		1	EA	$ 800,000	NA				$ 800,000		$ 800,000
Steam Reforming System (2,000 LB/HR)		1	EA	$ 12,000,000	NA				$ 12,000,000		$ 12,000,000
Off-Gas System (2,500 ACFM/MIN), to Include:		2	EA	$ 2,900,000	NA				$ 5,800,000		$ 5,800,000
Quencher, Venturi Scrubber, Packed Bed Scrubber, Demister											
Reheater, Parallel HEPA Filters, Parallel Off-Gas Fans, After Burner											
Secondary Liquid Waste System (Brine)		1	EA	$ 5,200,000	NA				$ 5,200,000		$ 5,200,000
Solidification System (100 drums/day) (Pugmill)		1	EA	$ 11,900,000	NA				$ 11,900,000		$ 11,900,000
Drum Assay System (100 drums/day)		8	EA	$ 1,800,000	NA				$ 14,400,000		$ 14,400,000
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 3,469,195	$ 3,469,195			$ 3,469,195
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 2,960,380	$ 2,960,380
Subtotal											**$ 150,979,000**
Operation (Proportionately Scaled from AMWTF)											
Pre-Operational System Testing		NA			1	LS	$ 38,234,403	$ 38,234,403			$ 38,234,403
Testing as Required by Federal and State Regulators		NA			1	LS	$ 19,117,202	$ 19,117,202			$ 19,117,202
Annual Estimated Operational Costs (FY 2019)		NA			1	YR	$ 9,690,000	$ 9,690,000			$ 9,690,000
Annual Estimated Operational Costs (FY 2020)		NA			1	YR	$ 29,529,000	$ 29,529,000			$ 29,529,000
Annual Estimated Operational Costs (FY 2021)		NA			1	YR	$ 42,500,000	$ 42,500,000			$ 42,500,000
Annual Estimated Operational Costs (FY 2022)		NA			1	YR	$ 56,100,000	$ 56,100,000			$ 56,100,000
Annual Estimated Operational Costs (FY 2023)		NA			1	YR	$ 56,100,000	$ 56,100,000			$ 56,100,000
Annual Estimated Operational Costs (FY 2024)		NA			1	YR	$ 56,100,000	$ 56,100,000			$ 56,100,000
Annual Estimated Operational Costs (FY 2025)		NA			1	YR	$ 56,100,000	$ 56,100,000			$ 56,100,000
Annual Estimated Operational Costs (FY 2026)		NA			1	YR	$ 56,100,000	$ 56,100,000			$ 56,100,000
Annual Estimated Operational Costs (FY 2027)		NA			1	YR	$ 56,100,000	$ 56,100,000			$ 56,100,000
Annual Estimated Operational Costs (FY 2028)		NA			1	YR	$ 56,100,000	$ 56,100,000			$ 56,100,000
Annual Estimated Operational Costs (FY 2029)		NA			1	YR	$ 56,100,000	$ 56,100,000			$ 56,100,000
Annual Estimated Operational Costs (FY 2030)		NA			1	YR	$ 56,100,000	$ 56,100,000			$ 56,100,000
Annual Estimated Operational Costs (FY 2031)		NA			1	YR	$ 56,100,000	$ 56,100,000			$ 56,100,000
Annual Estimated Operational Costs (FY 2032)		NA			1	YR	$ 29,529,000	$ 29,529,000			$ 29,529,000
Annual Estimated Operational Costs (FY 2033)		NA			1	YR	$ 20,910,000	$ 20,910,000			$ 20,910,000
Annual Estimated Operational Costs (FY 2034)		NA			1	YR	$ 20,910,000	$ 20,910,000			$ 20,910,000
RCRA Closure of Treatment Facilities		NA			1	LS	$ 16,780,000	$ 16,780,000			$ 16,780,000
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 15,763,992	$ 15,763,992
Subtotal											**$ 803,984,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE RETRIEVAL, TREATMENT, AND DISPOSAL ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: RETRIEVAL/TREATMENT/DISPOSAL (RTD) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
ON-SITE TRANSPORTATION AND DISPOSAL											
Equipment/Materials											
Soil for use During Waste Placement		42,750	CY	$ 5	NA				$ 203,918		$ 203,918
Truck to Transport Waste		1	LS	$ 175,000	NA				$ 175,000		$ 175,000
Transportation Costs		192	MO	$ 2,380	NA				$ 456,960		$ 456,960
Containers for Disposal		50,000	EA	$ 125	NA				$ 6,250,000		$ 6,250,000
Construction/Operations											
Transport to on-Site Landfill		200,000	CY	$ 5	NA				$ 954,000		$ 954,000
Waste Placement/Compaction		250,000	CY	$ 38	NA				$ 9,520,000		$ 9,520,000
Surfactants/Dust Suppression		16	YR	$ 125,000	NA				$ 2,000,000		$ 2,000,000
Decommission Evaporation Ponds/Haul to Land Fill		8,000	CY	$ 105	NA				$ 840,000		$ 840,000
OFF-SITE TRANSPORTATION AND DISPOSAL AT WIPP											
Transport TRU Waste to WIPP (Not Included)		NA									
Disposal Costs at WIPP (Not Included)		NA									
Drum Characterization for Transport to WIPP		265,000	EA	$ 1,500	NA				$ 397,500,000		$ 397,500,000
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 489,597	$ 489,597			$ 489,597
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 8,367,789	$ 8,367,789
Subtotal											**$ 426,757,000**
SURFACE BARRIER											
PRE-CONSTRUCTION ACTIVITIES											
Borrow Source Site Investigation		1	LS	$ 250,000	NA				$ 250,000		$ 250,000
Spreading Area "B" 404 Permit Application (6-months)		1	LS	$ 200,000	NA				$ 200,000		$ 200,000
Surface Water Controls/Soil Erosion Sediment Control Features		1	LS	$ 250,000	NA				$ 250,000		$ 250,000
Site Preparation: Clear, Grub & Grade		113	AC	$ 3,800	NA				$ 429,400		$ 429,400
Construct 2-mile Haul Road from Borrow to Site (Stone Road)		2	MI	$ 500,000	NA				$ 1,000,000		$ 1,000,000
Install/Develop GW Wells for Compaction Water		3	EA	$ 250,000	NA				$ 750,000		$ 750,000
Subtotal											**$ 2,879,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE RETRIEVAL, TREATMENT, AND DISPOSAL ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: RETRIEVAL/TREATMENT/DISPOSAL (RTD) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
CONSTRUCTION - MODIFIED RCRA SUBTITLE C COVER											
Pea Gravel Admixture with Topsoil 20-inches		264,000	CCY	$ 6	NA				$ 1,581,360		$ 1,581,360
Compacted Silt Loam (Topsoil) 20-inches		264,000	CCY	$ 5	NA				$ 1,259,280		$ 1,259,280
Sand Filter Layer 6-inches		79,000	CCY	$ 25	NA				$ 1,975,000		$ 1,975,000
Gravel Filter Layer 6-inches		79,000	CCY	$ 10	NA				$ 790,000		$ 790,000
Lateral Drainage Layer 6-inches		79,000	CCY	$ 10	NA				$ 790,000		$ 790,000
Low-Perm Asphalt 6-inches		79,000	CCY	$ 19	NA				$ 1,461,500		$ 1,461,500
Asphalt Base Course 4-inches		53,000	CCY	$ 19	NA				$ 980,500		$ 980,500
Gravel Gas Collection Layer, 6-inches		79,000	CCY	$ 10	NA				$ 790,000		$ 790,000
Fine Filter - Sideslopes, 12-inches		6,000	CCY	$ 25	NA				$ 150,000		$ 150,000
Coarse Filter - Sideslopes, 12-inches		6,000	CCY	$ 10	NA				$ 60,000		$ 60,000
Sideslope Rip-Rap 12-inches		6,000	CCY	$ 40	NA				$ 240,000		$ 240,000
Rip-Rap, Sideslope , 36-inches		18,000	CCY	$ 40	NA				$ 720,000		$ 720,000
Grading Fill, 10-ft Thick Average (Less post ISG decon fill)		1,564,000	CCY	$ 5	NA				$ 7,460,280		$ 7,460,280
Perimeter Berm		244,200	CCY	$ 5	NA				$ 1,164,834		$ 1,164,834
Install (37) New Lysimeters and Cap Penetrations		37	EA	$ 131,756	NA				$ 4,874,972		$ 4,874,972
OCVZ System Relocation/Well Extension		1	LS	$ 300,000	NA				$ 300,000		$ 300,000
Lab Geotechnical Testing/Compaction		40	MO	$ 50,000	NA				$ 2,000,000		$ 2,000,000
Filed Geotechnical Testing/Compaction		40	MO	$ 90,000	NA				$ 3,600,000		$ 3,600,000
Surveying/Grade Control		40	MO	$ 65,000	NA				$ 2,600,000		$ 2,600,000
Third-Party Independent CQA Testing/Certification		40	MO	$ 75,000	NA				$ 3,000,000		$ 3,000,000
									$ -		$ -
Hydroseeding/Mulching (Re-seeding Included)		113	AC	$ 2,750	NA				$ 310,750		$ 310,750
Seasonal Shutdown/Re-Mobilization		3	EA	$ 500,000	NA				$ 1,500,000		$ 1,500,000
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 779,758	NA				$ 779,758		$ 779,758
INEEL Site-Specific Training/Work Order Requirements		NA			1	LS	$ 990,423	$ 990,423			$ 990,423
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 845,161	$ 845,161
Pre-Final Inspection Report, Phase I					1	LS	$ 250,000	$ 250,000			$ 250,000
Subtotal											**$ 40,474,000**
Landfill Cover											
Topsoil , 1-ft		19,400	CCY	$ 6	NA				$ 116,206		$ 116,206
Sand Filter Layer, 1-ft Thick		19,400	CCY	$ 25	NA				$ 485,000		$ 485,000
Gravel Filter Layer, 1-ft Thick		19,400	CCY	$ 10	NA				$ 194,000		$ 194,000
Biotic Barrier Layer - 2.5-ft Thick		48,400	CCY	$ 50	NA				$ 2,420,000		$ 2,420,000
Gravel Gas Collection, 0.5-ft Thick		9,700	CCY	$ 10	NA				$ 97,000		$ 97,000
Compacted Clay Liner		38,800	CCY	$ 12	NA				$ 465,988		$ 465,988
Gravel Filter Layer, 1-ft Thick		19,400	CCY	$ 10	NA				$ 194,000		$ 194,000
Sand Filter Layer, 1-ft Thick		19,400	CCY	$ 25	NA				$ 485,000		$ 485,000
HDPE Geomembrane		58,100	SY	$ 6	NA				$ 319,550		$ 319,550
Engineered Earth Fill, 8-ft Thick		154,800	CCY	$ 5	NA				$ 738,396		$ 738,396
Hydroseeding/Mulching (Re-seeding Included)		12	AC	$ 2,750	NA				$ 33,000		$ 33,000
Lab Geotechnical Testing (Gradation, hardness, density)		10	MO	$ 50,000	NA				$ 500,000		$ 500,000
Filed Geotechnical Testing (Density)		10	MO	$ 90,000	NA				$ 900,000		$ 900,000
Surveying/Grade Control		10	MO	$ 65,000	NA				$ 650,000		$ 650,000
Third-Party Independent CQA Testing/Certification		10	MO	$ 75,000	NA				$ 750,000		$ 750,000
Seasonal Shutdown/Re-Mobilization		1	EA	$ 500,000	NA				$ 500,000		$ 500,000
Mobilization and Demobilization	2.0%	1	LS	$ 166,963	NA				$ 166,963		$ 166,963
INEEL Site-Specific Training/Work Order Requirements					1	LS	$ 216,362.47	$ 216,362.47			$ 216,362
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 184,629	$ 184,629
Pre-Final Inspection Report, Phase 2		NA			1	LS	$ 125,000.00	$ 125,000.00			$ 125,000
Subtotal											**$ 9,541,000**

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: RETRIEVAL/TREATMENT/DISPOSAL (RTD) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

	DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
	Subtotal Subcontractor Directs - Remedial Action											**$ 3,338,927,000**
	Subcontractor Overhead	15.0%										$ 500,839,050
	Subcontractor Profit	10.0%										$ 383,976,605
	TOTAL REMEDIAL ACTION COST											**$ 4,223,743,000**
	TOTAL COST - Remedial Action Contracts											**$ 4,889,950,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE RETRIEVAL, TREATMENT, AND DISPOSAL ALTERNATIVE
(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: RETRIEVAL/TREATMENT/DISPOSAL (RTD) ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
POST-REMEDIAL ACTION OPERATIONS (100 YEAR DURATION)											
INSTITUTIONAL CONTROLS FOR 100 YEARS											
Install Permanent Markers/Survey		12	EA	$ 5,000	NA				$ 60,000		$ 60,000.0
Replace Perimeter Security Fence		10,000	LF	$ 20	NA				$ 200,000		$ 200,000.0
Repair and Replace Perimeter Signs		1	LS	$ 10,000	NA				$ 10,000		$ 10,000.0
Subtotal											**$ 270,000**
COVER MAINTENANCE											
Cover Maintenance Cost - 100 Year Duration Annual Cap Maintenance Costs		100	YR	$ 75,000	NA				$ 7,500,000		$ 7,500,000
Subtotal											**$ 7,500,000**
SURVEILLANCE AND MONITORING											
Groundwater Monitoring: (16-wells)											
Groundwater Monitoring, Quarterly for 2 Years - (8-Sampling Events)		8	EVT	$ 1,000	8	EVT	$ 11,000	$ 88,000	$ 8,000	$ 854,936	$ 950,936
Groundwater Monitoring, Semi -Annually for 3 Years - (6-Sampling Events)		6	EVT	$ 1,000	6	EVT	$ 11,000	$ 66,000	$ 6,000	$ 641,202	$ 713,202
Groundwater Monitoring, Annually for 95 Years (95-Sampling Events)		95	EVT	$ 500	95	EVT	$ 5,500	$ 522,500	$ 47,500	$ 5,076,183	$ 5,646,183
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 731,032	NA				$ 731,032		$ 731,032
Vadose Zone Monitoring:											
Sample 37 Lysimeters 1 Time per Year in Late Spring (Initial 5 years)		5	EVT	$ 1,000	100	EVT	$ 17,875	$ 89,375	$ 5,000	$ 133,585	$ 227,960
Sample 37 Lysimeters 1 Time per Year in Late Spring (95 years)		95	EVT	$ 500	100	EVT	$ 8,938	$ 849,063	$ 47,500	$ 1,269,058	$ 2,165,620
Sample & Analyze 20 Vapor Ports 4 Times per Year for 5 Years		20	EVT	$ 1,000	20	EVT	$ 27,500	$ 550,000	$ 20,000	$ 140,000	$ 710,000
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 310,358	NA				$ 310,358		$ 310,358
Surface Water Monitoring:											
Collect Sample from 2 Points 2 Times Every 5 Years (20 Sample Events)		20	EVT	100	20	EVT	$ 1,375.00	$ 27,500.00	$ 2,000	$ 320,660	$ 350,160
Vegetation Monitoring:											
1 Inspection per Year in Early Fall for 5 years		NA			5	EVT	$ 1,100	$ 5,500			$ 5,500
Re-seed 10 Acres Each Year for 5 Years (50 Acres Total)		50	AC	$ 15,000	NA				$ 750,000		$ 750,000
1 Inspection Every 5th Year in Early Fall Thereafter for 95 Years		NA			19	EVT	$ 1,100	$ 20,900			$ 20,900
Re-seed 10 Acres Every 5 Years		19	EVT	$ 15,000	NA				$ 285,000		$ 285,000
Air Monitoring (Radiological/Organic):											
Monitor 4 Existing CAMs		100	EVT	$ 1,000	1	LS	$ 2,200	$ 220,000	$ 100,000	$ 15,300	$ 335,300
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 33,530					$ 33,530		$ 33,530
Perimeter Radiological Monitoring GPS with NaI Detector											
2 People, 1-Time per Year, 2 Days in Summer with Hummer & GPS		100	YR	$ 500	100	YR	$ 2,200	$ 220,000	$ 50,000		$ 270,000
Data Interpretation/Plot Data		100	YR	$ 750	100	YR	$ 2,500	$ 250,000	$ 75,000		$ 325,000
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 59,500	NA				$ 59,500		$ 59,500
Biological Monitoring:											
2 People 2-Times, First 5-Years for Intrusion Monitoring		NA			2	EVT	$ 1,100	$ 2,200			$ 2,200
2 People 1-Time, Every 5th Year thereafter for 95 years		NA			19	EVT	$ 1,100	$ 20,900			$ 20,900
Subtotal											**$ 13,913,000**
Subtotal Surveillance and Monitoring (Sampling & Monitoring Activities)											**$ 21,683,000**
WAG 7 MANAGEMENT											
WAG 7 Management (@ 5% of other post-RA operations costs)	5%				1	LS	$ 1,084,150	$ 1,084,150			$ 1,084,150
Annual Data Summary Report (100 reports @ 200 hrs/report)					20,000	HR	75.00	$ 1,500,000			$ 1,500,000
WAG-Wide RA 5 Year Reviews for 100 Years (20 5-year reviews @ 600 hrs/review)					12,000	HR	$ 75	$ 900,000			$ 900,000
Subtotal											**$ 3,484,150**
TOTAL COST - Post-Remedial Action Operations (100 Year Duration)											**$ 25,167,150**

Attachment D-6

Operable Unit 7-13/14 Feasibility Study Cost Estimate for the Limited Action Alternative

The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost estimate are likely to occur as a result of new information and data collected during the engineering design, safety reviews, and remedial alternative. Major changes may be documented in the form of a memorandum in the administrative record file, an explanation of significant differences, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within –30 to +50 percent of the actual project cost.

