AR TARGET SHEET

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

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TITLE: FS for 200-CS-1 Chemical Sewer Group OU

5.0 REMEDIAL ACTION ALTERNATIVES

The U.S. Environmental Protection Agency (EPA) guidance for conducting feasibility studies under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* recommends that a limited number of technologies be carried forward from the technology identification and screening activity; these technologies then are grouped into remedial alternatives to address the site-specific conditions. In Chapter 4.0, technologies were identified and screened based on site-specific characteristics and contaminants of concern. In this chapter, these technologies are grouped into remedial alternatives to address site contamination problems. Several remedial alternatives are developed and described in this chapter for the waste sites in the 200-CS-1 Operable Unit (OU). The applicability of these alternatives to the individual waste sites also is considered.

5.1 DEVELOPMENT OF ALTERNATIVES

Significant activities and evaluations have contributed to defining applicable technologies and process options that address the 200-CS-1 OU representative and analogous waste sites. DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan), Appendix D, provides initial information on identification and screening of remedial technologies for 200 Area waste sites. The Implementation Plan, in conjunction with Chapter 4.0 of this feasibility study (FS), represents a Phase I FS and thus forms the basis for the development of remedial alternatives. The Implementation Plan also preliminarily develops remedial alternatives based on the results of the technology screening for the waste sites. Remedial alternatives identified in the Implementation Plan for the 200-CS-1 OU include the following:

- No action
- Monitored natural attenuation/institutional controls
- Removal, treatment, and disposal (onsite disposal and geologic repository)
- Containment using surface barriers.

Table 5-1 illustrates the process of identifying technology types, combining process options, and presenting the elements of each alternative. Evaluation of the no-action alternative is a requirement under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*. The monitored natural attenuation/institutional controls alternative is retained and further developed in this FS for sites where existing remedial actions are in place or where contamination is expected to reach remedial action objectives (RAO) within a reasonable institutional controls period. The removal, treatment, and disposal alternative and the containment using surface barriers alternative also are retained and further developed in this FS. The in situ grouting or stabilization alternative, as a standalone alternative, is screened out of this FS because of implementation problems associated with the size and depth of the waste sites and unproven effectiveness on large-scale sites having radiological and chemical hazards. However, in situ grouting or stabilization technologies are retained for inclusion as elements of other remedial actions. The following subsections further develop and describe the alternatives.

One important factor in the development of site-specific remedial alternatives is that radionuclides, heavy metals, and some inorganic compounds cannot be destroyed. As such, these compounds must be physically immobilized, contained, or chemically converted to a less mobile or less toxic form to meet the RAOs.

5.2 DESCRIPTION OF ALTERNATIVES

This section provides a description of the selected alternatives considered for evaluation in this FS, including the following:

- Alternative 1 – No Action
- Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls
- Alternative 3 – Removal, Treatment, and Disposal
- Alternative 4 – Engineered Barrier.

5.2.1 Alternative 1 – No Action

The "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300) (NCP) requires that a no-action alternative be evaluated as a baseline for comparison with other remedial alternatives. The no-action alternative represents a situation where no legal restrictions, access controls, or active remedial measures are applied to the site. No action implies "walking away from the waste site" and allowing the wastes to remain in their current configuration, affected only by natural processes. No maintenance or other activities are instituted or continued. Selecting the no-action alternative would require that a waste site pose no unacceptable threat to human health or the environment.

Based on the waste site evaluations and the results of the risk assessment, only one representative site and its analogous site in this FS may meet the RAOs using the no-action alternative. The sites are as follows:

- 216-S-10 Pond
- 216-S-11 Pond.

As stated above, the no-action alternative implies "walking away from the waste site." However, before walking away from the site, confirmatory sampling would be performed at the 216-S-11 Pond. The no-action alternative is carried forward in this FS for comparison purposes and to address analogous waste sites that are expected to meet the RAOs and preliminary remediation goals (PRG) without any action.

5.2.2 Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls

This alternative takes advantage of existing soil covers and the nature of the contaminants, in combination with institutional controls, to provide protection of human health and the environment. Monitoring also is an element of this alternative. For most of the waste sites in this OU, an existing soil cover is present that is associated with the waste stabilization activities. Under this alternative, these existing soil covers would be maintained and/or augmented as needed to provide protection from intrusion by human and/or biological receptors. Institutional controls, including legal and physical barriers, also would be used to prevent human access to the site. The existing soil covers and/or caps would break the pathway between human and ecological receptors and the contaminants. *Washington Administrative Code* (WAC) 173-340-745(7), "Soil Cleanup Standards for Industrial Properties," "Point of Compliance," identifies the points of compliance for different pathways as follows.

- "For soil cleanup levels based on protection of groundwater, the point of compliance shall be established in the soils throughout the site."
- "For soil cleanup levels based on protection from vapors, the point of compliance shall be established in the soils throughout the site from the ground surface to the uppermost groundwater saturated zone."
- "For soil cleanup levels based on human exposure via direct contact or other exposure pathways where direct contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the site from the ground surface to fifteen feet below the ground surface."

WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures," specifies a standard point of compliance at 4.6 m (15 ft) for ecological receptors; institutional control is not required under this option. WAC 173-340-7490 also specifies a conditional point of compliance at the biologically active soil zone, with a requirement for institutional controls. The regulation assumes a 1.8 m (6 ft) below ground surface biologically active zone, but a site-specific zone may be established.

Based on literature searches regarding the root and burrowing depths of vegetation and animals present on the Hanford Site, a sufficient soil thickness to prevent biological intrusion generally would be 2.4 to 3.0 m (8 to 10 ft). Most of the 200-CS-1 OU waste sites have a soil cover (i.e., surface stabilization, backfill) over the contaminated zone of only a few feet.

Institutional controls involve the use of physical barriers (fences) and access restrictions (deed restrictions) to reduce or eliminate exposure to contaminants of concern. Institutional controls also can include groundwater, vadose zone, surface soil, biotic, and/or air monitoring. Institutional controls for this alternative include periodic surveillance of the waste sites for evidence of contamination and biologic intrusion; emplacement of vegetation, herbicide application, manual removal, or other activities to control deep-rooted plants; control of deep-burrowing animals; maintenance of signs and/or fencing; maintenance of the existing soil cover (including an assumed periodic addition of soil); administrative controls; and site reviews.

For sites having a clean soil cover of less than 4.6 m (15 ft), more stringent institutional controls (e.g., physical and legal barriers) would need to be implemented to address potential risks from direct human and ecological contact with the contaminants. Water and land-use restrictions also would be used to prevent exposure.

Contaminants remaining beneath the clean soil cover would be allowed to attenuate naturally until remediation goals are met. Natural attenuation relies on natural processes to lower contaminant concentrations until cleanup levels are met. Monitored natural attenuation would include sampling and/or environmental monitoring, consistent with EPA guidance (EPA/540/R-99/009, *Use of Monitored Natural Attenuation at Superfund RCRA Corrective Action and Underground Storage Tank Sites November 1997*, OSWER No. 9200.17P), to verify that contaminants are attenuating as expected. Attenuation monitoring activities could include monitoring of the vadose zone using geophysical logging methods or groundwater monitoring to verify that natural attenuation processes are effective.

The existing network of groundwater monitoring wells in the Central Plateau is adequate for monitoring most sites, in coordination with the groundwater OUs 200-BP-5, 200-PO-1, and 200-UP-1. Where the existing network is unsatisfactory, additional monitoring wells are planned. If remediation activities result in the decommissioning of groundwater monitoring wells in the area of remediation, an evaluation of future monitoring needs will be conducted.

5.2.3 Alternative 3 – Removal, Treatment, and Disposal

Under this alternative, contaminated soil would be removed, treated if required to meet waste acceptance criteria, and disposed of to an appropriate facility. Some soil blending may be required to meet health and safety standards and waste acceptance criteria. A generalized cross-section for this alternative is shown in Figure 5-1. The disposal facility chosen depends on the type of waste to be disposed. The majority of the waste generated under this alternative would be disposed of at the Environmental Restoration Disposal Facility (ERDF).

Soil and associated structures (such as cribs) with contaminant concentrations above the PRGs would be removed using conventional excavation techniques where appropriate, or specialized excavation techniques where contamination levels require added protection (these specialized techniques are discussed in greater detail in Chapter 4.0). Excavated materials would be disposed of at an approved disposal facility, currently envisioned as the ERDF. Precautions would be used to minimize the generation of onsite fugitive dust. Depending on the configuration and depth of the area to be excavated, shoring might be required to comply with safety requirements and to reduce the quantity of excavated soil. The depth, and therefore the volume, of soil removed largely depend on the categories of PRGs that are exceeded. For example, if human health direct contact or ecological PRGs are exceeded, removals generally would be conducted to a maximum of 4.6 m (15 ft) in line with the points of compliance identified in WAC 173-340-745(7) and WAC 173-340-7490. If groundwater protection is required, soils would be removed to meet groundwater protection PRGs. Below-grade structures extending below 4.6 m (15 ft) would be removed, if practicable, or stabilized in place. Implementability, short-term risk to workers, and cost need to be evaluated to determine appropriate excavation depths and to drive decisions between removal and other remedial actions.

The remediation of soil and associated structures for this alternative would be guided by the observational approach. The observational approach is a method of planning, designing, and implementing a remedial action that relies on information (e.g., samples, field screening) collected during remediation to guide the direction and scope of the activity. Data are collected to assess the extent of contamination and to make "real-time" decisions in the field. Targeted (or hot spot) removals could be considered under this alternative if contamination were localized in only a portion of a waste site.

Based on existing information, soil and/or debris removed from the waste sites may require treatment to meet ERDF waste acceptance criteria (BHI-00139, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*). Additional activities may be required to meet health and safety requirements during excavation, handling, transportation, and disposal. Contaminated soil and structures will be containerized (e.g., containers, burrito wraps, bulk shipment) on site and transported to the ERDF, located in the 200 West Area.

After the PRGs are met, uncontaminated soil would be used to backfill the excavation. The backfill material could be found at a variety of sources, including local borrow pits and any remaining excavated material that is determined to be clean (verified as clean by meeting the PRGs). Following remediation, the site will be recontoured, resurfaced, and/or revegetated to establish natural site conditions. Maintenance of the site is required until the vegetation is sufficiently established to prevent intrusion by noxious, non-native plants such as cheatgrass or Russian thistle.

5.2.4 Alternative 4 – Engineered Barrier

The engineered barrier alternative, also known as the capping alternative, consists of constructing surface barriers over contaminated waste sites to control the amount of water that infiltrates into contaminated media, in order to reduce or eliminate leaching of contamination to groundwater. These barriers may include vertical slurry or grout walls to limit intrusion of water from the sides. In addition to their hydrological performance, barriers also can function as physical barriers to prevent intrusion by human and ecological receptors, limit wind and water erosion, and attenuate radiation. Additional elements to the capping alternative include institutional controls, discussed earlier, and monitored natural attenuation, where contamination undergoes natural processes in a reasonable amount of time.

The preferred capping technology for the Hanford Site is an evapotranspiration (ET) barrier, as shown in Figure 5-2. The ET surface barriers rely on the water-holding capacity of a soil, evaporation from the near-surface, and plant transpiration to control water movement through the barrier. These sites could have a variety of ET barriers; the most appropriate one would be determined during design.

If capping is identified as the preferred alternative, finalization of site-specific designs will occur as part of the remedial design process and will consider the RAOs and requirements defined in the record of decision, regulatory design and performance standards, material availability, cost effectiveness, current surface barrier technology information, and site-specific hydrologic and physical performance requirements to ensure waste containment. Different waste sites likely will have varying barrier performance requirements, and more than one barrier design (e.g., monolithic and capillary barrier) may be deployed to address waste site capping needs.

When groundwater protection is required, the cap will limit the infiltration of precipitation. When the prevention of ecological and human intrusion is a performance requirement, then the physical barrier components to the cap become more important. The capping alternative includes provisions for groundwater monitoring for those waste sites with contamination predicted to threaten groundwater maximum concentration levels.

The effectiveness of the cap is related to the design, which must be specific to the conditions at the waste site, and to continued monitoring activities. Some recent preliminary fate and transport modeling for the BC Cribs and Trenches area has shown that reducing the infiltration rate to 0.1 mm/yr by use of a cap would cause a five-fold reduction in the resulting groundwater concentration versus that for uncapped sites. Additional modeling will be needed to design an appropriate cap to achieve the most effective protection of groundwater.

Use of a capping alternative would require an assessment of the lateral extent of contamination during the confirmatory and/or remedial design sampling phases to properly size the cap to ensure containment. The site-specific extent of contamination can be assessed using a variety of approaches including, but not limited to, process knowledge, previous site investigations, geophysical logging, and/or soil sampling. Some degree of oversizing of the barrier beyond the footprint of the waste zone (referred to as overlap) is expected and is dependent on the barrier design used and the depth of contamination. For the purposes of this FS, an overlap of 6.1 m (20 ft) is assumed based on the performance of the Hanford Barrier. The type and availability of barrier construction materials also is a design consideration. The results of the most recent investigation (BHI-01551, *Alternative Fine-Grained Soil Borrow Source Study Final Report*) will be considered during remedial design for selection of the barrier construction materials.

Caps require surveillance and maintenance throughout their life to ensure continued protection. Performance monitoring will be conducted to ensure that the cap is performing as designed. Performance monitoring for this alternative will be twofold. The first component is groundwater monitoring. The second component is vadose zone monitoring, if practical. This FS assumes a robust performance-monitoring activity during the first 5 years after construction, followed by a more focused activity in subsequent years. The effectiveness of institutional controls to maintain the cap becomes uncertain past 150 years. For the majority of the sites in this FS, a design life of 500 years is considered sufficient, because the fate and transport modeling indicate the contaminants do not reach groundwater within 1,000 years. For barriers that use naturally stable geologic materials, the key factor establishing life expectancy is projected wind-erosion rates, which will be minimized by maintaining the vegetation cover, adding gravel to the upper portion of the surface layer, or by using other armoring methods.

5.3 REFERENCES

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Title 40, *Code of Federal Regulations*, Part 300, as amended.

BHI-00139, 2002, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, Rev. 4, Bechtel Hanford, Inc, Richland, Washington.

BHI-01551, 2002, *Alternative Fine-Grained Soil Borrow Source Study Final Report*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.

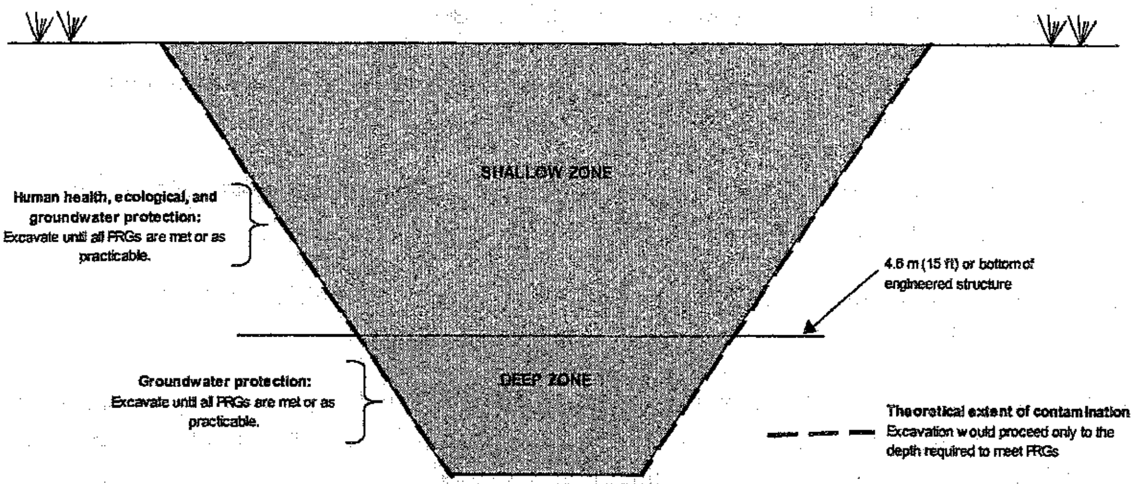
DOE/RL-98-28, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA/540/R-99/009, 1999, *Use of Monitored Natural Attenuation at Superfund RCRA Corrective Action and Underground Storage Tank Sites November 1997*, OSWER 9200.4-17P, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

WAC 173-340-745(7), "Soil Cleanup Standards for Industrial Properties," "Point of Compliance," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

Figure 5-1. Generalized Removal, Treatment, and Disposal Alternative (Alternative 3).



PRG = preliminary remediation goal.

Figure 5-2. Evapotranspiration Barrier.

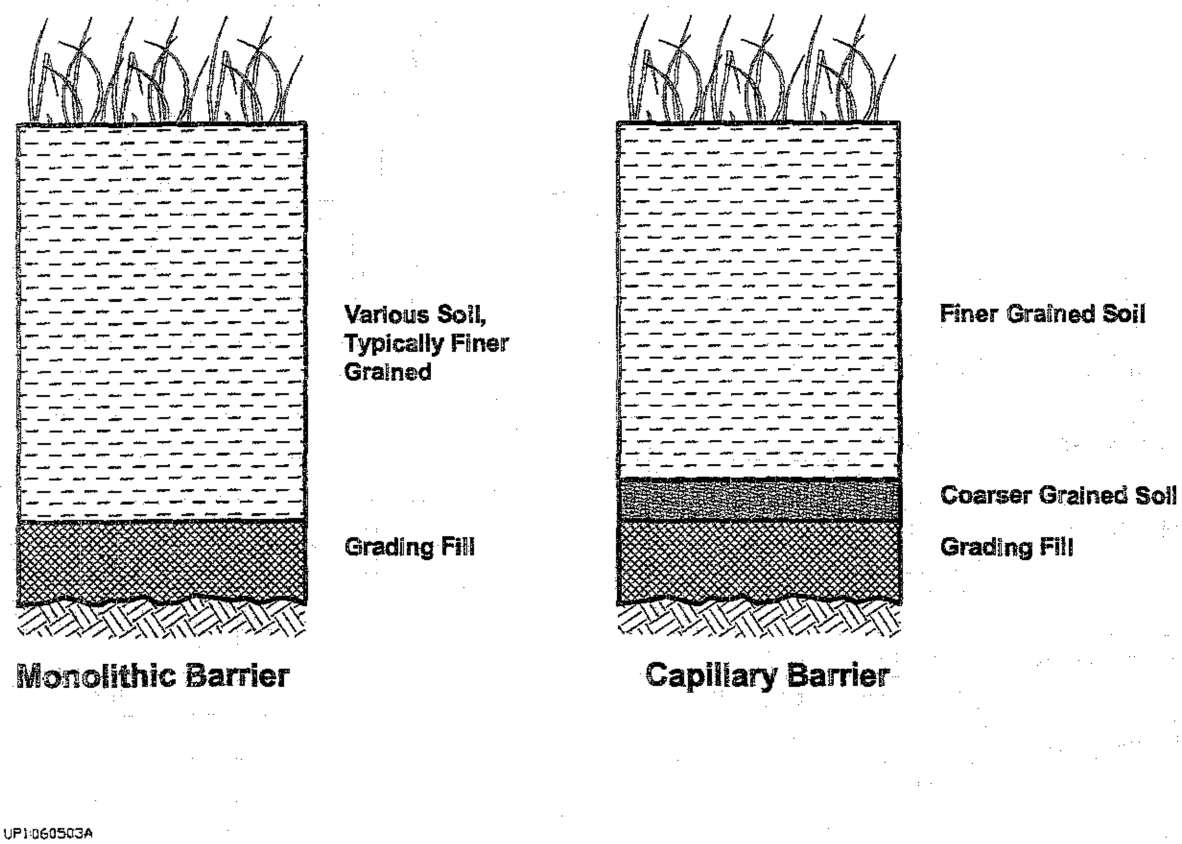


Table 5-1. Summary of Remedial Alternatives and Associated Components.

Technology Type	Process Option	Alternative 1 – No Action	Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls	Alternative 3 – Removal, Treatment, and Disposal	Alternative 4 – Engineered Barrier
No action	No action	X			
Land-use restrictions	Deed restrictions		X		X
Access controls	Signs/fences		X		X
	Entry control		X		X
Monitoring	Groundwater		X	X	X
	Vadose zone		X		X
	Air		X	X	X
Surface barriers	Existing soil cover		X		X
	Evapotranspiration barriers				X
In situ physical treatment	Dynamic compaction				X
	Grout injection				X
In situ thermal treatment	In situ vitrification				
Ex situ physical treatment	Soil mixing			X	
Removal	Conventional excavation			X	
	Excavation in high-concentration areas			X	
Landfill disposal	Onsite landfill			X	
Monitored natural attenuation	Offsite landfill/ repository			X	X
	Monitored natural attenuation	X	X	X	X

CHAPTER 6.0 TERMS

95%UCL	95th upper confidence level
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
DOE	U.S. Department of Energy
Eco	Ecological
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FS	feasibility study
GW	groundwater
HH	human health
mrem	millirem
N/A	not applicable
NEPA	*National Environmental Policy Act of 1969*
OU	operable unit
PRG	preliminary remediation goal
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
SESOIL	Seasonal Soil Compartment model
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
WAC	*Washington Administrative Code*

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6.0 DETAILED ANALYSIS OF ALTERNATIVES

This chapter presents the detailed analysis of the remedial alternatives described in Chapter 5.0 for the 200-CS-1 Operable Unit (OU) waste sites included in this feasibility study (FS). Figure 6-1 presents the guiding logic for selecting alternatives. The remedial alternatives are evaluated relative to seven of the nine *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) criteria, described in the next section. The remedial alternatives are evaluated for each site to determine if the CERCLA evaluation criteria are met.

The analogous waste site (216-S-11 Pond) was assigned to the representative site (216-S-10 Pond) based on physical similarities, waste management function (i.e., disposal versus conveyance), and similarities in the expected distribution of contamination using available information and process knowledge. For this reason, the analogous site is assumed to have contaminant distributions and risks similar to the representative site. Therefore, the detailed analysis for the representative site is assumed to be appropriate for the analogous site. The assignment of the analogous site to the representative site is explained in detail in Chapter 2.0.

The detailed analysis is presented by alternative. Within each alternative, each site is compared with each CERCLA evaluation criterion. Tables 6-1 through 6-3 provide a summary of the detailed analyses for the sites and the one analogous site.

The sites analyzed are as follows:

- 216-A-29 Ditch
- 216-B-63 Trench
- 216-S-10 Ditch
- 216-S-10 Pond and analogous site 216-S-11 Pond.

The analysis of the alternatives takes into account the nature of the contaminants at each site and the assumed land use. Currently, the land use for the 200 Areas is industrial in nature, associated with the management of waste. This land use can be reasonably predicted to be the same for the next 50 years, given the U.S. Department of Energy's (DOE) current commitment to vitrify waste in the tank farms. Industrial use is assumed for the foreseeable future.

6.1 DESCRIPTION OF EVALUATION CRITERIA

The U.S. Environmental Protection Agency (EPA) has developed nine CERCLA evaluation criteria, defined in EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, (Interim Final)*, OSWER 9355.3-01, to address the statutory requirements and the technical and policy considerations important for selecting remedial alternatives. These criteria serve as the basis for conducting detailed and comparative analyses and for the subsequent selection of appropriate remedial actions.

The nine CERCLA evaluation criteria are as follows:

- Overall protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirements (ARAR)
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance.

The first two criteria, overall protection of human health and the environment and compliance with ARARs, are threshold criteria. Alternatives that do not protect human health and the environment or those that do not comply with ARARs (or do not justify a waiver) do not meet statutory requirements and are eliminated from further consideration in this FS.

The next five criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost) are balancing criteria on which the remedy selection is based. The CERCLA guidance for conducting an FS lists appropriate questions to be answered when evaluating an alternative against the balancing criteria (EPA/540/G-89/004). The detailed analysis process in this chapter addresses these questions, providing a consistent basis for the evaluation of each alternative.

The final two criteria, state and community acceptance, are modifying criteria. The criterion of state acceptance will be addressed in DOE/RL-2005-64, *Proposed Plan for the 200-CS-1 Chemical Sewer Group Operable Unit*), prepared by the DOE, EPA, and Washington State Department of Ecology (Ecology) (Tri-Parties). The Proposed Plan will identify the preferred remedy (or remedies) accepted by the Tri-Parties. The criterion of community acceptance will be evaluated following the issuance of the Proposed Plan for public review and comment.

In addition to the CERCLA criteria, *National Environmental Policy Act of 1969* (NEPA) values have been incorporated into this document. Assessment of these considerations is important for the integration of NEPA values into CERCLA documents, as called for by the *Secretarial Policy on the National Environmental Policy Act* (DOE 1994) and DOE O 451.1A, *National Environmental Policy Act Compliance Program*. Potential effects on NEPA values also are discussed in this chapter.

6.1.1 Overall Protection of Human Health and the Environment

This criterion determines whether adequate protection of human health and the environment, including preservation of natural systems and biological diversity, is achieved through implementation of the remedial alternative. Protection includes reducing risk to acceptable levels, either by reducing contaminant concentrations or by eliminating potential routes for exposure, and minimizing exposure threats introduced by actions during remediation. Environmental protection includes avoiding or minimizing impacts to natural, cultural, and historical resources. This criterion also evaluates the potential for human health risks, the extent of those risks, and whether a net environmental benefit will result from implementing the remedial alternative.

This first criterion is a threshold requirement and is the primary objective of the remedial action program. As indicated in EPA guidance, this criterion, and the criteria for compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness, overlap (EPA/540/G-89/004). This FS used the CERCLA risk range of 1×10^{-4} to 1×10^{-6} excess lifetime cancer risk for human health as the range of protectiveness. Alternatives were measured against this standard to determine if the alternative meets this criterion. Protection of groundwater was measured against groundwater protection standards derived from the maximum contaminant levels identified in 40 CFR 141, "National Primary Drinking Water Regulations," and in fate and transport modeling, reported in DOE/RL-2004-17, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit*, and Appendix C of this FS. Ecological compliance was judged using *Washington Administrative Code* (WAC) 173-340-900, "Tables," and DOE/STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*.

6.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

The ARARs are any appropriate standards, criteria, or limitations under any Federal environmental law or more stringent state requirement that must be either met or waived for any hazardous substance, pollutant, or contaminant that will remain on site during or after completion of a remedial action. The ARAR identification process is based on CERCLA guidance (EPA/540/2-88/002, *Technological Approaches to Cleanup of Radiologically Contaminated Superfund Sites*; EPA/540/G-89/004). Potential Federal and state chemical-, location-, and action-specific ARARs associated with remediation of the waste sites addressed in this FS are presented in Appendix B, and each alternative is assessed for compliance against these ARARs. When an ARAR cannot be met, the lead agency can request a waiver if there is a solid basis for justifying the waiver.

6.1.3 Long-Term Effectiveness and Permanence

This criterion addresses the results of a remedial action in terms of risks that remain at the site after remedial action objectives (RAO) are met. The primary focus of this evaluation is the extent and effectiveness of the controls that could be required to manage the risk posed by treatment residuals and/or untreated wastes. The following components of the criterion are considered for each alternative:

- Magnitude of residual risk to human and ecological receptors. This factor assesses the residual risk from untreated waste or treatment residue after remedial activities are completed. The 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. This factor assesses the adequacy and suitability of controls used to manage treatment residues or untreated wastes that remain at the site. It also assesses the long-term reliability of management controls for providing continued protection from residues, and it includes an assessment of the potential need to replace the alternative's technical components.

A related consideration is the restoration time required to reestablish sustainable environmental conditions, including fish and wildlife habitat and cultural resources, where appropriate. Residual risk to natural and cultural resources after conclusion of remedial activities also is evaluated. Current environmental conditions are assessed against the alternative's long-term and permanent solutions. The assessment considerations are based on whether lasting environmental losses would be incurred for the sake of short-term cleanup gains, including whether environmental restoration and/or mitigation options would be precluded if a remedial alternative were implemented.

6.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the degree to which a remedial alternative reduces the toxicity, mobility, or volume of a hazardous substance through treatment. Significant overall reduction can be achieved by destroying toxic contaminants or by reducing total mass, contaminant mobility, or total volume of contaminated media.

This criterion focuses on the following factors for each alternative:

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

6.1.5 Short-Term Effectiveness

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

- Health and safety of remediation workers and reliability of protective measures taken. Specifically, this involves any risk resulting from implementation, such as fugitive dust, transportation of hazardous materials, or air quality impacts from offgas emissions.

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

- The amount of time for the RAOs to be met.

Short-term human health impacts are closely related to the duration of exposure to hazardous waste and the risks associated with waste removal. The greater the exposure time, the greater the risk. Guidelines will be followed during implementation of the remedial action to minimize worker risks and to maintain radiation exposures as low as reasonably achievable.

Short-term environmental impacts are related primarily to the extent of physical disturbance of a site and its associated habitat. Risks also can be associated with the potential disturbance of sensitive species (e.g., bald eagles) because of increased human activity in the area.

6.1.6 Implementability

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

The following factors are considered for each alternative:

- Technical feasibility
  - The likelihood of technical difficulties in constructing and operating the alternative
  - The likelihood of delays because of technical problems
  - Uncertainties related to innovative technologies (e.g., failures)

- Administrative feasibility
  - Ability to coordinate activities with other offices and agencies
  - Potential for regulatory constraints to develop (e.g., as a result of uncovering buried cultural resources or encountering endangered species)

- Availability of services and materials
  - Availability of adequate onsite or offsite treatment storage capacity, and disposal services, if necessary
  - Availability of necessary equipment, specialists, and provisions to ensure obtaining any additional resources, if necessary.

6.1.7 Cost

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

The cost estimates for the purposes of this study are presented in either 2003 constant dollars or present-value terms. The cost estimates were prepared from information available at the time of this study. The actual cost of the project will depend on additional information gained during the remedial design phase, the final scope and design of the selected remedial action, the schedule of implementation, the competitive market conditions, and other variables. However, most of these factors are not expected to significantly affect the relative cost differences of alternatives.

6.1.8 State Acceptance

This criterion evaluates the technical issues and concerns that the EPA and Ecology could have regarding a remedial alternative. The regulatory acceptance process would involve a review and concurrence by the EPA and the Ecology. This criterion will be addressed at the time that the Proposed Plan (DOE/RL-2005-64) is published.