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE LIMITED ACTION ALTERNATIVE

Project Title:	WAG 7 OU 13/14 Feasibility Study
Estimator:	Brian K. Corb
Date:	December 2002
Estimate Type:	Planning
Reviewed/Appr.:	Lee Lindig/Bruce L. Stevens

I. SCOPE OF WORK:

A. Remedial Design and Remedial Action

Constructing the Limited Action alternative will be implemented in two phases because a portion of the SDA is currently active and receiving waste material. Phase 1 will cover the inactive portion of the site (105 acres) and Phase 2 will cover the active portion of the site (5 acres) after disposal operations are completed in 2020. Constructing the Limited Action alternative includes preconstruction activities, placing earthen fill, and placing gravel, coarse fractured basalt, and riprap layers. Preconstruction activities will include investigating borrow sources, preparing final design, completing a readiness assessment, and mobilizing.

B. Long-Term Monitoring and Maintenance

After the Remedial Action has been completed, long-term monitoring and maintenance will continue for 100 years, with CERCLA reviews conducted every 5 years. The long-term environmental monitoring will be conducted for groundwater, vadose zone water, surface water, and air. In addition, the biotic barrier itself will be monitored annually during the first 5 years following completion of construction. After that, monitoring will be reduced to every 5 years concurrent with the 5-year reviews required under CERCLA. The biotic barrier will be monitored for damage from erosion and differential settlement. Areas of erosion and settlement damage will be repaired with additional earthen fill, gravel, coarse fractured basalt, or riprap as needed to maintain barrier integrity.

II. BASIS OF ESTIMATE:

The basis of the estimate was developed from the following sources to provide a defensible and comparative cost of the remedial alternatives. The applicable sources available for the Limited Action alternative include:

A. EPA, "A Guide to Developing and Documenting Cost Estimates During Feasibility Study," July 2000

B. INEEL, "Cost Estimating Guide," DOE/ID-10473, 2000

C. "Environmental Assessment and Plan for New Silt/Clay Source Development and Use at the Idaho National Engineering and Environmental Laboratory," DOE/EA-1083, May 1997

D. *Caterpillar Equipment Performance Handbook*, 31st Edition

E. The INEEL Site Stabilization Agreement, Union Labor Agreement

F. Facilities Unit Costs—Military Construction, PAX Newsletter No. 3.2.2—10, March 2000

G. ICDF Construction Cost Estimate, Cap Construction Cost (CH2MHILL, December 2000)

H. Subject Matter Experts—M. Jackson, BBWI, and T. Borschel, BBWI, "Availability of Borrow Source Material at the INEEL"

I. BBWI, "INEEL Site Craft and Professional Services Labor Rates," February 2002

J. OMB, 2002, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Appendix C, "Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses," OMB Circular A-94, February 2002.

K. R. S. Means, 2002, *Heavy Construction and Industrial Building Unit Costs Data* 16th edition, Kingston, Massachusetts.

L. INEEL, "Analytical Laboratory Unit Costs."

III. ASSUMPTIONS:

The primary work associated with the Limited Action alternative includes placing earthen fill, gravel, coarse fractured basalt, and riprap over the SDA. Because some portions of the SDA will continue operating until 2020, the biotic barrier construction effort is divided into two phases. Phase 1 includes placing the biotic barrier over approximately 105 acres of inactive portions of the SDA. Phase 2 includes placing the biotic barrier over an estimated 5 acres of the SDA that will remain active until 2020. Specific elements of the work and important assumptions are provided below:

A. Management and Oversight

A.1 Project Management for the BBWI oversight of this alternative has been estimated based on an average classification of job categories using the BBWI rates. The number of FTEs are based on 2,000 MH per person per year.

A.2 The RD/RA schedule assumes that budgetary funding will not be constrained.

A.3 The RD/RA schedule assumes no unexpected delays will result from changes to the USQ/SAR process.

A.4 The estimate assumes that INEEL site resources (i.e., CFA, medical facilities, geotechnical lab, fire department, security, utilities at the SDA) will be available for the duration.

B. Design and Preconstruction

B.1 Preconstruction activities—Borrow source investigations, cultural resource clearance, developing an onsite source of basalt rock, final design, readiness assessment completion, and mobilizing.

C. Site Preparation and Support Activities and Facilities

C.1 Placing earthen fill—Site clearing, grubbing, and leveling will be followed by placing a site-grading fill (averaging 7-ft thick over the SDA) to facilitate positive perimeter drainage.

C.2 It is assumed that after grading fill placement has been completed, heavy equipment operation can commence without any ground subsidence. No additional cost for cribbing or temporary road stabilization is included in the estimate.

C.3 The capital cost for the project includes relocating the existing OCVZ extraction and treatment units, and extending the well casings through the biotic barrier.

D. Borrow Areas

D.1 Spreading Area B will be available and will not be flooded. No additional costs have been provided to dewater Spreading Area B.

D.2 Adequate quantity and quality of borrow source material is available from Spreading Area B, the Borax Pit, and the Basalt Source (for riprap and coarse fractured basalt). Furthermore, no royalty fee or earthen material costs are provided for in the estimate.

D.3 An adequate water source will be available to support the earthmoving and soil moisture conditioning for placement and compaction based on the equipment productivities assumed for this estimate.

E. Biotic Barrier Construction

E.1 Placing gravel, coarse fractured basalt, and riprap—Placing a 1-ft-thick gravel layer over earth fill, a 3-ft-thick layer of coarse fractured basalt over gravel, a 1-ft-thick layer of gravel over coarse fractured basalt, and a 3-ft-thick layer of riprap over gravel.

F. Capital Costs, Unit Rates, and other Pricing Assumptions

F.1 The unit prices have been developed from a crew build-up to process, load, haul, place, and compact. The volume of material represented in the cost tables identifies CCY. The appropriate factors convert the estimated unit material weights (bank, loose, and fill) and are factored into the equipment productivity.

F.2 Crew labor rates were developed based on hourly rates stipulated in the INEEL Site Stabilization Agreement. Labor and equipment spreads were developed based on the assumed achievable daily productivity. Other factors that influenced the selection of labor and equipment quantities include safety, level of PPE of the work to be performed, haul routes, and availability of resources on the INEEL. Each daily crew cost also includes field oversight personnel (e.g., HSO, superintendents, foremen, CIH, and maintenance personnel) and supplies (e.g., fuel, oil, grease, and spare parts).

F.3 Primarily all capital equipment and pricing were selected from commercially available sources or similar projects allowing a scale factor to be applied to yield an estimated cost of the conceptual equipment and operational requirements. Equipment installation is considered to be a significant cost variable in estimating individual components of a given system. The installation cost of the capital equipment was based on a percentage of capital costs ranging from 110 to 160% of the estimated capital expenditure, based on the unknowns and level of complexity.

F.4 Subcontractors' bond and insurance rate of 2% of the total subcontractor dollars includes overhead and profit based on each alternative.

F.5 The estimate includes an allocation for the INEEL specific work order PRD requirements and safety meetings. Because this estimate includes primarily unit prices, the labor cost is estimated to be 40% of the unit prices and, based on historical data, cost of the INEEL-specific process is approximately 6% of the total labor dollars.

G. Schedule

G.1 The estimate assumes that earthwork operations can be performed for 10 months per year without weather impacts. The work will be performed working two 10-hour shifts, with a back shift working 5 days per week to perform maintenance.

G.2 The estimate assumes that the field crews will demobilize equipment during the 2-month winter shutdown to refurbish and replace the equipment. The estimate includes an allocation to cover these costs in addition to the 2% estimated.

H. Health and Safety

H.1 It is assumed that the after the initial site grading material is placed over the SDA, all earthmoving operations can be performed in Level D.

I. Long-term Operating and Maintenance and Monitoring

I.1 The capital cost for the project includes replacing and reinstalling 37 existing lysimeters. The estimate assumes that lysimeters will be installed at varying depths of 20, 90, 200, and 600 ft along the interbed surfaces.

I.2 The lysimeter analytical cost assumes that liquid samples will be recovered in 10% of the wells. Therefore, analytical costs are included only for the assumed number of recoverable samples.

I.3 Ongoing maintenance of the biotic barrier will be required in perpetuity after construction is completed. It is assumed that frequent maintenance will be required during the years immediately following construction to repair damage from erosion. In addition, the added weight of the biotic barrier is expected to result in increased settlement during the initial years following construction. Some areas of the biotic barrier will require ongoing maintenance to repair damage resulting from settlement. It is expected that annual maintenance and repairs will be required during the first 5 years following construction. Ongoing maintenance and repairs will continue every 5 years concurrent with the 5-year review process.

J. Design Costs

The following discussion provides the basis for the assumed percentage for design, construction, and contingency. EPA provides guidance for estimating remedial design costs in the EPA Guidance. Exhibit 5-8 of the EPA Guidance provides examples of remedial design costs as a percentage of total capital costs. The percentages range from 20% for projects with capital costs less than $100,000 to 6% for projects with capital costs greater than $10 million. The EPA Guidance does not provide an example of design costs that vary according to the complexity of technologies.

The alternatives include technologies that have been demonstrated on other sites and have well developed engineering design criteria (e.g., capping) and technologies that have not been demonstrated on a large scale and require development of engineering design criteria (e.g., ISV). Remedial design costs are expected to vary significantly according to the degree of complexity and the estimated costs for remedial design needed to reflect the varying degrees of complexity. Based on the complexity of the technology application, a percentage of capital and operating cost specific to the technology was assumed.

The biotic barrier system has been demonstrated on other sites, and design standards have been developed for various materials and construction methods. Some borrow source investigations will be needed to verify material properties and quantities, but the methods for conducting these investigations are not expected to require specialized equipment or personnel. Because capping for the biotic barrier is a demonstrated technology with established design standards, the cost for remedial design is assumed to be 6% of capital costs.

K. Construction Management Costs

Cost considerations for BBWI oversight, regulatory agency interaction, and project management were estimated on a representative basis of an assumed level of effort required to implement the selected alternative. Additionally, estimated costs for the remedial design, safety equipment and PPE, construction management, general conditions, and insurance and bonds were included to capture a relative basis for cost comparison and to identify other costs associated with implementing a given remedial alternative.

The percentage is based on total capital construction cost to implement the alternative. The percentage basis assumed for each category identified was selected considering the complexity of the alternative and risk and uncertainty of the approach. The cost identified under the category general conditions includes administration buildings, parking area, utilities, and support infrastructure to facilitate the remedial alternative.

L. Contingency Costs

The EPA provides guidance for estimating contingency costs in the EPA Guidance, which distinguishes between scope contingency and bid contingency costs. Scope contingency costs represent risks associated with incomplete design and include factors such as limited experience with technologies, additional requirements because of regulatory or policy changes, and inaccuracies in defining quantities or characteristics. Exhibit 5-6 of the EPA Guidance provides examples of scope contingencies. Bid contingency costs are unknown costs at the time of estimate preparation that become known as remedial action construction or O&M proceeds. Bid contingencies represent reserves for quantity overruns, modifications, change orders, and claims during construction. The EPA Guidance states that bid contingencies may be added to construction and O&M costs and typically range from 10 to 20%.

Because EPA Guidance suggests that contingency costs will vary according to the alternative technologies, it is necessary to estimate varying contingency costs for the technologies included in the alternatives. Biotic barrier technology includes placing earthen fill, gravel, and armor (fractured basalt and riprap) over the SDA to prevent access to waste materials. Constructing an infiltration barrier using synthetic materials is not included as part of this technology. The only risk related to scope and bid contingencies associated with this technology is the ability to locate and permit borrow sources for biotic barrier materials. Biotic barrier technology is assumed to require a scope contingency for a clay cap listed in Table 1 (5 to 10%). Because of the low risk associated with this technology, the costs for scope and bid contingencies would be 10% each for a total contingency of 20% of capital costs.

IV. SCHEDULE:

The following activities comprise the RD/RA portion the Limited Action alternative. The corresponding durations are based on the estimated crew productivity, regulatory reviews and approvals, and weather constraints inherent to the INEEL site. They are presented in Tables 2 and 3.

V. PRESENT WORTH ANALYSIS:

Guidance for present value analysis is provided in Chapter 4 of the EPA Guidance, which states that the present value analysis of a remedial alternative involves four basic steps:

1. Define the period of analysis
2. Calculate the cash outflows (payments) for each project year
3. Select a discount rate to use in the present value calculation
4. Calculate the present value.

Periods of analysis for the Limited Action alternative include Phase 1 design and construction, Phase 2 design and construction, and O&M. Phase 1 is estimated to last 6 years, beginning shortly after issuance of a ROD for the site. Phase 2 is estimated to last 2 years beginning shortly after currently active areas of the site are closed in 2020. O&M will begin toward the end of the vegetation establishment period for Phase 1 construction and will continue for 100 years.

Cash outflows for the Limited Action alternative will include payments for design and construction, periodic payments for major repairs, and annual O&M costs. EPA Guidance suggests that most capital costs occur in the first year of remedial action. While this suggestion might be realistic for short-duration remedial actions, it is not a realistic assumption for the Limited Action alternative because of the time required for design and construction. Cash outflows for the Limited Action alternative would be paid on an annual basis as costs are incurred, beginning with the borrow source investigation and remedial design and ending with riprap placement for Phase 1 and Phase 2 construction.

Annual capital cost payments vary with the level of activity with relatively low annual payments during the borrow source investigation, remedial design, and readiness assessment and relatively high annual payments during heavy construction periods (material excavation, processing, stockpiling, and placement). Periodic costs for major repairs would occur every 5 years, concurrent with the 5-year reviews required by CERCLA. Periodic costs would begin 5 years after Phase 1 construction and continue through the O&M period. Annual O&M costs would begin the first year after completion of Phase 1 and continue for 100 years. In accordance with EPA Guidance requirements, 2002 constant dollars are used for all annual and periodic cash outflows.

EPA Guidance requires using a real discount rate that approximates the marginal pretax rate of return on an average investment and has been adjusted to eliminate the effect of expected inflation. The real discount rate must be used with constant or real dollars that have not been adjusted for inflation. EPA Guidance recommends using a 7% real discount rate for present value analysis in most remedial action cost estimates. However, for federal facility sites being cleaned up using Superfund authority, EPA Guidance states that it is appropriate to apply the real discount rates found in Appendix C of OMB Circular A-94. Suggested rates for federal facility sites are based on interest rates from Treasury notes and bonds and are appropriate because the federal government has a different cost of capital than the private sector. The most current version of Appendix C of OMB Circular A-94 (revised February 2002) proposes a real discount rate of 3.9% for programs lasting longer than 30 years. The 3.9% discount rate and constant dollars are used for the present value analysis of the Limited Action alternative. The present value of the Limited Action alternative is calculated using the equations provided in EPA Guidance.

VI. RISK AND UNCERTAINTY:

Because the primary construction activity associated with the Limited Action alternative is excavation, hauling, and placing large quantities of borrow material, the highest risk for this alternative is losing of a primary borrow source located close to the site. Increased haul distances could result in a significant increase in the construction schedule and the cost of materials. The primary materials needed for the biotic barrier are silt loam and mined and processed basalt. For this alternative, it is assumed that sufficient quantities of silt loam will be available from Spreading Area B, located very near the site. If this source is lacking in capacity or otherwise unavailable, the nearest alternative sources are the Ryegrass Flats and WRRTF borrow areas. Ryegrass Flats is 12 mi from the site and the WRRTF borrow area is 34 mi. The haul distance from Spreading Area B is 1.5 mi. Mined and processed basalt is assumed to be available from a basalt outcrop located 5 mi from the site. If Spreading Area B is not available for excavation or the basalt outcrop is not available for mining, other sources more distant from the site would need to be developed at greater cost.

An additional assumption related to borrow sources is that coarse fractured basalt may be substituted for cobbles as part of the biotic barrier. If this substitution is not allowed and cobbles must be used, cobbles would need to be obtained from Idaho Falls, about 45 mi from the site. The required using cobbles would result in significant increases in costs and time.

VII. ESTIMATED MATERIAL VOLUME TABLES:

Tables 4 and 5 summarize required materials for the Limited Action alternative and related design layers, thickness, and volume.

VIII. TABLES:

Table 1. Example feasibility study-level scope contingency percentages.

Remedial Technology	Scope Contingency (%)
Soil excavation	15 to 55
Synthetic cap	10 to 20
Clay cap	5 to 10
Surface grading and diking	5 to 10
Revegetation	5 to 10

Table 2. Phase 1—design and construction.

Activity Description	Estimated Duration
Borrow source investigation	1 year
Remedial design and procurement	1.0 year (overlaps borrow source inv. by 0.5 year)
Readiness assessment	0.5 year (no overlap with design)
Mobilization	0.5 year (no overlap with readiness assessment)
Earthen fill placement	2 years (no overlap with readiness assessment)
Gravel placement	0.5 year (overlaps earthen fill by 0.5 year)
Coarse fractured basalt placement	1 year (no overlap with gravel placement)
Gravel placement	0.5 year (overlaps basalt placement by 0.5 year)
Riprap placement	1 year (no overlap with gravel placement)

Table 3. Phase 2—Design and construction.

Activity Description	Estimated Duration
Remedial design and procurement	1 year assumed
Readiness assessment	1 year (no overlap with design)
Mobilization	0.5 year (no overlap with readiness assessment)
Placement of all biotic barrier layers	1 year (no overlap with mobilization)

Table 4. Distances and sources of borrow materials for the modified RCRA Subtitle C cover system.

Material	Issue	One-Way Haul Distance	Source
Silt loam	This material would be used to construct the earthen fill layer of the barrier.	1.5 mi	This material is expected to be unprocessed silt loam derived from Spreading Area B. Additional material is available from Ryegrass Flats (haul distance = 12 mi) and WRRTF borrow area (haul distance = 34 mi).
Gravel	This material would be used for the gravel layers within the barrier. Sufficient quantities of good structural gravel are available.	2.5 mi	This material is assumed to be unprocessed gravel derived from the Borax Gravel Pit.
Riprap	Riprap would be used on the surface of the barrier. The majority of the mined riprap material at the INEEL has been used for other remedial actions at the INEEL.	5 mi	This material is assumed to be processed material mined from a basalt outcropping identified 5 mi from the site, directly west of the RWMC and just outside the Big Lost River System.
Coarse fractured basalt	This material would be used between the gravel layers of the barrier. The majority of the mined coarse fractured basalt material at the INEEL has been used for other remedial actions at the INEEL.	5 mi	This material is assumed to be processed material mined from a basalt outcropping identified 5 mi from the site, directly west of the RWMC and just outside the Big Lost River System.
Cobbles	This material would be used between the gravel layers of the barrier if coarse fractured basalt is not available or is not allowed for such use. No identified borrow areas are within the INEEL boundary.	45 mi	This material is assumed to be processed material transported to the INEEL from Idaho Falls.

RWMC = Radioactive Waste Management Complex
WRRTF = Water Reactor Research Test Facility

Table 5. Biotic barrier design layers, thickness, and volume.

Layer	Thickness	Approximate Volume[a]	Material Description
Phase 1—Construction (105 acres)			
Riprap	36 in.	508,200 CCY	Processed basalt mined from an INEEL site.
Gravel	12 in.	169,400 CCY	Unprocessed gravel from the Borax Gravel Pit.
Coarse basalt	36 in.	508,200 CCY	Processed basalt mined from an INEEL site.
Gravel	12 in.	169,400 CCY	Unprocessed gravel from the Borax Gravel Pit.
Earthen fill	84 in.	1,185,800 CCY	Unprocessed silt loam from Spreading Area B.
Perimeter berm	NA	244,200 CCY	Unprocessed silt loam from Spreading Area A; berm average 6-ft high; 100-ft wide; 10,000-ft perimeter; 2H:1V side slopes.
Phase 2 —Construction (5 acres)			
Riprap	36 in.	24,200 CCY	Processed basalt mined from an INEEL site.
Gravel	12 in.	8,100 CCY	Unprocessed gravel from the Borax Gravel Pit.
Coarse basalt	36 in.	24,200 CCY	Processed basalt mined from an INEEL site.
Gravel	12 in.	8,100 CCY	Unprocessed gravel from the Borax Gravel Pit.
Earthen fill	84 in.	56,500 CCY	Unprocessed silt loam from Spreading Area B.

a. This table provides estimated in-place volumes rounded to the nearest 100 CCY.
CCY = compacted cubic yard
INEEL = Idaho National Engineering and Environmental Laboratory
NA = not applicable

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE LIMITED ACTION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: LIMITED ACTION ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/24/02

	DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
	FFA/CO MANAGEMENT AND OVERSIGHT											
	WAG 7 Management (8-Years)											
	Coordination/Oversight Tech Support (E28) - 1.0 FTE/YR		NA			16,000	HR	$ 93	$ 1,483,520			$ 1,483,520
	Coordination with Agency Participants (E28) - 0.5 FTE/YR		NA			8,000	HR	$ 93	$ 741,760			$ 741,760
	Environmental Engineering (E08) - 1.0 FTE/YR		NA			16,000	HR	$ 76	$ 1,210,720			$ 1,210,720
	Cost and Schedule Control (F10) - 2.0 FTE/YR		NA			32,000	HR	$ 59	$ 1,884,480			$ 1,884,480
	Regulatory Compliance (S11) - 1.0 FTE/YR		NA			16,000	HR	$ 79	$ 1,264,160			$ 1,264,160
	Quarterly and Annual Reviews (S21) - 1.0 FTE/YR		NA			16,000	HR	$ 73	$ 1,162,880			$ 1,162,880
	Audit Preparation and Coordination (S11) - 0.5 FTE/YR		NA			8,000	HR	$ 79	$ 632,080			$ 632,080
	Health and Safety Coordination/Training (S08) - 2.0 FTE/YR		NA			32,000	HR	$ 62	$ 1,994,240			$ 1,994,240
	Annual O&M Reports (S15) - 0.5 FTE/YR		NA			8,000	HR	$ 79	$ 628,320			$ 628,320
	Attorney/Legal Fees, 0.3 FTE/YR		NA			4,800	HR	$ 150	$ 720,000			$ 720,000
	Allocation for Other Direct Costs (ODCs) - 10% of Total Labor		NA			1	LS	$ 1,100,216	$ 1,100,216			$ 1,100,216
	TOTAL COST - FFA/CO Management and Oversight											$ 12,822,000
	Construction Management											
	Construction Management (@ 6% of Phase 1 & 2 RA Costs)	6%	NA			1	LS	$ 5,573,160	$ 5,573,160			$ 5,573,160
	General Conditions (@ 1.25% of Phase 1 & 2 RA Costs)	1.25%	NA			1	LS	$ 1,161,075	$ 1,161,075			$ 1,161,075
	Health and Safety Equipment Allocation (@ 0.25% of Phase 1 & 2 RA Costs)	0.25%	NA			1	LS	$ 232,215	$ 232,215			$ 232,215
	Medical Monitoring/Surveillance/Air Monitoring (@ 0.10% of Phase 1 & 2 RA Costs)	0.10%	NA			1	LS	$ 92,886	$ 92,886			$ 92,886
	TOTAL COST - Construction Management											$ 7,059,000
	REMEDIAL DESIGN AND REMEDIAL ACTION PLANS/REPORTS											
	Biotic Barrier RD/RA Workplan (@ 6% of Phase 1 & 2 Construction)	6%	NA			1	LS	$ 4,405,680	$ 4,405,680			$ 4,405,680
	Readiness Assessment (@ 1.5% of Construction)	1.5%	NA			1	LS	$ 1,393,290	$ 1,393,290			$ 1,393,290
	Remedial Action Report		NA			3,000	HR	$ 76	$ 227,010			$ 227,010
	TOTAL COST - Remedial Design											$ 6,026,000

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE LIMITED ACTION ALTERNATIVE

(continued).

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OU7-13/14 DRAFT COMPREHENSIVE FS
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BIOTIC BARRIER - PHASE 1											
PRE-CONSTRUCTION ACTIVITIES											
Borrow Source Site Investigation		1	LS	$ 250,000	NA				$ 250,000		$ 250,000
Surface Water Controls/Soil Erosion Sediment Control Features		1	LS	$ 250,000	NA				$ 250,000		$ 250,000
Spreading Area "B" 404 Permit Application (6-months)		1	LS	$ 200,000	NA				$ 200,000		$ 200,000
Site Preparation: Clear, Grub & Grade		125	AC	$ 3,800	NA				$ 475,000		$ 475,000
Construct 2-mile Haul Road from Borrow to Site (Stone Road)		2	MI	$ 500,000	NA				$ 1,000,000		$ 1,000,000
Subtotal											**$ 2,175,000**
CONSTRUCTION											
Rip-Rap Layer - 3-ft Thick		508,200	CCY	$ 15	NA				$ 7,506,114		$ 7,506,114
Gravel Layer - 1.0-ft Thick		169,400	CCY	$ 10	NA				$ 1,694,000		$ 1,694,000
Coarse Fractured Basalt Layer - Sideslope of Surface Barrier, 3-ft		508,200	CCY	$ 50	NA				$ 25,410,000		$ 25,410,000
Gravel Filter Layer, 1-ft Thick		169,400	CCY	$ 10	NA				$ 1,694,000		$ 1,694,000
Engineered Earth Fill - 7-ft Thick Average		1,185,800	CCY	$ 5	NA				$ 5,656,266		$ 5,656,266
Perimeter Berm		244,200	CCY	$ 5	NA				$ 1,164,834		$ 1,164,834
Install (37) New Lysimeters and Cap Penetrations		37	EA	$ 131,756	NA				$ 4,874,972		$ 4,874,972
OCVZ System Relocation/Well Extension		1	LS	$ 300,000	NA				$ 300,000		$ 300,000
Lab Geotechnical Testing (Gradation, hardness, density)		40	MO	$ 50,000	NA				$ 2,000,000		$ 2,000,000
Filed Geotechnical Testing (Density)		40	MO	$ 90,000	NA				$ 3,600,000		$ 3,600,000
Surveying/Grade Control		40	MO	$ 65,000	NA				$ 2,600,000		$ 2,600,000
Third-Party Independent CQA Testing/Certification		40	MO	$ 75,000	NA				$ 3,000,000		$ 3,000,000
Seasonal Shutdown/Re-Mobilization		3	EA	$ 500,000	NA				$ 1,500,000		$ 1,500,000
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 1,233,504	NA				$ 1,233,504		$ 1,233,504
INEEL Site-Specific Training/Work Order Requirements	6%				1	LS	$ 1,545,809	$ 1,545,809			$ 1,545,809
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 1,319,090	$ 1,319,090
Pre-Final Inspection Report, Phase I		NA			1	LS	$ 175,000	$ 175,000			$ 175,000
Subtotal											**$ 65,274,000**
Subtotal Subcontractor Directs - Phase 1 Remedial Action											**$ 67,449,000**
Subcontractor Overhead	15.0%									$ 10,117,350	$ 10,117,350
Subcontractor Profit	10.0%									$ 7,756,635	$ 7,756,635
TOTAL COST - Phase 1 Remedial Action											**$ 85,323,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE LIMITED ACTION ALTERNATIVE

(continued).