6.1.9 Community Acceptance

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

6.2 DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of the alternatives evaluated under an industrial (exclusive) land-use scenario. This section is followed by a NEPA evaluation. Detailed evaluations were performed at the 216-A-29 Ditch, 216-B-63 Trench, 216-S-10 Ditch, and 216-S-10 Pond. Data obtained at the representative site were used to evaluate the analogous site.

The following detailed evaluations are applicable to the waste sites and the one analogous site. Unless noted, when a site name is used, it means the representative site plus the associated analogous site.

6.2.1 Detailed Analysis of Alternative 1 – No Action

Alternative 1 is retained for detailed analysis as a baseline description of the effects of taking no action and is required by CERCLA regulations.

6.2.1.1 Overall Protection of Human Health and the Environment

For the four waste sites addressed by this FS, the no-action alternative would fail at the 216-A-29 Ditch and 216-S-10 Ditch to provide overall protection of human health and the environment. These sites fail to meet the overall protection criteria because contaminants at concentrations above the preliminary remediation goals (PRG) would remain on site with no measures performed to prevent intrusion to the contaminants or to monitor their migration. At two sites, 216-S-10 Pond and 216-S-11 Pond, the no-action alternative would meet PRGs. The No Action alternative meets the threshold criteria for overall protection of human health and the environment and compliance with ARARs at the 216-B-63 Trench because contaminants are within the 95th upper confidence level (95%UCL) for direct human contact, groundwater protection, or ecological receptors

6.2.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

Because no action would be taken to control the exposure pathway, this alternative would not meet the ARARs for two of the waste sites mentioned above. For the 216-B-63 Trench, 216-S-10 Pond, and its analogous site, all ARARs are anticipated to be met under Alternative 1 because they meet the PRGs or are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.

ARARs include risk-based concentrations for soil cleanup that, if exceeded, would result in a radiological dose of 15 mrem/yr or greater under an industrial scenario. As shown in Table 2-39, the 216-A-29 Ditch, and 216-S-10 Ditch exceed PRGs for ecological protection.

Modeling indicates that only the 216-A-29 Ditch is predicted to require groundwater protection. EPA's Seasonal Soil compartment model (SESOIL) was used to predict whether contaminants of concern (COC) in soil may migrate to groundwater and result in groundwater concentrations that exceed Federal maximum contaminant levels. These levels are defined as the average annual activity of beta particles and photon radioactivity from manmade radionuclides in drinking water that produces an annual dose equivalent to the total body or any internal organ of greater than 4 mrem/yr (40 CFR 141.66, "National Primary Drinking Water Regulations," "Maximum Contaminant Levels for Radionuclides").

As summarized in Table 2-39, concentrations of nonradiological constituents at the 216-A-29 Ditch and 216-S-10 Ditch exceed wildlife-screening values presented in WAC 173-340-900, Table 749-3.

Because no remedial activities would take place under this alternative, action-specific ARARs would not be triggered. No location-specific ARARs have been identified for the waste sites.

6.2.1.3 Long-Term Effectiveness and Permanence

Long-Term Effectiveness and Permanence for Human Health. The no-action alternative provides long-term effectiveness and permanence for human health, because the COCs are below the human health PRGs.

Long-Term Effectiveness and Permanence for Groundwater. Contaminants are predicted to reach the groundwater at the 216-A-29 Ditch. No contaminants are predicted to reach the groundwater in excess of maximum contaminant levels at any of the other sites. Therefore, Alternative 1 does provide long-term effectiveness for groundwater protection for those sites and their analogous site.

Long-Term Effectiveness and Permanence for the Environment. Two sites, 216-A-29 Ditch, and 216-S-10 Ditch, do not meet the standard for protection of the environment in the 0 to 4.6 m

(0 to 15 ft) below ground surface (bgs) zone. The other three sites, 216-B-63 Trench, 216-S-10 Pond, and 216-S-11 Pond, meet the standard for protection of the environment.

6.2.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur at all the waste sites in the form of natural attenuation. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. The radioactive decay process would influence some of the contaminants identified during characterization. In addition, the heavy metals and Aroclor 1254[1] (polychlorinated biphenyl) are persistent in the environment and require a long period to attenuate naturally.

In EPA/540/R-99/009, *Use of Monitored Natural Attenuation at Superfund RCRA Corrective Action and Underground Storage Tank Sites November 1997*, OSWER 9200.4-17P, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation processes, the EPA considers source control and performance monitoring to be fundamental components of the remedy. The no-action alternative does not use any source control or monitoring. Because of the concentrations of contaminants and the substantial length of time required for natural attenuation processes to meet PRGs, this alternative fails for waste sites 216-A-29 Ditch and 216-S-10 Ditch to meet this criterion under CERCLA. The other sites meet the requirements of this criterion because they meet PRGs or are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.

6.2.1.5 Short-Term Effectiveness

No short-term risks to humans would be associated with the no-action alternative because remedial activities would not be conducted. Current risks to workers are not an issue because of protective soil covers and appropriate safety measures for work activities. Ecological risk currently exists at two sites (216-A-29 Ditch and 216-S-10 Ditch), and, therefore, this alternative fails to meet the criterion for short-term effectiveness at two of the sites. These risks would not be mitigated in the no-action alternative. The other sites meet the requirements of this criterion because they meet PRGs or are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.

6.2.1.6 Implementability

The no-action alternative could be implemented immediately and would not present any technical problems. Radionuclides at the waste sites addressed by this FS are currently undergoing natural attenuation.

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[1]Aroclor is an expired trademark.

6.2.1.7 Cost

The no-action alternative would involve no cost, except the confirmatory sampling cost associated with the one analogous site. The cost associated with this additional work is assumed minimal.

6.2.2 Detailed Analysis of Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls

Under this alternative, existing soil covers and/or caps would be maintained to provide protection from intrusion by human and/or biological receptors. Legal and physical barriers also would be used to prevent human access to the site. The existing soil covers and/or caps would break the pathway between human and ecological receptors and the contaminants. Groundwater monitoring is included in this alternative.

The following sections present a detailed analysis of Alternative 2 against the evaluation criteria. This analysis is summarized in Table 6-1.

6.2.2.1 Overall Protection of Human Health and the Environment

Alternative 2 would provide overall protection of human health and the environment for sites that show protection of groundwater and achieve human health and environmental protection within 500 years. Because the viability of institutional controls cannot be ensured past 500 years, this alternative fails to meet this criterion for sites with long-lived contaminants such as heavy metals because the waste sites would have contamination that would not attenuate to acceptable levels within 500 years. Risk assessment details are contained in Chapter 2.0.

216-A-29 Ditch – This waste site does not exceed human health direct-contact protection criteria; however, it exceeds both groundwater and ecological PRGs in the 0 to 4.6 m (0 to 15 ft) zone. As such, this alternative is not protective of groundwater or the environment.

216-B-63 Trench – The 216-B-63 Trench meets the criteria for overall protection of human health and the environment because contaminants are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.

216-S-10 Ditch – The 216-S-10 Ditch site does not exceed groundwater protection criteria or human health direct-contact PRGs. However, it does exceed the ecological PRGs in the 0 to 4.6 m (0 to 15 ft) zone. As such, this alternative is not protective of the environment.

216-S-10 Pond and its Analogous Site – The 216-S-10 Pond and its analogous site (216-S-11 Pond) meet the criteria for overall protection of human health and the environment because they currently meet PRGs.

6.2.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

Under Alternative 2, groundwater ARARs would not be met at the 216-A-29 Ditch. ARARs would not be met at two sites (216-A-29 Ditch and 216-S-10 Ditch) for ecological protection. Risk analysis (Chapter 2.0 and Table 2-39) shows that ecological protection standards will be exceeded at the 216-A-29 Ditch and 216-S-10 Ditch. Conversely, the 216-B-63 Trench and the 216-S-10 Pond representative site meets ARARs.

6.2.2.3 Long-Term Effectiveness and Permanence

Human Health

Alternative 2 would rely on natural attenuation (e.g., radioactive decay) to decrease contaminants until concentrations reached levels that would be protective of human health and the environment. As mentioned under Alternative 1, natural attenuation is a proven and acceptable technology. This alternative would incorporate the use of institutional controls to prevent inadvertent human and biological intrusion into the waste until contaminant concentrations reached acceptable levels. Institutional controls (e.g., deed restrictions, fencing, signage, monitoring of groundwater) would be required components of this alternative. Institutional controls generally are considered to be proven and acceptable technologies meant to prevent access to hazards. To be effective, institutional control and monitoring would be required for the entire time that contaminants exceed PRGs. Institutional controls are assumed to lapse after 500 years.

Table 2-39 summarizes risk assessments for the four sites. The 216-A-29 Ditch groundwater protection standards are exceeded. At the 216-A-29 Ditch and 216-S-10 Ditch, the ecological contaminants are persistent in the environment. The chemical contaminants that pose ecological risk will not decay, and after the institutional control period, it may be expected that deep-rooted flora may be exposed to these contaminant.

216-A-29 Ditch – Under Alternative 2, COCs would remain in the vadose zone at concentrations below the PRGs. Therefore, this alternative is protective of human health in the long term.

216-B-63 Trench – Under Alternative 2, the 216-B-63 Trench meet the criteria for long-term effectiveness because contaminants are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.

216-S-10 Ditch – Under Alternative 2, COCs would remain in the vadose zone at concentrations below the PRGs. Therefore, this alternative is protective of human health in the long term.

216-S-10 Pond and its Analogous Site – Under Alternative 2, the 216-S-10 Pond and its analogous site meet the criteria for long-term effectiveness because they currently meet PRGs.

Protection of Groundwater

216-A-29 Ditch – Nitrate is predicted to reach the groundwater at this site. Therefore, Alternative 2 does not provide long-term effectiveness for groundwater protection for this site.

216-B-63 Trench – No contaminants are predicted to reach the groundwater above maximum contaminant levels at this site. Therefore, Alternative 2 provides long-term effectiveness for groundwater protection for this site.

216-S-10 Ditch – No contaminants are predicted to reach the groundwater at this site. Therefore, Alternative 2 provides long-term effectiveness for groundwater protection for this site.

216-S-10 Pond and its Analogous Site – No contaminants are predicted to reach the groundwater at this site. Therefore, Alternative 2 provides long-term effectiveness for groundwater protection for this representative site and its analogous site.

The Environment

Two of the sites (216-A-29 Ditch and 216-S-10 Ditch) have contaminants located in the shallow soils (0 to 4.6 m [0 to 15 ft] bgs) that present potential risks to burrowing animals. At the 216-A-29 and 216-S-10 Ditches, the COCs are persistent in the environment. As such, this alternative fails to provide long-term protection to the environment. The 216-B-63 Trench and the 216-S-10 Pond sites currently meet ARARs. Therefore, this alternative provides long-term protection to the environment.

6.2.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 does not provide any engineered treatment to reduce toxicity, mobility, or volume. However, natural attenuation will occur through radioactive decay. In EPA/540/R-99/009, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation process, the EPA considers source control and performance monitoring to be fundamental components of the alternative.

This alternative provides a reduction in the mass of radionuclides and chemical contaminants at the four sites. However, two sites, the 216-A-29 Ditch and 216-S-10 Ditch, contain polychlorinated biphenyls and heavy metals, which are persistent in the environment.

6.2.2.5 Short-Term Effectiveness

6.2.2.5.1 Remediation Worker Risk

For Alternative 2, only minimal short-term worker risks are expected, and these risks are associated with monitoring and maintenance activities. Experienced workers using appropriate safety precautions would conduct these activities. Risks would decrease over time as the chemicals decompose. As such, the risk to workers is qualitatively identified as low. Additionally, active DOE control of the Central Plateau is assumed for the next 50 years given DOE's commitment to vitrify the waste in the tank farms. Therefore, failure of this alternative in the short term is considered unlikely.

6.2.2.5.2 Impact to Environment During Remediation

This alternative reduces the risk to human and ecological receptors using existing soil covers and the implementation of institutional controls. Currently, the 216-A-29 Ditch and 216-S-10 Ditch have contamination within the shallow soils (0 to 4.6 m [0 to 15 ft]). As such, short-term impacts to vegetation and wildlife may occur at these sites during the implementation of this alternative. The waste sites have been highly disturbed, and the existing soil cover provides protection for all but the deep-rooted flora or deep-burrowing animals. The short-term impacts to the environment are expected to be low.

6.2.2.5.3 Time to Meet the Remedial Action Objectives

In this alternative, RAOs only can be fully met through natural decomposition of contaminants, which can take hundreds of years to achieve. As such, the 216-B-63 Trench, 216-S-10 Pond, and the analogous site meet this RAO. However, the remaining sites do not meet RAOs in a reasonable time frame.

6.2.2.6 Implementability

Alternative 2 could be readily implemented and would not present technical problems. This alternative currently is being implemented through Hanford Site access controls, surface and subsurface radiation area work and access controls, and the waste site/radiation area surveillance and maintenance program.

6.2.2.7 Cost

Cost estimates for Alternative 2 were developed based on existing costs for similar activities currently conducted on the Hanford Site. Details of the cost estimates are presented in Appendix D. Summarized costs for the sites are presented in Table 6-1. The input parameters used in these estimates are the best available at this time, but in many cases the data on COCs, site locations, and site dimensions are limited. The uncertainties identified above are similar for all the sites evaluated in this FS. Despite these uncertainties, the cost estimates are of sufficient quality to fulfill the primary objective, which is to aid in selecting preferred remedial alternatives.

This alternative involves costs for activities similar to current activities. These activities involve periodic surveillance of the waste sites for evidence of contamination and biologic intrusion; emplacement of vegetation, herbicide application, or other activities to control deep-rooted plants; control of deep-burrowing animals; maintenance of signs and/or fencing; maintenance of the existing soil cover (including an assumed periodic addition of soil); administrative controls; and site reviews. The present-worth costs assume a 3.2 percent discount rate (based on 2003 Office of Management and Budget information) and assumes an operation and maintenance period equal to the time required for PRGs to be met.

6.2.3 Detailed Analysis of Alternative 3 – Removal, Treatment, and Disposal

Under Alternative 3, contaminated soil and debris (such as concrete or pipe associated with the sites) would be removed, treated as necessary to meet disposal facility waste acceptance criteria, and transported for disposal at an approved waste disposal facility. Soils would be removed to meet PRGs. Alternative 3 has two potential disposal paths: one for disposal of soils contaminated with only chemicals and one for disposal of soils that are not contaminated with both chemicals and radionuclides. These latter soils would be disposed on-site at the Environmental Restoration Disposal Facility (ERDF). Soils are not anticipated to require treatment before disposal at the ERDF, based on the data collected for the waste sites. Alternative 3 would remove contaminated waste and soil from waste sites to a depth to meet the RAOs.

This alternative generally provides a high degree of overall protection of human health and the environment, because contaminants are removed to meet PRGs. Removal of the contaminants provides for the most flexibility for future land use.

This alternative would provide future protection to humans and the environment because the contaminants are removed from the waste site. The groundwater would be protected because COCs are removed to meet the PRGs. The contaminated soil would be removed from a waste site and placed in an approved disposal facility; therefore, failure of this alternative is not likely. Residual risks would be at acceptable levels for protection of human health, the environment, and groundwater. Verification sampling would be conducted to determine that PRGs are met by the removal activities. Risks associated with the failure of the disposal facility are not evaluated here, but are evaluated as part of the permitting process for the facility.

6.2.3.1 Overall Protection of Human Health and the Environment

Because this alternative removes contaminants that are above PRGs, it provides overall protection (human health and the environment) in all cases.

- **216-A-29 Ditch** – Risk analysis of the 216-A-29 Ditch showed that contamination above PRGs occurs only in the shallow zone (0 to 4.6 m [0 to 15 ft]). A groundwater and ecological risk is present due to presence of nitrates, Aroclor 1254, and heavy metals. Chemical and radiological contaminants in excess of the PRGs extend to a depth of approximately 4 m (13 ft). Existing data indicate that the southern 306.4 m (1,005 ft) and the 779.9 m (2,558 ft) of the ditch exceed PRGs.

- **216-B-63 Trench** – Analysis of the 216-B-63 Trench shows contaminants are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors. Therefore, this alternative does not apply

- **216-S-10 Ditch** – Risk analysis of the 216-S-10 Ditch showed that contamination above PRGs occurs only in the shallow zone (0 to 4.6 m [0 to 15 ft]). The only risk to human health and the environment is an ecological risk from Aroclor 1254 and heavy metals. Chemical contaminants in excess of the PRGs extend to a depth of approximately 4.6 m

(15 ft). Existing data indicate that only the northern 296.3 m (972 ft) of the ditch exceed PRGs. Therefore, only the northern portion of the ditch requires remedial action.

- **216-S-10 Pond and its Analogous Site** – Analysis of the 216-S-10 Pond shows no contaminants above PRGs. Therefore, this alternative does not apply.

6.2.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 3 would comply with chemical-specific ARARs by removing soil that exceeds the PRGs and by removing or abandoning structures. Removal of all contaminants would achieve the chemical-specific ARARs discussed in Section 6.2.1.2 for protection of human health, ecological receptors, and groundwater protection. Other action-specific ARARs that could be pertinent to Alternative 3 are Washington State solid and dangerous waste regulations (for management of characterization and remediation wastes and performance standards for waste left in place), *Atomic Energy Act of 1954* regulations (for performance standards for radioactive waste sites), and Federal and state regulations related to air emissions. It is anticipated that these ARARs could be met. No location-specific ARARs have been identified for the waste sites addressed in this FS.

6.2.3.3 Long-Term Effectiveness and Permanence

Human Health

With regard to human health, this alternative would be effective and permanent in the long term for all sites because excavation activities under Alternative 3 would remove contaminants to meet human health and ecological RAOs. EPA and Ecology cleanup authorities prescribe remedies that use permanent solutions to the maximum extent practicable and where cost effective. Removal of contaminants would be a permanent solution at the waste sites; however, much of the waste would remain on site at the ERDF.

The removal of buried materials from the Central Plateau, for disposal on the Hanford Site at the ERDF, transfers the long-term impact of buried waste from individual waste sites to one consolidated disposal facility. The ERDF is designed for long-term management of buried waste.

Protection of Groundwater

The groundwater would be protected because modeling shows no impact to the groundwater in 1,000 years. Therefore, Alternative 3 meets this criterion.

The Environment

All contaminated soil in the 0 to 4.6 m (0 to 15 ft) bgs zone is removed in this alternative. Therefore, this alternative would be effective and permanent for all sites with respect to the environment. Excavation and transportation of waste and structures would disturb areas beyond the waste site boundaries during the implementation period. These areas would need to be revegetated after disturbance and would require activities to control intrusion by non-native, noxious plants. This should not adversely affect the alternative in the long term or permanently.

6.2.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur in the form of natural attenuation. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. Some of the contaminants identified during characterization would be influenced by the radioactive decay process; however, concentrations are high enough to require long time periods for radionuclides to decay to PRG levels (hundreds and, in a few cases, thousands of years).

In EPA/540/R-99/009, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation process, the EPA considers source control and performance monitoring to be fundamental components of the alternative.

In general, the removal, treatment, and disposal alternative would include treatment to reduce toxicity, mobility, or volume. However, with the availability of the ERDF, treatment is not anticipated. Radiological decay ultimately results in reduction of toxicity and volume. Movement of the waste to the ERDF would result in reduction of mobility. Both facilities would provide additional protection against remobilization of contaminants over their current location.

6.2.3.5 Short-Term Effectiveness

6.2.3.5.1 Remediation Worker Risk

The levels of contamination in the 216-A-29 Ditch and 216-S-10 Ditch do not pose a significant dose threat to workers. As such, shielded excavation equipment for these wastes should not be required. Worker protection may include dust suppression. These activities limit the worker risk, but also have a direct impact on schedule and cost. Nonetheless, excavation with dust suppression and health and safety controls has been proven effective in excavating soil sites.

6.2.3.5.2 Impact to Environment During Remediation

Physical disruption of the waste sites during excavation, increased human activity, and noise, in addition to the generation of fugitive dust, affect local biological resources. However, the waste sites are located within historically disturbed industrial areas. Potential animal intrusion and biological uptake also are issues that will require control of open excavations and exposed contaminated soils at the end of each day. This control could be accomplished through placement of covers or fixatives. Areas of disturbed surface are documented in Appendix D and reported below. The additional disturbed area was estimated to average 20 percent of the site area.

- **216-A-29 Ditch** – The surface area disturbed during excavation of this site will be 1.3 ha (3.2 a). A conservative assumption is that an additional 0.2 ha (0.5 a) will be disturbed by activities such as staging construction activities and stockpiling clean soil, for a total disturbed area of 1.5 ha (3.7 a).

- **216-B-63 Trench** – No surface area will be disturbed at this representative site because this alternative is not applicable to this site.
- **216-S-10 Ditch** – The surface area disturbed during excavation of this site will be 0.49 ha (1.2 a). It is assumed that an additional 0.2 ha (0.5 a) will be disturbed by activities such as staging construction activities and stockpiling clean soil, for a total disturbed area of 0.69 ha (1.7 a).
- **216-S-10 Pond and its Analogous Site** – No surface area will be disturbed at this representative site because this alternative is not applicable to this site.

Transportation activities on the Central Plateau would increase as a result of bringing construction equipment to the site, transporting contaminated soils to the ERDF, and bringing clean fill to the excavated sites. Because the ERDF is located onsite, minimal uncertainties are associated with the transport of waste. Air monitoring around the waste sites would be used to monitor potential air releases (e.g., waste or fill-material particulates) that could affect the public and the environment.

6.2.3.5.3 Time to Achieve the Remedial Action Objectives

This alternative prevents the risk to human or ecological receptors by moving the source to an engineered disposal facility. Construction and waste excavation activities would be expected to require approximately a month to complete. Once completed, all long-term RAOs will be met (reducing risk to human health and ecological receptors, protection of groundwater, and reduction of exposure to industrial workers). The following estimates of time to complete remediation activities under Alternative 3 are from Appendix D. The time frame for the waste sites is based on assumptions used in Appendix D and an assumed 12-month design schedule.

- **216-A-29 Ditch** – Design and remediation of this site would take approximately 18 months.
- **216-B-63 Trench** – The 216-B-63 Trench site currently meet risk requirements.
- **216-S-10 Ditch** – Remediation of this waste site would take approximately 14 months.
- **216-S-10 Pond and its Analogous Site** – The 216-S-10 Pond and its analogous site currently meet risk requirements.

6.2.3.6 Implementability

Excavation is a proven and implementable technology used to remove wastes. Deeper excavations will require the use of more sophisticated digging equipment and techniques, the use of approach ramps and shoring, extensive removal of clean material to obtain adequately safe side slopes, etc. The aboveground structures (e.g., vent pipes and concrete structures) would be removed along with the waste site soil covers and contaminated soils. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio.

216-A-29 Ditch – To remove soils above the PRGs, standard excavation equipment is needed. Standard construction practices will be used. The excavation would be advanced to a depth of about 4 m (13 ft) bgs for approximately 295.7 m (970 ft). Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure increases the amount of material excavated. To remove the COCs at this group, 1,835.6 m^3 (2,399 yd^3) of contaminated soil would have to be removed and sent to the ERDF.

216-B-63 Trench – Analysis of the 216-B-63 Trench site shows contaminants are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors. Therefore, this alternative does not apply.

216-S-10 Ditch – To remove soils above the PRGs, the excavation would be advanced to a depth of 4.6 m (15 ft) bgs for approximately 296.3 m (972 ft). Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure increases the amount of material excavated. To remove the COCs at this site, 2,498.2 m^3 (3,265 yd^3) of soil would have to be removed and sent to the ERDF.

216-S-10 Pond and its Analogous Site – Analysis of the 216-S-10 Pond and its analogous site shows no contaminants above PRGs. Therefore, this alternative does not apply.

Coordination with other agencies and local governments would be necessary after approval of the alternative. Excavation and disposal would require coordination with state agencies to assess matters relative to storm water control and the potential for radioactive air emissions.

6.2.3.7 Cost

Costs include mobilizing personnel and equipment; monitoring, sampling, and analysis; excavating; disposing of the waste at the ERDF; backfilling with onsite resources and additional backfilling from a local stockpile; revegetating; and performing prime contractor oversight.

Costs are based on the use of standard excavation equipment (e.g., hydraulic excavators, front-end loaders, tractor-trailers). The costs are based on the assumption that a subcontractor would do the work, with oversight performed by prime contractor personnel. Details of the cost estimates are presented in Appendix D. Summarized costs for the sites are presented in Table 6-2.

6.2.4 Detailed Analysis of Alternative 4 – Engineered Barrier

The following sections present a detailed analysis of Alternative 4 against the evaluation criteria. Table 6-3 summarizes this analysis. This alternative analyzed two types of caps: an evapotranspiration and a modified *Resource Conservation and Recovery Act of 1976* (RCRA) C. The evapotranspiration barrier was analyzed at the 216-A-29 Ditch, the 216-B-63 Trench, and the 216-S-10 Ditch.

6.2.4.1 Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment because the capping system would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion. The cap would be sufficiently robust to account for the types and levels of contamination in the waste sites. A capping system would provide additional distance between potential human and ecological receptors beyond the existing soil cover over the waste sites. Additionally, the capping system would include institutional controls such as monitoring, and provide a warning to potential intruders and notification of land-use restrictions.

Institutional controls, including maintenance of the cap, use restrictions, and monitoring, would be instituted at capped sites until the PRGs are achieved through natural attenuation. Institutional controls would provide additional protection against human intrusion. No groundwater monitoring is proposed because modeling shows no impact within 1,000 years. The cap would be designed to address potential lapse of the institutional controls after the 500-year period. Alternative 4 would be protective, because the barrier would be constructed to meet the ecological point of compliance.

6.2.4.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 4 would comply with all ARARs for the waste sites by breaking the pathways for exposure and emplacing caps that meet the intent of the regulations. In addition to the cap, institutional controls such as additional land-use restrictions and groundwater monitoring are elements of this alternative.

6.2.4.3 Long-Term Effectiveness and Permanence

Human Health

The capping alternative would be protective of human health and the environment by breaking exposure pathways. Chemicals and radionuclides left in place at the waste sites would be physically separated from receptors by the thickness of the cap and by the additional thickness of the existing soil covers. Intrusion layers in the caps, along with institutional controls such as markers and use restrictions, would help protect against inadvertent intruders. Because contaminants at the waste sites have the potential to impact ecological receptors, caps would be designed to meet the point of compliance.

A significant amount of risk attenuates within the active institutional controls period for sites with significant risk contribution from short-lived radioisotopes. Therefore, failure of the caps in later years would be associated with lower risks than at present. Additionally, the 5-year reviews required for sites with contaminants above PRGs would serve to monitor the effectiveness and reliability of the caps; adjustments and maintenance activities could be instituted to help prevent failure, based on the 5-year review results.

The long-term effectiveness depends on the proper construction and maintenance of the barrier and associated institutional controls throughout the natural attenuation time frame to prevent exposure to potential receptors. Maintenance activities would include erosion repairs and possible vegetation maintenance. Subsidence is not considered a major factor in maintenance activities for these waste sites. Failure of the cap is unlikely if maintenance and institutional control activities continue. The assumption used is that institutional controls past 500 years or so would not necessarily be maintained and could lapse. Caps would be designed and constructed to account for the necessary time frame to reach acceptable risk levels and to minimize maintenance requirements and impacts from a lapse in the institutional controls.

In addition, management controls (e.g., deed restrictions, fencing, signage) would be required components of this alternative. Once remediated, the barrier and surrounding disturbed area would be revegetated to further enhance evapotranspiration, limit erosion, and blend the site area into the surrounding landscape.

216-A-29 Ditch – The COCs for this site are Aroclor 1254, nitrate, and heavy metals. These COCs represent an unacceptable groundwater and ecological risk. With the exception of nitrate, the remaining COCs are relatively immobile. Based on previous modeling results, this cap inhibits the migration of nitrate and is protective of groundwater.

216-B-63 Trench – Analysis of the 216-B-63 Trench shows contaminants are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors. Therefore, this alternative does not apply

216-S-10 Ditch – The COCs for this site are Aroclor 1254, silver, and total chromium. These COCs represent an unacceptable ecological risk.

216-S-10 Pond and its Analogous Site – Analysis of the 216-S-10 Pond and its analogous site shows no contaminants above PRGs. Therefore, this alternative does not apply.

Protection of Groundwater

The groundwater would be protected because modeling shows no impact to the groundwater in 1,000 years. Therefore, Alternative 4 meets this criterion.

The Environment

This alternative would provide protection to the environment by placing a barrier between the waste and the surface flora and fauna. As previously mentioned, two sites (216-A-29 Ditch and 216-S-10 Ditch) fail the protection of the environment. At these sites, the caps would be designed to prevent the intrusion of deep-rooted flora and burrowing animals.

6.2.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur in the form of natural attenuation. The capping alternative would rely on natural attenuation processes (most importantly radioactive decay) to reduce radioactivity to levels that would not present a risk to human health or the environment. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. The contaminants identified during characterization would be influenced by the radioactive decay process.

In EPA/540/R-99/009, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation process, the EPA considers source control and performance monitoring to be fundamental components of the alternative.

6.2.4.5 Short-Term Effectiveness

6.2.4.5.1 Remediation Worker Risk

Experienced workers using appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline no-action alternative. For Alternative 4, only moderate short-term risks are expected. The capping alternative would not require excavation of contaminated soils, so the risks to workers primarily would be associated with general construction activities at the borrow sites and placement of the cap. If structures were removed, workers could be exposed to potentially contaminated debris. Worker risk would be controlled through adherence to site health and safety procedures. Air monitoring would address potential air releases (e.g., barrier-material particulates) that could affect the public during construction of the surface barriers.

6.2.4.5.2 Impact to Environment During Remediation

Physical disruption of the waste sites during cap construction, increased human activity and noise, and the generation of fugitive dust affect local biological resources. However, the waste sites are located within historically disturbed industrial areas. As such, short-term impacts to vegetation and animals at these sites would be low because these sites currently are poor wildlife habitats.

6.2.4.5.3 Time to Meet the Remedial Action Objectives

The following estimates of time to complete remediation activities under Alternative 4 are from Appendix D and an assumed 12-month design schedule. Appendix D calculated time to complete remediation for the sites only; time to complete remediation for the analogous sites was calculated by using the cap surface areas ratio. This technique may overestimate time to complete remediation for the entire waste group, because operations may proceed concurrently rather than consecutively.