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ROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
UBJECT: LIMITED ACTION ALTERNATIVE
OCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
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Reviewed/Updated: MAG 10/24/02

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BIOTIC BARRIER - PHASE 2											
SITE PREPARATION											
Site Preparation: Clear, Grub & Grade		5	AC	$ 5,400.0	NA				$ 27,000		$ 27,000
Subtotal											**$ 27,000**
CONSTRUCTION											
Rip-Rap Layer - 3-ft Thick		24,200	CCY	$ 15					$ 357,434		$ 357,434
Gravel Layer - 1.0-ft Thick		8,100	CCY	$ 15					$ 118,827		$ 118,827
Coarse Fractured Basalt Layer - Sideslope of Surface Barrier, 3-ft		24,200	CCY	$ 50					$ 1,210,000		$ 1,210,000
Gravel Filter Layer, 1-ft Thick		8,100	CCY	$ 15					$ 118,827		$ 118,827
Engineered Earth Fill - 7-ft Thick Average		56,500	CCY	$ 5					$ 269,505		$ 269,505
Lab Geotechnical Testing (Gradation, hardness, density)		10	MO	$ 50,000					$ 500,000		$ 500,000
Filed Geotechnical Testing (Density)		10	MO	$ 90,000					$ 900,000		$ 900,000
Surveying/Grade Control		10	MO	$ 85,000					$ 850,000		$ 850,000
Third-Party Independent CQA Testing/Certification		10	MO	$ 70,000					$ 700,000		$ 700,000
Seasonal Shutdown/Re-Mobilization		1	EA	$ 500,000					$ 500,000		$ 500,000
Mobilization and Demobilization	2%	1	LS	$ 101,032					$ 101,032		$ 101,032
INEEL Site-Specific Training/Work Order Requirements	6%	NA			1	LS	$ 135,663	$ 135,663			$ 135,663
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 115,766	$ 115,766
Pre-Final Inspection Report, Phase 2		NA			1	LS	$ 75,000	$ 75,000			$ 75,000
Subtotal											**$ 5,952,000**
Subtotal Subcontractor Directs - Phase 2											**$ 5,979,000**
Subcontractor Overhead	15.0%	NA			NA					$ 896,850	$ 896,850
Subcontractor Profit	10.0%	NA			NA					$ 687,585	$ 687,585
TOTAL COST - Phase 2 Remedial Action											**$ 7,563,000**
TOTAL COST - Phase 1 & 2 Remedial Action Contracts											**$ 92,886,000**
TOTAL CAPITAL COSTS											$ 118,793,000

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE LIMITED ACTION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
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POST-REMEDIAL ACTION OPERATIONS (100 YEAR DURATION)										
Install Permanent Markers/Survey	12	EA	$ 5,000	NA				$ 60,000		$ 60,000
Replace Perimeter Security Fence	10,000	LF	$ 20	NA				$ 200,000		$ 200,000
Repair and Replace Perimeter Signs	1	LS	$ 10,000	NA				$ 10,000		$ 10,000
Subtotal										**$ 270,000**
COVER MAINTENANCE										
Cover Maintenance Cost - 100 Year Duration Annual Cap Maintenance Costs	100	YR	$ 22,500	NA				$ 2,250,000		$ 2,250,000
Subtotal										**$ 2,250,000**
SURVEILLANCE AND MONITORING										
Groundwater Monitoring: (16-wells)										
Groundwater Monitoring, Quarterly for 2 Years - (8-Sampling Events)	8	EVT	$ 1,000	8	EVT	$ 11,000	$ 88,000	$ 8,000	$ 854,936	$ 950,936
Groundwater Monitoring, Semi -Annually for 3 Years - (6-Sampling Events)	6	EVT	$ 1,000	6	EVT	$ 11,000	$ 66,000	$ 6,000	$ 641,202	$ 713,202
Groundwater Monitoring, Annually for 95 Years (95-Sampling Events)	95	EVT	$ 1,000	95	EVT	$ 11,000	$ 1,045,000	$ 95,000	$ 10,152,365	$ 11,292,365
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)	1	LS	1,295,650	NA				$ 1,295,650		$ 1,295,650
Vadose Zone Monitoring:										
Sample 37 Lysimeters 1 Time per Year in Late Spring	100	EVT	$ 1,000	100	EVT	$ 17,875	$ 1,787,500	$ 100,000	$ 2,671,700	$ 4,559,200
Sample & Analyze 20 Vapor Ports 4 Times per Year for 5 Years	20	EVT	$ 1,000	20	EVT	$ 27,500	$ 550,000	$ 20,000	$ 140,000	$ 710,000
Sample & Analyze 20 Vapor Ports 1 Time per Year thereafter	95	EVT	$ 1,000	95	EVT	$ 27,500	$ 2,612,500	$ 95,000	$ 665,000	$ 3,372,500
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)	1	LS	$ 864,170	NA				$ 864,170		$ 864,170
Surface Water Monitoring:										
Collect Sample from 2 Points 2 Times Every 5 Years (20 Sample Events)	20	EVT	$ 100	20	EVT	$ 1,375	$ 27,500	$ 2,000	$ 320,660	$ 350,160
Air Monitoring (Radiological/Organic):										
Monitor 4 Existing CAMs	100	EVT	$ 1,000	100	EVT	$ 2,200	$ 220,000	$ 100,000	$ 15,300	$ 335,300
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)	1	LS	$ 33,530	NA				$ 33,530		$ 33,530
Perimeter Radiological Monitoring GPS with NaI Detector										
2 People, 1-Time per Year, 2 Days in Summer with Hummer & GPS	100	YR	$ 500	100	YR	$ 2,200	$ 220,000	$ 50,000		$ 270,000
Data Interpretation/Plot Data	100	YR	$ 750	100	YR	$ 2,500	$ 250,000	$ 75,000		$ 325,000
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)	1	LS	59,500	NA				$ 59,500		$ 59,500
Biological Monitoring:										
2 People 2-Times per year, First 5-Years for Intrusion Monitoring	NA			2	EVT	$ 1,100	$ 2,200			$ 2,200
2 People 1-Time, Every 5th Year thereafter for 95 years	NA			19	EVT	$ 1,100	$ 20,900			$ 20,900
Subtotal										**$ 25,155,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE LIMITED ACTION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: LIMITED ACTION ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/24/02

	DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP COST	OTHER COST	TOTAL COST
	Subtotal Surveillance and Monitoring (Sampling & Monitoring Activities)											**$ 27,675,000**
	WAG 7 MANAGEMENT											
	WAG 7 Management (@ 5% of other post-RA operations costs)	5%	NA			1	LS	$ 1,383,750	$ 1,383,750			$ 1,383,750
	Annual Data Summary Report (100 reports @ 200 hrs/report)					20,000	HR	75.00	$ 1,500,000			$ 1,500,000
	WAG-Wide RA 5 Year Reviews for 100 Years (20 5-year reviews @ 600 hrs/review)		NA			12,000	HR	$ 75	$ 900,000			$ 900,000
	Subtotal											**$ 3,783,750**
	TOTAL COST - Post-Remedial Action Operations (100 Year Duration)											**$ 31,458,750**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE LIMITED ACTION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

Attachment D-7

Operable Unit 7-13/14 Feasibility Study Cost Estimate for the Full Encapsulation Alternative

The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost estimate are likely to occur as a result of new information and data collected during the engineering design, safety reviews, and remedial alternative. Major changes may be documented in the form of a memorandum in the administrative record file, an explanation of significant differences, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within –30 to +50 percent of the actual project cost.

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE FULL ENCAPSULATION ALTERNATIVE

Project Title:	WAG 7 OU 13/14 Feasibility Study
Estimator:	Brian K. Corb
Date:	December 2002
Estimate Type:	Planning
Reviewed/Appr.:	Lee Lindig/Bruce L. Stevens

I. SCOPE OF WORK:

A. Remedial Design and Remedial Action

Constructing the Full Encapsulation alternative will be implemented in two phases because a portion of the SDA is currently active and receiving waste material. Phase 1 will cover the inactive portion of the site (105 acres) and Phase 2 will cover the currently active portion of the site (5 acres) after disposal operations are completed in 2020. Constructing the Full Encapsulation alternative includes preconstruction activities, placing earth fill, horizontal barrier construction (grouting subsurface basalt), vertical barrier construction (slurry wall), ISG for waste treatment and stabilization, foundation stabilization grouting for waste stability, placing cover system layers, and placing erosion control materials. Preconstruction activities will include field testing horizontal barrier installation, investigating borrow sources, preparing final design, completing a readiness assessment, and mobilizing.

Initially, a minimum 5-ft-thick layer of earthen fill will be placed over the SDA to minimize contact with waste materials during subsequent construction activities. This will provide a contouring layering with an average thickness of 5 ft across the site. Concurrent the earthen fill operations, the Pad A waste will be excavated and placed without treatment beneath the grading fill to reduce the vertical profile of the waste pile. Before grouting activities, ISTD technology will be applied to the waste streams in pits containing high organic concentrations to remove VOCs (approximately 5 acres). Following completion of earthen fill placement and ISTD, grouting the subsurface basalt layer and slurry wall construction will begin for making horizontal and vertical barriers. As the horizontal barrier is completed, other activities will begin including jet grouting with specialized grout to treat waste in SVRs and other areas. Foundation grouting with cement-based grout will stabilize waste and reduce settlement in other areas of the SDA.

As grouting is completed, various cover system layers will be installed, including additional earthen fill, gas collection, infiltration barrier, biotic barrier, filter, and topsoil layers. Placing erosion control materials will include constructing a flood control berm around the perimeter of the cover system, placing armor (riprap and other materials) on cover system and berm side slopes, and establishing vegetation.

B. Long-Term Monitoring and Maintenance

After the remedial action has been completed, long-term monitoring and maintenance will continue for 100 years, with CERCLA reviews conducted every 5 years. The long-term environmental monitoring will be conducted for groundwater, vadose zone water, surface water, and air. In addition, the cover system itself will be monitored annually during the first 5 years following completion of construction (beginning after the vegetation establishment period). After that, monitoring frequency will be reduced to every 5 years concurrent with 5-year reviews required under CERCLA. The cover system will be monitored for vegetation density, erosion damage, and differential settlement. Areas of erosion damage will be repaired with additional topsoil or earthen fill and reseeded. Areas without established vegetation will be reseeded.

II. BASIS OF ESTIMATE:

The basis of the estimate was developed from the following sources to provide a defensible and comparative cost of the remedial alternatives. The applicable sources available for the Full Encapsulation alternative include:

A. EPA, "A Guide to Developing and Documenting Cost Estimates During Feasibility Study," July 2000.

B. INEEL, "Cost Estimating Guide," DOE/ID-10473, September 2000.

C. "Environmental Assessment and Plan for New Silt/Clay Source Development and Use at the Idaho National Engineering and Environmental Laboratory," DOE/EA-1083, May 1997.

D. *Caterpillar Equipment Performance Handbook*, 31st edition.

E. The INEEL Site Stabilization Agreement, Union Labor Agreement.

F. Facilities Unit Costs—Military Construction, PAX Newsletter No. 3.2.2—10, March 2000.

G. ICDF Construction Cost Estimate, Cap Construction Cost (CH2MHILL) December 2000.

H. Subject Matter Experts—M. Jackson, BBWI and T. Borschel, BBWI, "Availability of Borrow Source Material at the INEEL."

I. BBWI, "INEEL Site Craft and Professional Services Labor Rates," February 2002.

J. OMB, 2002, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Appendix C, "Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses," OMB Circular A-94, February 2002.

K. R. S. Means, 2002, *Heavy Construction and Industrial Building Unit Costs Data* 16th edition, Kingston, Massachusetts.

L. INEEL, "Analytical Laboratory Unit Costs."

III. ASSUMPTIONS:

The primary work associated with the Full Encapsulation alternative includes placing horizontal and vertical barriers, waste and foundation stabilization grouting, and placing a cover system over the SDA. Because some portions of the SDA will continue operating until 2020, construction is divided into two phases. Phase 1 includes placing the cover system over approximately 105 acres of inactive portions of the SDA. Phase 2 includes placing the cover system over an estimated 5 acres of the SDA that will remain active until 2020. Specific elements of the work and important assumptions are provided below:

A. Management and Oversight

A.1 Project Management for the BBWI oversight of this alternative has been estimated based on an average classification of job categories using the BBWI rates. The number of FTEs are based on 2,000 MH per person per year.

A.2 The RD/RA schedule assumes that the budgetary funding will not be constrained.

A.3 The RD/RA schedule assumes that no unexpected delays will result from changes to the USQ/SAR process.

A.4 The estimate assumes that INEEL site resources (i.e., CFA, medical facilities, geotechnical lab, fire department, security, utilities at the SDA) will be available for the duration.

B. Design and Preconstruction

B.1 Preconstruction activities—Borrow source investigations, field testing of horizontal barrier construction, cultural resource clearance, developing an onsite source of basalt rock, final design, readiness assessment completion, and mobilizing.

C. Site Preparation and Support Activities and Facilities

C.1 Placing initial earthen fill—Site clearing and grubbing and leveling (including regrading of Pad A) and placing minimum 5 ft of earthen fill over grouting areas.

C.2 In situ thermal desorption will be performed to remove VOCs from high-concentration waste streams in the pits before grouting operations. The ISTD technology will be applied over a surface area of 5 acres, 14 ft deep.

C.3 Modular containment buildings were evaluated including Butler and Sprung structures. The cost provided for the ISG considers a Sprung-type containment structure for the grouting operation. No containment structure is required for the horizontal barrier or foundation stabilization grouting operations. Costs for these facilities include fire protection, HVAC, lighting, communication lines, and power distribution.

D. Horizontal and Vertical Barrier Construction

D.1 Horizontal barrier construction—A horizontal barrier will be constructed by pressure grouting the basalt layer beneath the SDA. This would be achieved by pushing casing through the waste, drilling through the casing into the subsurface basalt layer, and pressure grouting the basalt.

D.2 For horizontal barrier construction, casing can be pushed through waste materials to the subsurface basalt layer, a 5-ft depth of the basalt layer will be drilled and grouted, 1 ft^3 of cuttings will be generated per drill hole and will be disposed of onsite or at another approved INEEL facility, average grout uptake will be 20%, and average grout hole spacing will be on 10-ft centers. Developing capital and operational costs for installing the subsurface horizontal barrier is presented in Table 1.

D.3 Vertical barrier construction—A vertical barrier will be installed by constructing a slurry wall around the SDA. A trench to the horizontal barrier (grouted basalt) at the perimeter of the SDA will be excavated and backfilled with a soil bentonite mixture.

D.4 For vertical barrier construction, a slurry wall will be constructed around the entire perimeter of the SDA (10,000 linear ft) with an average depth of 20 ft and an average width of 3 ft.

E. Organic Area Treatment with In Situ Thermal Desorbtion

E.1 In situ thermal desorption will be used to treat the high organic waste streams before placing the surface barrier. ISTD will employ an array of heated stainless steel pipe assemblies inserted into the ground on an 8 × 8-ft spacing to a depth of approximately 3 ft below the buried waste.

E.2 Each pipe assembly will include a sealed pipe that contains an electrical-resistance-heating element, a vented pipe to extract gases, and thermocouples. Extraction pipes will be connected to a pipe manifold that conveys gases to an off-gas treatment system. The average pipe assembly will be inserted to a depth of 24 ft. Pipe assemblies will be inserted into the ground using either nonstandard vibratory or hydraulic techniques.

E.3 Heat can be transferred from the heating elements to the pipes and then to the waste at a nominal rate of 350 W per lineal ft of heated pipe.

E.4 Six ISTD systems will be used. With the 8 × 8-ft spacing of the pipe assemblies, heating will occur over about a 90-day period. The six systems are projected to treat approximately 0.5 acres per year, requiring 2.5 years to complete the projected five acres.

E.5 The ISTD systems will require about 330 kW.

E.6 When a subsystem reaches its heating objectives, the pipe manifold that collects off-gases will be isolated from the rest of the off-gas manifold by closing valves. The 12 or 20 extraction pipes in the subsystem will be crimped closed, the manifold section will be disconnected and transported to the front of the advancing ISTD system, and reconnected after purging at that location.

F. Pad A waste retrieval and management.

F.1 It is assumed that 20 drums of TRU waste will be generated during the retrieval actions, which will require off-Site disposal at WIPP.

F.2 The Pad A retrieval operations will require a primary and secondary containment structure, approximately 230 x 410 ft in plan dimensions and designed in accordance with the IBC. Frost depth for building foundations is 5 ft (DOE-ID 2001). The ground snow load of at least 35 lb/ft^2 shall be used in ASCE 7 calculations and a minimum roof snow load of 30 lb/ft^2 shall be used for all buildings (DOE-ID 2001). Retrieval buildings and other structures shall not be designed for tornado loads (DOE-ID 2001). All structures shall be designed for PC 2 standards for wind, seismic, and flood design requirements. The PC 2 seismic return period is 1,000 years (STD-1020). The fastest wind speed for INEEL structures is 70 mph, and the 3-second gust wind speed is 90 mph (DOE-ID 2001). The design mean hazard annual probability for floods is 5E-04, or a 2,000-year return period (STD-1020). Fire protection systems shall meet or exceed the minimum requirements established by the NFPA and DOE O 420.1.

F.3 The primary and secondary containment structure is a double-walled structure equipped with radiation alarm systems such as constant air monitors that would alarm when airborne contamination reached unacceptable levels. Criticality alarms would be installed in the primary containment structure. These alarm systems would require periodic testing and calibration.

F.4 The containment building will be dismantled, collapsed, and buried beneath the surface barrier. A cost allowance of 25% of the capital expenditures of the building costs is assumed representative of the estimated level of effort to dispose of the buildings and equipment.

F.5 The structure would include a gantry crane that would be used to apply water, foams, and foggers to keep dust and contamination at a minimum within the retrieval operation. The crane would provide support for lifters, detectors, and other equipment.

F.6 Negative pressure would be applied to the digface at all times and directed to HEPA filters to control the contamination and keep it from entering the secondary containment structure. Air exhausted from the retrieval zone would be fully saturated with water vapor because of misting to control airborne contamination. Some water vapor would condense in the ductwork leading to the air treatment system. This condensate would be recycled through the retrieval-face misting system, as would other condensates. The air treatment system consists of chillers, demisters, heaters, and banks of HEPA filters in two parallel systems to provide redundancy if one system failed. The chillers would cool the air, which would decrease the dew point and cause mists to form. The air would then pass through a demister to remove moisture. The air would then pass through heating elements to raise the temperature to about 10°C above dew point. The air then would pass through the HEPA filters.

G. ISG and Foundation Grouting Assumptions

G.1 The ISG equipment and enclosures will be dismantled and disposed of under the surface barrier. Twenty-five percent of the capital equipment expenditure is assumed and included in the estimate for D&D&D of equipment.

G.2 The TRU pits and other trenches will be only low-pressure grouted for foundation stabilization.

G.3 The grouting operations can be performed without any surface radiological contamination from the grout returns observed at the ground surface.

G.4 The grout production rate of one hole every 4 minutes can be maintained and no subsurface anomalies would further reduce the assumed efficiency of 70%. ISG will begin after placing initial earthen fill over a significant portion of grouting areas. ISG for waste treatment will be performed using the same grouting technique and grout types described for the ISG alternative, however ISG will be limited to the SVRs and portions of the waste trenches where activation and fission product waste are located. Specific assumptions related to ISG are provided in the ISG alternative cost estimate.

G.5 The SVRs and trench areas containing activation and fission products will be treated using the ISG technology and based on a 2-ft center-to-center spacing. One hole will be grouted every 4 minutes.

G.6 Foundation stabilization grouting will be applied using low-pressure jet grouting technology and based on a 4-ft center-to-center spacing. One hole will be grouted every 4 minutes.

G.7 Grouting for foundation stabilization will be performed using a modified drill rig to inject grout under high pressure into the waste stream. The grout will fill readily accessible void space and cure into a solid monolith. This technique allows using a relatively low-cost cement-based grout instead of specialized grout types for waste treatment. Unlike the ISG portion of the alternative, the foundation stabilization operation would not be required to completely mix the grout with the waste or soil. Voids that could threaten integrity of the surface barrier are large and would be intersected if the spacing between grout holes were larger than the spacing for ISG. In addition, it is assumed that substantially less grout would be needed for foundation stabilization because the grout would be injected on a less dense spacing, and waste was compacted when initially placed in the SDA. Assumptions for foundation stabilization grouting for the Surface Barrier are addressed in the ISG alternative cost estimate.

G.8 The equipment and crew size needed for ISG and foundation stabilization grouting is similar to the crew size and equipment needed for the ISG alternative.

G.9 Remaining earthen fill and the gravel gas collection layer of the surface barrier will be placed during grouting activities.

H. Borrow Areas

H.1 This PERA assumes that touse Spreading Area B as a borrow source, the area will need to be drilled and tested for material quality and quantity; an Environmental Assessment Plan will need to be revised; an Army Corps of Engineers Section 404 permit must be obtained, and a National Pollutant Discharge Elimination System

H.2 permit must be completed and approved. It is assumed that the permitting process for Spreading Area B will be completed concurrent with other preconstruction activities to avoid extending the construction schedule.

H.3 Spreading Area B will be available and will not be flooded. No additional costs have been provided to dewater Spreading Area B.

H.4 Adequate quantity and quality of borrow source material has been identified from Spreading Area B, the Borax Pit, and the Basalt Source (for riprap and coarse fractured material). Furthermore, no royalty fee or earthen material costs are provided for in the estimate.

H.5 An adequate water source will be available to support the earthmoving and soil moisture conditioning for placement and compaction based on equipment productivities assumed for this estimate.

H.6 The source of low-permeability soil will meet the hydraulic conductivity requirements of 10^{-7} cm/s and the soil will not require amendment with bentonite.

I. Cover System Construction

I.1 Placing earthen fill and gravel gas collection layers—Additional earthen fill (approximately 5 ft thick) will be placed to make an average 10-ft thick earthen fill covering the SDA, to grade the site for cover system construction. Six inches of gravel will be placed to collect gas that may be generated beneath the cover system.

I.2 Placing clay, geomembrane, and filter layers—A 2-ft-thick compacted clay layer and 60-mil HDPE geomembrane layer will be placed as infiltration barriers. A 1-ft-thick filter section consisting of sand and gravel will be placed over the geomembrane.

I.3 Placing remaining cover system layers—Remaining cover system layers will consist of a 2.5-ft-thick layer of coarse fractured basalt (biotic barrier layer), a 1-ft-thick filter layer consisting of sand and gravel, an 8-ft-thick layer of engineered earthen fill, and a 1-ft-thick layer of topsoil.

I.4 Placing perimeter berm and erosion controls—A 6-ft-high berm will be constructed around the perimeter of the cover system to control flooding; filter layers, coarse fractured basalt, and riprap will be placed on the side slopes to minimize erosion.

I.5 Establishing vegetation—The topsoil layer will be seeded with a specialized seed mix to provide a vegetative cover. The cover will be monitored and reseeded as necessary to maintain the vegetative layer.

J. Capital Costs, Unit Rates, and Other Pricing Assumptions

J.1 The unit prices have been developed from a crew build-up to process, load, haul, place, and compact. The volume of material represented in the cost tables identifies CCY. The appropriate factors convert the estimated unit material weights (bank, loose, and fill) and are factored into the equipment productivity.

J.2 Crew labor rates were based on hourly rates stipulated in the INEEL Site Stabilization Agreement. Labor and equipment spreads were based on assumed achievable daily productivity. Other factors that influenced the selection of labor and equipment quantities include safety, level of PPE of the work to be performed, haul routes, and availability of resources on the INEEL. Each daily crew cost also includes field oversight personnel such as the HSO, superintendents, foremen, CIHs, maintenance personnel, and allocation of supplies (e.g., fuel, oil, grease, and spare parts).

J.3 Primarily all capital equipment and pricing were selected from commercially available sources or similar projects allowing a scale factor to be applied to yield an estimated cost of conceptual equipment and operational requirements. Equipment installation cost is considered a significant variable in estimating individual components of a given system. The installation cost of the capital equipment was based on a percentage of capital costs ranging from 110 to 160% of the estimated capital expenditure based on the unknowns and level of complexity.

J.4 Subcontractors' bond and insurance rate of 2% of the total subcontractor dollars includes overhead and profit based on each alternative.

J.5 The estimate includes an allocation for the INEEL specific work order PRD requirements and safety meetings. Because this estimate includes primarily unit prices, the labor cost is estimated to be 40% of the unit prices and, based on historical data, cost of the INEEL-specific process is approximately 6% of total labor dollars.

K. Schedule

K.1 The estimate assumes that earthwork operations can be performed for 10 months per year without weather impacts. The work will be performed working two 10-hour shifts, with a back shift working 5 days per week performing maintenance.

K.2 The estimate assumes that field crews will demobilize the equipment during the 2-month winter shutdown to refurbish and replace the equipment. The estimate includes an allocation to cover these costs in addition to the 2% estimated.

L. Health and Safety

L.1 After the initial site grading material is placed over the SDA, all earthmoving operations can be performed in Level D.

L.2 The Pad A waste will be excavated and tightly placed in a single layer and buried beneath the cap grade fill. The estimate assumes that this waste will not be treated and the work will be performed in Level B.

M. Long-term Operating and Maintenance and Monitoring

M.1 The capital cost for the project includes the replacement and reinstallation of 37 existing lysimeters. The estimate assumes that lysimeters will be installed at varying depths of 20, 90, 200, and 600 ft along the interbed surfaces.

M.2 The lysimeter analytical cost assumes that liquid samples will be recovered in 10% of the wells. Therefore, analytical costs are included only for the assumed number of recoverable samples.

M.3 After topsoil has been placed as the final layer on the cover system, it will be seeded with native grasses to provide vegetative cover to reduce erosion. However, because of the arid climate, an extended period will be required to establish a permanent vegetative cover. Erosion of the uppermost layers of the cover system during snowmelt will occur during the years immediately following construction and repairs and reseeding will be required.

M.4 Ongoing maintenance of the cover system will be required in perpetuity after construction is completed. Frequent maintenance will be required during the years immediately following construction to repair damage from erosion and establish a permanent vegetative cover. In addition, the added weight of the cover system is expected to result in increased settlement during the initial years following construction. Some areas of the cover system will require ongoing maintenance to repair damage resulting from settlement. It is expected that annual maintenance and repairs will be required during the first 5 years following construction. Ongoing maintenance and repairs will continue every 5 years concurrent with the 5-year review process.

N. Design Costs

The following discussion provides the basis for the assumed percentage for design, construction, and contingency. EPA provides guidance for estimating remedial design costs in the EPA Guidance. Exhibit 5-8 of the EPA Guidance provides examples of remedial design costs as a percentage of total capital costs. The percentages range from 20% for projects with capital costs less than $100,000 to 6% for projects with capital costs greater than $10 million. The EPA Guidance does not provide an example of design costs that vary according to the complexity of technologies.

The alternatives include technologies that have been demonstrated on other sites and have well developed engineering design criteria (such as capping) and technologies that have not been demonstrated on a large scale and require development of engineering design criteria (such as ISV). Remedial design costs are expected to vary significantly according to the degree of complexity and the estimated costs for remedial design need to reflect that. Based on the complexity of the technology application, a percentage of the capital and operating cost specific to the technology was assumed.

The Surface Barrier system has been demonstrated on other sites and design standards have been developed for the various types of materials and construction methods. Some borrow source investigations will be needed to verify material properties and quantities, but methods for conducting these investigations are not expected to require specialized equipment or personnel. Because capping is a demonstrated technology with established design standards, the cost for remedial design is assumed to be 6% of capital costs.

ISG includes subsurface jet injection of specialized types of grout into waste disposal areas of the SDA to stabilize and treat waste materials. ISG will be carried out inside a modular building to contain possible releases of contaminants. Considerable effort will be needed to design appropriate grout types for the waste disposal areas, design the modular building and grouting equipment, and field test various design elements. Because of the additional design effort required for ISG, the cost for remedial design is assumed to be 8% of capital costs.

Foundation stabilization grouting using modified grouting equipment to jet grout areas of the SDA to fill voids within the waste and provide a stable foundation for placing and maintaining cover systems. Foundation stabilization grouting is similar to ISG except specialized grout and grouting equipment (including a modular building) will not be needed and grout holes will be spaced farther apart than for ISG. Cement-based grout and modified grouting equipment will be used for this technology. Field demonstrations will be conducted to verify the ability of the grouting equipment to penetrate waste disposal areas and to estimate how much grout will be needed. Because the design effort will be considerably less for foundation stabilization grouting than for ISG, the cost for remedial design is assumed to be 7% of capital costs.

The vertical barrier includes placing a slurry wall around the perimeter of the SDA. The wall will be constructed by excavating a trench to the basalt layer, placing slurry within the trench for stability during construction, and replacing the slurry with soil bentonite to create an impervious vertical barrier. Slurry wall technology has been demonstrated successfully at numerous sites and engineering design standards have been developed for this technology. Field testing would be needed to estimate the average depth of the slurry wall and the soil to bentonite ratio needed for the impervious barrier. Because the vertical barrier is a demonstrated technology with established engineering design standards, the cost for remedial design is assumed to be 6% of capital costs.

The horizontal barrier includes advancing a casing through soil and waste materials within the SDA to the top of the basalt layer beneath the site, drilling through the casing approximately 5 ft into the basalt layer, and pressure grouting the basalt layer with cement-based grout. The grouted basalt would create an impervious horizontal barrier. A modified ODEX drill rig will be used to advance the casing and drill into the basalt. Specialized equipment will need to be designed for the rig to contain cuttings and particulates generated during drilling into the basalt layer. Field testing will be needed to verify that casing can be advanced through the waste materials to the basalt layer and to estimate the variable hole spacing and grout quantities needed. Because of the additional design effort to contain cuttings and the field testing required, the cost for remedial design is assumed to be 8% of capital costs.

The various technologies and the percentages of capital costs estimated for remedial design are summarized in Table 1. These percentages are applied to individual technologies in the cost estimate to establish estimated design costs for the various alternatives.

O. Construction Management Costs

Cost considerations for BBWI oversight, regulatory agency interaction, and project management were estimated on a representative basis of an assumed level of effort required to implement the selected alternative. Additionally, costs for the remedial design, safety equipment and PPE, construction management, general conditions, and insurance and bonds were included to capture a relative basis for cost comparison and to identify other costs associated with implementing a given remedial alternative.

The percentage is based on total capital construction cost to implement the alternative. The percentage basis assumed for each category was selected considering the complexity of the alternative and risk and uncertainty of the approach. The cost identified under the category general conditions includes administration buildings, parking area, utilities, and support infrastructure to facilitate the remedial alternative.

P. Contingency Costs

EPA provides guidance for estimating contingency costs in the EPA Guidance (EPA 2000). EPA Guidance distinguishes between scope contingency and bid contingency costs. Scope contingency costs represent risks associated with incomplete design and include factors such as limited experience with technologies, additional requirements because of regulatory or policy changes, and inaccuracies in defining quantities or characteristics. Exhibit 5-6 of the EPA Guidance provides examples of scope contingencies. Bid contingency costs are ones unknown at the time of estimate preparation that become known as remedial action construction or O&M proceeds. Bid contingencies represent reserves for quantity overruns, modifications, change orders, or claims during construction. The EPA Guidance states that bid contingencies may be added to construction and O&M costs and typically range from 10 to 20%.

Because EPA Guidance suggests that contingency costs will vary according to the alternative technologies, varying contingency costs must be estimated for the PERA alternatives. Technologies have been evaluated separately to determine appropriate contingency costs. Scope and bid contingencies for each technology are discussed below.

Capping technology includes the using several types of materials in addition to those planned for biotic barrier technology, constructing infiltration barriers, and using synthetic materials. One significant assumption for this technology is that native materials will be available that meet infiltration barrier layer permeability requirements without using additives such as bentonite. Capping technology is assumed to require a scope contingency within the range of 10 to 20% as shown in Table 2. Because of the risk associated with the need for additional borrow sources for materials, using synthetic materials, and the possible need to use additives for infiltration barrier layer construction, the cost for scope contingency is assumed to be 15%. Most risks associated with capping technology will be significantly reduced during remedial design, therefore, the cost for the bid contingency is assumed to be 10%. The total contingency for capping technology is assumed to be 25% of capital costs.

ISG includes jet injection of various types of grout into waste materials in the SDA to stabilize and treat waste materials. ISG technology will require considering grout design, design of specialized grouting equipment and a modular containment building, and field demonstrations. ISG technology is assumed to require a scope contingency within the range of 15 to 35%. Because of the specialized design efforts required for this technology, the cost for the scope contingency is assumed to be 20%. Some significant construction risks will be associated with this technology because of unanticipated subsurface conditions, therefore, cost for the bid contingency is assumed to be 15%. The total contingency for ISG technology is assumed to be 35% of capital costs.