- **216-A-29 Ditch** – Design and construction of the cap for this waste site would take approximately 18 months.
- **216-B-63 Trench** – The 216-B-63 Trench site currently meets risk requirements.
- **216-S-10 Ditch** – Design and construction of the cap for this waste site would take approximately 19 months.
- **216-S-10 Pond and its Analogous Site** – The 216-S-10 Pond and its analogous site currently meet risk requirements.

6.2.4.6 Implementability

The capping alternative is considered implementable at all waste sites. Other types of barriers have not been used at the Hanford Site, but have been implemented at other sites and are straightforward to construct and maintain. The existing soil covers over the waste sites would be considered a part of the overall design to minimize the cost of materials and to minimize the impact to visual aesthetics.

Construction of the caps would follow standard procedures that have been thoroughly field-tested. The caps likely would require minor repair and possibly replacement during the restoration time frame. Monitoring the continued integrity of the caps would be accomplished through visual inspection and would be supplemented with groundwater sampling. Implementation of the capping alternative would require additional design data (e.g., ground-penetrating radar) and possibly confirmatory sampling, because existing data may not be adequate for determining the lateral extent of the caps.

Gravel, sand, and silt/loam soil used for the caps would be transported from borrow areas located on or near the Hanford Site. Anticipated volumes of these materials are identified in Appendix D. Area C currently is designated as a silt borrow location; the area has a large volume of fine-grained material. Other locations have not yet been determined. Soil most likely would come from near the waste sites or from Pit 30, which is located between the 200 East and 200 West Areas. Borrow material may occur in environmentally sensitive areas; obtaining sufficient capping material, especially for a multilayered cap, would affect areas of ecological significance and is a consideration in evaluating the relative risk reduction gained by installing the cap. Materials such as rip-rap that may be used in the cap construction could be obtained on the Hanford Site or could be purchased from local dealers.

Capping materials hauled to the Central Plateau from borrow areas and gravel pits within the Hanford Site would increase heavy equipment use and transportation activities at the sites. However, radioactive or hazardous waste would not have to be hauled from the Site.

216-A-29 Ditch – An evapotranspiration cap would be installed at the 216-A-29 Ditch. The main design feature would be to store water during the wet periods and release it back to indigenous vegetation during prolonged periods of dry weather. The cap would be built to cover 0.93 ha (2.3 a) on the southern portion of the ditch and 2.35 ha (5.8 a) on the northern section of the ditch.

216-B-63 Trench – Analysis of the 216-B-63 Trench shows contaminants are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors. Therefore, this alternative does not apply.

216-S-10 Ditch – An evapotranspiration cap would be installed at the 216-S-10 Ditch site. The main design feature would be to store water during the wet periods and release it back to indigenous vegetation during prolonged periods of dry weather. The cap would be built to cover 0.93 ha (2.3 a) on the northern section of the ditch.

216-S-10 Pond and its Analogous Site – Analysis of the 216-S-10 Pond and its analogous site shows no contaminants above PRGs. Therefore, this alternative does not apply.

6.2.4.7 Cost

Costs, shown in Table 6-3, include stabilization of the existing site; excavation or import, transportation, and placement of capping material; compaction of the cap; prime contractor oversight; and confirmatory sampling. Costs are based on the use of standard equipment (e.g., hydraulic excavators, front-end loaders, dozers) and assume that a subcontractor would do the work, with oversight performed by the prime contractor. The subcontractor personnel are assumed to be wearing Level D personal protective equipment (e.g., blues and no respirators) during construction. The present-worth costs assume a 3.2 percent discount rate (based on 2003 Office of Management and Budget information) and assume operations and maintenance (active institutional controls period) for 150 years. The operations and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, biotic control, maintenance of signs and markers, cover maintenance, and site reviews. Details of the cost estimates are presented in Appendix D. Summarized costs for the sites are presented in Table 6-3.

6.3 NEPA VALUES EVALUATION

The NEPA process is intended to help Federal agencies make decisions that are based on understanding environmental consequences, then to take actions that protect, restore, and enhance the environment. Secretarial policies (DOE 1994) and DOE O 451.1A require that CERCLA documents incorporate NEPA values, such as analysis of cumulative, offsite, ecological, and socioeconomic impacts to the extent practicable, in lieu of preparing separate NEPA documentation for CERCLA activities.

6.3.1 Description of NEPA Values

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

The NEPA-related resources and values that the DOE has considered in this evaluation include the following.

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

- Air quality. This value considers potential air quality concerns associated with emissions generated during the proposed remedial actions.
- Natural, cultural, and historical resources. This value considers impacts of the proposed remedial actions on wildlife, wildlife habitat, archeological sites and artifacts, and historically significant properties on the Central Plateau.
- Noise, visual, and aesthetic effects. This value considers increases in noise levels or impaired visual or aesthetic values during or after the proposed remedial actions.
- Socioeconomic impacts. This value considers impacts pertaining to employment, income, other services (e.g., water and power utilities), and the effect of implementation of the proposed remedial actions on the availability of services and materials.
- Environmental justice. Environmental justice, as mandated by Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, refers to fair treatment of humans of all races, cultures, and income levels with respect to laws, policies, and government actions. This value considers whether the proposed remedial actions would have inappropriately or disproportionately high and adverse human health or environmental effects on minority or low-income populations.
- Cumulative impacts (direct and indirect). This value considers whether the proposed remedial actions could have cumulative impacts on human health or the environment when considered together with other activities on the Central Plateau, at the Hanford Site, or in the region.
- Mitigation. If adverse impacts cannot be avoided, remedial action planning should minimize them to the extent practicable. This value identifies required mitigation activities.
- Irreversible and irretrievable commitment of resources. This value evaluates the use of nonrenewable resources for the proposed remedial actions and the effects that resource consumption would have on future generations. When a resource (e.g., energy, minerals, water, wetland) is used or destroyed and cannot be replaced within a reasonable amount of time, its use is considered irreversible.

6.3.2 Detailed Evaluation of NEPA

6.3.2.1 Transportation Impacts

Implementation of remedial action at the waste sites likely would have some short-term impacts on local traffic and traffic in the surrounding region. For Alternative 4, impacts would result from hauling cover material to the waste site areas. For Alternatives 3, impacts would result from hauling waste to the ERDF and hauling clean fill to the waste sites. For Alternatives 3 and 4, impacts could be expected from increased traffic bringing supplies, equipment, and workers to the sites. To mitigate these potential impacts, a transportation safety analysis would be performed before any transport activities began. The analysis would identify the need for specific precautions (e.g., road closures, preferred hauling times, staggered work shifts) to be taken as necessary. Increases in the workforce traffic related to waste treatment would be expected to be minor.

6.3.2.2 Air Quality

No current air quality impacts are associated with Alternatives 1 and 2; however, potential impacts to air quality could be associated with plant or animal uptake of contaminants and wind dispersion. Potential near-term impacts to air quality associated with Alternatives 3 and 4 are expected to be minor and could be mitigated through appropriate engineering controls.

Potential air quality impacts primarily would be associated with fugitive dust during site preparation, structure demolition, excavation, placement of backfill or barriers, and revegetation activities. Dust suppression (using water and water treated with soil fixatives) would be used to control visible fugitive dust, so neither local nor regional air quality is expected to be affected. Routine emissions from vehicles would occur.

6.3.2.3 Natural, Cultural, and Historical Resources

In all cases, remediation will be performed on sites that have been disturbed by industrial activities. Therefore, although cultural resources could be encountered with Alternatives 3 and 4 during the excavation and construction of staging areas, the probability is low. To ensure that impacts to cultural resources are avoided and/or mitigated, a cultural resource mitigation plan would be established before remediation was begun. If cultural resources were encountered during excavation, *work would be stopped in the area and unanticipated and inadvertent discovery procedures would be followed pursuant to* DOE/RL-98-10, *Hanford Cultural Resource Management Plan.*

Some short-term adverse impacts to natural resources (e.g., local wildlife) could occur during the construction and implementation phases of remedial action. Ecological surveys would be performed to identify the species present and the special precautions that should be taken to minimize adverse impacts.

6.3.2.4 Noise, Visual, and Aesthetic Effects

Alternatives 1 and 2 would have little to no impact on current noise, visual, or aesthetic site characteristics. Alternative 3 would increase noise levels and impair visual values, but the impacts would be short-term during remedial actions and ultimately would improve the aesthetics by removing any remaining site structures. Likewise, Alternative 4 would increase noise levels and impair visual values in the short term during construction of the cap. These alternatives also could have some long-term visual and aesthetic impacts, both positive and negative. Positive impacts would result from the removal of aboveground site structures. Negative impacts would be associated with the visibility and aesthetics of the caps over large distances if they are not contoured to blend in with the surrounding area. Aesthetically, given the past disturbance in the 200 Areas and on the Central Plateau, no impacts would be expected from the alternatives.

6.3.2.5 Socioeconomic Impacts

Alternative 1 would have no socioeconomic impacts. The other alternatives would have some positive socioeconomic impacts related to the employment opportunities that would occur during the life of the remedial action project. The labor force required to implement remedial action would be drawn from current Hanford Site contractors and the local labor force, so the socioeconomic impacts would be expected to be minimal.

6.3.2.6 Environmental Justice

Under Alternative 3, environmental justice issues would not be a concern because future surface uses on the Central Plateau would not be restricted beyond the Central Plateau-wide restrictions. Under Alternatives 1, 2, and 4, environmental justice impacts would be minimal because future-use restrictions would pertain to only a small percentage of the Central Plateau, and the Central Plateau still would be under active waste management industrial-land use.

6.3.2.7 Irreversible and Irretrievable Commitment of Resources

Alternatives 3 and 4 would require some irreversible or irretrievable commitment of natural resources. All of the alternatives with the exception of Alternative 1 would result in some land-use loss. Alternatives 3 and 4 would require additional soils, including materials that could come from ecologically sensitive areas, and some energy resources. They would require a commitment of resources in the form of land-use loss in the waste site areas until RAOs and goals were met through the natural attenuation process. The amount of land-use loss would vary among alternatives. Alternative 2 generally would require land-use loss of the entire site surface and subsurface for the necessary attenuation period to meet RAOs. Alternative 3 generally would allow land use from the ground surface to a depth of 4.6 m (15 ft) bgs or greater following the completion and regulatory acceptance of remedial activities. Alternative 4 would allow surface use of the sites, but would not allow any subsurface site use until the end of the necessary attenuation period to meet RAOs. This use would be limited based on potential impacts to surface-barrier integrity.

For Alternative 3, the ERDF would not need to be expanded to accommodate the additional waste. The waste volumes from the aboveground structure demolition in Alternatives 3 and 4 are relatively small and are not anticipated to specifically require additional ERDF capacity.

Alternatives 3 and 4 would require an irretrievable and irreversible commitment of resources in the form of geologic materials and petroleum products (e.g., diesel fuel, gasoline). With Alternative 3, excavated material would be replaced with a stockpile of clean soil cover removed from the site, as well as clean sand and gravel fill from onsite borrow pits (e.g., Area C borrow area). The sand and gravel for the surface-barrier alternative would come from nearby borrow pits, but the silt would need to come either from the Fitzner-Eberhardt Arid Lands Ecology Reserve or from off site. Rip-rap or other armoring materials needed to provide intrusion protection likely would come from off site.

6.3.2.8 Cumulative Impacts

The proposed RAOs could have impacts when considered together with impacts from past and foreseeable future actions at and near the Hanford Site. Authorized current and future activities include soil and groundwater remediation; waste management and treatment (e.g., tank farms, the Waste Treatment Plant); and surveillance, maintenance, decontamination, and decommissioning of facilities. Other Hanford Site activities that might be ongoing during remedial action at the Central Plateau waste sites include deactivation and decontamination of reprocessing facilities and operation of the Energy Northwest reactor. Activities near the Hanford Site include a privately owned radioactive and mixed waste treatment facility, a commercial fuel manufacturer, a commercial low-level radioactive waste disposal site, and a titanium reprocessing plant.

The proposed remediation alternatives would have minimal impacts on transportation; air quality; and natural, cultural, and historical resources. Noise, visual, and aesthetic effects and socioeconomic impacts also would be minimal. Therefore, cumulative impacts with respect to these values are expected to be insignificant. The most notable area for cumulative impacts is with respect to the irretrievable and irreversible commitment of resources. All of the proposed alternatives except Alternative 1 would require long-term land-use restrictions.

To varying levels, Alternatives 2, 3, and 4 would result in the loss of some land uses on the Central Plateau, but the cumulative impacts with respect to loss of land use are not expected to be significant. Alternative 3 also would require a commitment of land use as a result of the ERDF expansion on the Central Plateau. This would be in addition to numerous other Hanford Site projects that would commit land use on the Central Plateau.

Under Alternatives 3 and 4, cumulative impacts also would occur with respect to the irretrievable and irreversible commitment of geologic resources. The Central Plateau waste sites constitute only a portion of the total actions requiring material for barriers and backfill at the Hanford Site. The total quantity of geologic materials required for other Hanford Site actions currently is being identified (BHI-01551, *Alternative Fine-Grained Soil Borrow Source Study Final Report*) and may be subject to a separate NEPA evaluation. Currently, a borrow area (Area C) is being developed west of Route 240 to support capping activities planned at the U Plant area. DISCUSS NEPA DOCUMENT FOR THIS.

6.3.2.9 Mitigation

Alternative 1 would not include mitigation. Mitigation measures under Alternative 2 would include surveillance, physical controls, and potential interim remedies. Mitigation measures taken under Alternatives 3 and 4 would include dust suppression, stockpiling clean topsoil for reuse, minimizing the size of construction areas, and planning activities to avoid nesting and breeding cycles of birds and mammals.

6.3.2.10 Summary of NEPA Evaluation

Remedial actions at the Central Plateau waste sites would result in some impacts to public health and the environment. However, the overall environmental impacts under normal operating conditions would not be very large, nor would they vary greatly among the remedial alternatives.

6.4 REFERENCES

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

40 CFR 141, "National Primary Drinking Water Regulations," Section 141.66, "Maximum Contaminant Levels for Radionuclides," Title 40, *Code of Federal Regulations*, Part 141, as amended.

40 CFR 1502.16, "Environmental Impact Statement," "Environmental Consequences," Title 40, *Code of Federal Regulations*, Part 1502.16, as amended.

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EPA/540/R-99/009, 1999, *Use of Monitored Natural Attenuation at Superfund RCRA Corrective Action and Underground Storage Tank Sites November 1997*, OSWER 9200.4-17P, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

Executive Order 12898, 1994, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, William J. Clinton, February 11.

National Environmental Policy Act of 1969, 42 USC 4321, et seq.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

WAC-173-340-900, "Tables," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

Figure 6-1. Logic Diagram for Selecting Applicable Alternatives.

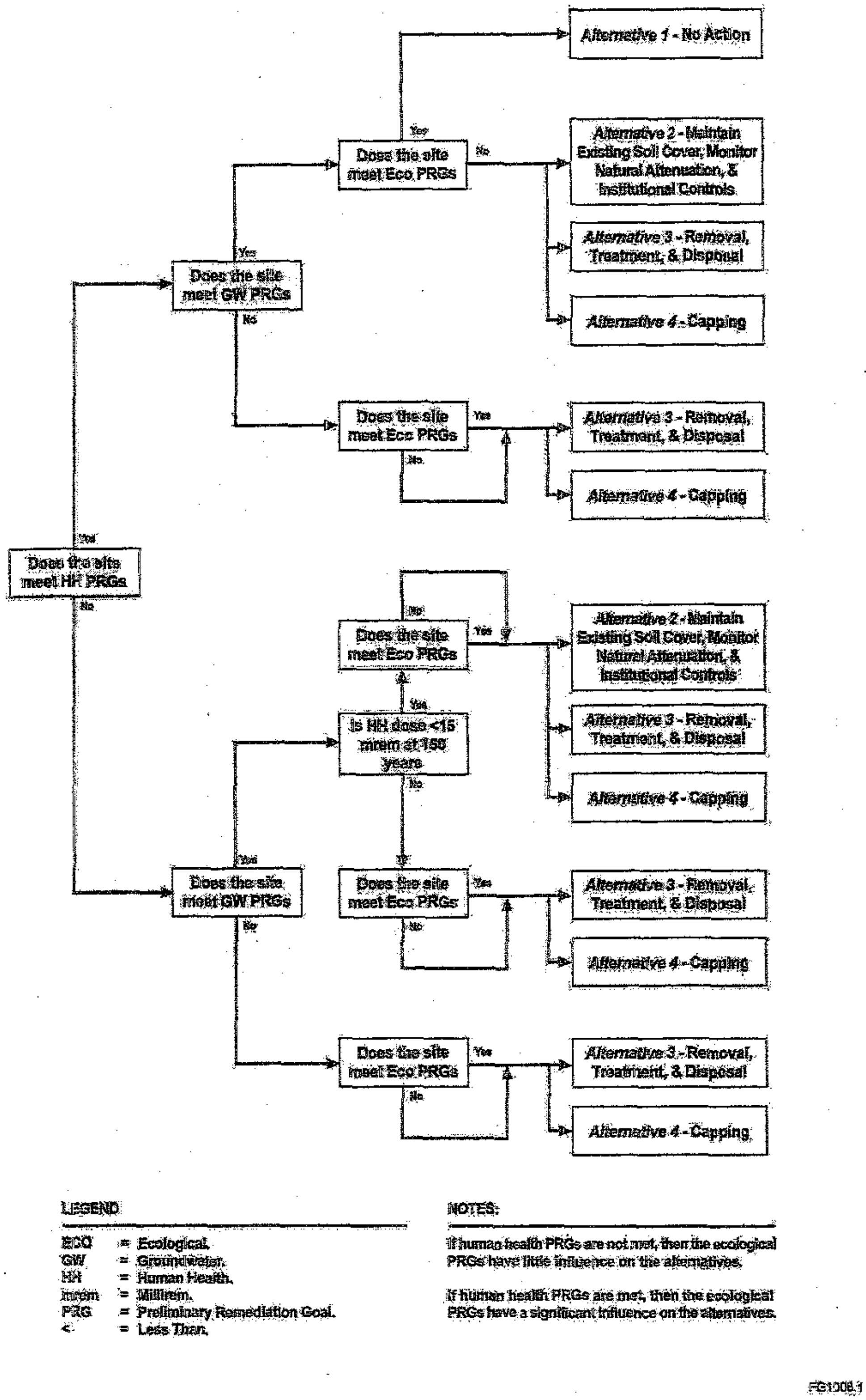

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Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (2 Pages)

Waste Site	Threshold Criteria		Balancing 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 in Thousands**
Representative Sites							
216-A-29 Ditch	Not protective, because contaminants remain above PRGs after 500 years.	Does not comply.	Groundwater is not protected. Potential risks to burrowing animals and deep-rooted plants exist.	Reduction through natural attenuation of radionuclides and Aroclor 1254.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$868,340
216-B-63 Trench	Protective. Existing contamination levels are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.	Complies.	Existing contamination levels are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.	There are no risk-based issues at this site.	Existing contamination levels are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.	Readily implementable.	N/A
216-S-10 Ditch	Not protective, because contaminants remain above PRGs .	Does not comply.	Groundwater is protected. Potential risks to burrowing animals and deep-rooted plants exist.	Reduction through natural attenuation of radionuclides and Aroclor 1254.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$876,538
216-S-10 Pond	Protective, because contaminants are below PRGs.	Complies.	Existing contamination levels are below PRGs.	Existing contamination levels are below PRGs.	Existing contamination levels are below PRGs.	Readily implementable.	N/A

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (2 Pages)

Waste Site	Threshold Criteria		Balancing 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 in Thousands**
Waste Site Analogous to 216-S-10 Pond							
216-S-11 Pond	Protective, because contaminants are below PRGs.	Complies.	Existing contamination levels are below PRGs.	Existing contamination levels are below PRGs.	Existing contamination levels are below PRGs.	Readily implementable.	N/A

ARAR = applicable or relevant and appropriate requirement.
N/A = not applicable.
PRG = preliminary remediation goal.

1

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (2 Pages)

Waste Site	Threshold Criteria		Balancing 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 in Thousands**
Representative Sites							
216-A-29 Ditch	Protective. Excavation would remove 2.7 m (9) ft of contaminants. Would eliminate direct contact with human and ecological receptors.	Complies.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, and the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides and decomposition of chemical.	Medium short-term risks to workers; ecological risks not expected because contaminants are removed.	Readily implementable.	$2,759,317
216-B-63 Trench	Analysis of the 216-B-63 Trench shows contaminants are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.	Complies.	Analysis of the 216-B-63 Trench shows contaminants are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.	Existing contamination levels are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors	Existing contamination levels are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.	Readily implementable.	N/A
216-S-10 Ditch	Protective. Excavation would remove 0.5 to 1.2 m (1.5 to 4 ft) of contaminants. Would eliminate direct contact with human and ecological receptors.	Complies.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, and the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of chemical.	Medium short-term risks to workers; ecological risks not expected because contaminants are removed.	Readily implementable.	$1,679,178
216-S-10 Pond	Protective, because contaminants are below PRGs.	Complies.	Effective, existing contamination levels are below PRGs.	Existing contamination levels are below PRGs.	Effective; existing contamination levels are below PRGs.	Readily implementable.	N/A

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (2 Pages)

Waste Site	Threshold Criteria		Balancing 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 in Thousands
Waste Site Analogous to 216-S-10 Pond							
216-S-11 Pond	Protective, because contaminants are below PRGs.	Complies.	Effective; existing contamination levels are below PRGs.	Existing contamination levels are below PRGs.	Effective; existing contamination levels are below PRGs.	Readily implementable.	N/A

ARAR = applicable or relevant and appropriate requirement.
N/A = not applicable.
PRG = preliminary remediation goal.
RAO = remedial action objective.

1

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (2 Pages)

Waste Site	**Threshold Criteria**		**Balancing 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 In Thousands**
Representative Sites							
216-A-29 Ditch	Protective. This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Cap is protective of groundwater.	Reduction through natural attenuation of radionuclides and decomposition of chemical.	Limited short-term risks to workers. No ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable.	$9,488,213
216-B-63 Trench	Protective. Analysis of the 216-B-63 Trench shows contaminants are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.	Complies with ARARs.	Analysis of the 216-B-63 Trench shows contaminants are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.	Existing contamination levels are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.	Existing contamination levels are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors.	Readily implementable.	N/A
216-S-10 Ditch	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective barrier to reach ecological PRGs.	Reduction through natural attenuation of chemical.	Limited short-term risks to workers. No ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable.	$3,573,574
216-S-10 Pond	Protective because contaminants are below PRGs.	Complies.	Effective; existing contamination levels are below PRGs.	Existing contamination levels are below PRGs.	Effective; existing contamination levels are below PRGs.	Readily implementable.	N/A

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (2 Pages)

Waste Site	Threshold Criteria		Balancing 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 In Thousands**
Waste Site Analogous to 216-S-10 Pond							
216-S-11 Pond	Protective, because contaminants are below PRGs.	Complies.	Effective; existing contamination levels are below PRGs.	Existing contamination levels are below PRGs.	Effective; existing contamination levels are below PRGs.	Readily implementable.	N/A

ARAR = applicable or relevant and appropriate requirement.
N/A = not applicable.
PRG = preliminary remediation goal.

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CHAPTER 7.0 TERMS

95%UCL	95th upper confidence level
ARAR	applicable or relevant and appropriate requirement
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
ERDF	Environmental Restoration Disposal Facility
PRG	preliminary remediation goal

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7.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This chapter presents the comparative analysis of the four remedial alternatives for the 200-CS-1 Operable Unit waste sites to identify their relative advantages and disadvantages. This comparison is based on the seven *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) evaluation criteria discussed in Chapter 6.0. The results of this analysis provide a basis for selecting a remedial alternative for each representative waste site and associated analogous waste site. These remedial alternatives are as follows:

- Alternative 1 – No Action
- Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls
- Alternative 3 – Removal, Treatment, and Disposal
- Alternative 4 – Capping.

7.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 1 would provide overall protection of human health and the environment at the 216-B-63 Trench because contaminants are within the 95th upper confidence level (95%UCL) for direct human contact, groundwater protection, or ecological receptors. Alternative 1 is also applicable at the 216-S-10 Pond and its analogous site because contaminants are below the preliminary remediation goals (PRG). Alternative 1 would fail to provide overall protection of human health and the environment at the 216-A-29 Ditch and 216-S-10 Ditch because contaminants at concentrations above the PRGs would remain on site with no actions to restrict intrusion.

Alternative 2 would provide overall protection of human health and the environment for the 216-B-63 Trench because contaminants are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors and at the 216-S-10 Pond and its analogous site. These sites have no contaminants of concern (COC) above PRGs. As such, this alternative is not applicable to these sites. Alternative 2 would not provide overall protection of human health at the 216-A-29 Ditch and the 216-S-10 Ditch if no credit is taken for existing soil covers. With the existing soil cover, this alternative is protective of human health. The 216-A-29 Ditch and 216-S-10 Ditch exceed ecological exposure. As such, these sites fail to protect the environment under this alternative.

Alternative 3 is considered protective of long-term human health and the environment, because contaminants are removed below PRGs. This alternative is applicable at the 216-A-29 Ditch and 216-S-10 Ditch. COCs are located within the shallow zone (0 to 4.6 m [0 to 15 ft]) and can be removed with conventional construction equipment. The COCs represent a minor worker risk. Furthermore, the COCs meet ERDF waste acceptance criteria and there is available disposal space. There are no risks at the 216-B-63-Trench, 216-S-10 Pond, and its analogous site. Therefore, this alternative is not applicable for these sites.

Alternative 4 is considered protective of human health and the environment, because it would break potential exposure pathways to receptors through placement of a surface barrier and implementation of institutional controls. The barrier also would provide ecological protection by providing at least 4.6 m (15 ft) of clean overburden above the waste. Barriers would be designed commensurate with site contaminant conditions, and institutional controls would be used at capped sites to augment protectiveness. The sites would incorporate monitoring and inspections of barrier performance.

7.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Alternative 1 complies with applicable or relevant and appropriate requirements (ARAR) for the 216-B-63 Trench because contaminants are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors. The 216-S-10 Pond and its analogous site meet the criteria for the no-action alternative, because contaminant levels are below PRGs. For the 216-A-29 Ditch and 216-S-10 Ditch, Alternative 1 does not comply with ARARs.

Alternative 2 generally does not comply with ARARs at the 216-A-29 Ditch and 216-S-10 Ditch because it is not protective of the environment. However, for reasons stated above, the 216-B-63 Trench does comply with ARARs. This alternative does comply with all ARARs for the 216-S-10 Pond and its analogous site because the contamination levels are below PRGs.

Alternative 3 complies with ARARs because it removes contamination to the PRGs. Worker protection ARARs will not be exceeded.

Alternative 4 complies with ARARs by breaking exposure pathways.

7.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternative 1 is effective in the long term for the 216-B-63 Trench site because contaminants are within the 95%UCL for direct human contact, groundwater protection, or ecological receptors. In addition, Alternative 1 is effective in the long term for the 216-S-10 Pond and its analogous site because they have no contamination above PRGs. Alternative 1 is not effective in the long term for the 216-A-29 Ditch and 216-S-10 Ditch waste sites because contamination would be left in place above PRGs.

Alternative 2 would be an effective and permanent remedial action in the long term for the 216-B-63 Trench, 216-S-10 Pond, and the analogous site. However, this alternative is not effective for the 216-A-29 Ditch and the 216-S-10 Ditch. Mobile contaminants at the 216-A-29 Ditch would adversely affect the groundwater. Also, heavy metal contaminants and polychlorinated biphenyls at the 216-A-29 and 216-S-10 Ditches would adversely affect the environment.

Alternative 3 would provide a high degree of effectiveness in the long term. With Alternative 3, contaminant concentrations above the PRGs would be removed. The removed contaminated material would be disposed of at the Environmental Restoration Disposal Facility (ERDF) or at a commercially permitted facility.

Alternative 4 also provides a high degree of overall effectiveness in the long term for a majority of the sites, because it addresses the potential pathways, groundwater, and biota. Several studies at the Hanford Site have shown that contaminant transport through the vadose zone is linked to the rate that water moves through the vadose zone or the recharge rate. PNNL-14744, *Recharge Data Package for the 2005 Integrated Disposal Facility Performance Assessment*, indicates recharge rates can vary from nearly zero in silt loam soil covered in sagebrush to more than 100 mm/yr (3.94 in/yr) in gravel-covered soil without vegetation. As shown in Appendix A, some of the sites currently are gravel covered to sparsely covered with vegetation. As such, the current recharge rate at these sites is expected to be closer to 100 mm/yr (3.94 in/yr).

Alternative 4 would be protective by breaking the exposure pathways and reducing the infiltration through the vadose zone. Long-term effectiveness depends on the design and maintenance of the cap and associated monitoring (e.g., cap performance, natural attenuation). For those waste sites where deeper contamination is identified as exceeding groundwater protection criteria, Alternative 4 would require additional monitoring (e.g., groundwater protection); therefore, long-term restrictions would apply.

7.4 REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

The alternatives do not include treatment and, therefore, do not reduce toxicity, mobility, or volume of the contaminants through treatment. All the alternatives incorporate natural attenuation in the form of radiological decay and or chemical decomposition, which ultimately results in reduced toxicity and volume.

7.5 SHORT-TERM EFFECTIVENESS

Alternative 1 would be effective in the short term at the 216-B-63 Trench and 216-S-10 Pond and its analogous site because it does not involve any remedial actions. However, at the 216-A-29 Ditch and 216-S-10 Ditch sites, contaminants are in the biological active zone (active rooting zone and burrowing animal zone), and biota could be exposed to unacceptable concentrations.

Alternatives 2 and 4 would be more effective in the short term than Alternative 3 predominantly because potential exposure to contaminated soil and fugitive dust would be greater in the short term. Alternative 3 would generate contaminated soil and debris, which would create a potential for short-term worker impacts during excavation and transportation of the excavated materials.

Worker risks for Alternative 3 are considered minimal due to the low concentrations of COCs at the 216-A-29 and 216-S-10 Ditch sites. There are no risk-related issues at the other sites.

7.6 IMPLEMENTABILITY

Alternative 1 would be easily implemented because no action is performed.

Alternative 2 is currently in use for all of the waste sites. The waste sites are in a surveillance and monitoring program and are posted with signs and/or the area is fenced. Access to the waste sites also is controlled through Hanford Site access requirements, an excavation permit program, and a radiation work permit program. The addition of monitoring wells or boreholes is easily implementable.