Foundation stabilization grouting includes jet-grouting areas of the SDA with cement-based grout to fill voids within the waste and provide a stable foundation for placing and maintaining cover systems. While foundation stabilization grouting is similar to ISG, design of specialized types of grout and a modular containment building will not be required. Scope and bid contingencies for foundation stabilization grouting are the same as for ISG (20 and 15%, respectively) with a total contingency for foundation stabilization grouting assumed to be 35% of capital costs.

Vertical barrier technology involves placing of a slurry wall around the perimeter of the SDA. Well-established engineering design standards have been developed for slurry wall technology so the risk for scope changes is low. Vertical barrier technology is assumed to require a scope contingency within the range of the scope contingency for vertical barriers in Table 2 (10 to 35%). A scope contingency of 15% is assumed for this technology because it has been demonstrated successfully at numerous sites and has well-established engineering design standards. The only construction risk for this technology will be the length and depth of the slurry wall and the percentage of bentonite to be added to the soil mix. These construction risks will be minimized by subsurface investigations and soil testing completed during design. Because of the low construction risks, a bid contingency of 10% is assumed for this technology. The total contingency for vertical barrier technology is assumed to be 25% of capital costs.

Horizontal barrier technology involves advancing a casing through soil and waste materials to the top of a subsurface basalt layer, drilling through the casing into the basalt layer, and pressure grouting the basalt layer with cement-based grout. Engineering design techniques for grouting fractured basalt have been developed for dam construction projects, and similar techniques will be used for this work. Field demonstrations will be necessary to verify that casing can be advanced through soil and waste material and to estimate grout hole spacing and grout quantities. Horizontal barrier technology is assumed to require a scope contingency within a range of 15 to 35%. Because grouting technology has been developed for fractured basalt, a scope contingency of 15% is assumed for this technology.

The construction risk for with this technology is very high. The degree of fracturing in the basalt is expected to vary significantly and this will impact the final spacing of grout holes and grout quantity. Because of the high construction risk, a bid contingency of 25% is assumed for this technology. The total contingency for horizontal barrier technology is assumed to be 40% of capital costs.

The scope and bid contingency percentages associated with this alternative are identified in Table 3. These percentages are applied to individual technologies in the cost estimate to establish a representative aggregate cost contingency.

Based on the scope contingency guidance provided in Table 2 for each of the technologies, a representative contingency was selected within the range provided, given the complexity and size of the project, and inherent uncertainties related to the remedial technology. However, the guidance document does not address all of the remedial technologies identified in this alternative. Specifically, the horizontal barrier, foundation stabilization grouting, and ISG technologieswould be within a scope contingency range of 15 to 35%, which is considered representative for this work and project scope.

IV. SCHEDULE:

The following activities comprise the RD/RA portion of the Full Encapsulation alternative. Table 4 and 5 show the corresponding durations, based on the estimated crew productivity, regulatory reviews and approvals, and weather constraints inherent to the INEEL site.

V. PRESENT WORTH ANALYSIS:

Guidance for present value analysis is provided in Chapter 4 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA 2000). EPA Guidance states that the present value analysis of a remedial alternative involves four basic steps:

1. Define the period of analysis
2. Calculate the cash outflows (payments) for each project year
3. Select a discount rate to use in the present value calculation
4. Calculate the present value.

Periods of analysis for the Full Encapsulation alternative include Phase 1 design and construction, Phase 2 design and construction, and O&M. The Phase 1 design and construction period is estimated to last 14.5 years beginning shortly after issuance of a ROD for the site. Phase 2 design and construction is estimated to last 5.5 years beginning shortly after currently active areas of the site are closed in 2020. The O&M period will begin at the end of the vegetation establishment period for Phase 1 construction and will continue for 100 years.

Cash outflows for the Full Encapsulation alternative will include payments for design and construction, periodic payments for major repairs, and annual O&M costs. EPA Guidance suggests that most capital costs should occur in the first year of remedial action. While this suggestion might be realistic for short-duration remedial actions, it is not a realistic assumption for the Full Encapsulation alternative because of the time required for design and construction. Cash outflows for the Full Encapsulation alternativewould be paid on an annual basis beginning with the borrow source and horizontal barrier investigations and remedial design and ending with the end of the vegetation establishment periods for Phase 1 and Phase 2 construction.

Annual capital cost payments vary with the level of activity. Relatively low annual payments would be made during the borrow source investigation, horizontal barrier investigation, remedial design, readiness assessment, and vegetation establishment periods, and relatively high annual payments would be made during heavy construction periods (vertical and horizontal barrier construction, grouting, and material excavation, processing, stockpiling, and placement). Periodic costs for major repairswould occur every 5 years concurrent with the 5 year reviews that CERCLA requires. Periodic costswould begin 5 years after Phase 1 construction and continue through the O&M period. Annual O&M costs would begin the first year after completion of Phase 1 construction and continue for 100 years. In accordance with EPA Guidance requirements, 2002 constant dollars are used for all annual and periodic cash outflows.

EPA Guidance requires using a real discount rate that approximates the marginal pretax rate of return on an average investment and has been adjusted to eliminate the effect of expected inflation. The real discount rate must be used with constant or real dollars that have not been adjusted for inflation. EPA Guidance recommends using a 7% real discount rate for present value analysis in most remedial action cost estimates. However, for federal facility sites being cleaned up using Superfund authority, EPA Guidance states that it is generally appropriate to apply the real discount rates found in Appendix C of OMB Circular A-94. The suggested rates for federal facility sites are based on interest rates from Treasury notes and bonds and are appropriate because the federal government has a different cost of capital than the private sector. The most current version of Appendix C of OMB Circular A-94 (revised February 2002) proposes a real discount rate of 3.9% for programs longer than 30 years. The 3.9% discount rate and constant dollars are used for the present value analysis of the full encapsulation alternative. The present value of the Full Encapsulation alternative is calculated using equations provided in EPA Guidance.

VI. RISK AND UNCERTAINTY:

Because a primary construction activity associated with the Full Encapsulation alternative is excavating, hauling, and placing of very large quantities of borrow material for the cover system, the highest risk for this alternative is losing use of a primary borrow source located close to the site. The largest quantity of material needed for the cover system is silt loam. For this alternative, it is assumed that sufficient quantities of silt loam will be available from Spreading Areas A and B, located near the site. If these sources are lacking in capacity or not available, the nearest alternative sources are the Ryegrass Flats and WRRTF borrow areas. Ryegrass Flats is 12 mi from the site and the WRRTF borrow area is 34 mi. Haul distances to the site from the spreading areas are 1.5 mi from Spreading Area A and 1 mi from Spreading Area B. Increased haul distances could increase the cost of materials and cause delays in the schedule.

Grouting for the subsurface horizontal barrier also has a high risk because the spacing of grout holes and the estimated grout uptake are unknown. The spacing of grout holes will be a function of the porosity (or fracturing) and the permeability of the subsurface basalt layer. If the basalt is highly fractured and the fractures are interconnected, the spacing could increase from 10-ft to 40-ft centers. If the basalt is massive with few fractures, the spacing could decrease from 10-ft to 5-ft centers. The degree of fracturing also will vary the estimated grout uptake by the basalt. A high degree of fracturing could allow the basalt to flow vertically as well as horizontally. This could result in the grout flowing deeper than 5 ft into the basalt or flowing upward into voids within the waste. Because the degree of fracturing in the basalt may vary significantly beneath the SDA, it is not possible to accurately predict the actual grout hole spacing or grout uptake for the subsurface horizontal barrier.

Another significant risk is the various assumptions related to grouting for waste treatment and foundation stabilization. Several general assumptions have been made concerning areas of the site that will need to be grouted, estimated grout uptake by the waste, and grouting production rate. None of these assumptions have been verified by tests using proposed grouting equipment in onsite waste pits, trenches, or soil vaults. Quantities of materials and the schedule for grouting could deviate significantly from the quantities and production rates assumed for this PERA.

Assumptions regarding the quality of material available for the cover system may be found invalid during borrow source investigations. Compacted clay from Spreading Area B is assumed to be capable of meeting project specifications without the need for additives. If low-permeability requirements cannot be met by using the native material, bentonite will need to be added to reduce permeability. However, the quantity of bentonite needed would probably be low (around 5%) and adding it would reduce the compactive effort needed during placement to achieve the specified permeability. The additional time required for adding bentonite to the material could extend the project schedule.

VII. ESTIMATED MATERIAL VOLUME:

Tables 6 and 7 summarize required materials for the cover system of the Full Encapsulation alternative and related design layers, thickness, and volume.

VIII. TABLES:

Table 1. Summary of remedial design costs as percentages of capital and operating costs.

Technology	Percentage of Capital and Operating Costs
Capping (Cover System)	6
In situ thermal desorption	10
In situ grouting	8
Foundation stabilization grouting	7
Vertical barrier construction	6
Horizontal barrier construction	8

Table 2. Example feasibility study-level scope contingency percentages.

Remedial Technology	Scope Contingency (%)
Soil excavation	15 – 55
Vertical barriers	10 – 30
Synthetic cap	10 – 20
Clay cap	5 – 10
Surface grading and diking	5 – 10
revegetation	5 – 10

Table 3. Summary of contingency costs as percentages of capital costs.

	Percent of Capital Cost		
Remedial Technology	Scope Contingency	Bid Contingency	Total Contingency
Capping	15	10	25
In situ thermal desorption	25	25	50
In situ grouting	20	15	35
Foundation stabilization grouting	20	15	35
Vertical barrier construction	15	10	25
Horizontal barrier construction	15	25	40

Table 4. Phase 1—Design and Construction.

Activity Description	Estimated Duration
Borrow source investigation	1 year
Remedial design and procurement	1.5 years (overlaps borrow source inv. by 0.5 year)
Readiness assessment	1 year (no overlap with design)
Mobilization	0.5 year (no overlap with readiness assessment)
Pad A waste excavation and placement	2 years (no overlap with mobilization)
Initial earthen fill placement	1 year (overlaps Pad A exc. and placement by 1 year)
Horizontal barrier construction	6 years (overlaps earthen fill placement by 1 year)
Vertical barrier construction	1 year (overlaps horizontal barrier const. by 1 year)
Foundation and soil vault grouting	6 years (overlaps horiz. barrier constr. by 5 years)
In situ thermal desorption	2.5 years (overlaps horiz. barrier constr)
Grading fill and gravel placement	1 year (overlaps grouting by 1.0 year)
Clay/Geomembrane/Filter Layers	1 year (overlaps grading fill placement by 0.5 year)
Placement of remaining layers	1 year (overlaps clay/geomembrane/filter by 0.5 year)
Vegetation establishment	2 years (no overlap with placement of rem. layers)

Table 5. Phase 2—Design and Construction.

Activity Description	Estimated Duration
Remedial design and procurement	1 year assumed
Readiness assessment	1 year (no overlap with design)
Mobilization	0.5 year (no overlap with readiness)
Grouting and cover system construction	1 year (no overlap with mobilization)
Vegetation establishment	2 years (no overlap w/grouting/cover system)

Table 6. Distances and sources of borrow materials for the modified Resource Conservation and Recovery Act Subtitle C cover system.

Material	Issue	One-way Haul Distance	Source
Topsoil	This material would consist of organic silt loam and would be used to construct a topsoil layer to support vegetation on top of the cover system.	1.5 mi	This material is assumed to be unprocessed organic silt loam derived from Spreading Area B.
Silt loam	This material would be used to construct a number of the layers within the cap including the general site grading fill, perimeter berm, and engineered earth fill.	1.5 mi	The majority of this material is expected to be unprocessed silt loam derived from Spreading Area B. Additional material is available from Ryegrass Flats (haul distance = 12 mi) and the WRRTF borrow area (haul distance = 34 mi).
Silt loam	This material would be used to construct the compacted clay layer within the cover system.	1 mi	If permits and approvals can be obtained, the majority of this material is expected to be unprocessed silt loam derived from Spreading Area B. Similar material might be available from Spreading Area A (haul distance = 1.5 mi), Ryegrass Flats (haul distance = 12 mi), and the WRRTF borrow area (haul distance = 34 mi).
Gravel	This material would be used for the coarse filter layers within the cap. Sufficient quantities of good structural gravel and fines materials are available.	2.5 mi	This material is assumed to be processed gravel derived from the Borax Gravel Pit.
Sand	This material would be used for the fine filter layers within the cover system. No identified bank run borrow areas are available within the INEEL boundary.	45 mi	This material is assumed to be imported from off-Site.

Table 6. (continued).

Material	Issue	One-way Haul Distance	Source
Riprap	Riprap would be used for erosion control. The majority of the mined riprap material at the INEEL has been used for other remedial actions at the INEEL.	5 mi	This material is assumed to be processed material mined from a basalt outcropping identified 5 mi from the site, directly west of the RWMC and just outside the Big Lost River System.
Coarse fractured basalt	This material would be used as bio-barrier material within the cover system. The majority of the mined coarse fractured basalt material at the INEEL has been used for other remedial actions at the INEEL.	5 mi	This material is assumed to be processed material mined from a basalt outcropping identified 5 mi from the site, directly west of the RWMC and just outside the Big Lost River System.
Cobbles	This material would be used as bio-barrier material if coarse fractured basalt is not available or is not allowed for such use. No identified borrow areas are within the INEEL boundary.	45 mi	This material is assumed to be processed material transported to the INEEL from Idaho Falls.

INEEL = Idaho National Engineering and Environmental Laboratory
RWMC = Radioactive Waste Management Complex
WRRTF = Water Reactor Research Test Facility

Table 7. Full encapsulation alternative cover system design layers, thickness, and volume.

Layer	Thickness	Approximate Volume[a]	Material Description
Phase 1 Construction (105 acres with initial grading fill for grouting plus perimeter berm and side slope. protection)			
Topsoil	12 in.	169,400 CCY	Unprocessed organic silt loam from Spreading Area B.
Engineered earth fill	96 in.	1,355,200 CCY	Unprocessed silt loam from Spreading Area B.
Fine filter	12 in.	169,400 CCY	Processed sand from an off-Site borrow source.
Coarse filter	12 in.	169,400 CCY	Processed gravel from the Borax Gravel Pit.
Coarse fractured basalt (biotic barrier)	30 in.	423,500 CCY	Processed basalt mined from an INEEL site.
Coarse filter	12 in.	169,400 CCY	Processed gravel from the Borax Gravel Pit.
Fine filter	12 in.	169,400 CCY	Processed sand from an off-Site borrow source.
Geomembrane	60 mil	508,200 SY^2	HDPE from off-Site sources.
Compacted clay	24 in.	338,800 CCY	Unprocessed silt loam from Spreading Area B.
Gravel gas collection layer	6 in.	84,700 CCY	Processed gravel from the Borax Gravel Pit.
Final grading fill	60 in.	847,000 CCY	Unprocessed silt loam from Spreading Area B.

Table 7. (continued).