Alternative 3 is implementable for sites with COCs above the PRGs. However, this alternative is judged slightly more difficult than Alternative 4 because of the safety requirements associated with the excavation, transportation, and disposal of contaminated soil and debris. Alternative 3 would involve excavation and segregation of solid waste, if found. Disposal of all the contaminated soils at the ERDF would require approximately 4,333.8 m^3 (5,664 yd^3) of space, which is available at the ERDF.

Alternative 4 is implementable. A barrier has been implemented at the Hanford Site; other types of barriers have been approved and implemented at other western arid sites and are straightforward to construct and maintain. Facilities and infrastructure near waste sites could influence the implementability of a surface barrier option at a particular site.

7.7 COST

The cost to implement the alternatives is presented in Chapter 6.0, Chapter 8.0, and Appendix D. The following comparisons are generic in nature only to compare the relative costs of the alternatives. Specific cost comparisons are in Chapter 6.0; Chapter 8.0, Tables 8-1 through 8-4; and Appendix D.

Alternative 1 has no cost associated with it and has no additional benefit to human health and the environment over current risks. Alternative 2 generally does not protect human health and the environment; however, Alternative 2 would have the lowest present-worth cost because it is minimally invasive and does not include labor-intensive activities. Alternative 3 is cost effective for this operable unit because the depth of excavation is relatively shallow (less than 3 m [10 ft] below ground surface). Alternative 4 is more expensive than Alternative 3 because of the small size of the barriers and additional fill material needed to contour the sites in comparison to the shallow nature of the contamination.

7.8 REFERENCES

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.

PNNL-14744, 2004, *Recharge Data Package for the 2005 Integrated Disposal Facility Performance Assessment*, Pacific Northwest National Laboratory, Richland, Washington.

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CHAPTER 8.0 TERMS

ARAR	applicable or relevant and appropriate requirement
FS	feasibility study
IC	institutional control
MESC	maintain existing soil cover
MNA	monitored natural attenuation
OU	operable unit
PRG	preliminary remediation goal
RAO	remedial action objective
ROD	record of decision
RTD	removal, treatment, and disposal
TMV	toxicity, mobility, or volume through treatment
TSD	treatment, storage, and/or disposal (unit)
WAC	*Washington Administrative Code*

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8.0 CONCLUSIONS AND PATH FORWARD

This chapter summarizes the results of the feasibility study (FS) and presents the path forward for the 200-CS-1 Operable Unit (OU) waste sites. This chapter also identifies the preferred alternatives for remediation of the waste sites.

8.1 FEASIBILITY STUDY SUMMARY

Four remedial alternatives were evaluated for the 200-CS-1 OU waste sites. These alternatives are as follows:

- Alternative 1 – No Action
- Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls
- Alternative 3 – Removal, Treatment, and Disposal
- Alternative 4 – Capping.

The alternatives were evaluated against the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) criteria, and then they were evaluated against each other using the CERCLA criteria. Tables 8-1 through 8-5 show the preferred remediation alternative for each representative site and associated analogous waste sites in the 200-CS-1 OU. These tables also provide summary justification for the preferred alternative selection based on the detailed and comparative analyses presented in Chapters 6.0 and 7.0 of this FS.

8.1.1 216-A-29 Ditch Site

The 216-A-29 Ditch exceeds ecological preliminary remediation goals (PRG) in the upper part of the ditch. The preferred alternative for this site is Alternative 3 – Removal, Treatment, and Disposal, because this alternative is protective of human health, the environment, and workers; is easily implementable; and is cost-effective. Table 8-1 provides a summary of the analysis of alternatives supporting the selection of the preferred alternative for this waste site.

8.1.2 216-B-63 Trench Site

Based on existing data at the 216-B-63 Trench, contaminants are within the 95th upper confidence level for direct human contact, groundwater protection, or ecological receptors. As such, the preferred alternative is the no-action alternative. Table 8-2 provides a summary of the analysis of alternatives supporting the selection of the preferred alternative for this waste site.

8.1.3 216-S-10 Ditch Site

The 216-S-10 Ditch exceeds the ecological PRGs in a portion of the ditch. Groundwater protection is not required. The preferred alternative for this site is Alternative 3 – Removal, Treatment, and Disposal, because this alternative is protective of the environment and workers, is easily implementable, and is cost-effective. Table 8-3 provides a summary of the analysis of alternatives supporting the selection of the preferred alternative for this waste site.

8.1.4 216-S-10 Pond and its Analogous Waste Site

Based on existing data at the 216-S-10 Pond, no PRGs are exceeded at this waste site or its analogous site (216-S-11 Pond). As such, the preferred alternative is the no-action alternative with confirmatory sampling. Confirmatory sampling would be performed at the 216-S-11 Pond. A data quality objectives document would guide sample selection and location. Tables 8-4 and 8-5 provide a summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites.

8.2 PATH FORWARD

A proposed plan is being prepared to document the preferred alternatives for the 200-CS-1 OU (DOE/RL-2005-64, *Proposed Plan for the 200-CS-1 Chemical Sewer Group Operable Units).* The proposed plan details the closure options, and it documents which waste sites will be remediated in accordance with the record of decision (ROD), developed following issuance of the proposed plan.

Four waste sites in the 200-CS-1 OU were evaluated in this FS, based on data reported in DOE/RL-2004-17, *Remedial Investigation Report for the 200-CS-1 Operable Unit.* DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, Section 2.5, defines this strategy as a means to streamline remedial investigations and focus the CERCLA process to obtain a decision. As identified in DOE/RL-98-28 Section , additional sampling phases conducted post-ROD are meant to augment the remedial investigation data, confirm the alternative selection, support the design, and provide information for final site closeout, as well as clean closure of the treatment, storage, and/or disposal (TSD) unit soils as described in Appendix E. Confirmatory sampling is conducted to confirm that the representative site model used to evaluate the analogous site is appropriate to the site conditions and to confirm that the appropriate remedial alternative was selected. Design sampling is conducted to obtain data necessary to design the remedial alternative and refine the cost estimated for the FS. Verification sampling is conducted to verify that the remedial goals have been met by the implementation of the remedial alternative.

Table 8-6 presents the confirmatory, design, and verification sampling phases for each site. This table illustrates the assumed data needs for each sampling phase for the representative sites and for analogous sites that are similar (or equal) to the representative sites (see Chapter 2.0 for additional details). This table builds off the decision logic presented in Figure 2-12 and Table 2-2 and provides a basis for initiating the data quality objectives process for the confirmatory sampling and design sampling phases.

Post-ROD sampling will be determined through data quality objectives identification and a sampling and analysis plan that will be developed to direct the sampling needed at the analogous sites. This sampling will be used to confirm that the correct alternative has been selected and to provide design data through a "plug-in" approach, as defined in the following sections.

Sites slated for no action will need verification sampling, depending on the amount, type, and quality of data available to support the no-action decision. CERCLA operations and maintenance sampling could include the monitoring of natural attenuation and performance monitoring of the cap.

8.2.1 Plug-in Approach of the 200-CS-1 Operable Unit Waste Sites

The plug-in approach is a process that helps make remedial action decisions for additional waste sites using existing CERCLA evaluations. In the future, the plug-in approach is proposed for any similar waste sites already defined within the 200-CS-1 OU and for newly discovered waste sites that have a similar conceptual site model to waste sites already addressed in this FS. The plug-in approach will be used on the analogous sites considered in this FS after additional data are collected in the confirmatory and design sampling phases.

The plug-in approach benefits the goal of remediating waste sites within the OUs in conjunction with the analogous site approach. The traditional CERCLA approach for remedy selection would require the development of multiple proposed plans and RODs that, for similar sites, would be nearly identical to the FSs, proposed plans, and RODs already developed and proven to be successful. The plug-in approach allows remedial actions to begin much more quickly at a waste site, without the need for redundant remedy selection processes.

The plug-in approach requires three main elements to establish its use as a cost-effective tool for remediation.

- First, multiple sites must be identified that share common physical and contaminant characteristics. These characteristics are referred to as the conceptual site model.
- Second, a remedial alternative, or standard remedy, must be established that has been shown to be protective and cost-effective for sites that share the common conceptual site model.
- Finally, sites sharing a common conceptual site model must be shown to require remedial action due to contaminant concentrations that pose risk to human health and the environment.

To use the plug-in approach for a waste site not evaluated in the FS, the site must fit the defined conceptual model and must be shown to require remedial action. The site then can be "plugged in" to the standard remedy. The following information describes how the plug-in approach is proposed for remedy selection.

8.2.1.1 Establishing the Conceptual Site Model

Four conceptual site models have been defined based on the site characteristics contained in the FS. These characteristics include the following:

- Type of contaminant inventory
- Concentrations of contaminants in environmental media
- Function of the waste site
- Types of contaminated environmental media (soil) or material (e.g., concrete, metal, wood)
- Extent of contamination within the environment (i.e., the depth of discharge, the expected contaminant distributions, and the potential for hydrologic and contaminant impacts to groundwater).

Based on the representative sites evaluated in the FS, the following three conceptual site models were developed:

- Waste sites where no hazardous material was disposed at the waste site or where contaminants disposed of currently meet the remedial action objectives (RAO).
- Waste sites where limited contamination exists at the waste sites, an existing soil cover is in place and of sufficient thickness to provide protection, contaminants are expected to meet the RAOs during the institutional control period (such as within 150 years), and groundwater PRGs are not exceeded. Contaminated environmental media include soil, solid waste, debris, and materials associated with the waste sites, such as timbers and pipes.
- Waste sites where contaminants exceed the RAOs and contamination is shallow, low-volume, and can be cost effectively remedied through removal, treatment, and disposal. Typically, these contaminants exceed the human health and ecological PRGs; however, groundwater PRGs are not exceeded at depths that make excavation impracticable. Contaminated environmental media include soil, solid waste, debris, and materials associated with the waste sites, such as timbers and vent pipes.

8.2.1.2 Establishment of the Standard Remedy

The standard remedies, based on the 200-CS-1 OU waste sites, have been defined on the basis of the conceptual models presented by the representative waste sites, as well as the alternative evaluations conducted for all waste sites. As such, three standard remedies are identified for potential plug-in sites. These remedies are highlighted below along with their required characteristics.

- **Alternative 1: No Action** has been defined as a standard remedy for waste sites whose conceptual site model indicates that no hazardous materials were disposed of at the waste site or that contaminants disposed of currently meet the RAOs.

- **Alternative 2: Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls** has been defined as the standard remedy for waste sites whose conceptual site model indicates that limited contamination exists at the waste sites, an existing soil cover is in place and of sufficient thickness to provide protection, contaminants are expected to meet the RAOs during the institutional control period (such as within 500 years), and groundwater PRGs are not exceeded. Contaminated environmental media are similar to the media at the waste sites included in this FS. These media include soil, solid waste, debris, and materials associated with the waste sites, such as timbers and pipes.

- **Alternative 3: Removal, Treatment, and Disposal** has been defined as the standard remedy for waste sites whose conceptual site model indicates that contaminants exceed the RAOs and that contamination is shallow, low-volume, and can be cost effectively remedied through the removal, treatment, and disposal of contaminated media. Typically, these contaminants exceed the human health and ecological PRGs. Contaminated environmental media are similar to the media at the waste sites included in this FS. These media include soil, solid waste, debris, and materials associated with the waste sites, such as timbers and pipes.

8.2.1.3 Establishing the Need for Remedial Action

Waste sites that share a common conceptual site model will "plug-in" to the standard remedy if they are determined to require remedial action due to a risk to human health and the environment (based on the defined RAOs and associated PRGs, as defined previously). Some of the waste sites in the 200-CS-1 OU likely will require confirmatory sampling to validate the conceptual site model and the identified preferred remedy. The preferred remedy will be implemented following confirmation of the conceptual site model. Should the confirmatory sampling indicate variations in the defined conceptual site model, this plug-in approach will be used to define the appropriate remedy.

8.3 CLOSURE OF RCRA TREATMENT, STORAGE, AND/OR DISPOSAL UNITS

The RCRA TSD units within the 200-CS-1 OU include the 216-A-29 Ditch, the 216-B-63 Trench, and the 216-S-10 Pond and Ditch (two waste sites are combined into one TSD unit). These TSD units will undergo closure following the requirements of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) (Tri-Party Agreement); WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit,* ; and *Washington Administrative Code* (WAC) 173-303-610, "Dangerous Waste Regulations," "Closure and Post-Closure." Characterization sampling of these TSD units occurred, during the remedial investigation, in conjunction with the CERCLA remedial action for the 200-CS-1 OU.

Tri-Party Agreement Milestone M-20-39 requires submittal of the 216-S-10 Pond and Ditch closure plan by March 31, 2006. Closure plans for the 216-B-63 Trench and the 216-A-29 Ditch were originally submitted in 1995 in accordance with Tri-Party Agreement Milestone M-20-36. The two 1995 closure plans are being superseded with the March 2006 submittal. The closure plans for 216-B-63 Trench and 216-S-10 Pond and Ditch TSD units will be submitted separately because soils and structures can be clean closed as is without any need to coordinate remedial activities with the 200-CS-1 OU. The closure plan for the 216-A-29 Ditch is contained in Appendix E of this FS because closure is dependent on 200-CS-1 OU remedial activities. Public review and approval of the 216-A-29 Ditch closure plan is anticipated to occur concurrently with the review of the Feasibility Study. Public review and approval for the 216-B-63 Trench and 216-S-10 Pond and Ditch closure plans can occur separately from the Feasibility Study or can also occur concurrently, if appropriate. The Hanford Facility RCRA Permit modification process will be determined based on the timing of the public review and approval process with when the TSD units will be incorporated into the Hanford Facility RCRA Permit. RCRA/CERCLA integration of closure plan activities with the 200-CS-1 OU remedial actions is only needed for the 216-A-29 Ditch closure plan.

The proposed closure strategy for each of these TSD units is as follows:

- **216-A-29 Ditch.** Based on analytical data obtained during the remedial investigation and review of Hanford Environmental Information System (HEIS) data, all elements of this unit (soil and groundwater) are expected to qualify for clean closure in accordance with WAC 173-303-610(2) after remediation of the soils. A plan for clean closure of this unit is provided in Appendix E. A RCRA final status groundwater monitoring plan will not be required for this unit.

- **216-B-63 Trench.** Based on analytical data obtained during the remedial investigation and review of HEIS data, all elements of this unit (soils, structures, and groundwater) qualify for clean closure in accordance with WAC 173-303-610(2) without further physical closure activities. A plan for clean closure of this unit is provided in DOE/RL-2006-11, *Hanford Facility Dangerous Waste Closure Plan for 216-B-63 Trench.* A RCRA final status groundwater monitoring plan will not be required for this unit.

- **216-S-10 Pond and Ditch.** Based on analytical data obtained during the remedial investigation, this soils for this unit qualify for clean closure in accordance with WAC 173-303-610(2) without further physical closure activities. Based on review of HEIS data, the groundwater associated with this TSD unit does not meet the clean closure levels and will require post closure monitoring. A plan for clean closure of the soils associated with this unit is provided in DOE/RL-2006-12, *Hanford Facility Dangerous Waste Closure/Postclosure Plan for* provided in DOE/RL-2006-12, *Hanford Facility Dangerous Waste Closure/Postclosure Plan for the 216-S-10 Pond and Ditch*. A RCRA final status groundwater-monitoring plan has been prepared separately from the closure plan.

8.4 PUBLIC INVOLVEMENT IN THE PLUG-IN APPROACH

To ensure that the public is involved in the application of the plug-in approach, the U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology will publish explanations of significant differences at the following points in the plug-in process:

- When newly discovered waste sites are proven through analysis to be above remediation goals and can plug in to the standard remedy
- When confirmatory sampling identified for the waste sites discussed herein indicates variations in the defined conceptual site model such that the preferred remedy is no longer protective.

8.5 REFERENCES

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.

DOE/RL-98-28, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2004-17, 2004, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2006-11, 2006, *Hanford Facility Dangerous Waste Closure Plan for 216-B-63 Trench*, Decisional Draft, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2006-12, 2006, *Hanford Facility Dangerous Waste Closure/Postclosure Plan for the 216-S-10 Pond and Ditch*, Decisional Draft, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

WA7890008967, 2004, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8, for the Treatment, Storage, and Disposal of Dangerous Waste*, Washington State Department of Ecology, Richland, Washington, as amended.

WAC 173-303-610, "Dangerous Waste Regulations," "Closure and Post-Closure," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

Table 8-1. Preferred Alternative for the Representative Site 216-A-29 Ditch.

Comparison of Alternatives - Representative Site 216-A-29 Ditch				
Criteria for Representative and Analogous Waste Sites	**Alternatives**			
	① No Action	**② MESC, MNA, IC**	**③ RTD**	**④ Capping**
Representative Site 216-A-29 Ditch			☒	
Threshold Criteria				
Overall protection	☐	☐	☑	☑
Compliance with ARARs	☐	☐	☑	☑
Balancing Criteria				
Long-term effectiveness	◇	◇	◆	◈
Reduction in TMV	◇	◇	◇	◇
Short-term effectiveness	◇	◇	◈	◆
Implementability	◇	◇	◆	◈
Cost (in thousands)				
Capital costs	$0	$35,400	$2,759,317	$3,587,527
Non-discounted costs	$0	$4,031,232		$25,954,293
Total present worth	$0	$868,340	$2,759,317	$9,488,213

NOTE: The choice of the preferred alternative is based on information at the writing of this feasibility study. The preferred alternative may be revised based on future characterization efforts at the analogous sites.

☒ = Indicates the preferred alternative (see Note).
☑ = Yes, meets criterion.
☐ = No, does not meet criterion.
◆ = High: best satisfies evaluation guidelines.
◈ = Moderate: satisfies evaluation guidelines.
◇ = Low: least satisfies evaluation guidelines.

ARAR = applicable or relevant and appropriate requirement.
IC = institutional controls.
MESC = maintain existing soil cover.
MNA = monitored natural attenuation.
RTD = removal, treatment, and disposal.

Table 8-2. Preferred Alternative for the Representative Site 216-B-63 Trench.

Comparison of Alternatives - Representative Site 216-B 63 Trench				
Criteria for Representative and Analogous Waste Sites	**Alternatives**			
	➊ No Action	**➋ MESC, MNA, IC**	**➌ RTD**	**➍ Capping**
Representative Site 216-B-63 Trench	**☑**			
Threshold Criteria				
Overall protection	☑	N/A	N/A	N/A
Compliance with ARARs	☑	N/A	N/A	N/A
Balancing Criteria				
Long-term effectiveness	◆	N/A	N/A	N/A
Reduction in TMV	◆	N/A	N/A	N/A
Short-term effectiveness	◆	N/A	N/A	N/A
Implementability	◆	N/A	N/A	N/A
Cost (in thousands)				
Capital costs	N/A	N/A	N/A	N/A
Non-discounted costs	N/A	N/A	N/A	N/A
Total present worth	N/A	N/A	N/A	N/A

NOTE: The choice of the preferred alternative is based on information at the writing of this feasibility study. The preferred alternative may be revised based on future characterization efforts at the analogous sites.

☑ = Indicates the preferred alternative (see Note).
☑ = Yes, meets criterion.
☐ = No, does not meet criterion.
◆ = High: best satisfies evaluation guidelines.
◈ = Moderate: satisfies evaluation guidelines.
◇ = Low: least satisfies evaluation guidelines.

ARAR = applicable or relevant and appropriate requirement.
IC = institutional controls.
MESC = maintain existing soil cover.
MNA = monitored natural attenuation.
N/A = not applicable.
RTD = removal, treatment, and disposal.

Table 8-3. Preferred Alternative for the Representative Site 216-S-10 Ditch.

Comparison of Alternatives - Representative Site 216-S-10 Ditch				
Criteria for Representative and Analogous Waste Sites	**Alternatives**			
	① No Action	**② MESC, MNA, IC**	**③ RTD**	**④ Capping**
Representative Site 216-S-10 Ditch			☒	
Threshold Criteria				
Overall protection	☐	☐	☑	☑
Compliance with ARARs	☐	☐	☑	☑
Balancing Criteria				
Long-term effectiveness	◇	◇	◆	◈
Reduction in TMV	◇	◇	◈	◇
Short-term effectiveness	◇	◇	◆	◈
Implementability	◇	◇	◈	◈
Cost (in thousands)				
Capital costs	$0	$35,400	$1,679,178	$1,647,518
Non-discounted costs	$0	$4,077,514		$8,456,185
Total present worth	$0	$876,538	$1,679,178	$3,573,574

NOTE: The choice of the preferred alternative is based on information at the writing of this feasibility study. The preferred alternative may be revised based on future characterization efforts at the analogous sites.

☒ = Indicates the preferred alternative (see Note).
☑ = Yes, meets criterion.
☐ = No, does not meet criterion.
◆ = High: best satisfies evaluation guidelines.
◈ = Moderate: satisfies evaluation guidelines.
◇ = Low: least satisfies evaluation guidelines.

ARAR = applicable or relevant and appropriate requirement.
IC = institutional controls.
MESC = maintain existing soil cover.
MNA = monitored natural attenuation.
RTD = removal, treatment, and disposal.

Table 8-4. Preferred Alternative for the Representative Site 216-10-Pond and Analogous Waste Sites.

Comparison of Alternatives - Representative Site 216-S-10 Pond				
Criteria for Representative and Analogous Waste Sites	**Alternatives**			
	❶ No Action	**❷ MESC, MNA, IC**	**❸ RTD**	**❹ Capping**
Representative Site 216-S-10-Pond	☒			
Threshold Criteria				
Overall protection	☑	N/A	N/A	N/A
Compliance with ARARs	☑	N/A	N/A	N/A
Balancing Criteria				
Long-term effectiveness	◆	N/A	N/A	N/A
Reduction in TMV	◆	N/A	N/A	N/A
Short-term effectiveness	◆	N/A	N/A	N/A
Implementability	◆	N/A	N/A	N/A
Cost (in thousands)				
Capital costs	N/A	N/A	N/A	N/A
Non-discounted costs	N/A	N/A	N/A	N/A
Total present worth	N/A	N/A	N/A	N/A

NOTE: The choice of the preferred alternative is based on information at the writing of this feasibility study. The preferred alternative may be revised based on future characterization efforts at the analogous sites.

☒ = Indicates the preferred alternative (see Note).
☑ = Yes, meets criterion.
☐ = No, does not meet criterion.
◆ = High: best satisfies evaluation guidelines.
◈ = Moderate: satisfies evaluation guidelines.
◇ = Low: least satisfies evaluation guidelines.

ARAR = applicable or relevant and appropriate requirement.
IC = institutional controls.
MESC = maintain existing soil cover.
MNA = monitored natural attenuation.
N/A = not applicable.
RTD = removal, treatment, and disposal.

Table 8-5. Preferred Alternative for the Representative Site 216-11 Pond.

Comparison of Alternatives - Representative Site 216-S-11 Pond				
Criteria for Representative and Analogous Waste Sites	Alternatives			
	① No Action	② MESC, MNA, IC	③ RTD	④ Capping
Representative Site 216-S-11 Pond	☑			
Threshold Criteria				
Overall protection	☑	N/A	N/A	N/A
Compliance with ARARs	☑	N/A	N/A	N/A
Balancing Criteria				
Long-term effectiveness	◆	N/A	N/A	N/A
Reduction in TMV	◆	N/A	N/A	N/A
Short-term effectiveness	◆	N/A	N/A	N/A
Implementability	◆	N/A	N/A	N/A
Cost (in thousands)				
Capital costs	N/A	N/A	N/A	N/A
Non-discounted costs	N/A	N/A	N/A	N/A
Total present worth	N/A	N/A	N/A	N/A

NOTE: The choice of the preferred alternative is based on information at the writing of this feasibility study. The preferred alternative may be revised based on future characterization efforts at the analogous sites.

☑ = Indicates the preferred alternative (see Note).
☑ = Yes, meets criterion.
☐ = No, does not meet criterion.
◆ = High: best satisfies evaluation guidelines.
◈ = Moderate: satisfies evaluation guidelines.
◇ = Low: least satisfies evaluation guidelines.

ARAR = applicable or relevant and appropriate requirement.
IC = institutional controls.
MESC = maintain existing soil cover.
MNA = monitored natural attenuation.
N/A = not applicable.
RTD = removal, treatment, and disposal.

Table 8-6. Post-Record of Decision Sampling.

Alternative	Confirmatory Sampling						Design Sampling	Verification Sampling		
	Confirm Appropriate Remedial Action	Nature of Contamination	Extent of Contamination	Groundwater Protection	Ecological Sampling	Observational Approach	Extent of Contamination	Verify No-Action Alternative	Ecological Sampling	Verify PRG Attainment
Alternative 1 – No Action										
216-B-63 Trench										
216-S-10 Pond										
216-S-11 Pond								●		
Alternative 3 – Removal, Treatment, and Disposal										
216-A-29 Ditch						●	●			●
216-S-10 Ditch						●	●			●

PRG = preliminary remediation goal.
● = proposed post-record of decision sampling.

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APPENDIX A

WASTE SITE PHOTOS

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FIGURES

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Figure A-1. 216-A-29 Ditch.

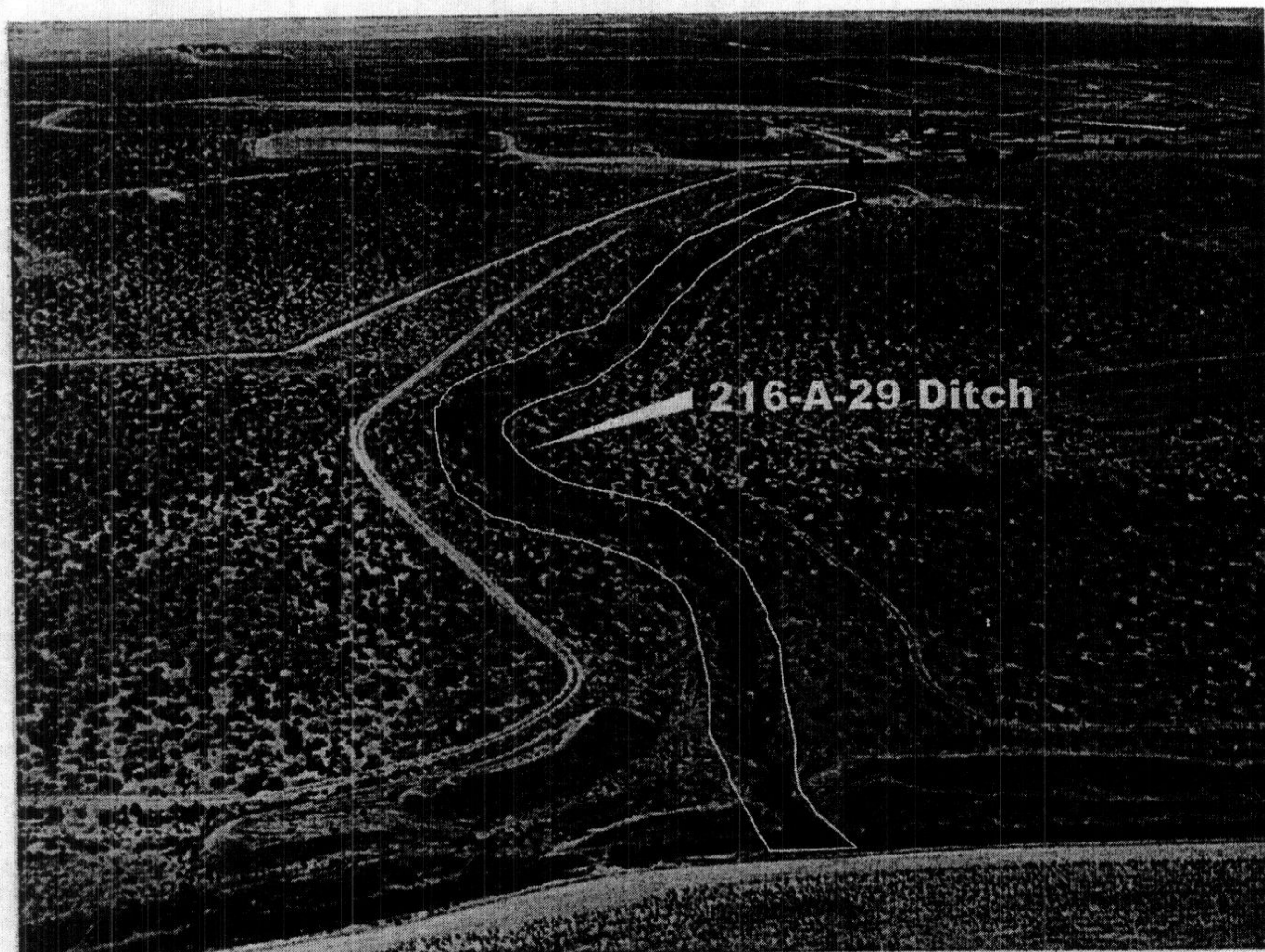


Figure A-2. 216-B-63 Trench.

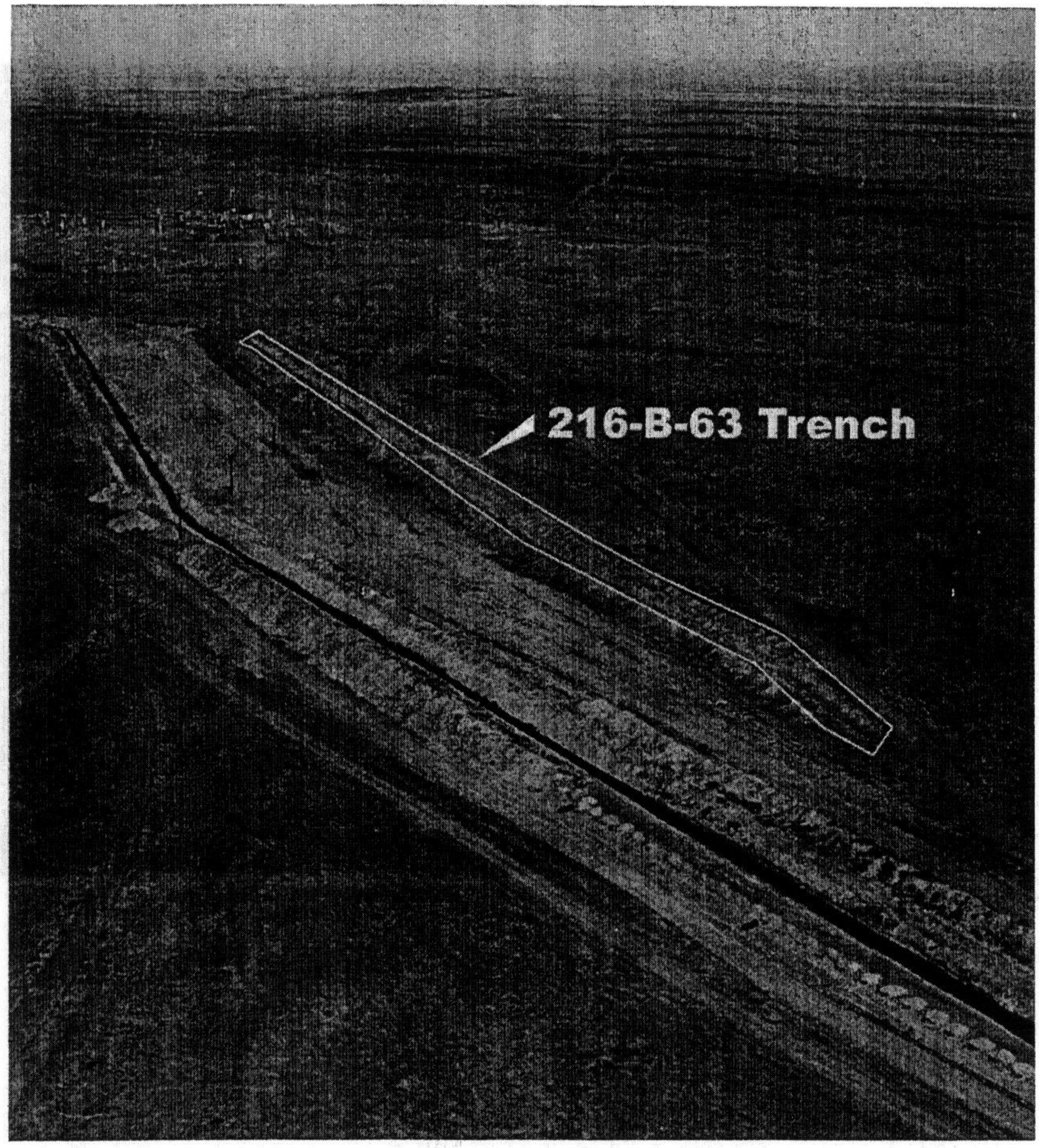


Figure A-3. 216-S-10 Ditch and 216-S-10 Pond.

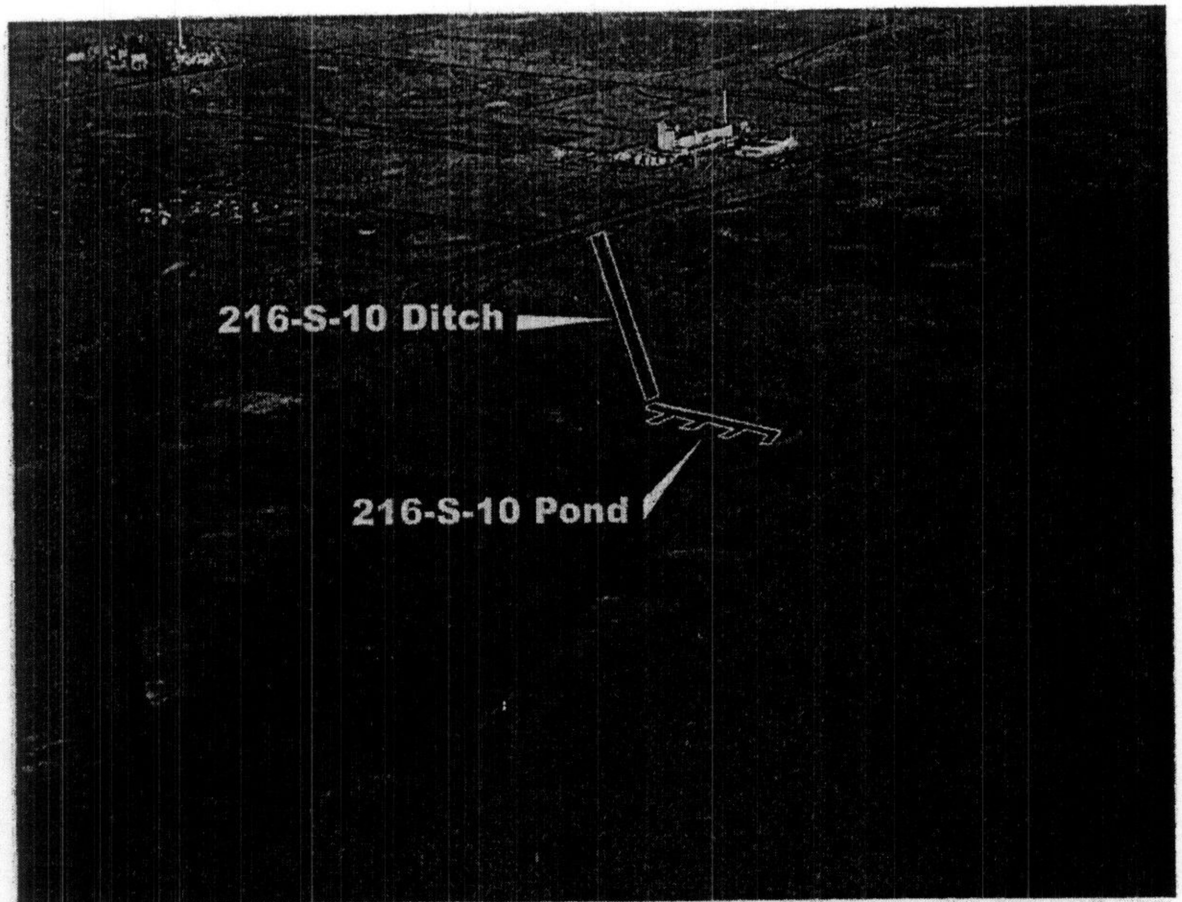
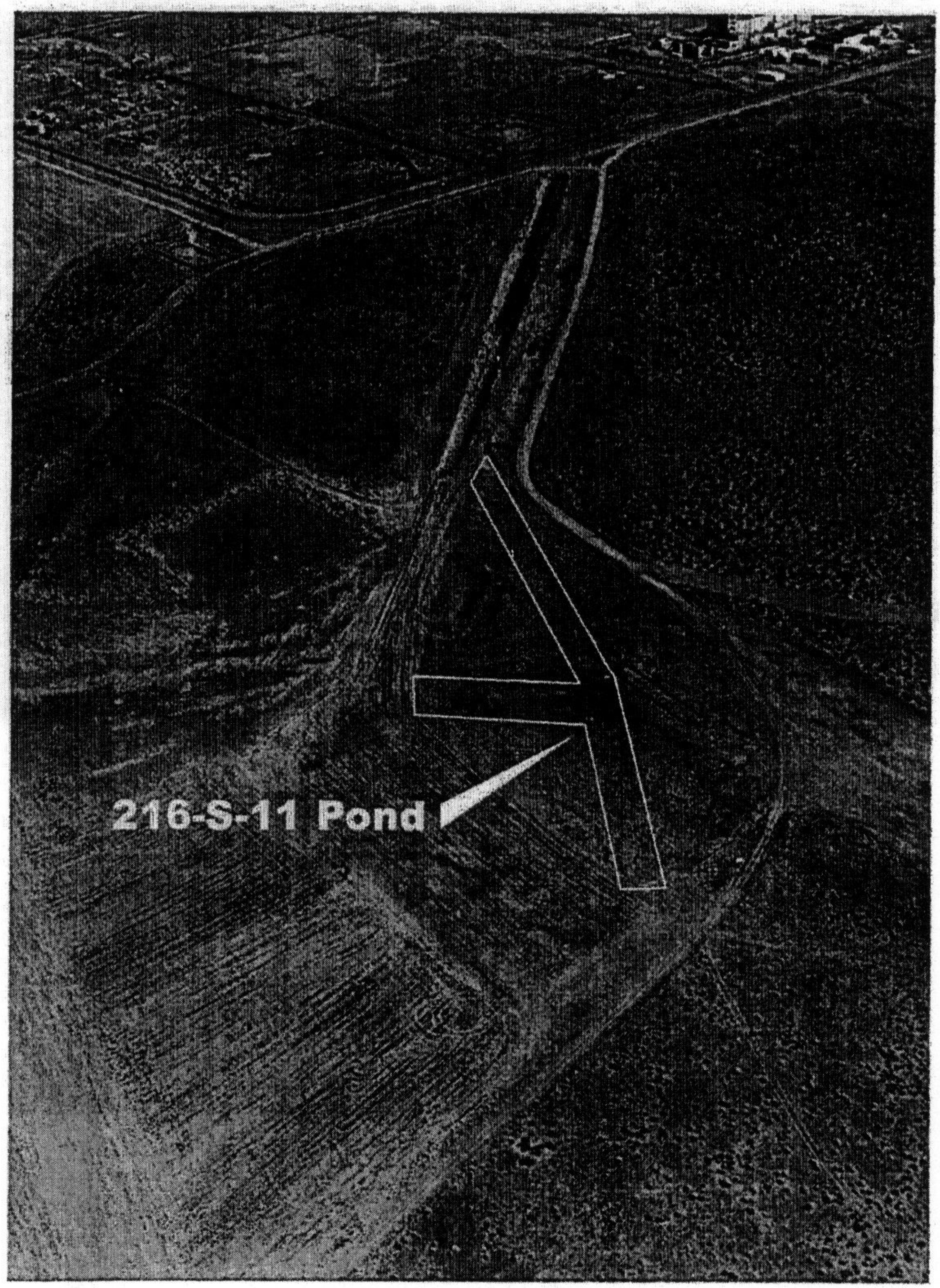


Figure A-4. 216-S-11 Pond.



APPENDIX B

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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CONTENTS

TABLES

TERMS

ARAR	applicable or relevant and appropriate requirement
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
MCL	maximum contaminant level
OU	operable unit
PCB	polychlorinated biphenyl
p/m	parts per million
RCRA	*Resource Conservation and Recovery Act of 1976*
TBC	to be considered
TSD	treatment, storage, and/or disposal (unit)
WAC	*Washington Administrative Code*

APPENDIX B

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

B1.0 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This appendix identifies and evaluates potential applicable or relevant and appropriate requirements (ARAR) for waste site remediation in the 200-CS-1 Operable Unit (OU). The potential ARARs identified in this document have been used to form the basis for the levels to which contaminates must be remediated to protect human health and the environment. The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) provides for the identification of to-be-considered (TBC) nonpromulgated advisories, criteria, guidance, or proposed standards that may be consulted to interpret ARAR to-be-determined remediation goals when ARARs do not exist or are insufficient. Independent of the TBC and ARARs identification process at the Hanford Site, the requirements of U.S. Department of Energy (DOE) orders must be met.

Because the waste sites in the 200-CS-1 OU will be remediated under a CERCLA decision document, remedial and corrective actions at the sites will be required to meet ARARs. This appendix identifies and evaluates potential ARARs for these sites. Final ARARs for remediation will be established in the record of decision. In many cases, the ARARs form the basis for the preliminary remediation goals to which contaminants must be remediated to protect human health and the environment. In other cases, the ARARs define or restrict how specific remedial measures can be implemented.

The ARARs identification process is based on CERCLA guidance (EPA/540/G-89/006, *CERCLA Compliance with Other Laws Manual: Interim Final* and EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, (Interim Final)*, OSWER 9355.3-01). Section 121 of CERCLA, as amended, requires, in part, that any applicable or relevant and appropriate standard, requirement, criterion, or limitation promulgated under any Federal environmental law, or any more stringent state requirement promulgated pursuant to a state environmental statute, be met (or a waiver justified) for any hazardous substance, pollutant, or contaminant that will remain on site after completion of remedial action.

Under this process, potential ARARs are classified into one of three categories: chemical-specific, location-specific, or action-specific. These categories are defined as follows.

- Chemical-specific requirements are usually health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of public and worker safety levels and site cleanup levels.

- Location-specific requirements are restrictions placed on the concentration of dangerous substances or the conduct of activities solely because they occur in special geographic areas.

- Action-specific requirements are usually technology- or activity-based requirements or limitations triggered by the remedial actions performed at the site.

When requirements in each of these categories are identified, a determination must be made as to whether those requirements are ARARs. A requirement is applicable if the specific terms or jurisdictional prerequisites of the law or regulations directly address the circumstances at a site. If not applicable, a requirement may nevertheless be relevant and appropriate if (1) circumstances at the site are, based on best professional judgment, sufficiently similar to the problems or situations regulated by the requirement and (2) the requirement's use is well suited to the site. Only the substantive requirements (e.g., use of control/containment equipment, compliance with numerical standards) associated with ARARs apply to CERCLA onsite activities. ARARs associated with administrative requirements, such as permitting, are not applicable to CERCLA onsite activities (CERCLA, Section 121[e][1]). In general, this CERCLA permitting exemption will be extended to all remedial and corrective action activities conducted at the 200-CS-1 OU, with the exception of the *Resource Conservation and Recovery Act of 1976* (RCRA) units, which will be incorporated into WA7890008967, *Hanford Facility RCRA Permit.*

TBC information is nonpromulgated advisories or guidance issued by Federal or state governments that is not legally binding and does not have the status of potential ARARs. In some circumstances, TBCs will be considered along with ARARs in determining the remedial action necessary for protection of human health and the environment. The TBCs complement the ARARs in determining protectiveness at a site or implementation of certain actions. For example, because soil cleanup standards do not exist for all contaminants, health advisories, which would be TBCs, may be helpful in defining appropriate remedial action goals.

B1.1 WAIVERS FROM APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The U.S. Environmental Protection Agency (EPA) may waive ARARs and select a remedial action that does not attain the same level of site cleanup as that identified by the ARARs. Section 121 of the *Superfund Amendments and Reauthorization Act of 1986* identifies six circumstances in which the EPA may waive ARARs for onsite remedial actions. The six circumstances are as follows:

- The remedial action selected is only a part of a total remedial action (such as an interim action), and the final remedy will attain the ARAR upon its completion

- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options

- Compliance with the ARAR is technically impracticable from an engineering perspective

- An alternative remedial action will attain an equivalent standard of performance through the use of another method or approach
- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances
- In the case of Section 104 (Superfund-financed remedial actions), compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

B1.2 POTENTIAL ARARS APPLICABLE TO REMEDIAL ACTIONS FOR WASTE SITES IN THE 200-CS-1 OPERABLE UNITS

Potential Federal and state ARARs are presented in Tables B-1 and B-2, respectively. The chemical-specific ARARs likely to be most relevant to remediation of the 200-CS-1 OU are elements of the Washington State regulations that implement *Washington Administrative Code* (WAC) 173-340, "Model Toxics Control Act – Cleanup," specifically associated with developing risk-based concentrations for cleanup (WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties"). The requirements of WAC 173-340-745 risk-based concentrations help establish soil cleanup standards for nonradioactive and radioactive contaminants at waste sites. The several Federal and state air emission standards are likely to be important in identifying air emission limits and control requirements for any remedial actions that produce air emissions. RCRA land-disposal restrictions will be important standards during the management of wastes generated during remedial actions.

No location-specific ARARs have been identified for the waste sites considered in this feasibility study.

Action-specific ARARs that could be pertinent to remediation are state solid and dangerous waste regulations (for management of characterization and remediation wastes and performance standards for waste left in place), *Atomic Energy Act of 1954* regulations (for performance standards for radioactive waste sites), and Federal and state regulations related to air emissions.

B2.0 REFERENCES

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Title 40, *Code of Federal Regulations*, Part 61, as amended.

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

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

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

40 CFR 761, "Polychorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," Title 40, *Code of Federal Regulations*, Part 761, as amended.

Atomic Energy Act of 1954, 42 USC 2011, et seq.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.

EPA/540/G-89/004, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, (Interim Final)*, OSWER 9355.3-01, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA/540/G-89/006, 1988, *CERCLA Compliance with Other Laws Manual: Interim Final*, U.S. Environmental Protection Agency, Washington, D.C.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

Superfund Amendments and Reauthorization Act of 1986, 42 USC 103, et seq.

WA7890008967, 1994, *Hanford Facility RCRA Permit*, Washington State Department of Ecology, Olympia, Washington.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-304, "Minimum Functional Standards for Solid Waste Handling," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340, "Model Toxics Control Act -- Cleanup," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-350, "Solid Waste Handling Standards," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-400, "General Regulations for Air Pollution Sources," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites. (2 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"National Primary Drinking Water Regulations," 40 CFR 141			
"Maximum Contaminant Levels for Organic Contaminants," 40 CFR 141.61	ARAR	Establishes MCLs that are drinking water criteria designed to protect human health from the potential adverse effects of organic contaminants in drinking water.	The groundwater in the 200-CS-1 OU is not currently used for drinking water. However, 200 Area groundwater is hydraulically connected to the Columbia River (which is used for drinking water). Remedial alternatives must that ensure migration of contaminants from the waste sites do not cause degradation at the point of compliance; therefore, the substantive requirements in 40 CFR 141.61 for organic constituents are relevant and appropriate.
"Maximum Contaminant Levels for Inorganic Contaminants," 40 CFR 141.62	ARAR	Establishes MCLs that are drinking water criteria designed to protect human health from the potential adverse effects of inorganic contaminants in drinking water.	The groundwater in the 200-CS-1 OU is not currently used for drinking water. However, 200 Area groundwater is hydraulically connected to the Columbia River (which is used for drinking water). Remedial alternatives must ensure that migration of contaminants from the waste sites do not cause degradation at the point of compliance; therefore, the substantive requirements in 40 CFR 141.62 for inorganic constituents are relevant and appropriate.
"Maximum Contaminant Levels for Radionuclides," 40 CFR 141.66	ARAR	Establishes MCLs that are drinking water criteria designed to protect human health from the potential adverse effects of radionuclides in drinking water.	The groundwater in the 200-CS-1 OU is not currently used for drinking water. However, 200 Area groundwater is hydraulically connected to the Columbia River (which is used for drinking water). Remedial alternatives must ensure that migration of contaminants from the waste sites do not cause degradation at the point of compliance; therefore, the substantive requirements in 40 CFR 141.66 for radionuclides are relevant and appropriate.
"Polychorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," 40 CFR 761			
"Applicability," Specific Subsections: 40 CFR 761.50(b)(1) 40 CFR 761.50(b)(2) 40 CFR 761.50(b)(3) 40 CFR 761.50(b)(4) 40 CFR 761.50(b)(7) 40 CFR 761.50(c)	ARAR	These regulations establish standards for the storage and disposal of PCB wastes.	The substantive requirements of these regulations are potentially applicable or relevant and appropriate to the storage and disposal of PCB liquids, items, remediation waste, and bulk product waste at ≥50 p/m. The specific subsections identified from 40 CFR 761.50(b) reference the specific sections for the management of PCB waste type. The disposal requirements for radioactive PCB waste are addressed in 40 CFR 761.50(b)(7).

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites. (2 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"National Emission Standards for Hazardous Air Pollutants," 40 CFR 61			
"Standard," 40 CFR 61.92	ARAR	Requires that emissions of radionuclides to the ambient air from U.S. Department of Energy facilities shall not exceed amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.	The substantive requirements of this standard are potentially applicable to remedial action activities in the 200-CS-1 OU, such as excavation of contaminated soils and the operation of air quality management equipment in support of remediation activities, which may result in the release of radioactive particulates to unrestricted areas. As a result, requirements limiting emissions potentially apply. This is a risk-based standard for protecting human health and the environment.
"Emission Monitoring and Test Procedures," 40 CFR 61.93	ARAR	Establishes the methods for monitoring emissions rates from existing point sources.	The substantive requirements of this standard are potentially applicable because emissions of radionuclides to the ambient air may result from remediation activities performed in the 200-CS-1 OU, or from related use of temporary sources such as air quality management equipment in support of remediation activities.
"Archaeological and Historic Preservation Act of 1976" 16 USC 469aa-mm	ARAR	Requires that remedial actions at 200-CS-1 OU waste sties do not cause the loss of any archaeological or historic data. This act mandates preservation of the data and does not require protection of the actual waste site or facility.	Archeological and historic sites have been identified within the 200 Areas, therefore the substantive requirements of this act are applicable to actions that might disturb these sites.
"National Historic Preservation Act of 1966," 16 USC 470, Section 106	ARAR	Requires federal agencies to consider the impacts of their undertaking on cultural properties through identification, evaluation and mitigation processes, and consultation with interested parties. .	Cultural and historic sites have been identified within the 200 Areas, and therefore the substantive requirements of this act are applicable to actions that might disturb these types of sites.
"Native American Graves Protection and Repatriation Act," 25 USC 3001, et seq.	ARAR	Establishes federal agency responsibility for discovery of human remains, associated and unassociated funerary objects, sacred objects and items of cultural patrimony.	Substantive requirements of this act are applicable if remains and sacred objects are found during remediation and will require Native American Tribal consultation in the event of discovery.
"Endangered Species Act of 1973" 16 USC 1531 et seq, subsection 16 USC 1536(c)	ARAR	Prohibits actions by federal agencies that are likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification or critical habitat. If remediation is within critical habitat or buffer zones surrounding threatened or endangered species, mitigation measures must be taken to protect the resource.	Substantive requirements of this act are applicable if threatened or endangered species are identified in areas where remedial actions will occur.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites. (2 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
Regulations pursuant to the *Resource Conservation and Recovery Act of 1976* and implemented through WAC 173-303, "Dangerous Waste Regulations" (see Table B-2).			

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants."

40 CFR 141, "National Primary Drinking Water Regulations."

40 CFR 761, "Polychorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions."

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

ARAR = applicable or relevant and appropriate requirement.
CFR = *Code of Federal Regulations.*
MCL = maximum contaminant level.
OU = operable unit.
p/m = parts per million.
PCB = polychlorinated biphenyl.
TBC = to be considered.
WAC = *Washington Administrative Code.*

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and to be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Dangerous Waste Regulations," WAC 173-303			
"Identifying Solid Waste," WAC 173-303-016	ARAR	Identifies those materials that are and are not solid wastes.	Substantive requirements of these regulations are potentially applicable because these define how to determine which materials are subject to the designation regulations. Specifically, materials that are generated for removal from the CERCLA site during the remedial action would be subject to the procedures for identification of solid waste to ensure proper management.
"Recycling Processes Involving Solid Waste," WAC 173-303-017	ARAR	Identifies materials that are and are not solid wastes when recycled.	Substantive requirements of these regulations are potentially applicable because these define how to determine which materials are subject to the designation regulations. Specifically, materials that are generated for removal from the CERCLA site during the remedial action would be subject to the procedures for identification of solid waste to ensure proper management.
"Designation of Dangerous Waste," WAC 173-303-070	ARAR	Establishes the method for determining whether a solid waste is, or is not, a dangerous waste or an extremely hazardous waste.	Substantive requirements of these regulations are potentially applicable to materials encountered during the remedial action. Specifically, solid waste that is generated for removal from the CERCLA site during this remedial action would be subject to the dangerous waste designation procedures to ensure proper management.
"Excluded Categories of Waste," WAC 173-303-071	ARAR	Describes those categories of wastes that are excluded from the requirements of WAC 173-303 (excluding WAC 173-303-050).	The conditions of this requirement are applicable to remedial actions in the 200-CS-1 OU should wastes identified in WAC 173-303-071 be encountered.
"Conditional Exclusion of Special Wastes," WAC 173-303-073	ARAR	Establishes the conditional exclusion and the management requirements of special wastes, as defined in WAC 173-303-040.	Substantive requirements of these regulations are potentially applicable to materials encountered during the remedial action. Specifically, the substantive standards for management of special waste are applicable to the interim management of certain waste that will be generated during the remedial action.

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and to be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Requirements for Universal Waste," WAC 173-303-077	ARAR	Identifies those wastes exempted from regulation under WAC 173-303-140 and WAC 173-303-170 through 173-303-9907 (excluding WAC 173-303-960). These wastes are subject to regulation under WAC 173-303-573.	Substantive requirements of these regulations are potentially applicable to materials encountered during the remedial action. Specifically, the substantive standards for management of universal waste are applicable to the interim management of certain waste that will be generated during the remedial action.
"Recycled, Reclaimed, and Recovered Wastes," WAC 173-303-120 Specific Subsections: WAC 173-303-120(3) WAC 173-303-120(5)	ARAR	These regulations define the requirements for the recycling of materials that are solid and dangerous waste. Specifically, WAC 173-303-120(3) provides for the management of certain recyclable materials, including spent refrigerants, antifreeze, and lead-acid batteries. WAC 173-303-120(5) provides for the recycling of used oil.	Substantive requirements of these regulations are potentially applicable to certain materials that might be encountered during the remedial action. Recyclable materials that are exempt from regulation as dangerous waste and that are not otherwise subject to CERCLA as hazardous substances can be recycled and/or conditionally excluded from certain dangerous waste requirements.
"Land Disposal Restrictions," WAC 173-303-140(4)	ARAR	This regulation establishes state standards for land disposal of dangerous waste and incorporates by reference, Federal land disposal restrictions of 40 CFR 268 that are applicable to solid waste that designates as dangerous or mixed waste in accordance with WAC 173-303-070(3).	The substantive requirements of this regulation are potentially applicable to materials encountered during the remedial action. Specifically, dangerous/mixed waste that is generated and removed from the CERCLA site during the remedial action for offsite (as defined by CERCLA) land disposal would be subject to the identification of applicable land disposal restrictions at the point of generation of the waste. The actual offsite treatment of such waste would not be ARAR to this remedial action, but would instead be subject to all applicable laws and regulations.
"Requirements for Generators of Dangerous Waste," WAC 173-303-170	ARAR	Establishes the requirements for dangerous waste generators.	Substantive requirements of these regulations are potentially applicable to materials encountered during the remedial action. Specifically, the substantive standards for management of dangerous/mixed waste are applicable to the interim management of certain waste that will be generated during the remedial action. For purposes of this remedial action, WAC 173-303-170(3) includes the substantive provisions of WAC 173-303-200 by reference. WAC 173-303-200 further includes certain substantive standards from WAC 173-303-630 and -640 by reference.

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and to be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Closure and post-closure," WAC 173-303-610	ARAR	Establishes the closure performance standards for RCRA TSD units.	These requirements are applicable to the closure of RCRA TSD units in the OU, 216-A-29 Ditch, 216-B-63 Trench, 216-S-10 Ditch, and 216-S-10 Pond.
"Model Toxics Control Act -- Cleanup," WAC 173-340			
"Soil Cleanup Standards for Industrial Properties," WAC 173-340-745(5)(b)	ARAR	Identifies the methods used to identify risk-based concentrations and their use in the selection of a cleanup action. Cleanup and remediation levels are based on protection of human health and the environment, the location of the site, and other regulations that apply to the site. The standard specifies cleanup goals that implement the strictest Federal or state cleanup criteria.	The state-established risk-based concentrations for soils and protection of groundwater are potentially relevant and appropriate to the 200-CS-1 OU waste site remedial actions, because no Federal standard exists.
"Minimum Functional Standards for Solid Waste Handling," WAC 173-304			
"On-Site Containerized Storage, Collection and Transportation Standards for Solid Waste," WAC 173-304-200(2)	ARAR	Establishes the requirements for the onsite storage of solid wastes that are not radioactive or dangerous wastes.	Substantive requirements of these regulations are potentially applicable to materials encountered during the remedial action. Specifically, nondangerous, nonradioactive solid wastes (i.e., hazardous substances that are only regulated as solid waste) that will be containerized for removal from the CERCLA site would be managed on site according to the substantive requirements of this standard.
"Solid Waste Handling Standards," WAC 173-350			
"On-Site Storage, Collection and Transportation Standards," WAC 173-350-300	ARAR	Establishes the requirements for the temporary storage of solid waste in a container on site and the collecting and transporting of the solid waste.	The substantive requirements of this newly promulgated rule are potentially relevant and appropriate to the onsite collection and temporary storage of solid wastes at the 200-CS-1 OU remediation waste sites. Compliance with this regulation is being implemented in phases for existing facilities.

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and to be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Minimum Standards for Construction and Maintenance of Wells," WAC 173-160			
WAC 173-160-161	ARAR	Identifies well planning and construction requirements.	The substantive requirements of this regulation are potentially applicable to actions that include construction of wells used for groundwater extraction, monitoring, or injection of treated groundwater or wastes. The requirements of WAC 173-160-161 through 173-160-381 (excluding 173-160-211, 173-160-251, 173-160-261, 173-160-361, 173-160-400, 173-160-420, 173-160-430, 173-160-440, 173-160-450, and 173-160-460) are applicable to groundwater well construction, monitoring, or injection of treated groundwater or wastes in the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OUs.
WAC 173-160-171	ARAR	Identifies the requirements for locating a well.	
WAC 173-160-181	ARAR	Identifies the requirements for preserving natural barriers to groundwater movement between aquifers.	
WAC 173-160-191	ARAR	Identifies the design and construction requirements for completing wells.	
WAC 173-160-201	ARAR	Identifies the casing and liner requirements for water supply wells.	
WAC 173-160-221	ARAR	Identifies the requirements for sealing materials.	
WAC 173-160-231	ARAR	Identifies the requirements for surface seals on water wells.	
WAC 173-160-241	ARAR	Identifies the requirements for formation sealing.	
WAC 173-160-271	ARAR	Identifies the special sealing standards for driven wells, jetted wells, and dewatering wells.	
WAC 173-160-281	ARAR	Identifies the construction standards for artificial gravel-packed wells.	
WAC 173-160-291	ARAR	Identifies the standards for the upper terminal of water wells.	
WAC 173-160-301	ARAR	Identifies the requirements for temporary capping.	
WAC 173-160-311	ARAR	Identifies the requirements for well tagging.	
WAC 173-160-321	ARAR	Identifies the standards for testing a well.	
WAC 173-160-331	ARAR	Identifies the method for keeping equipment and the water well free of contaminants.	
WAC 173-160-341	ARAR	Identifies the method for ensuring the quality of the well water.	
WAC 173-160-351	ARAR	Identifies the standards for the installation of a pump.	
WAC 173-160-371	ARAR	Identifies the standard for chemical conditioning.	