Layer	Thickness	Approximate Volume[a]	Material Description
Initial grading fill	60 in.	847,000 CCY	Unprocessed silt loam from Spreading Area B for initial 5-ft layer before grouting.
Fine filter	12 in.	15,200 CCY	Processed sand from off-Site borrow source for cover system side slope protection; 41-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V side slopes.
Coarse filter	12 in.	15,200 CCY	Processed gravel from the Borax Gravel Pit for cover system side slope protection; 41-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V side slopes.
Coarse fractured Basalt	12 in.	15,200 CCY	Processed basalt mined from an INEEL site for cover system side slope protection; 41-ft long; 1-ft thick; 10,000-ft perimeter; 2.5H:1V side slopes.
Riprap	36 in.	45,600 CCY	Processed basalt mined from an INEEL site for cover system side slope protection; 41-ft long; 3-ft thick; 10,000-ft perimeter; 2.5H:1V side slopes.
Riprap	36 in.	15,600 CCY	Processed basalt mined from an INEEL site for berm side slope protection; 14-ft long; 3-ft thick; 10,000-ft perimeter; 2H:1V side slopes.
Perimeter berm	NA	244,200 CCY	Unprocessed silt loam from Spreading Area B; berm average 6- ft high; 100-ft wide; 10,000-ft perimeter; 2H:1V side slopes.
Phase 2 Construction (5 acres with no grouting, berm construction, or side slope protection)			
Topsoil	12 in.	8,100 CCY	Unprocessed organic silt loam from Spreading Area B.
Engineered earthen fill	96 in.	64,500 CCY	Unprocessed silt loam from Spreading Area B.
Fine filter	12 in.	8,100 CCY	Processed sand from an off-Site borrow source.
Coarse filter	12 in.	8,100 CCY	Processed gravel from the Borax Gravel Pit.
Coarse fractured basalt (biotic barrier)	30 in.	20,200 CCY	Processed basalt mined from an INEEL site.
Coarse filter	12 in.	8,100 CCY	Processed gravel from the Borax Gravel Pit.
Fine filter	12 in.	8,100 CCY	Processed sand from an off-Site borrow source.
Geomembrane	60 mil	24,200 SY	HDPE from off-Site sources.
Compacted clay	24 in.	16,100 CCY	Unprocessed silt loam from Spreading Area B.
Gravel gas collection layer	6 in.	4,000 CCY	Processed gravel from the Borax Gravel Pit.
Grading fill	120 in.	80,700 CCY	Unprocessed silt loam from Spreading Area B

a. This table provides estimated in-place volumes rounded to the nearest 100 CCY.
CCY = compacted cubic yard
HDPE = high density polyethylene
INEEL = Idaho National Engineering and Environmental Laboratory
SY = surface yard

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE FULL ENCAPSULATION ALTERNATIVE
(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: FULL ENCAPSULATION ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP	OTHER COST	TOTAL COST
FFA/CO MANAGEMENT AND OVERSIGHT											
WAG 7 Management (16-Years)											
Coordination/Oversight Tech Support (E28) - 1.0 FTE/YR		NA			32,000	HR	$ 93	$ 2,967,040			$ 2,967,040
Coordination with Agency Participants (E28) - 0.5 FTE/YR		NA			16,000	HR	$ 93	$ 1,483,520			$ 1,483,520
Environmental Engineering (E08) - 1.0 FTE/YR		NA			32,000	HR	$ 76	$ 2,421,440			$ 2,421,440
Cost and Schedule Control (F10) - 2.0 FTE/YR		NA			64,000	HR	$ 59	$ 3,768,960			$ 3,768,960
Regulatory Compliance (S11) - 1.0 FTE/YR		NA			32,000	HR	$ 79	$ 2,528,320			$ 2,528,320
Quarterly and Annual Reviews (S21) - 1.0 FTE/YR		NA			32,000	HR	$ 73	$ 2,325,760			$ 2,325,760
Audit Preparation and Coordination (S11) - 0.5 FTE/YR		NA			16,000	HR	$ 79	$ 1,264,160			$ 1,264,160
Health and Safety Coordination/Training (S08) - 2.0 FTE/YR		NA			64,000	HR	$ 62	$ 3,988,480			$ 3,988,480
Annual O&M Reports (S15) - 0.5 FTE/YR		NA			16,000	HR	$ 79	$ 1,256,640			$ 1,256,640
Attorney/Legal Fees, 0.3 FTE/YR		NA			9,600	HR	$ 150	$ 1,440,000			$ 1,440,000
Allocation for Other Direct Costs (ODCs) - 10% of Total Labor		NA			1	LS	$ 2,200,432	$ 2,200,432			$ 2,200,432
TOTAL COST - FFA/CO Management and Oversight											$ 25,645,000
Construction Management											
Construction Management (@ 6% of Phase 1 & 2 RA Costs)	6%	NA			1	LS	$ 42,482,040	$ 42,482,040			$ 42,482,040
General Conditions (@ 1.25% of Phase 1 & 2 RA Costs)	1.25%	NA			1	LS	$ 8,850,425	$ 8,850,425			$ 8,850,425
Health and Safety Equipment Allocation (@ 0.25% of Phase 1 & 2 RA Costs)	0.25%	NA			1	LS	$ 1,770,085	$ 1,770,085			$ 1,770,085
Medical Monitoring/Surveillance/Air Monitoring (@ 0.10% of Phase 1 & 2 RA Costs)	0.10%	NA			1	LS	$ 708,034	$ 708,034			$ 708,034
TOTAL COST - Construction Management											$ 53,811,000
TREATABILITY STUDIES											
Treatment Treatability Studies, ISG/ISTD (@ 5% of Grouting, ISTD, Horizontal Barrier)	5%				1	LS	$ 14,710,350	$ 14,710,350			$ 14,710,350
TOTAL COST - Treatability Studies											$ 14,710,000
REMEDIAL DESIGN AND REMEDIAL ACTION PLANS/REPORTS											
Grouting RD/RA Workplan (@ 8% of Grouting Capital & Operations)	8%				1	LS	$ 11,545,920	$ 11,545,920			$ 11,545,920
ISTD RD/RA Workplan (@ 8% of ISTD/PAD A Capital/Operations Cost)	8%				1	LS	$ 4,396,240	$ 4,396,240			$ 4,396,240
PAD (A) Excavation RD/RA Workplan (@ 10% of PAD A Capital/Operations)	10%				1	LS	$ 8,884,400	$ 8,884,400			$ 8,884,400
Perimeter Slurry Wall RD/RA Workplan (@ 6% of Installation Costs)	6%				1	LS	$ 1,452,180	$ 1,452,180			$ 1,452,180
Horizontal Barrier RD/RA Workplan (@ 8% of Installation Costs)	8%				1	LS	$ 11,990,640	$ 11,990,640			$ 11,990,640
Surface Barrier RD/RA Workplan (@ 6% of Phase 1 & 2 Surface Barrier Operations)	6%				1	LS	$ 5,850,180	$ 5,850,180			$ 5,850,180
Readiness Assessment (@ 1.5% of RA)	1.5%				1	LS	$ 10,620,510	$ 10,620,510			$ 10,620,510
Remedial Action Report					7,500	HR	$ 76	$ 567,525			$ 567,525
TOTAL COST - Remedial Design											$ 55,308,000

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE FULL ENCAPSULATION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: FULL ENCAPSULATION ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP	OTHER COST	TOTAL COST
ISTD APPLICATION FOR VOC REMOVAL (5 acres)											
Capital Equipment Costs											
ISTD Control Trailer		6	EA	$ 325,000	NA				$ 1,950,000		$ 1,950,000
ISTD Off-Gas Treatment		6	EA	$ 250,000	NA				$ 1,500,000		$ 1,500,000
ISTD Off-Gas Treatment Support (Chillers)		6	EA	$ 725,000	NA				$ 4,350,000		$ 4,350,000
ISTD Capital Costs (Assume 6-ISTD Systems Are Required)		1	LS	$ 5,256,620	NA				$ 5,256,620		$ 5,256,620
Electrical Power Supply/Overhead Powerline H-Frame		3	MI	$ 375,000	NA				$ 1,125,000		$ 1,125,000
Electrical Substation/Transformers for Site Distribution		2	EA	$ 125,000	NA				$ 250,000		$ 250,000
Operation											
ISTD Operational Costs (acreage)		5	AC	$ 153,103	5	AC	$ 4,030,658	$ 20,153,290	$ 765,515		$ 20,918,805
Power Consumption/Utilities		NA			NA					$ 2,285,000	$ 2,285,000
ISTD Secondary Waste Disposal		NA			NA					$ 5,000,000	$ 5,000,000
Installation/Pre-Operational Set-up/Testing (Percentage of Total Capital Costs)	10.0%				1	LS	$ 1,519,714	$ 1,519,714			$ 1,519,714
Back-up Generators (Diesel Powered)		2	EA	$ 137,500	NA				$ 275,000		$ 275,000
Repair/Maintenance/Spare Parts (Percentage of Operating/Treatment Costs)	25.0%				1	LS	$ 5,038,323	$ 5,038,323			$ 5,038,323
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 989,369	NA				$ 989,369		$ 989,369
D&D Cost for Equipment (Percentage of Capital Equipment)	10.0%	NA			NA					$ 1,443,162	$ 1,443,162
INEEL Site-Specific Training/PRD/Work Order		NA			1	LS	1,974,011	$ 1,974,011			$ 1,974,011
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 1,077,500	$ 1,077,500
Subtotal											**$ 54,953,000**
PAD A EXCAVATION											
Capital Equipment/Disposal Bins		1	LS	$ 7,620,000	NA				$ 7,620,000		$ 7,620,000
Building; RCS Materials and Erection		94,300	SF	$ 350	NA				$ 33,005,000		$ 33,005,000
Building; Radiological, Fire Protection, CCTV, HVAC		94,300	SF	$ 250	NA				$ 23,575,000		$ 23,575,000
Weather Enclosure (Assume 10% Larger Footprint)		103,730	SF	$ 65	NA				$ 6,742,450		$ 6,742,450
Over head Crane, Monitors, Misters		1	LS	$ 350,000	NA				$ 350,000		$ 350,000
Building Operations Costs		20	MO	$ 130,208	NA				$ 2,604,160		$ 2,604,160
Overburden Soil Removal/Stockpile		12,110	CY	$ 5	NA				$ 57,765		$ 57,765
PAD A Excavation and Waste Handling (2-years)		300	CD	$ 3,217	300	CD	$ 9,115	$ 2,734,500	$ 965,100		$ 3,699,600
Equipment Repair and Maintenance (10%)		1	LS	$ 96,510					$ 96,510		$ 96,510
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 227,547	NA				$ 227,547		$ 227,547
D&D Cost for Equipment	10.0%	NA			NA					$ 7,129,245	$ 7,129,245
Characterize TRU waste for WIPP disposal (per drum)		20	EA	$ 1,500	NA				$ 30,000		$ 30,000
INEEL Site-Specific Training/PRD/Work Order		NA			1	LS	$1,964,454	$ 1,964,454			$ 1,964,454
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 1,742,035	$ 1,742,035
Subtotal											**$ 88,844,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE FULL ENCAPSULATION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: FULL ENCAPSULATION ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP	OTHER COST	TOTAL COST
GROUTING											
EQUIPMENT											
Purchase & Modify Grout Batch Plant Capital Cost		1	LS	$ 8,326,000.0	NA				$ 8,326,000		$ 8,326,000
Mobilize/Erect Weather Structure Grouting Operations		2	EA	$ 750,198.0	NA				$ 1,500,396		$ 1,500,396
HEPA Filtration System/Lighting/Redundant Systems		2	EA	$ 2,147,448.0	NA				$ 4,294,896		$ 4,294,896
Back-up Generators (Diesel Powered)		2	EA	$ 375,000.0	NA				$ 750,000		$ 750,000
Building Foundation Construction		30,277	LF	$ 561.0	NA				$ 16,985,397		$ 16,985,397
Bridge Crane/Control System		3	EA	$ 670,000.0	NA				$ 2,010,000		$ 2,010,000
Bridge Crane/Control System/Modify and Install		NA			1	LS	$ 1,005,000	$ 1,005,000			$ 1,005,000
D&D Cost for Equipment/Enclosures	10.0%									$ 3,386,669	$ 3,386,669
INEEL Site-Specific Training/PRD/Work Order		NA			1	LS	873,100.54	$ 873,101			$ 873,101
Subcontractor Insurance/Bonds	2.0%				NA					$ 782,629	$ 782,629
Subtotal											**$ 39,914,000**
PRE-CONSTRUCTION ACTIVITIES											
Plug and Abandon (P&A) Existing GW Wells		NA			71	EA	$ 15,000	$ 1,065,000		$ 1,775,000	$ 2,840,000
Install New Nested GW Wells Outside Perimeter of Cap (Drilling Sub and Equipment)		NA			24	EA	$ 50,000	$ 1,200,000		$ 3,000,000	$ 4,200,000
Construct Rail Spur for Bulk Grout Delivery/Storage		1	LS	$ 1,200,000					$ 1,200,000		$ 1,200,000
INEEL Site-Specific Training/PRD/Work Order					1	LS	$ 164,700	$ 164,700			$ 164,700
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 168,094	$ 168,094
Subtotal											**$ 8,573,000**
OPERATIONS											
Fill Placment for Post ISG Decon (2-dt thick)		130,000	CCY	$ 10	NA				$ 1,300,000		$ 1,300,000
Grout Trench Areas (58-MD) Crew/Additives (Specialized)		79	CD	$ 181,314	79	CD	$ 40,902	$ 3,231,258	$ 14,323,806		$ 17,555,064
Grout SVRs (102-MD) Crew/Additives (Specialized)		34	CD	$ 181,314	34	CD	$ 40,902	$ 1,390,668	$ 6,164,676		$ 7,555,344
Repair/Maintenance/Spare Parts (Percentage of Operating/Treatment Costs)	10.0%				1	LS	$ 5,460,743	5,460,743			$ 5,460,743
Grout Rig Decontamination		3	EA	$ 2,125,800	NA				$ 6,377,400		$ 6,377,400
HEPA Filtration System Operation		2	YR	$ 2,000,000	NA				$ 4,000,000		$ 4,000,000
Verification Testing Geophysical Survey		4	MO	$ 40,000	2,500	HR	$ 76	$ 189,175	$ 160,000		$ 349,175
Foundation Stabilization Grouting (TRU Pits, Other Trenches, 739-MD)		342	CD	$ 99,763	286	CD	$ 40,902	$ 11,697,972	$ 34,118,946		$ 45,816,918
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 2,630,527	NA				$ 2,630,527		$ 2,630,527
INEEL Site-Specific Training/PRD/Work Order	6.0%	NA			1	LS	2,912,865	$ 2,912,865			$ 2,912,865
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 1,879,161	$ 1,879,161
Subtotal											**$ 95,837,000**
PERIMETER SLURRY WALL CONSTRUCTION (SDA)											
Installation/Construction of Slurry Wall (10,000 LF)		150	CD	$ 4,100	NA				$ 615,000		$ 615,000
Grout Plant Operation/Material Delivery		150	CD	$ 134,570	NA				$ 20,185,500		$ 20,185,500
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 2,428,591	NA				$ 2,428,591		$ 2,428,591
INEEL Site-Specific Training/PRD/Work Order		NA			1	LS	$ 499,212	$ 499,212			$ 499,212
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 474,566	$ 474,566
Subtotal											**$ 24,203,000**
HORIZONTAL BARRIER CONSTRUCTION											
Capital Cost		1	LS	$ 5,131,500	NA				$ 5,131,500		$ 5,131,500
Operation/Material Delivery (2-Shifts Per Day)		900	CD	$ 87,358	900	CD	$ 29,657	$ 26,691,300	$ 78,622,200		$ 105,313,500
Operation/Rig Maintenance Crew (Back-Shift)		900	CD	$ 6,829	900	CD	$ 5,054	$ 4,548,600	$ 6,146,100		$ 10,694,700
Equipment Decontamination		900	CD	$ 11,953	900	CD	$ 8,156	$ 7,340,400	$ 10,757,700		$ 18,098,100
Transportation/Disposal of Cuttings at ICDF		48,000	CF	$ 50	NA				$ 2,400,000		$ 2,400,000
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 2,832,756	NA				$ 2,832,756		$ 2,832,756
INEEL Site-Specific Training/PRD/Work Order		NA			1	LS	$ 2,473,380	$ 2,473,380			$ 2,473,380
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 2,938,879	$ 2,938,879
Subtotal											**$ 149,883,000**