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and to be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
WAC 173-160-381	ARAR	Identifies the standard for decommissioning a well.	
WAC 173-160-400	ARAR	Identifies the minimum standards for resource protection wells and geotechnical soil borings.	
WAC 173-160-420	ARAR	Identifies the general construction requirements for resource protection wells.	
WAC 173-160-430	ARAR	Identifies the minimum casing standards.	
WAC 173-160-440	ARAR	Identifies the equipment cleaning standards.	
WAC 173-160-450	ARAR	Identifies the well sealing requirements.	
WAC 173-160-460	ARAR	Identifies the decommissioning process for resource protection wells.	
"General Regulations for Air Pollution Sources," WAC 173-400			
"General Standards for Maximum Emissions," WAC 173-400-040	ARAR	Establishes the general emission standards for emission units. Emission standards identified in other chapters for specific emission units will take precedence over the general emission standards of this section.	The substantive requirements of this standard are potentially relevant and appropriate to remedial actions performed at the site that could result in the emission of criteria pollutants (i.e., fugitive dust). Substantive standards established for the control and prevention of air pollution under this regulation are considered to be relevant and appropriate to remedial actions that may be proposed at a site.
"Ambient Air Quality Standards and Emission Limits for Radionuclides," WAC 173-480			
"Emission Monitoring and Compliance Procedures," WAC 173-480-070	TBC	Requires that radionuclide emissions shall be determined by calculating the dose to members of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public may be.	The substantive requirements of this standard are applicable to remedial actions conducted in the 200-CS-1 OU, because excavation of contaminated soil may emit radionuclides to unrestricted areas.

40 CFR 268, "Land Disposal Restrictions."
Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.
Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.
WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."
WAC 173-303, "Dangerous Waste Regulations."
WAC 173-304, "Minimum Functional Standards for Solid Waste Handling."
WAC 173-340, "Model Toxics Control Act -- Cleanup."
WAC 173-350, "Solid Waste Handling Standards."
WAC 173-400, "General Regulations for Air Pollution Sources."
WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides."

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and to be Considered for the Remedial Action Sites. (6 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use

ARAR = applicable or relevant and appropriate requirement.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
CFR = *Code of Federal Regulations.*
OU = operable unit.
RCRA = *Resource Conservation and Recovery Act of 1976.*
TBC = to be considered.
WAC = *Washington Administrative Code.*

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APPENDIX C

NATIVE AMERICAN EXPOSURE SCENARIO RISK ASSESSMENT

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FIGURES

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APPENDIX C

NATIVE AMERICAN EXPOSURE SCENARIO RISK ASSESSMENT

C1.0 INTRODUCTION

This appendix provides the results of the hypothetical Native American Scenario Risk Assessment (NARA) for four representative sites in the 200-CS-1 Area: the 216-A-29 Ditch, 216-B-63 Trench, 216-S-10 Ditch, and 216-S-10 Pond. The human health risk assessment described in this appendix addresses pathways associated chemical and radionuclide contamination found within the shallow zone soil (0 to 4.6 m [0 to 15 ft] below ground surface [bgs].

This risk assessment was performed to evaluate the potential for risk to human health under conditions described in Harris 2004, "Exposure Scenario for CTUIR Traditional Subsistence Lifeways." The results are used, in part, to help assess whether remedial action may need further evaluation and to focus the feasibility study (FS). The assessment draws from information presented previously in the FS, particularly Chapter 2.0, where a summary of the remedial investigation baseline risk assessment and a description of the extended risk assessment are found.

Introduction to the Hypothetical Native American Traditional Subsistence Lifeways Scenario

The U.S. Department of Energy (DOE) remains committed to considering Tribal exposure scenarios for conducting the risk assessments necessary to evaluate whether Hanford Site cleanup alternatives are protective of human health and the environment (Roberson 2002, "Hazard Categorization of EM Inactive Waste Sites as Less Than Hazard Category 3"). The DOE, U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Tri-Parties) have interacted with the stakeholder Tribes over the past several years to obtain their input on developing a Native American exposure scenario or scenarios, including key parameters for the Central Plateau risk assessment models.

The Tribes were involved in the risk assessment framework workshops during the summer of 2002, and in October 2002, they were asked to provide written suggestions on specific risk assessment parameters (exposure assumptions) for Tribal-use scenarios (DOE-RCA-2002-0584, 2002a, Letter [no title; topic: Tribal Input on the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) Risk Assessment], to Richard Gay, Confederated Tribes of the Umatilla Indian Reservation, from the Tri-Party Agreement signatories; DOE-RCA-2002-0584, 2002b, Letter [no title; topic: Tribal Input on CERCLA Risk Assessment], to Russell Jim, Confederated Tribes and Bands of the Yakama Nation, from the Tri-Party Agreement signatories; DOE-RCA-2002-0584, 2002c, Letter [no title; topic: Tribal Input on CERCLA Risk Assessment], to Patrick Sobotta, Nez Perce Tribe, from the Tri-Party Agreement signatories). This request culminated in a workshop in December 2002 that included the Tri-Parties and representatives from the Confederated Tribes of the Umatilla Indian

Reservation, the Confederated Tribes and Bands of the Yakama Nation, and the Nez Perce Tribe. The Yakamas and the Nez Perce participated in the workshop but believed they needed additional time to provide input. The Umatillas asked that the information from DOE/RL-91-45, *Hanford Site Baseline Risk Assessment Methodology,* and Harris and Harper 1997, "A Native American Exposure Scenario," be used to calculate risk estimates for a Native American subsistence scenario. The information from this study was used to estimate potential risks to a Native American from radiological constituents.

The Native American subsistence scenario proposed in Harris and Harper (1997) represents a "typical" Native American culture that incorporates the use of the entire Columbia Basin for food, water, and shelter.

The Harris and Harper 1997 scenario has been revised, based on additional work by Harris (2004), and it is now referred to as the Native American Traditional Subsistence Lifeways scenario. Harris' revision has resulted in a more concisely structured age stratification including description of infant (ages 0 to 2 years), child (ages 2 to 6 years), youth (ages 7 to 16), adult worker (ages 17 to 55 years), and elder (ages 56 to 70 years) activities. Harris (2004) also provides updated consumption exposure factors that emerge from distinguishing between a fish-focused diet (applicable for Hanford Reach areas near the Columbia River) and a game-focused diet (applicable to locations that do not rely on consumption from the river). In this risk assessment, the game-focused diet is used because the Central Plateau, where the 200-CS-1 Operable Unit (OU) sites are located, is in the dry upland land portion of the Hanford Site; nearly 5 miles from the Columbia River. Additionally, as discussed later, the conceptual site model (CSM) indicates that constituents in the soils at the 200-CS-1 OU sites will not affect the river.

This hypothetical scenario was evaluated to provide a basis of comparison (assuming unrestricted land use) to the site-specific scenario (e.g., industrial) and the hypothetical intruder scenario previously described in Chapter 2.0 of the FS. Considerable uncertainty is associated with applying the Native American Traditional Subsistence Lifeways exposure assumptions to each waste site, because applying these assumptions likely overestimates the dose, risk, and hazard index associated with each waste site.

Risk Assessment Organization

This Native American Traditional Subsistence Lifeways risk assessment consists of the following components:

- An **Introduction** (this section) that discusses the NARA framework and orients the reader to the report.
- Development of the **CSM**, which identifies the pathways by which human exposures could occur is discussed in Chapter C2.0.
- **Exposure factors, toxicity data and other method issues** including the contact rate, frequency, and duration factors used to quantify exposure are presented in Chapter C3.0.

- **Risk assessments for each Representative Site are presented in** Chapters C4.0 through C4.4.
- Risk assessment **uncertainties** are discussed in Chapter C5.0.
- A listing of **references** used in Appendix C is provided in Chapter C6.0.

C2.0 CONCEPTUAL SITE MODEL

The CSM, illustrated in Figure C-1, identifies the means by which receptors on the 200-CS-1 OU waste sites could be exposed to chemicals in environmental media. The CSM addresses exposures that could result under from potential future Traditional Subsistence Lifeways uses for the sites and the surrounding areas. The CSM provides a current understanding of the sources of contamination, physical setting, and current and future land use, and identifies potentially complete human exposure pathways for the study areas. Information generated during the RI/FS process has been incorporated into this CSM to help identify potential exposure scenarios. Key features of the CSM include the following:

- Soil contamination existing within the 0 to 4.6 m (0 to 15 ft), resulting from surface deposition is the principal source of contamination for all pathways.
- The deep-zone groundwater is not accessible to Tribal members. This is due to its significant depth, typically about 270 ft, beneath the surface. This fact eliminates domestic use of groundwater and the application of contaminated groundwater for sweat lodge use of as potential exposure pathways.
- The CSM illustrates that, conceptually, the deep groundwater could discharge to the Columbia River. However, the river is on-the-order-of 5 miles from the Central Plateau where the four sites are located. This gives rise to two important risk assessment findings.

    1. The pathway from soils at the sites to fish in the Columbia River is, for practical purposes incomplete. Migration of soil contaminants from the vadose zone to the deep groundwater has been largely been discounted as a viable transport pathway in the RI/FS. Moreover, even if migration of soil contaminants from the vadose zone to the deep groundwater were a viable pathway, contaminant concentrations in the surface water would be so low that they would not accumulate in the edible tissues of fish in the River. This is because of significant reduction in concentration that would come about from initially mixing in the deep groundwater, followed by additional concentration reduction from saturated zone adjective migration over 5 miles, and further mixing upon discharge into the Columbia River.

2. Future Tribal members residing on the Central Plateau are not likely to obtain a principal portion of their protein intake from consumption of fish obtained from the Columbia River.

- Future Tribal members participate in a subsistence lifestyle described by Harris and Harper (1997) and Harris (2004) as "hunting, fishing, and gathering activities." Tribal member consume (1) plants that grow in the shallow soils and (2) local game that also consume plants growing in the soil as which also consume contaminated soils while grazing. The Traditional Subsistence Lifeways scenario is not an agricultural arrangement like the Intruder scenario discussed in Chapter 2.0 of the FS. The two scenarios are similar in that they both employ food chain pathways as the important exposure features. However, the Traditional Subsistence Lifeways scenario is similar to a "living of the land" situation whereby significant portions of the Tribal member's diet are fulfilled by consumption of native plants and game.

Readers will note that Figure C-1 is a modification and expansion of Figure 2-23, Intruder Scenario Conceptual Site Model and Garden, in the FS. The significant differences between two CSMs are as follows. First, there is no garden employing drill cuttings mixed with clean soils for plant anchorage in the Traditional Subsistence Lifeways scenario. Rather, native plants grow in the unadulterated, though contaminated soils. Second, the Traditional Subsistence Lifeways scenario includes a simplified game-based food chain model incorporating consumption of native animals that graze and forage in the affected soils. The Traditional Subsistence Lifeways scenario also includes an infant consumption of breast milk as described by Harris and Harper (1997) and Harris (2004).

Complete pathways, those with an X in the Potential Receptor box, will be evaluated.

C3.0 EXPOSURE ASSUMPTIONS, TOXICITY FACTORS, AND METHODS

Scenario Overview

Exposure assumptions for the Traditional Subsistence Lifeways scenario were obtained from Harris and Harper (1997) and modified to conform to Harris (2004). Harris and Harper (1997) suggested that a traditional Tribal member would lead a moderately active lifestyle, spending 180 days/yr conducting various subsistence activities (e.g., hunting, fishing, and gathering), and spending the full year consuming materials obtained through these activities. For the purposes of this assessment, it is assumed that a Tribal member spends 365 days/yr near the representative sites (Harris 2004). This conservative simplification will tend to overstate the risk. However, the assumption parallels the intent of EPA guidance to identify reasonable maximum exposure conditions to provide an upper bound hazard assessment (EPA 1990).

The scenario assumes that a Tribal member is residing within the boundaries of the specific 200-CS-1 OU site and he/she obtains all of his/her daily caloric need from consuming plant intake and game consumption from local plants and animals. Key features of this scenario include the following:

- Direct contact outdoors with dust that originated as contaminated soils, including incidental ingestion, inhalation, and dermal contact from day-to-day living, including hunting and foraging
- Secondary contact indoors with dust that originated as soils, including additional incidental ingestion, inhalation, and dermal contact
- Consumption of vegetables and fruits that grow in the contaminated soils
- Consumption of game that grazes and feeds on vegetation that grows in the contaminated soils
- Irradiation from radionuclides in the soil
- Exposure occurs 365 days/yr for 70 years.

Additional Exposure Conditions

For purposes of evaluating the impacts of the intruder scenario, it is assumed that after 150 years, Tribal members could obtain access to the area. The scenario assumes no significant attenuation of nonradionuclides; however, natural decay of radionuclides is assumed to occur over the 150-year period. No attenuation of decay is assumed for the nonradionuclide contaminants of potential concern (COPC).

The scenario is intentionally conservative and may not actually be plausible. For example, it may not be possible for the lands in the Central Plateau to produce and sustain sufficient native fruits and vegetables, and game to support 2500 per day calorie adult specified by Harris (2004).

Exposure factors used to characterize the scenario are presented in Table C-1. As indicated, with one exception (infant exposure to milk), Tribal member exposure is modeled as a hybrid of a small child-adult receptor, occasionally referred to as the child-to-adult receptor. As indicated in Table C-1, exposure factors were taken directly from Harris (2004) and Harris and Harper (2004). Age durations for the different segments of life stages were taken from Harris (2004). These were augmented with typical bodyweight values from EPA/600/P-95/002B, *Exposure Factor Handbook, Volume I, General Factors*, to arrive at the Age/Body Weight Weighted Average exposure factors.

In addition to the human exposure factors, several chemical-specific variables are necessary to compute exposures; they are shown in Table C-2.

Contaminants of Potential Concern and Exposure Point Concentrations

Nonradionuclide COPCs were identified as those constituents that were assessed in the intruder risk assessment(s) found in Chapter 2.0 of the FS. Readers will recall that COPCs for the intruder risk assessment used background considerations and conservative residential exposure values for screening.

To focus the radiological assessment on the important radionuclides, a screening step, designed to identify the radionuclides posing the greatest dose potential, was used. The screening step used maximum concentrations from the top 0 to 15 ft soils interval from each site as inputs into the RESidual RADioactivity dose model (RESRAD). The dose output was viewed for the 150-year interval. Radionuclides that contributed less than 1 percent to the total dose were excluded from further analysis. The screening results are presented in Table C-3. For those radionuclides that were retained, 95th upper confidence level (95%UCL) exposure point concentrations (EPC) were computed using EPA's PROUCL statistical program in accordance with EPA guidance (EPA 2002, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*, OSWER 9285.6-10). Additional discussion of the method for computing 95%UCL concentrations can be found in Chapter 2.0 of the FS.

Toxicity information (cancer slope factors and reference doses) tabulated in Table C-4 were obtained from the Cleanup Levels and Risk Calculations (CLARC) Web site (Ecology 2005, *Cleanup Levels and Risk Calculations (CLARC) Database*, https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx .). As indicated in Table C-4, the provisional chronic reference dose (RfD) for sulfate was developed in Chapter 2.0 of the FS.

All radiological COPCs were evaluated under the hypothetical Traditional Subsistence Lifeways exposure scenario using RESRAD version 6.3 (ANL 2004, *RESRAD for Windows*). Nonradiological COPCs were evaluated using a simplified exposure paradigm patterned after EPA/540/1-89/002, *Risk Assessment Guidance for Superfund (RAGS), Volume I -- Human Health Evaluation Manual, (Part A) Interim Final,* OSWER 9285.7-01A and EPA/530-D-98-001A, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*. All scenarios were evaluated assuming the absence of clean cover and a contaminated zone ranging from 0 m to 4.6 m (0 to 15 ft).

C4.0 SUMMARY OF DOSE AND RISK ESTIMATES FOR NONRADIOLOGICAL AND RADIOLOGICAL CONSTITUENTS

Tables C-5 through C-10 summarize the dose and risk estimates for the Native American Traditional Lifeways Subsistence scenario for the four 200-CS-1 OU representative waste sites.

For comparison, risk and dose estimates are discussed relative to the following exposure times, which are based on the results of risk framework workshops as documented in the Tri-Parties' response to the Hanford Advisory Board (Klein et al. 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area"), as amended.

- 50 years is the estimated time that the DOE will have an onsite presence.
- 150 years is the estimated time that institution controls are assumed effective.
- Dose estimates are provided for the exposure time when the target dose limit of 15 mrem/yr is achieved.[1]
- Excess lifetime cancer risk (ELCR) is compared to the 1E-6 to 1E-4 risk management range identified in the NCP (EPA 1990).
- Hazard Indexes (HI) are compared to the unity benchmark, 1.0, also identified in the NCP (1990).

The nonradiological risk assessment assumes that site conditions are at steady state and that there is no attenuation or decay of COPC concentrations. In essence, the nonradiological is equivalent to a time interval "0" years assessment.

C4.1 216-A-29 DITCH

As shown in Table C-5, the maximum estimated total Tribal member radiological dose at the 216-A-29 Ditch is 225 mrem/yr and the maximum ELCR is 3E-3 at year 0 (i.e., 2005). This dose exceeds the 15 mrem/y target and the ELCR under this exposure scenario is above the target 1E-6 to 1E-4 risk management range at all simulation times. The primary contributors to total dose and risk are Cs-137 and Pu-239; the chief pathways are plant consumption, the ground, and the soil.

Inspection of Table C-6 indicates that the maximum nonradiological ELCR for the child to adult Tribal member is 1E-1; the maximum hazard quotient (HQ) is 1E4. The ELCR exceeds 1E-6 to 1E-4 risk management range. Additionally, the HQ is also well above the benchmark HQ of 1.0. The polycyclic aromatic hydrocarbons (PAH) benzo(a)anthracene and chrysene are the major ELCR contributors; the HQ is dominated by Aroclor 1254. Consumption of game is the dominant pathway for exposure to nonradionuclide constituents.

Table C-6 also indicates that the maximum nonradiological ELCR for the infant breast milk consumption 8E-2 and the maximum HQ is 3E8. The ELCR exceeds 1E-6 to 1E-4 risk range management range and the HQ is well above the benchmark HQ of 1.0. Once again,

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[1] For the purposes of this risk assessment, the radiation dose limit is 15 mrem/yr (EPA/540/R-99/006, *Radiation Risk Assessment At CERCLA Sites: Q & A*, Directive 9200.4-31P). This dose limit was developed for members of the public who are unknowingly exposed to radiation.

benzo(a)anthracene and chrysene are the major ELCR contributors; the HQ is dominated by Aroclor 1254. Maternal consumption of game is the dominant pathway.

As indicated in the note section of Table C-6, these risk and HQs are driven by isolated detections of conspicuously elevated maximum concentrations that are not representative of site conditions (discussed in the FS, Chapter 2.0). Additionally, the food chain and infant milk consumption models are conservative. Consequently, estimated ELCRs and HQs are likely to be overestimated.

C4.2 216-B-63 TRENCH

Table C-7 reveals the estimated maximum total Tribal member radiological dose at the 216-B-63 Trench site is 88 mrem/yr and the maximum ELCR is 2E-3 at year 0 (i.e., 2005). This maximum dose exceeds the 15 mrem/y target and the ELCR under this exposure scenario at this time interval is above the target 1E-6 to 1E-4 risk range. However, as the Sr-90 decays, the dose drops significantly and is below the 15 mrem/yr target at all times after year 150. Similarly, after year 150, the ELCR is 1E-4, which is within the 1E-6 to 1E-4 risk management range. The primary contributors to total dose and risk are Sr-80 and Th-230. Consumption of plants is the principal exposure pathways.

There are no nonradiological COPCs associated with the 216-B-63 Trench site.

C4.3 216-S-10 DITCH

As shown in Table C-8, the maximum estimated total Tribal member radiological dose at the 216-S-10 Ditch is 14 mrem/yr and the maximum ELCR is 3E-4 at year 0 (i.e., 2005). This maximum dose does not exceed the 15 mrem/y target; however, the ELCR under this exposure scenario is just above the target 1E-6 to 1E-4 risk range management range. Notably, as the Cs-137 decays, by simulation year 50, the ELCR comes down to 1E-4 and it continues to diminish to 3E-6 by the year 1000. Thus, after year 50, the ELCR is within the 1E-6 to 1E-4 risk management range. The primary contributors to total dose and risk are Cs-137 and Pu-239; the chief exposure pathways are the ground and plant consumption.

Examination of Table C-9 points out that the maximum nonradiological ELCR for the child to adult Tribal member is 1E-1; the maximum HQ is 5E3. The ELCR exceeds 1E-6 to 1E-4 risk range management range and the HQ is well above the benchmark HQ of 1.0. Once again, the PAHs benzo(a)anthracene, benzo(a)pyrene, and chrysene are the major ELCR contributors and the HQ is dominated by Aroclor 1254. Consumption of game is the dominant pathway for exposure to nonradionuclide constituents.

Table C-9 also indicates that the maximum nonradiological ELCR for the infant breast milk consumption 5E-1 and the maximum HQ is 1E8. The ELCR exceeds 1E-6 to 1E-4 risk range management range and the HQ is well above the benchmark HQ of 1.0. As noted above, benzo(a)anthracene, benzo(a)pyrene, and chrysene are the major ELCR contributors; the HQ is dominated by Aroclor 1254. Maternal consumption of game is the dominant pathway.

Once again, the estimated ELCR and HQ are likely to be overestimated. The note section of Table C-9, indicates that these risk and HQs are driven by isolated maximum detections and that the food chain and infant milk consumption models are conservative.

C4.4 216-S-10 POND

Review of Table C-10 reveals the estimated maximum total Tribal member radiological dose at the 216-S-10-Pond site is 11 mrem/yr and the maximum ELCR is 2E-4 at year 0 (i.e., 2005). This maximum dose exceeds the 15 mrem/y target and the ELCR under this exposure scenario is just above the target 1E-6 to 1E-4 risk range. As the short-lived radionuclides decay, the dose and risk both drop of precipitously, such that at all times after year 1, all risk are within the 1E-6 to 1E-4 risk management range. The primary contributors to total dose and risk are Sr-90, C-14, Cs-137, Pu-239, and Th-230 in the later simulation years. Consumption of plants is the principal exposure pathway.

There are no nonradiological COPCs associated with the 216-S-10 Pond site.

C5.0 UNCERTAINTY ANALYSIS

Several sources of uncertainty affect the overall estimates of ELCR and no carcinogenic hazards as presented in this human health risk assessment.

Uncertainty Associated with Sampling and Analysis

Uncertainties associated with sampling and analysis include the inherent variability (standard error) in the analysis, representativeness of the samples, sampling errors, and heterogeneity of the sample matrix. While the quality assurance/quality control program used in conducting the sampling and analysis reduces errors, it cannot eliminate all errors associated with sampling and analysis.

Uncertainty Associated with Exposure Assessment

Future soil EPCs were assumed to be equal to existing soil concentrations. This assumption does not account for fate and transport processes likely to occur in the future. For example, ignoring the fact that contaminant soil concentrations will decrease as contaminant mass migrates into the vadose zone will tend to overestimate future soil exposure risks.

In addition, existing soil concentrations are based on biased sampling results. These results were collected at a limited number of points on each release site, and the sampling may or may not have produced results that are truly representative of the average contaminant concentrations at each site. In the case of nonradiological COPCs, maximum concentration of PAHs and Aroclor 1254 were used, even though the bulk of the data suggests that the overall EPC would be much lower. Risk calculations may be overestimated as a result of the limited amount of sampling that was available.

The estimation of exposure requires many assumptions to describe potential exposure situations. Uncertainties exist regarding the likelihood of exposure, frequency of contact with contaminated media, the concentration of contaminants at exposure points, and the time period of exposure. These tend to simplify and approximate actual waste site conditions. In general, these assumptions are intended to be conservative and yield an overestimate of the true risk or hazard.

The RESRAD model was used to evaluate the potential for unacceptable radiation dose impacts at a given waste site. The input parameter values that were used in this model are uncertain, because the future is uncertain and modeling is based on many exposure assumptions. This parameter uncertainty may cause risk to be over- or underestimated at a given waste site. All of the uncertainties discussed in this section might cause errors in dose estimates in the same way they may cause errors in risk estimates.

Similarly, the model used to evaluate nonradiological COPCs is a simplified spreadsheet calculation using common algorithms from EPA/540/1-89/002 and EPA/530-D-98-001A. These screening-level equations cannot capture and express the dynamic conditions of a complicated exposure situation such as that of the Traditional Lifeways Subsistence scenario.

Uncertainty Associated with Toxicity Assessment

The toxicological database also was a source of uncertainty. The EPA has outlined some of the sources of uncertainty in EPA/540/1-89/002. These sources may include or result from the extrapolation from high to low doses and from animals to humans; the species, gender, age, and strain differences in a toxin's uptake, metabolism, organ distribution, and target site susceptibility; and the human population's variability with respect to diet, environment, activity patterns, and cultural factors.

Uncertainty Associated with Risk Characterization

In the risk characterization, the assumption was made that the total risk of developing cancer from exposure to site contaminants is the sum of the risk attributed to each individual contaminant. Likewise, the potential for the development of noncancerous adverse effects is the sum of the HQs estimated for exposure to each individual contaminant. This approach, in accordance with EPA guidance, did not account for the possibility that constituents act synergistically or antagonistically.

C6.0 REFERENCES

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Figure C-1. Game-Based Native American Traditional Subsistence Lifeways Conceptual Site Model and Garden.

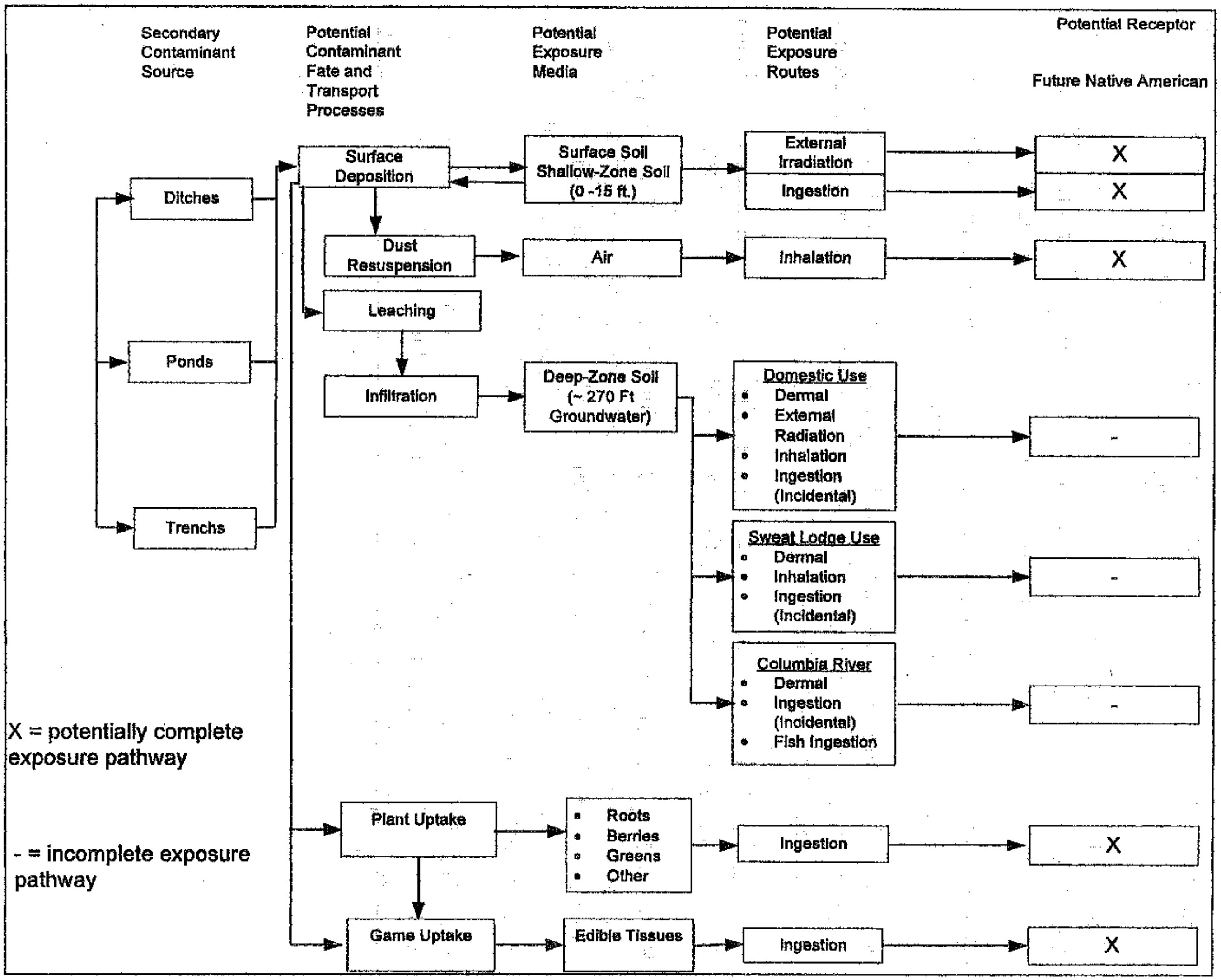

Figure C-2. Model for Estimating Chemical Concentrations in Breast Milk.*

$$C_{\text{Chemical in breast milk, per mg/L of milk fat}},\ \text{mg/L} = \frac{m * h * f_1}{0.693 * f_2}$$

where

C is the chemical concentration in the portion of breast milk, mg/L,

m = average maternal intake (i.e., exposure dose), mg/kg-day

h = the maternal biological half-life of the chemical, days

f_1= fraction of ingested chemical stored in maternal fat

0.693 = half – life constant

f_2= fraction of mother's weight that is fat.

Variable	Value Used	Remark
m	Chemical-specific sum exposure dose all pathways	A function of concentration and all pathways and exposure factors.
h	Assume to be 5 years (1,825 days)	Based on dioxin, a long-lived organic (EPA 1993). Probably conservative.
f1	90%	Based on dioxin, a long-lived organic (EPA 1993). Probably conservative.
f2	10%	Based on dioxin, a long-lived organic (EPA 1993). Probably conservative.

Fat content in mothers milk assume to be 5%. Whole dairy milk typically is 4%.

*EPA 1993, "Guidance on Indirect Exposure Assessments for Hazardous Waste Combustion Facilities."

Table C-1. Native American Exposure Scenario, Traditional Subsistence Lifeways (Harris 2004; Harris and Harper 1997). [a]

Exposure Route	Adult [b]	Age/Body Weight Weighted Average [c]	Reference
Soil, ingestion, mg/day	400	347	Harris 2004
Soil, dermal, mg/cm^2-day	5,000	4,340	Harris and Harper 1997
Soil, inhalation (dust), m^3/day	20	17	Harris and Harper 1997
Soil, external, h/day	24	24	Harris and Harper 1997
Air, inhalation, m^3/day	30	26	Harris 2004
Water, ingestion, L/day	4	3.5	Harris and Harper 1997
Water, inhalation, m^3/day	1	0.87	Harris and Harper 1997
Water, dermal, h/day	0.17	0.15	Harris and Harper 1997
Water, external, h/day, swimming	2.6	2.6	Harris and Harper 1997
Biota, fish, g/day	0	0	See below
Biota, meat (game, fowl, other organs), g/day	958	833	Harris 2004 (The caloric requirement specified from fish consumption is compensated for by additional consumption of meat)
Biota, breast milk, mL/day	742 for 1 to 2 yr	742 for 1 to 2 yr	Harris and Harper 1997
Biota, fruit and vegetation (roots, berries, fruits, greens, other) g/day	1350	1172	Harris 2004
Sweat lodge, inhalation, and dermal h/day	2	2	Harris 2004

[a]Harris, S. G., "Exposure Scenario for CTUIR Traditional Subsistence Lifeways" (2004). Harris, S. G., and B. L. Harper, 1997, "A Native American Exposure Scenario," *Risk Analysis*, Vol. 17, No. 6, Plenum Publishing Corporation, New York, New York.

[b]Harris provides an exposure factor breakdown by life stage including: infant (0 to 2 years), child (2-6 years), youth (7-16 years), adult (17-55 years), and elder (56 to 70 years). This column contains the exposure factors for the adult segment. It is comparable to previous exposure factors provided by Harris and Harper (1997).

[c] Age/body weight adjusted exposure factors derived from the following equation:

$$\text{Age} - \text{Body Weight Adjusted Factor} = \sum_{\text{all age inervals}} \prod_{\text{ith age interval}} \frac{\text{Years}_{\text{ith age interval}}}{\text{Years Exposure (70years)}} * \frac{\text{Average Body Weight}_{\text{ith age interval}}}{\text{Adult Body Weight (70kg)}} * \text{Adult}$$

The age-body weight adjustment results in an approximate 13% adjustment.

1

Table C-2. Native American, Traditional Subsistence Lifeways Scenario Chemical-Specific Input Parameters.

COPC	Soil to Plant Transfer[a]	Soil and Plant to Animal Tissue Transfer[a]	Dermal Absorption[b]
Arsenic	0.036	0.002	0.001
Sulfate	00.036	0.002	0.001
Aroclor 1254	0.01	3.097	0.14
Benzo(a)anthracene	0.0202	3.99	0.13
Benzo(a)pyrene	0.0111	3.99	0.13
Benzo(b)fluoranthene	0.01007	3.76	0.13
Benzo(k)fluoranthene	0.0101	3.61	0.13
Chrysene	0.01866	3.99	0.13

NOTE: Transfer factors are not readily available for sulfate. Based on sulfate's inorganic and ionic nature; transfer factors for arsenic were assumed to be conservatively representative for sulfate.

[a] Source: EPA/530-D-98-001A, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities.*
[b] Source: EPA/540/R-99/005, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim.*

Table C-3. Radionuclide Screening Result and 95%UCL Concentrations.

216-A-29 Ditch											
Radionuclide	Am^{241}	Sb^{125}	Cs^{137}	Np^{237}	Pu^{238}	$Pu^{230/240}$	Ra^{226}	Th^{230}	Sr^{90}	H^{3}	$U^{233/234}$
Percent Contribution to Dose	14%	<1%	2%	<1%	<1%	79%	4%	<1%	<1%	ND	<1%
95%UCL pCi/g	30.1	--	22	--	--	200.2	0.65	--	--	--	--
216-B-63 Trench											
Radionuclide	Am^{241}	Cs^{137}	Np^{237}	Ni^{63}	Tc^{99}	Sr^{90}	Th^{230}	H^{3}	--	--	--
Percent Contribution to Dose	<1%	4%	8%	ND	ND	57%	30%	ND	--	--	--
95%UCL pCi/g	--	2.4	0.06	--	--	15.0	0.7	--	--	--	--
216-S-10 Ditch											
Radionuclide	Am^{241}	Cs^{137}	Ni^{63}	Pu^{239}	Ra^{226}	Th^{228}	Th^{230}	Th^{232}	Sr^{90}	H^{3}	--
Percent Contribution to Dose	7%	26%	a	67%	a	a	a	a	2	b	--
95%UCL pCi/g	0.2	4.1	--	1.5	--	--	--	--	0.2	--	--

Table C-3. Radionuclide Screening Result and 95%UCL Concentrations.

216-S-10 Pond											
Radionuclide	Am^{241}	C^{14}	Cs^{137}	Np^{237}	Ni^{63}	$Pu^{239/240}$	Th^{228}	Th^{230}	Sr^{90}	H^{3}	--
Percent Contribution to Dose	4	<1	4	a	b	34	<1	53	4	b	--
95%UCL pCi/g	0.23	12.2[c]	0.8	--	--	0.9	--	0.7	0.7	--	--

[a]Not above background in the 0 to 15-ft interval.
[b]No laboratory analysis in the 0 to 15-ft interval.
[c]Maximum concentration use because 95%UCL exceeded the maximum.

95%UCL = 95th upper confidence level.
ND = Not detected in the 0 to 15-ft depth interval.

Table C-4. Native American, Traditional Subsistence Lifeways Scenario Chemical-Specific Toxicity Factors.

Constituent	Sf_{oral} (Risk/mg/kg d)	$Sf_{inhalation}$ (Risk/mg/kg d)	Sf_{dermal} (Risk/mg/kg d)	RfD_{oral} (mg/kg d)	$RfD_{inhalation}$ (mg/kg d)	RfD_{dermal} (mg/kg d)
Arsenic	1.5E+00	1.5E+01	--	3.0E-04	1.5E+01	--
Sulfate*	--	--	--	7.8 E1	7.8 E1	7.8 E1
Aroclor 1254	--	--	--	2.0E-05	--	2.0E-05
Benzo(a)anthracene	7.30E+00	--	7.30E+00	--	--	--
Benzo(a)pyrene	7.30E+00	--	7.30E+00	--	--	--
Benzo(b)fluoranthene	7.30E+00	--	7.30E+00	--	--	--
Benzo(k)fluoranthene	7.30E+00	--	7.30E+00	--	--	--
Chrysene	7.30E+00	--	7.30E+00	--	--	--

*Derived oral RFD based on U.S. Environmental Protection Agency data. See Equation 4 in Section 2.12.7.2 of the feasibility study.
-- No toxicity data.

Source: Ecology 94-145, *Cleanup Levels and Risk Calculations Under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1.*

RfD = chronic reference dose.
RfD_{dermal} = [illegible]
$RfD_{inhalation}$ = inhalation chronic reference dose.
RfD_{oral} = oral chronic reference dose.
Sf_{dermal} = [illegible]
$Sf_{inhalation}$ = [illegible]
Sf_{oral} = [illegible]

Table C-5. 216-A-29 Ditch Native American Subsistence Lifeways Radiological Dose and Risk.

Time (years)	Total Dose (mrem/y)	Total ELCR	Primary Radionuclide	Percent of Total Dose	Primary Pathway
0	225	3E-3	Pu-239	58	Plant
			Cs-137	28	Ground
1	224	3E-3	Pu-239	58	Plant
			Cs-137	28	Ground
50	183	2E-3	Pu-239	71	Plant
			Cs-137	11	Ground
150	162	1E-3	Pu-239	80	Plant
			Am-241	11	Soil
500	148	1E-3	Pu-239	86	Plant
1,000	139	8E-4	Pu-239	91	Plant

ELCR = excess lifetime cancer risk.

Table C-6. 216-A-29 Ditch Native American Subsistence Lifeways Nonradiological Risk and Hazard Index.

All Life Stages Child to Adult Model (Excluding Infant Milk Consumption)							
Carcinogenic Constituents				**Non-Carcinogenic Constituents**			
Sum ELCR	Primary Constituent	Percent of Total Risk	Primary Pathway	Hazard Index	Primary Constituent	Percent of Total Hazard Index	Primary Pathway
1E-1	Benzo(a)anthracene Chrysene	46 53	Game consumption	1E4	Aroclor 1254	99	Game consumption
Infant Milk Consumption							
Sum ELCR	Primary Constituent	Percent of Total Risk	Primary Pathway	Hazard Index	Primary Constituent	Percent of Total Hazard Index	Primary Pathway
8E-2	Benzo(a)anthracene Chrysene	46 53	Maternal game consumption	3E8	Aroclor 1254	~100	Maternal game consumption

NOTE:
All constituent concentrations arise from isolated detections and doe not reflect integrated exposure
The food chain and infant milk consumption models are conservative and subject to significant uncertainty.

ELCR = excess lifetime cancer risk.

Table C-7. 216-B-63 Trench Native American Subsistence Lifeways Radiological Dose and Risk.

Time (years)	Total Dose (mrem/y)	Total ELCR	Primary Radionuclide	Percent of Total Dose	Primary Pathway
0	88	2E-3	Sr-90	91	Plant
1	86	2E-3	Sr-90	91	Plant
50	27	6E-4	Sr-90	88	Plant
150	4	1E-4	Sr-90 Th-230	54 26	Plant
500	4	1E-4	Th-230	85	Plant
1,000	4	1E-4	Th-230	91	Plant

ELCR = excess lifetime cancer risk.

Table C-8. 216-S-10 Ditch Native American Subsistence Lifeways Radiological Dose and Risk.

Time (years)	Total Dose (mrem/y)	Total ELCR	Primary Radionuclide	Percent of Total Dose	Primary Pathway
0	14	3E-4	Cs-137	85	Ground
1	14	3E-4	Cs-137	84	Ground
50	5	1E-4	Cs-137	72	Ground
150	1	1E-5	Pu-239	66	Plant
500	1	4E-6	Pu-239	96	Plant
1,000	1	3E-6	Pu-239	98	Plant

ELCR = excess lifetime cancer risk.

Table C-9. 216-S-10 Ditch, Native American Subsistence Lifeways Nonradiological Risk and Hazard Index.

All Life Stages Child to Adult Model (Excluding Infant Milk Consumption)							
Carcinogenic Constituents				Non-Carcinogenic Constituents			
Sum ELCR	Primary Constituent	Percent of Total Risk	Primary Pathway	Hazard Index	Primary Constituent	Percent of Total Hazard Index	Primary Pathway
1E-1	Benzo(a)anthracene Benzo(a)pyrene Chrysene	22% 20% 27%	Game consumption	5E3	Aroclor 1254	100%	Game consumption
Infant Milk Consumption							
Sum ELCR	Primary Constituent	Percent of Total Risk	Primary Pathway	Hazard Index	Primary Constituent	Percent of Total Hazard Index	Primary Pathway
5E-1	Benzo(a)anthracene Benzo(a)pyrene Chrysene	22% 20% 27%	Maternal game consumption	1E8	Aroclor 1254	100%	Maternal game consumption

Note:
All constituent concentrations arise from isolated detections and doe not reflect integrated exposure
The food chain and infant milk consumption models are conservative and subject to significant uncertainty.

ELCR = excess lifetime cancer risk.

Table C-10. 216-S-10 Pond Native American Subsistence Lifeways Radiological Dose and Risk.

Time (years)	Total Dose (mrem/y)	Total ELCR	Primary Radionuclide	Percent of Total Dose	Primary Pathway
0	11	2E-4	C-14 Sr-90	39% 33%	Plant
1	8	1E-4	Cs-137 Sr-90	30% 45%	Plant
2.9	3	7E-5	Cs-137 Sr-90	25% 37%	Plant
150	2	5E-5	Th-230 Pu-239	54% 30%	Plant
500	4	1E-4	Th-230	83%	Plant
1,000	4	12E-4	Th-230	90%	Plant

Note there are no nonradiological COPCs for the 216-B-63 Trench site.

ELCR = excess lifetime cancer risk.

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APPENDIX D

COST ESTIMATE BACKUP

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CONTENTS

TABLES

APPENDIX D

COST ESTIMATE BACKUP

D1.0 INTRODUCTION

The feasibility study (FS) provides a logical progression for evaluating sites that require remedial action. During the detailed analysis portion of the FS, nine factors (two threshold, five balancing, and two modifying) are evaluated. This FS evaluated the two threshold criteria and five balancing criteria. The remaining two factors are assessed during the review and comment period. One of the balancing criteria is the cost to implement the various alternative remedial actions.

Cost estimates for the feasibility study (FS) have an accuracy of +50 percent, -30 percent, which is the accuracy specified in EPA/540/R-00/002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, OSWER 9355.0-75. The cost estimates provide a discriminator for deciding between similar protective and implemental alternatives for a specific waste site. Therefore, the costs are relational, not absolute, costs for the evaluation of the alternatives. Cost estimates by waste site were developed using the MAESTRO cost models developed by the Fluor Hanford, Inc. (FH) Project Controls Estimating department.

The various cost elements are taken from EPA/540/R-00/002; the FH contract with the U.S. Department of Energy (DE-AC06-96RL13200, *Contract Between the U.S. Department of Energy, Richland Operations Office, and Fluor Daniel Hanford, Inc.*); R. S. Means; and technical and historical site information. Contingency is applied to the cost estimate to cover potential cost overruns. Contingency covers two types, scope and bid. Scope covers the unknown elements of the alternative as remedial design proceeds, while bid contingency covers the unknown elements of remedial action and operations and maintenance as they proceed. A contingency of 25 percent is applied based on the level of engineering information available at this time. This FS does not evaluate the economies associated with implementing multiple sites or groups with a common alternative or aggregated remediation. They will be considered in the future as part of long-range planning and through the post-record-of-decision activities, such as remedial design. Potential areas of cost sharing to reduce overall remediation costs include the following:

- Remediating all waste sites with a common preferred alternative at the same time
- Sharing mobilization/demobilization costs
- Sharing surveillance and maintenance costs
- Sharing barrier performance monitoring costs.
- Sharing training costs.

Present-net-worth costs were estimated using the real discount rate published in Appendix C of the Office of Management and Budget Circular No. A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, which is effective through the end of January 2004. Programs with durations longer than 30 years use the 30-year interest rate of 3.1 percent. Present-net-worth costs are discussed for each alternative in the following subsections.

Non-discounted costs were calculated because of recommendations presented in EPA/540/R-00/002. Non-discounted constant dollar costs demonstrate the impact of a discount rate on the total present-value cost. The non-discounted costs are presented for comparison purposes only.

Major assumptions are covered in Chapter D3.0. These assumptions are necessary to provide the level of detail necessary for independent review.

D2.0 ALTERNATIVE COST ESTIMATES

This chapter describes the cost estimates based on the remedial alternatives developed in Chapter 6.0 of the FS. This chapter also summarizes the alternatives considered and the total present-worth costs, and provides summary and backup information for costs by waste site or group.

D2.1 ALTERNATIVE 1 – NO ACTION

The no-action alternative represents a situation where no legal restrictions, access controls, or active remedial measures are applied to the waste site. Taking no action implies "walking away from the waste site" and allowing the waste to remain in its current configuration, affected only by natural processes. No maintenance or other activities would be instituted or continued. Chapter 6.0 of the FS describes the no-action alternative.

Because the no-action alternative assumes no further actions will be taken at a waste site, costs are assumed to be zero.

D2.2 ALTERNATIVE 2 – MAINTAIN EXISTING SOIL COVER, MONITORED NATURAL ATTENUATION, AND INSTITUTIONAL CONTROLS

Chapter 6.0 of the FS provides a description of the Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls alternative. Cost models for each representative site are discussed in detail in Section D3.2. The primary annual/periodic costs associated with this alternative are surveillance and cover maintenance and monitored natural attenuation costs. This alternative also includes the cost of long term groundwater monitoring. The costs for these annual/periodic activities were estimated based on the area of the individual waste sites or groups. Tables D-1 and D-2 provide details of the capital and annual/periodic cost estimates.

The unit cost for surveillance and maintenance was assumed to be the same as the current unit cost for surveillance and maintenance activities conducted annually on the waste sites. The unit cost accounts for such activities as site radiation surveys, and repair of the existing soil cover on the sites where it is present. Because the existing soil cover is maintained annually, costs for replacing all or large portions of the existing cover at specified intervals (i.e., every 20 years) are considered unnecessary.

The costs associated with natural attenuation monitoring are divided into three components: radiological surveys of surface soils, spectral gamma logging of vadose zone boreholes, and groundwater monitoring. The costs to perform radiological surveys of surface soils at waste sites are assumed to be similar to those for current survey practices at the sites and are included in the surveillance and maintenance costs.

Vadose zone monitoring costs assume spectral gamma logging of one borehole per waste site to a 15 m (50 ft) depth once every 5 years until the site meets all preliminary remediation goals. This monitoring is considered for sites with high concentrations of contaminants in the shallow zone or near the bottom of crib and trench structures. It also assumes that the service life of vadose zone boreholes is 30 years. Costs are included for logging and periodic replacement of these boreholes until all preliminary remediation goals are met for the site (assume 150 years).

Groundwater monitoring costs likely will be incurred for sites that have high concentrations of mobile contaminants deep within the vadose zone and/or where groundwater contamination is known to have occurred. However, for the purpose of this FS the groundwater sampling activity will be considered as a periodic cost.

Institutional controls, which can have one-time or recurring costs (capital, annual operation and maintenance, or periodic), are non-engineering or legal/administrative measures to reduce or minimize the potential for exposure to site contamination or hazards by limiting or restricting site access.

Examples include institutional controls plan, restrictive covenants, property easements, zoning, deed notices, advisories, groundwater use restrictions, and site information database. An institutional controls plan would describe the controls for a site and how to implement them. A site information database would provide a system for managing data necessary to characterize the current nature and extent of contamination. Institutional controls are project-specific costs that can be an important component of a remedial alternative and, as such, should generally be estimated separately from other costs, usually on a sub-element basis. Institutional controls may need to be updated or maintained, either annually or periodically.

The institutional control cost model used for this alternative was developed by the FH Project Controls and Estimating Department. The duration for institutional controls only considers the initial, "Year-one" period. The annual/periodic activities were based on the length of time required to reach the preliminary remediation goals of 150 years. The combined present-net-worth costs for surveillance and maintenance, natural attenuation monitoring and institutional control activities represent the present-worth cost for this alternative. The real discount rate of 3.1 percent is used for discounting real (constant-dollar) flows for the duration until all preliminary remediation goals are reached at each site (assume 150 years). The non-discounted cost for the 150 year project duration is presented for comparison purposes.

D2.3 ALTERNATIVE 3 – REMOVAL, TREATMENT, AND DISPOSAL

Chapter 6.0 of this FS describes the removal, treatment, and disposal (RTD) alternative. Cost models for each representative site are discussed in detail in Section D3.3. Cost estimates for the RTD alternative are provided in Tables D-3 and D-4. Table D-7 lists the excavation depths for this alternative.

Annual/periodic and institutional control costs were not added to the removal, treatment, and disposal alternative because the contaminants are assumed to be removed to concentrations at or below the preliminary remediation goals. This alternative removes the human health and ecological risks associated with the contaminated soils at each site evaluated in this FS.

The RTD construction activities represent the present-worth cost for this alternative. The real discount rate of 3.1 percent is used for discounting real (constant-dollar) flows for the duration until all preliminary remediation goals are reached at each site (assume 150 years). The non-discounted cost for the 150 year project duration is presented for comparison purposes. For this alternative, the present worth cost and non discounted cost are zeroed-out once the RTD activities are complete.

D2.4 ALTERNATIVE 4 – ENGINEERED BARRIER

Chapter 6.0 of this FS provides a description of the barrier alternative. Cost models for each representative site are discussed in detail in Section D3.4. Cost estimates for the capping alternative are included in Tables D-5 and D-6. Figures D-1 to D-2 shows details of the assumed barrier design for the Evapotranspiration Capillary Barrier (ET).

Operation and maintenance costs for the barrier alternative include barrier performance monitoring and repair costs. For purposes of this FS, all sites will assume annual repairs to the barrier (replacement of 15.2 cm [2 ft] of topsoil layer and revegetation over 10 percent of the barrier area). This is considered a conservative estimate because the barrier has been designed to require minimal maintenance, particularly after vegetation has been established.

Institutional controls are an integral component of the barrier alternative and would be required to prevent both intrusion to the barrier area and activities that might alter the integrity and effectiveness of the barrier. Groundwater monitoring likely would be a part of the barrier alternative. However, the cost estimate considers groundwater sampling periodic costs. Therefore, they are not considered in the capital cost estimates.

The institutional control cost model used for this alternative was developed by the FH Project Controls and Estimating Department. The duration for institutional controls only considers the initial, "Year-one" period. The Annual/Periodic activities were based on the length of time required to reach the preliminary remediation goals (assume 150 years).

The combined present-net-worth costs for remove and dispose construction activities, surveillance and maintenance; natural attenuation monitoring and institutional control activities represent the present-worth cost for this alternative. The real discount rate of 3.1 percent is used for discounting real (constant-dollar) flows for the duration until all preliminary remediation goals are reached at each site (assume 150 years). The non-discounted cost for the 150-year project duration is presented for comparison purposes.

D3.0 ASSUMPTIONS

Assumptions used for Alternatives 3 and 4 are discussed in the following sections.

D3.1 GLOBAL ASSUMPTIONS

D3.1.1 Labor

- Fixed price construction craft labor rates are those listed in Appendix A to the Hanford Site Stabilization Agreement (HSSA). The HSSA rates include base wage, fringe benefits, and other compensation as negotiated between FH and the National Building and Construction Trades Department AFL-CIO. Other factors to cover additional costs for Workman's Compensation, FICA, state and federal unemployment insurance to develop a fully burdened rate by craft have been incorporated. The labor rates used are for 2006.

- FH labor rates for management, engineering, safety oversight, and technical support are based on the FH approved planning rates for FY2006.

D3.1.2 Markups

Direct Cost Factors

- Sales tax has been applied to all materials and equipment purchases at 8.3%.
- Construction consumables are estimated at 3.5% of FP direct craft labor costs to allow for small tools, tape, plastics, gloves, etc.
- General foreman factor of 3% has been applied to FP craft labor hours.

Indirect Cost Factors

- Fixed Price contractor overhead, profit, bond and insurance costs have been applied at 26.5% on FP labor, materials, and equipment.
- FH G&A of 16.5% has been applied to all FH labor, material and equipment. The G&A is also applied to the FP Contractor costs.

D3.1.3 General Assumptions

- FH Cost Estimating Templates for site remediation were used as the basis for each waste site. Standard templates used include trench/ ditch/ crib and ET Capillary Barrier.
- Construction labor, material and equipment units have been estimated based upon standard commercial estimating resources and databases: R. S. Means, Richardson's Process Plant Construction Estimating Standards, and the US Army Corps MCACES Database. The units may have been factored or adjusted by the estimator as appropriate to reflect influences by contract, work site, or other identified project or special conditions.
- Quotes from local commercial sources have been used for materials that need to be acquired for the construction of barriers or temporary improvements.
- Equipment Rates are based on 21 working days per month.
- Equipment operation is based on one shift of 8 hours per day.
- Work week equals 5 days per week.
- Work stoppages or shut downs due to inclement weather are not factored into the estimates or planning schedules for this study.
- Work delays or stoppages due caused by waiting for lab results or approval for backfilling waste site excavations are not factored into the estimates or planning schedules for this study.

- The cost estimates does include costs for design, work plan preparation, or any other preparation costs normally associated with activities occurring before field mobilization.
- Remedial Design Capital Costs are based on EPA/540/R-00/002 Exhibit 5-8. The following guide is used in this study:
  - For projects with construction costs less than $100K – Remedial design is planned at 20% of construction costs.
  - For projects with construction costs from $100K to $500K – Remedial design is planned at 15% of construction costs.
  - For projects with construction costs from $500K to $2M – Remedial design is planned at 12% of construction costs.
  - For projects with construction costs from $2M to $10M – Remedial design is planned at 8% of construction costs.
  - For projects with construction costs greater than $10M – Remedial design is planned at 6% of construction costs.
- Escalation has not been included in the calculations. All costs are present day (FY2006).
- Contingency Rates are based on Section 5.4 of EPA/540/R-00/002.

D3.1.4 Long-Term Groundwater Monitoring Costs

Under each alternative that includes annual inspections and maintenance costs (Alternatives 2 and 4) there will be a cost for periodic groundwater monitoring. The cost associated with periodic groundwater monitoring is distributed equally over applicable closure zones. The following is a description of the periodic groundwater costs.

Periodic groundwater sampling will be performed in each closure zone. Each closure zone will contain three monitoring wells that will be sampled during the periodic sampling event. The present worth cost for the periodic groundwater monitoring program will be the same for each closure zone. That cost then will be divided equally among all the waste sites within that closure zone. A summary of the facility closure zones associated with this FS is presented below.

Closure Zone	Number of Sites in Each Closure Zone
200-E Ponds	55
200-W Ponds	28

Based on historical information from similar Hanford Site planning, the cost to install a compliant monitoring well is approximately $180,000[1] per well. It is assumed that this cost includes all required labor and material. In addition, each of the wells will need to be replaced every 30 years.

Cost to install wells (3 wells) = $180,000/well x 3 wells

[1] Installation/replacement, as well as maintenance and sampling, costs have been rounded-off to facilitate explanation of long-term groundwater program costs.

= $540,000

Replacement costs (3 wells) = $180,000/well x 3 wells

= $540,000 every 30 years

Maintenance will need to be performed on each of the wells every 5 years during the 150-year active monitoring period.

Maintenance costs (3 wells) = $5,000/well x 3 wells

= $15,000 every 5 years

During each sampling event, three groundwater samples will be collected for analysis.

Total analytical cost per sampling event = $1,599

The labor cost of doing all the paper work, labeling, monitoring, and delivery to the laboratory is approximately $300 per well sampled.

Total labor cost = $300/well x 3 wells

= $900/sampling event

Total cost to collect and analyze samples per sampling event = $2,499

Sampling events will occur at the following frequencies:

Year 1	Quarterly (4 sampling events)
Year 2	Semi-annually (2 sampling events)
Years 3 through 5	Annually (3 sampling events)
Years 6 through 10	Every 2 years (3 sampling events)
Years 11 through 50	Every 5 years (8 sampling events)
Years 51 through 150	Every 10 years (10 sampling events).

The present worth cost to conduct a periodic groundwater-monitoring program for each closure zone for 150 years was calculated.

Present-worth cost for long-term groundwater program = $557,583/closure zone.

As a comparison, the non-discounted present worth cost for long-term groundwater program was calculated to compare the effect of a discount rate on the total project cost.

Present worth non-discounted costs for long-term groundwater program = $3,089,808/closure zone.

The present worth cost, on a per site basis, will be added to the calculated costs. Because there are a different number of sites in each closure zone, the following list presents the long-term groundwater monitoring cost per site for each closure zone and the sites included in this FS. The non-discounted long-term groundwater monitoring cost per site is presented in parentheses.

Closure Zone	Number of Sites in Each Closure Zone	Cost Per Site
200-E Ponds	55	$10,138 ($56178)
200-W Ponds	28	$19,914 ($110,350)

Lastly, the following table lists the sites included in this cost estimate, their associated closure zone, and the cost that will be added into the costs for Alternatives 2 and 4. Non-discounted costs are presented in parentheses.

Closure Zone: 200-E Ponds	Cost per Site: $10,138 ($56,178)
216-A-29 Ditch	
Closure Zone: 200-W Ponds	Cost per Site: $19,914 ($110,350)
216-S-10 Ditch	

D3.2 ALTERNATIVE 2 – MAINTAIN EXISTING SOIL COVER, MONITORED NATURAL ATTENUATION, AND INSTITUTIONAL CONTROLS

D3.2.1 General Assumptions

The general assumptions for Alternative 2 are as follows:

D3.2.1.1 Similar to the cost estimates for Alternatives 3 and 4, Alternative 2 costs were calculated for each of the sites. Using the processes presented in the site cost backup text presented in this appendix, equations were used to calculate the cost for each Site using the specific area of each Site.

D3.2.1.2 Typical site areas range from under 100 ft^2 to 1,000,000 ft^2. Because of this difference, larger construction crews will be used for sites larger than 100,000 ft^2. For example, existing cover maintenance will use five trucks to haul material to the site for areas greater than 100,000 ft^2 and one truck for sites less than 100,000 ft^2.

D3.2.1.3 Fencing and monuments/signs for institutional controls and fencing maintenance are considered institutional costs and are considered in this cost estimate.

D3.2.1.4 Periodic groundwater monitoring costs will be added to long term monitoring costs as indicated in Section D3.1.4.

D3.2.1.5 Alternative 2 consists of seven general activities: institutional controls, site inspection and surveillance, existing cover maintenance, natural attenuation monitoring, reporting, site reviews and monitoring. These activities are described for the representative sites in the following sections.

D3.2.1.6 The prices that make up the cost estimate were obtained from one of the following sources:

- *ECHOS Environmental Remediation Cost Data – Unit Price*, 7th Annual Edition (Means 2001a)
- *Facility Construction Cost Data*, 19th Annual Edition (Means 2004b)
- Experience on similar projects.

D3.2.2 Representative Site 216-A-29 Ditch

Institutional Controls Implementation: Preparing and implementing institutional controls is a capital cost and includes office or administrative costs to implement deed restrictions, land-use restrictions, and groundwater-use restrictions. Costs presented in the cost estimates are based on the following:

- Time to produce institutional controls = 200 hours (assumption)
- Labor rate = $56/h (assumption).

Site Inspection and Surveillance: The cost associated with site inspection and surveillance is an operation and maintenance cost. This cost will be incurred annually as long as the alternative is being used. The activities performed under site inspection and surveillance include radiation surveys of surface soil and physical site inspection. Activities may include control of deeply burrowing animals and deep-rooted plants by using herbicide or by physical removal (cost for these items are not included).

<u>Site radiation surveys</u>: For costing purposes, sites 1 acre or smaller are assumed to cost $8,712 for every surveying event. An additional $1,000 will be required for site radiation surveys for every additional 5,000 ft^2 of site area above 1 acre.

- Area of site = 16,117 ft^2 (see Table D-7)
  = minimum 1 acre
- Radiation surveys of surface soil = $8,712/event ($1,000/5,000 ft^2).