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE FULL ENCAPSULATION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: FULL ENCAPSULATION ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP	OTHER COST	TOTAL COST
SURFACE BARRIER											
PRE-CONSTRUCTION ACTIVITIES											
Borrow Source Site Investigation		1	LS	$ 250,000	NA				$ 250,000		$ 250,000
Spreading Area "B" 404 Permit Application (6-months)		1	LS	$ 200,000	NA				$ 200,000		$ 200,000
Surface Water Controls/Soil Erosion Sediment Control Features		1	LS	$ 250,000	NA				$ 250,000		$ 250,000
Site Preparation: Clear, Grub & Grade		125	AC	$ 3,800	NA				$ 475,000		$ 475,000
Construct 2-mile Haul Road from Borrow to Site (Stone Road)		2	MI	$ 500,000	NA				$ 1,000,000		$ 1,000,000
Install/Develop GW Wells for Compaction Water		3	EA	$ 250,000	NA				$ 750,000		$ 750,000
BUILDINGS AND EQUIPMENT											
Administrative Buildings (Lunch Room and Change Room)		10,000	SF	$ 95	NA				$ 950,000		$ 950,000
Equipment Maintenance/Storage Area		10,000	SF	$ 175	NA				$ 1,750,000		$ 1,750,000
Decontamintation Area		5,000	SF	$ 150	NA				$ 750,000		$ 750,000
Subtotal											**$ 6,375,000**
CONSTRUCTION											
Topsoil Layer - 1-ft Thick		169,400	CCY	$ 6	NA				$ 1,014,706.0		$ 1,014,706
Rip-Rap Layer - Perimeter Berm		15,600	CCY	$ 40	NA				$ 624,000.0		$ 624,000
Rip-Rap Layer - Sideslopes of Surface Barrier		45,600	CCY	$ 40	NA				$ 1,824,000.0		$ 1,824,000
Gravel Filter Layer, 1-ft Thick		169,400	CCY	$ 10	NA				$ 1,694,000.0		$ 1,694,000
Sand Filter Layer, 1-ft Thick		169,400	CCY	$ 25	NA				$ 4,235,000.0		$ 4,235,000
Gravel Filter Layer - Sideslopes of Surface Barrier, 1-ft Thick		15,200	CCY	$ 10	NA				$ 152,000.0		$ 152,000
Sand Filter Layer, - Sideslopes of Surface Barrier, 1-ft Thick		15,200	CCY	$ 25	NA				$ 380,000.0		$ 380,000
Gravel Gas Collection Layer - 0.5-ft Thick		84,700	CCY	$ 10	NA				$ 847,000.0		$ 847,000
Sand Filter Layer, 1-ft Thick		169,400	CCY	$ 25	NA				$ 4,235,000.0		$ 4,235,000
Gravel Filter Layer, 1-ft Thick		169,400	CCY	$ 10	NA				$ 1,694,000.0		$ 1,694,000
HDPE Geomembrane, 60-mil		508,200	SY	$ 6	NA				$ 2,795,100.0		$ 2,795,100
Compacted Clay Liner, 2-ft Thick		338,800	CCY	$ 12	NA				$ 4,068,988.0		$ 4,068,988
Biotic Barrier Layer - 2.5-ft		423,500	CCY	$ 50	NA				$ 21,175,000.0		$ 21,175,000
Coarse Fractured Basalt Layer - Sideslope of Surface Barrier, 1-ft		15,200	CCY	$ 50	NA				$ 760,000.0		$ 760,000
Engineered Earth Fill - 8-ft Thick		1,355,200	CCY	$ 5	NA				$ 6,464,304.0		$ 6,464,304
Grading Fill, 10-ft Thick Average (Less post ISG decon fill)		1,564,000	CCY	$ 5	NA				$ 7,460,280.0		$ 7,460,280
Perimeter Berm		244,200	CCY	$ 5	NA				$ 1,164,834.0		$ 1,164,834
Hydroseeding/Mulching (Re-seeding Included)		125	AC	$ 2,750	NA				$ 343,750.0		$ 343,750
Install (37) New Lysimeters and Cap Penetrations		37	EA	$ 131,756	NA				$ 4,874,972.0		$ 4,874,972
OCVZ Relocation/Well Extension		1	LS	$ 300,000	NA				$ 300,000.0		$ 300,000
Lab Geotechnical Testing (Gradation, hardness,density)		40	MO	$ 50,000	NA				$ 2,000,000.0		$ 2,000,000
Filed Geotechnical Testing (Density)		*40*	*MO*	*$ 90,000*	NA				*$ 3,600,000.0*		$ 3,600,000
Surveying/Grade Control		40	MO	$ 65,000	NA				$ 2,600,000.0		$ 2,600,000
Third-Party Independent CQA Testing/Certification		40	MO	$ 75,000	NA				$ 3,000,000.0		$ 3,000,000
Seasonal Shutdown/Re-Mobilization		3	EA	$ 500,000	NA				$ 1,500,000.0		$ 1,500,000
Mobilization and Demobilization (2% of Total Cost)	2.0%	1	LS	$ 1,673,639	NA				$ 1,673,638.7		$ 1,673,639
INEEL Site-Specific Training/PRD/Work Order		NA			1	LS	$ 2,084,534	$ 2,084,534			$ 2,084,534
Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 1,778,802	$ 1,778,802
Pre-Final Inspection Report, Phase I		NA			1	LS	$ 250,000	$ 250,000			$ 250,000
Subtotal											**$ 84,594,000**
Subtotal Subcontractor Directs - Phase 1 Remedial Action											**$ 553,176,000**
Subcontractor Overhead	15.0%										$ 82,976,400
Subcontractor Profit	10.0%										$ 63,615,240
TOTAL REMEDIAL ACTION COST - Phase 1											**$ 699,768,000**

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3/21/2002

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE FOR THE FULL ENCAPSULATION ALTERNATIVE

(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: FULL ENCAPSULATION ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

	DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP	OTHER COST	TOTAL COST
	SURFACE BARRIER - PHASE 2											
	SITE PREPARATION											
	Site Preparation: Clear, Grub & Grade		5	AC	$ 5,400	NA				$ 27,000		$ 27,000
	Subtotal											$ 27,000
	SURFACE BARRIER CONSTRUCTION											
	Topsoil , 1-ft		8,100	CCY	$ 6	NA				$ 48,519		$ 48,519
	Sand Filter Layer, 1-ft Thick		8,100	CCY	$ 25	NA				$ 202,500		$ 202,500
	Gravel Filter Layer, 1-ft Thick		8,100	CCY	$ 10	NA				$ 81,000		$ 81,000
	Biotic Barrier Layer - 2.5-ft Thick		20,200	CCY	$ 50	NA				$ 1,010,000		$ 1,010,000
	Gravel Gas Collection, 0.5-ft Thick		4,000	CCY	$ 10	NA				$ 40,000		$ 40,000
	Compacted Clay Liner		16,100	CCY	$ 12	NA				$ 193,361		$ 193,361
	Gravel Filter Layer, 1-ft Thick		8,100	CCY	$ 10	NA				$ 81,000		$ 81,000
	Sand Filter Layer, 1-ft Thick		8,100	CCY	$ 25	NA				$ 202,500		$ 202,500
	HDPE Geomembrane		24,200	SY	$ 6	NA				$ 133,100		$ 133,100
	Engineered Earth Fill, 8-ft Thick		64,500	CCY	$ 5	NA				$ 307,665		$ 307,665
	Earth Grading Fill, 10-ft Thick		80,700	CCY	$ 5	NA				$ 384,939		$ 384,939
	Hydroseeding/Mulching (Re-seeding Included)		5	AC	$ 2,750	NA				$ 13,750		$ 13,750
	Lab Geotechnical Testing (Gradation, hardness, density)		10	MO	$ 50,000	NA				$ 500,000		$ 500,000
	Filed Geotechnical Testing (Density)		10	MO	$ 90,000	NA				$ 900,000		$ 900,000
	Surveying/Grade Control		10	MO	$ 65,000	NA				$ 650,000		$ 650,000
	Third-Party Independent CQA Testing/Certification		10	MO	$ 75,000	NA				$ 750,000		$ 750,000
	Seasonal Shutdown/Re-Mobilization		1	EA	$ 500,000	NA				$ 500,000		$ 500,000
	Mobilization and Demobilization	2.0%	1	LS	$ 110,507	NA				$ 110,507		$ 110,507
	INEEL Site-Specific Training/PRD/Work Order					1	LS	$ 147,260.18	$ 147,260.18			$ 147,260
	Subcontractor Insurance/Bonds	2.0%	NA			NA					$ 125,662	$ 125,662
	Pre-Final Inspection Report, Phase 2		NA			1	LS	$ 125,000.00	$ 125,000.00			$ 125,000
	Subtotal											$ 6,507,000
	Subtotal Subcontractor Directs - Phase 2 Remedial Action											6,534,000
	Subcontractor Overhead	15.0%										$ 980,100
	Subcontractor Profit	10.0%										$ 751,410
	TOTAL REMEDIAL ACTION COST - Phase 2											$ 8,266,000
	TOTAL COST - Phase 1 & 2 Remedial Action Contracts											$ 708,034,000
	TOTAL CAPITAL COSTS											$ 857,508,000

OPERABLE UNIT 7-13/14 FEASIBILITY STUDY COST ESTIMATE
FOR THE FULL ENCAPSULATION ALTERNATIVE
(continued).

Project Title: WAG 7 OU 13/14 Feasibility Study

PROJECT: WAG 7, FS COST ESTIMATES
OU7-13/14 DRAFT COMPREHENSIVE FS
SUBJECT: FULL ENCAPSULATION ALTERNATIVE
LOCATION: INEEL - RWMC

TYPE OF ESTIMATE: PLANNING

PREPARED BY: BKC
CHECKED BY: BS/LL
Reviewed/Updated: MAG 10/25/02

DESCRIPTION		MATERIAL/ EQUIP QTY	MATERIAL/ EQUIP UNIT	MATERIAL/ EQUIP COST PER UNIT	LABOR QTY	LABOR UNIT	LABOR RATE PER UNIT	TOTAL LABOR COST	TOTAL MATERIAL/ EQUIP	OTHER COST	TOTAL COST
POST-REMEDIAL ACTION OPERATIONS (100 YEAR DURATION)											
INSTITUTIONAL CONTROLS FOR 100 YEARS											
Install Permanent Markers/Survey		12	EA	$ 5,000	NA				$ 60,000		$ 60,000.0
Replace Perimeter Security Fence		10,000	LF	$ 20	NA				$ 200,000		$ 200,000.0
Repair and Replace Perimeter Signs		1	LS	$ 10,000	NA				$ 10,000		$ 10,000.0
Subtotal											**$ 270,000**
COVER MAINTENANCE											
Cover Maintenance Cost - 100 Year Duration Annual Cap Maintenance Costs		100	YR	$ 75,000	NA				$ 7,500,000		$ 7,500,000
Subtotal											**$ 7,500,000**
SURVEILLANCE AND MONITORING											
Groundwater Monitoring: (16-wells)											
Groundwater Monitoring, Quarterly for 2 Years - (8-Sampling Events)		8	EVT	$ 1,000	8	EVT	$ 11,000	$ 88,000	$ 8,000	$ 854,936	$ 950,936
Groundwater Monitoring, Semi -Annually for 3 Years - (6-Sampling Events)		6	EVT	$ 1,000	6	EVT	$ 11,000	$ 66,000	$ 6,000	$ 641,202	$ 713,202
Groundwater Monitoring, Annually for 95 Years (95-Sampling Events)		95	EVT	$ 1,000	95	EVT	$ 11,000	$ 1,045,000	$ 95,000	$ 10,152,365	$ 11,292,365
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 1,295,650	NA				$ 1,295,650		$ 1,295,650
Vadose Zone Monitoring:											
Sample 37 Lysimeters 1 Time per Year in Late Spring		100	EVT	$ 1,000	100	EVT	$ 17,875	$ 1,787,500	$ 100,000	$ 2,671,700	$ 4,559,200
Sample & Analyze 20 Vapor Ports 4 Times per Year for 5 Years		20	EVT	$ 1,000	20	EVT	$ 27,500	$ 550,000	$ 20,000	$ 140,000	$ 710,000
Sample & Analyze 20 Vapor Ports 1 Time per Year thereafter		95	EVT	$ 1,000	95	EVT	$ 27,500	$ 2,612,500	$ 95,000	$ 665,000	$ 3,372,500
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 864,170	NA				$ 864,170		$ 864,170
Surface Water Monitoring:											
Collect Sample from 2 Points 2 Times Every 5 Years (20 Sample Events)		20	EVT	100	20	EVT	$ 1,375.00	$ 27,500.00	$ 2,000	$ 320,660	$ 350,160
Vegetation Monitoring:											
1 Inspection per Year in Early Fall for 5 years		NA			5	EVT	$ 1,100	$ 5,500			$ 5,500
Re-seed 10 Acres Each Year for 5 Years (50 Acres Total)		50	AC	$ 15,000	NA				$ 750,000		$ 750,000
1 Inspection Every 5th Year in Early Fall Thereafter for 95 Years		NA			19	EVT	$ 1,100	$ 20,900			$ 20,900
Re-seed 10 Acres Every 5 Years		19	EVT	$ 15,000	NA				$ 285,000		$ 285,000
Air Monitoring (Radiological/Organic):											
Monitor 4 Existing CAMs		100	EVT	$ 1,000	100	EVT	$ 2,200	$ 220,000	$ 100,000	$ 15,300	$ 335,300
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 33,530					$ 33,530		$ 33,530
Perimeter Radiological Monitoring GPS with NaI Detector											
2 People, 1-Time per Year, 2 Days in Summer with Hummer & GPS		100	YR	$ 500	100	YR	$ 2,200	$ 220,000	$ 50,000		$ 270,000
Data Interpretation/Plot Data		100	YR	$ 750	100	YR	$ 2,500	$ 250,000	$ 75,000		$ 325,000
Replacement Parts/Equipment Costs (Assume 10% of Total Costs)		1	LS	$ 59,500	NA				$ 59,500		$ 59,500
Biological Monitoring:											
2 People once per year, First 5-Years for Intrusion Monitoring		NA			2	EVT	$ 1,100	$ 2,200			$ 2,200
2 People 1-Time, Every 5th Year thereafter for 95 years		NA			19	EVT	$ 1,100	$ 20,900			$ 20,900
Subtotal											**$ 26,216,000**
Subtotal Surveillance and Monitoring (Sampling & Monitoring Activities)											**$ 33,986,000**
WAG 7 MANAGEMENT											
WAG 7 Management (@ 5% of other post-RA operations costs)	5%				1	LS	$ 1,699,300	$ 1,699,300			$ 1,699,300
Annual Data Summary Report (100 reports @ 200 hrs/report)					20,000	HR	75.00	$ 1,500,000			$ 1,500,000
WAG-Wide RA 5 Year Reviews for 100 Years (20 5-year reviews @ 600 hrs/review)					12,000	HR	$ 75	$ 900,000			$ 900,000
Subtotal											**$ 4,099,000**
TOTAL COST - Post-Remedial Action Operations (100 Year Duration)											**$ 38,085,000**

Prepared by CH2M HILL 3/21/2002

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