<u>Physical site inspection</u>: For costing purposes, sites 1 acre (43,560 ft^2) or smaller are assumed to require a team of two inspectors to perform the activities associated with site inspection and surveillance. An additional crew time will be needed for site inspection and surveillance for site areas larger than 1 acre.

The cost for site inspection and surveillance is based on the following.

- Area of site = 16,117 ft^2 (see Table D-7)
  = minimum 1 acre
- Cost to complete inspection = $781/acre.

Existing Cover Maintenance: The cost associated with existing cover maintenance is an operation and maintenance cost. This cost will be incurred annually as long as the alternative is being used. Because cover maintenance is performed annually, including costs for replacing all or large portions of the existing cover at specified intervals is unnecessary. Rather, cover maintenance is assumed to include replacing cover soils over 10 percent of the area to a depth of

2 ft. The soil used to repair the existing cover is a silt loam and pea gravel mixture. The pea gravel is used to make the soil resistant to wind erosion.

For costing purposes, it is assumed that the silt loam can be acquired for no material cost from an on site borrow source (Area C) and that pea gravel must be purchased at an offsite location. Both materials (silt loam and pea gravel) must be mixed before being transported and placed at the site. It is assumed that periodically a large volume of silt and pea gravel will be mixed and stockpiled by a subcontractor at Area C. This mixture will be for the repair of barrier surfaces. The material and transportation cost of pea gravel, excavation and hauling of the silt, and the blending and stockpiling are estimated to cost $8.95/yd^3$ for the mixture in stockpile at Area C.

For representative sites whose area are greater than 100,000 ft^2, it is assumed for transporting the silt loam/pea gravel mixture to the waste site, that one front end loader, with operator will load dump trucks for transportation to the site. To transport the silt loam to the site, it is assumed that five dump trucks and five drivers will be used and each dump truck will be able to make 2 trips an hour to the site carrying 12 yd^3 per trip. For representative sites less than 100,000 ft^2 in size, one front end loader with one operator will directly load 2 dump trucks making 2 trips an hour to the site.

Once the material is at the waste site it is assumed that the silt loam/pea gravel mixture will be unloaded at the repair area and spread with a Low Ground Pressure (LPG) dozer over the area. A 3,000-gal water truck will be used for dust control during the spreading process. For sites with areas less than 100,000 ft^2 one LGP dozer will be used. For sites with areas greater than 100,000 ft^2, two LGP dozers will be used. Once the silt loam and pea gravel is in place these areas will need to be revegetated. It is assumed that a revegetation crew can reseed one acre in an hour.

In addition to the transportation, spreading, and revegetation costs, it is assumed that FH will have a site engineer on site during cover maintenance activities to provide oversight.

For planning purposes the repair of a 1-acre waste site will require 323 yd^3 of silt loam/pea gravel mixture, 3 hours to load and transport, 4 hours to spread, and 1 hour to reseed. With supervisory over site the cost per acre is $5,728. Waste sites less than 1 acre in size are assumed to cost the same as one acre.

The cover maintenance costs are calculated as follows:

- Cover maintenance (footprint of cover)

- Area of cover system	= 0.37 acres
	= minimum 1 acre
- Area requiring repair (10% of total area)	= 484 yd^2 (minimum)
- Volume of cover repair (2 ft)	= 323 yd^3
- Oversight	= 3 hours.

Natural Attenuation Monitoring: The cost associated with natural attenuation monitoring is an operation and maintenance cost. This cost will be incurred annually as long as the alternative is being used. The cost for natural attenuation monitoring includes spectral gamma logging of vadose zone boreholes.

Vadose zone monitoring costs assume spectral gamma logging of one borehole per waste site to a depth of 50 ft once every 5 years. The service life of a vadose zone borehole is assumed to be

30 years. Therefore, every 30 years a replacement borehole will be drilled. Costs are based on the following:

- Unit cost for vadose zone monitoring= $75/ft of borehole
- Length of borehole drilling = 50 ft
- Cost of vadose zone monitoring = $75/ft x 50 ft = $3,750
- Installation cost of borehole = $50/ft of borehole
- Length of borehole installation = 50 ft
- Cost of borehole installation =$50/ft x 50 ft = $2,500
- Oversight (assumption) = 1 day = 8 hours ($56/h).

Other costs associated with installing replacement boreholes are included on the cost estimate sheets. These items include, but are not limited to, mobilization of a drill rig, decontamination of a drill rig, and handling of investigation derived waste (IDW).

Reporting: Annual and periodic activities will be recorded in an annual report. The report will contain descriptions of activities that occurred during the year. Reports will contain all appropriate/required backup and material purchase information. The cost for the annual reports is based on the following assumption:

- Annual reports = $10,000/report.

Site Reviews: The cost associated with site reviews is an operation-and-maintenance cost. This cost will be incurred every 5 years as long as the alternative is being used. Site reviews will be conducted to assess site conditions and to evaluate the selected alternative and determine whether additional steps toward remediation are required. The cost for the five year site reviews is based on the following assumption:

- 5-year site review = $20,000/review.

Monitoring: Monitoring includes collecting groundwater samples from down-gradient wells to evaluate the performance of the barrier system. Refer to Section D3.1.4.

D3.2.3 Representative Site 216-S-10 Ditch

Institutional Controls Implementation: Preparing and implementing institutional controls is a capital cost and includes office or administrative costs to implement deed restrictions, land-use restrictions, and groundwater-use restrictions. Costs presented in the cost estimates are based on the following:

- Time to produce institutional controls = 200 hours (assumption)
- Labor rate = $56/h (assumption).

Site Inspection and Surveillance: The cost associated with site inspection and surveillance is an operation and maintenance cost. This cost will be incurred annually as long as the alternative is being used. The activities performed under site inspection and surveillance include radiation surveys of surface soil and physical site inspection. Activities may include control of deeply burrowing animals and deep-rooted plants by using herbicide or by physical removal (cost for these items are not included).

Site radiation surveys: For costing purposes, sites 1 acre or smaller are assumed to cost $8,712 for ever surveying event. An additional $1,000 will be required for site radiation surveys for every additional 5,000 ft^2 of site area above 1 acre.

- Area of representative site = 5,663 ft^2 (see Table D-7)
  = minimum 1 acre
- Radiation surveys of surface soil = $8,712/event ($1,000/5,000 ft^2).

Physical site inspection: For costing purposes, sites 1 acre (43,560 ft^2) or smaller are assumed to require a team of two inspectors to perform the activities associated with site inspection and surveillance. An additional crew time will be needed for site inspection and surveillance for site areas larger than 1 acre.

The cost for site inspection and surveillance is based on the following.

- Area of representative site = 5,663 ft^2 (see Table D-7)
  = minimum 1 acre
- Cost to complete inspection = $781/acre.

Existing Cover Maintenance: The cost associated with existing cover maintenance is an operation and maintenance cost. This cost will be incurred annually as long as the alternative is being used. Because cover maintenance is performed annually, including costs for replacing all or large portions of the existing cover at specified intervals is unnecessary. Rather, cover maintenance is assumed to include replacing cover soils over 10 percent of the area to a depth of 2 ft. The soil used to repair the existing cover is a silt loam and pea gravel mixture. The pea gravel is used to make the soil resistant to wind erosion.

For costing purposes, it is assumed that the silt loam can be acquired for no material cost from an on site borrow source (Area C) and that pea gravel must be purchased at an offsite location. Both materials (silt loam and pea gravel) must be mixed before being transported and placed at the site. It is assumed that periodically a large volume of silt and pea gravel will be mixed and stockpiled by a subcontractor at Area C. This mixture will be for the repair of barrier surfaces. The material and transportation cost of pea gravel, excavation and hauling of the silt, and the blending and stockpiling are estimated to cost $8.95/CY for the mixture in stockpile at Area C.

For representative sites whose area are greater than 100,000 ft^2, it is assumed for transporting the silt loam/pea gravel mixture to the waste site, that one front end loader, with operator will load dump trucks for transportation to the site. To transport the silt loam to the site, it is assumed that five dump trucks and five drivers will be used and each dump truck will be able to make 2 trips an hour to the site carrying 12 yd^3 per trip. For representative sites less than 100,000 ft^2 in size, one front end loader with one operator will directly load 2 dump trucks making 2 trips an hour to the site.

Once the material is at the waste site it is assumed that the silt loam/pea gravel mixture will be unloaded at the repair area and spread with a LGP dozer over the area. A 3,000-gal water truck will be used for dust control during the spreading process. For sites with areas less than 100,000 ft^2 one LGP dozer will be used. For sites with areas greater than 100,000 ft^2, two LGP dozers will be used. Once the silt loam and pea gravel is in place these areas will need to be revegetated. It is assumed that a revegetation crew can reseed a one acre in an hour.

In addition to the transportation, spreading, and revegetation costs, it is assumed that FH will have a site engineer on site during cover maintenance activities to provide oversight.

For planning purposes the repair of a 1-acre waste site will require 323 yd^3 of silt loam/pea gravel mixture, 3 hours to load and transport, 4 hours to spread, and one hour to reseed. With supervisory over site the cost per acre is $5,728. Waste sites less than 1 acre in size are assumed to cost the same as one acre.

The cover maintenance costs are calculated as follows:

- Cover maintenance (footprint of cover)

- Area of cover system	= 0.13 Acres
	= minimum 1 acre
- Area requiring repair (10% of total area)	= 484 yd^2
- Volume of cover repair (2 ft)	= 323 yd^3
- Oversight	= 3 hours.

Monitoring for Natural Attenuation: The cost associated with natural attenuation monitoring is an operation and maintenance cost. This cost will be incurred annually as long as the alternative is being used. The cost for natural attenuation monitoring includes spectral gamma logging of vadose zone boreholes.

Vadose zone monitoring costs assume spectral gamma logging of one borehole per waste site to a depth of 50 ft once every 5 years. The service life of a vadose zone borehole is assumed to be 30 years. Therefore, every 30 years a replacement borehole will be drilled. Costs are based on the following:

- Unit cost for vadose zone monitoring= $75/ft of borehole
- Length of borehole drilling = 50 ft
- Cost of vadose zone monitoring = $75/ft x 50 ft = $3,750
- Installation cost of borehole = $50/ft of borehole
- Length of borehole installation = 50 ft
- Cost of borehole installation =$50/ft x 50 ft = $2,500
- Oversight (assumption) = 1 day = 8 hours ($56/h).

Other costs associated with installing replacement boreholes are included on the cost estimate sheets. These items include, but are not limited to, mobilization of a drill rig, decontamination of a drill rig, and handling of investigation derived waste (IDW).

Reporting: Annual and periodic activities will be recorded in an annual report. The report will contain descriptions of activities that occurred during the year. Reports will contain all appropriate/required backup and material purchase information. The cost for the annual reports is based on the following assumption:

- Annual reports = $10,000/report.

Site Reviews: The cost associated with site reviews is an operation-and-maintenance cost. This cost will be incurred every 5 years as long as the alternative is being used. Site reviews will be conducted to assess site conditions and to evaluate the selected alternative and determine whether additional steps toward remediation are required. The cost for the five year site reviews is based on the following assumption:

- 5-year site review = $20,000/review.

Monitoring: Monitoring includes collecting groundwater samples from down-gradient wells to evaluate the performance of the cap system. Refer to Section D3.1.4.

D3.3 ALTERNATIVE 3 – REMOVAL, TREATMENT, AND DISPOSAL

Trenches and cribs are excavated to the required depth and contaminated material is removed to the Environmental Restoration Disposal Facility (ERDF) for disposal. The sites are then remediated.

General Assumptions

The general assumptions for Alternative 3 are as follows:

D3.3.1.1 The field work such as mobilization/demobilization, excavation, backfill, revegetation, and some of the post construction work will be contracted to a Fixed Price Contractor (FP). The Project Management, Radiological Control Technician (RCT) support, sampling, and Safety oversight will be performed by FH. The waste disposal work involved with hauling from the site to ERDF and ERDF dumping cost/fees will be performed by the Environmental Restoration Contractor responsible for ERDF.

D3.3.1.2 Mobilization and Start Up include site training, mobilization of equipment and personnel, installing temporary construction fences, construction of staging/container storage areas and access roads, setting up office, change, and storage trailers with utilities, truck scales, temporary survey buildings, and decontamination areas.

D3.3.1.3 For excavation sites that will have contaminated waste removed to a maximum depth of 62 feet. The sides of the excavation will be sloped at 1.5:1 to the bottom of the excavation; except for those sites that were originally constructed using 2:1 slopes. For sites were the total depth of excavation is less than 5 ft the sloping of the sides of the excavation is not required. During the removal process heavy equipment will be kept out of the excavation site.

D3.3.1.4 For excavation sites overburden will be removed with a 2-3 yd^3 excavator, and two haul trucks. The soil will be stockpiled near by the waste site. A highway truck with water tank trailer is used to control dust during this activity. The production rate for one crew is 127 yd^3/h.

D3.3.1.5 Contaminated waste will be excavated using a 2-3 yd^3 hydraulic crawler excavator. The contaminated soil will be directly placed into lined ERDF Containers and hauled from the excavation site. A highway truck with water tank trailer is used to control dust during this activity. Depending on the volume of waste to move, one to four crews can be working at a site. Crew labor is made up of one operator, one laborer, and one truck driver. The production rate for one crew is 55 yd^3/h. An FH RCT supports the work at 1 ½ hours per excavation crew hour.

D3.3.1.6 Air sampling will be performed during the excavation of contaminated soil. A minimum of two samples will be taken per day. Planning cost per sample is $520 each. The sampling crew is made up of one sampler and RCT.

D3.3.1.7 Soil samples will be taken of the overburden, from ERDF containers, and for verification that the completion of the excavation. The soil sampling cost developed as follows:

- Non Contaminated Soil sampling
  - Maximum of 6 samples or 1 sample per yd^3 which ever is less.
  - Quality Assurance (QA) sample required is 1
  - The planning cost per sample is $754/sample
  - The soil being sampled is the overburden that is uncontaminated and will not be removed from the site.
- Sampling required for waste going to ERDF:
  - One sample is required for every 70 containers
  - There will be a minimum of 6 samples per site
  - QA samples required is a minimum of 1 or 5% of total of ERDF samples which ever is greater.
  - The planning cost per sample is $452/sample
- Pre – Verification Process sampling
  - One sample will be required per 2500 sq m (50m x 50m)(26899 sf)
  - There will be a minimum of 6 samples per site
  - QA samples required are a minimum of 2 or 5% of total the samples which ever is greater
  - The planning cost per sample is $1,146/sample
  - These samples are the preliminary samples needed to see if all of the required waste has been removed from a site being excavated.
  - This process is expected to happen twice during the excavation process.
  - If the samples show that the site has met the requirement then the Verification Process will start.
- Verification Process Sampling
  - One sample will be required per 625 sq m (25m x 25m)(6724 sf)
  - There will be a minimum of 6 samples per site
  - QA samples required are a minimum of 2 or 5% of total the samples which ever is greater

- The planning cost per sample is $1,404/sample
- These samples are the final samples needed to see if all of the required waste has been removed from a site being excavated
- This process happens once during the excavation process.

- Sampling Crews
  - Verification Sampling – 1 hour for each sample taken by a crew made up of one FH RCT and sampler technician.
  - Other sampling (Air, ERDF, Non Contaminated) – 1 hour for each sample taken by a crew made up of one FH RCT and sampler technician.

D3.3.1.8 The ERDF Container handling and loading process starts with a site haul truck picking up an empty container at the staging area. The container is moved to a preparation area where laborers install a bed liner and it is inspected by a ½ time RCT. The haul truck and container proceed to the loading area. After loading the liner is sealed and the container is secured by laborers. The container is moved to the survey building where a team of three RCTs inspect and survey the container and truck for contamination. From there the haul truck and container are weighed on a platform scale and then driven to the storage area. The container is unloaded from the truck at the storage area. Three trucks are required to support each contaminated excavation crew.

D3.3.1.9 ERDF disposal fee, transportation, and handling costs are estimated at $980 per container. An Environmental Restoration Contractor driver and truck/trailer will move a loaded container to ERDF and place an empty container in the staging area. The estimated costs include the rental of the containers used. For planning purposes the capacity of an ERDF container is 11 bank yd^3 or 12.7 loose yd^3 of contaminated waste.

D3.3.1.10 Backfilling is performed by three different operations:

- The moving of the stockpiled overburden back to the excavation site will require one crew. The equipment used by a crew is one 4-5 yd^3 loader, and two haul trucks. Labor is one operator, and two truck drivers. The production rate for one crew is 185 yd^3/h.
- The moving of borrow material to the excavation site is typically performed by one crew hauling from an on site pit source. The equipment used by a crew is one 4-5 yd^3 loader, six 20 yd^3 highway truck/trailers and one water truck. Labor is one operators, and seven truck drivers. The production rate for one crew is 185 yd^3/h.
- Spreading and compaction of the backfill at the site is performed by one crew. The equipment used per crew is one 300-hp dozers, and one 6,000-gal water truck/trailer. Labor is made up of one operator, one truck driver, and one laborer. The production rate for one crew is 185 yd^3/h.

D3.3.1.11 Revegetation of the waste site includes planting native dry land grass using tractors with seed drills and hand broadcasting, hand planting sage brush seedlings, and irrigation four times in the spring or early summer. All disturbed areas such as the waste site, stockpile, staging areas and access roads are to be replanted.

D3.3.1.12 The FH Project Management team is made up of a part time project manager, with a full time field supervisor, and part time engineering support. QA, Rad Con, and Safety also provide oversight along with other support for contract management, and project controls. Total hours for this staff are planned at 22.5 hours per day. The duration of this work is based on total project duration.

D3.3.1.13 The Fix Price Contractor field supervisory team is made up of a full construction manager and field supervisor, along with part time QA, construction safety, and clerical support. Two pickup trucks are included in the cost. Total hours for this staff are planned at 21 hours per day. The duration of this work is based on total project duration.

D3.3.1.14 Demobilization include demobilization of equipment and personnel, removing temporary construction fences, construction of staging/container storage areas, access roads, office/change/storage trailers, truck scales, temporary survey buildings, and decon areas.

D3.3.1.15 Excavation and backfill quantities listed below are based on loose or truck cubic yards. The swell factor used is 15%.

D3.3.1 Representative Site 216-A-29 Ditch

The site work is estimated to 117 working days based on the following breakdown. Time required for remedial engineering, proposal/bidding/selection process, and startup submittals/permits is in addition to the times shown.

- Mobilization: 10 days to mobilize personnel, equipment, and materials, construction staging areas with roads, installing temporary trailers with utilities, setting up survey buildings and decontamination sites.
- Excavate contaminated and uncontaminated soil: 57 days
- Restore site: 40 days to backfill and revegetation of site
- Demobilize: 10 days

Total construction duration = 117 days = 23.4 weeks = 5.6 months

Site Description: The basis for the following information can be found on Table D-7):

- Area of contamination: 2698 ft X 6 ft = 16,188 sq ft
- Depth of clean overburden: 0 to 6 ft below ground surface
- Total excavated depth: 7 to 17 ft below ground surface
- Volume of contaminated soil to be removed: 4,361 yd^3
- Total excavated volume (1.5:1 side slopes): 45,117 yd^3
- Volume of clean overburden: 40,756 yd^3
- Volume of borrow from onsite source: 4,361 yd^3

Mobilization and Demobilization: The activities involved in mobilizing and demobilizing personnel, equipment, and other startup work have been broken down in to several categories.

Typical heavy equipment mobilized to and demobilized from the site is:

- one large dozer
- one 2-3 yd^3 excavator
- one 4-5 yd^3 wheel loader
- six off highway dump trucks
- backhoe loader
- two farm tractors
- motor grader
- six semi tractors and 20 yd^3 bottom dump trailers
- two 4,000 to 6,000-gal water trucks
- one flatbed truck
- three trucks with tilt container beds
- revegetation equipment-seed drill, mulcher, and tiller.

The cost of moving equipment 35 miles from a commercial storage yard to the waste site is planned at $5,950 to mobilize. The cost to demobilize is planned at $16,947, which also includes the decontamination of the equipment included, along with moving the equipment to the storage yard. This includes the FP labor to clean the equipment. The FH RCT labor hours support to decontamination of the construction equipment 40 hours, which is planned at $2,565.

Contractor personnel are given training before the start of work at the site. The cost of training is planned at $28,420. The training will meet site requirements to work at a waste site. The four typical crews were used to calculate the cost of training.

The contractor will setup or construct a temporary staging area, two office trailers, change trailer, storage container, truck scales, and survey building at a cost of $58,768. The rental cost of the trailers, scales and utilities are also included and are based on the duration of the work. Site access roads will also be constructed at a cost of $8,393. Decon areas will be setup as part of the site mobilization at a cost of $47,194. The staging area and roads will be scarified as part of demobilization and the planning costs is $882. The decon areas will also be removed at planning cost of $21,454. The office trailers, truck scales, storage containers will be remove by contractor or off site vender and are considered part to the rental cost.

A temporary fence is constructed around the waste site work area. It will be a steel post with orange mesh fabric. The planning cost for this site is $21,418 to construct and $4,273 to remove.

Before remediation work starts at the waste site, a boundary/topog/location survey is performed by the contractor. The planning cost for this work is $9,775 and is based on the area of the waste site.

Monitoring and Sampling: FH will perform all sampling required.

Soil sampling (non contaminated soil, ERDF certification, Pre Verification, Verification samples). See D3.3.1 General Assumption for sampling rate and process.

- Non contaminated samples (includes QA samples): 7 samples
- ERDF Certification samples(includes QA samples): 7 samples
- Pre Verification samples(includes QA samples): 16 samples
- Verification samples (includes QA samples): 16 samples
- Soil Sampling Cost: $56,534

Air Sampling (Industrial and Environmental) See assumption for sampling rate.

- Industrial Air Samples: 184 samples
- Quarterly Environmental Permit Samples: 6 samples
- Air Sampling Cost: $113,432

Field Sampling FH Crew Support

- Sampling crew: 220 hours
- Sampling crew cost: $25,284.

Site Work: This activity covers the backfilling of the site with the overburden soil and soil hauled from an on site borrow source. There are three items of work for this activity: Loading and hauling the overburden, Loading and hauling the borrow soil, and spreading backfill at the site. Dust control is included in this work. See D3.3.1 General Assumptions for crews and production rates. For this site one crew working one shift per day has been used to for the planned work. Miscellaneous site cleanup covers the labor and equipment to cover a work area cleanup on a weekly basis. Overburden, borrow and backfill quantities are based on loose or truck cubic yards.

- Load/ Haul Overburden Volume: 46,870 yd^3
- Planning cost to Load/ Haul Overburden: $101,412
- Load/ Haul Borrow Soil Volume: 5016 yd^3
- Planning cost to Load/ Haul Borrow Soil: $29,918
- Spread Backfill/Compaction Volume: 51,886 yd^3
- Planning cost to Spread Backfill/Compaction: $115,418
- Miscellaneous Clean up Duration: 28 weeks
- Planning cost for Miscellaneous Clean up: $11,184

Site Revegetation is part of Site Restoration. This work covers the seeding of native dry land grasses; planting sage brush and irrigation for four times during the spring and early summer months. The areas to be re-vegetated include the waste site, overburden stockpile, staging areas and access roads.

- Total area to be re-vegetated: 11 acres
- Planning cost for reseeding: $12,894

- Planning cost for planting sagebrush: $14,408
- Planning cost for Irrigation: $67,370

Soil Excavation:

- Excavation: The work activities covered by Excavation include stripping and stockpiling overburden soil, and excavation of contaminated soil. The contaminated soil is placed directly into the ERDF containers. The moving from of the containers from excavation site and processing of the containers is covered in the section Container Loading and Handling Process. Dust suppression is included in each activity. A description of how the work is performed is discussed in D3.3.1 General Assumptions. For this site one crew working one shift per day has been used to for the planned work. Overburden, and contaminated soil quantities are based on loose or truck cubic yards.
    - Overburden soil removed and stockpiled: 46,870 yd^3
    - Planning cost to remove overburden: $205,247
    - Excavation of contaminated soil: 5,016 yd^3
    - Planning cost to excavate contaminated soil: $26,341
    - RCT support for soil excavation: 387 hours
    - RCT Excavation support cost: $37,232
    - FH Industrial Safety support: 448 hours
    - FH Industrial Safety cost: $30,957
- Container Loading and Handling Process: This activity involves installing liners in containers, hauling the containers to a survey area, weighing, unloading at a temporary storage area. See D3.3.1 General Assumption for detail of how the work is performed. For this site one crew working one shift per day has been used to for the planned work.
    - Number of ERDF Containers hauled, weigh, processed: 390 containers
    - The planning cost for hauling and securing the containers is $36,418
    - The planning cost for preparing containers for loading is $18,485
    - The planning cost for weighing and storing containers: $35,384
    - RCT support for Queue operations survey: 65 hours
    - RCT support for Queue operations planning cost: $2,085
    - RCT support for container radiation surveying: 65 hours
    - RCT support for container radiation surveying planning cost: $12,506
- ERDF Transportation and Disposal: The planning cost for disposal and transportation is $882 per container without overhead charges. This cost includes the disposal fee, the transportation cost from the wastes site staging area to ERDF, and the replacement of the loaded container with an empty container at the staging area.
    - Total number of containers required: 390 containers

- o Cost of containers: $402,774

Construction Staff: The contactor will have a field staff to manage the work at the site. See D3.3.1 General Assumption for a description of the crew and trucks. The duration of this work is based on total project duration. Prepare Final D&D Report covers the cost of the contractor to turn over submittals required to close out the work. This activity is considered a lump sum cost to the project.

- Duration of project: 117 days
- Planning cost for Field management: $336,552
- Planning cost for Final D&D Report: $9,780

Fluor Hanford Project Management: FH will provide oversight for the duration of the construction activities (mobilization through demobilization). See D3.3.1 for a description of the crew. Prepare Final D&D Report covers the cost of the as built documentation process for FH. This activity is considered lump sum cost to the project. The final site survey by FH survey team is part of the as built process and is based on the area of the waste site.

- Duration of project management: 117 days
- Project management cost: $216,863
- Planning cost for Final D&D Report: $2,342
- Area of Final Site Survey: 11 acres
- Planning cost for Final Site Survey: $4,312

Annual Cost: No annual costs are associated with Alternative 3. No site monitoring is required because all of the contaminated waste will be removed.

D3.3.2 Representative Site 216-S-10 Ditch

The site work is estimated to 25 working days based on the following breakdown. Time required for remedial engineering, proposal/bidding/selection process, and startup submittals/permits is in addition to the times shown.

- Mobilization: 10 days to mobilize personnel, equipment, and materials, construction staging areas with roads, installing temporary trailers with utilities, setting up survey buildings and decontamination sites.
- Excavate contaminated and uncontaminated soil: 2 days
- Restore site: 3 days to backfill and revegetation of site
- Demobilize: 10 days

Total construction duration = 25 days = 5 weeks = 1.2 months

Site Description: The basis for the following information can be found on Table D-7)

- Area of contamination: 958 ft X 6 ft = 5,748 sq ft
- Depth of clean overburden: 0 ft below ground surface
- Total excavated depth: 1.5 to 4 ft below ground surface

- Volume of contaminated soil to be removed: 523 yd^3
- Total excavated volume (no side slopes): 523 yd^3
- Volume of clean overburden: 0 yd^3
- Volume of borrow from onsite source: 523 yd^3

Mobilization and Demobilization: The activities involved in mobilizing and demobilizing personnel, equipment, and other startup work have been broken down in to several categories.

Typical heavy equipment mobilized to and demobilized from the site is:

- one large dozer
- one 2-3 yd^3 excavator
- one 4-5 yd^3 wheel loader
- six off highway dump trucks
- backhoe loader
- two farm tractors
- motor grader
- six semi tractors and 20 yd^3 bottom dump trailers
- two 4,000 to 6,000-gal water trucks
- one flatbed truck
- three trucks with tilt container beds
- revegetation equipment -seed drill, mulcher & tiller

The cost of moving equipment 35 miles from a commercial storage yard to the waste site is planned at $5,950 to mobilize. The cost to demobilize is planned at $16,947, which also includes the decontamination of the equipment included, along with moving the equipment to the storage yard. This includes the FP labor to clean the equipment. The FH RCT labor hours support to decontamination of the construction equipment 40 hours, which is planned at $2,565.

Contractor personnel are given training before the start of work at the site. The cost of training is planned at $28,420. The training will meet site requirements to work at a waste site. The four typical crews were used to calculate the cost of training.

The contractor will setup or construct a temporary staging area, two office trailers, change trailer, storage container, truck scales, and survey building at a cost of $38,712. The rental cost of the trailers, scales and utilities are also included and are based on the duration of the work. Site access roads will also be constructed at a cost of $8,226. Decon areas will be setup as part of the site mobilization at a cost of $47,194. The staging area and roads will be scarified as part of demobilization and the planning costs is $882. The decon areas will also be removed at planning cost of $21,454. The office trailers, truck scales, storage containers will be remove by contractor or off site vender and are considered part to the rental cost.

A temporary fence is constructed around the waste site work area. It will be a steel post with orange mesh fabric. The planning cost for this site is $8,217 to construct and $1,639 to remove.

Before remediation work starts at the waste site, a boundary /topog /location survey is performed by the contractor. The planning cost for this work is $2,665 and is based on the area of the waste site.

Monitoring and Sampling: FH will perform all sampling required.

Soil sampling (non contaminated soil, ERDF certification, Pre Verification, Verification samples). See D3.3.1 General Assumption for sampling rate and process.

- Non contaminated samples (includes QA samples): 1 samples
- ERDF Certification samples(includes QA samples): 2 samples
- Pre Verification samples(includes QA samples): 16 samples
- Verification samples (includes QA samples): 8 samples
- Soil Sampling Cost: $35,850

Air Sampling (Industrial and Environmental) See assumption for sampling rate.

- Industrial Air Samples: 4 samples
- Quarterly Environmental Permit Samples: 4 samples
- Air Sampling Cost: $4,776

Field Sampling FH Crew Support

- Sampling crew: 8 hours
- Sampling crew cost: $2,027

Site Work: This activity covers the backfilling of the site with the overburden soil and soil hauled from an on site borrow source. There are three items of work for this activity: Loading and hauling the overburden, Loading and hauling the borrow soil, and spreading backfill at the site. Dust control is included in this work. See D3.3.1 General Assumptions for crews and production rates. For this site one crew working one shift per day has been used to for the planned work. Miscellaneous site cleanup covers the labor and equipment to cover a work area cleanup on a weekly basis. Overburden, borrow and backfill quantities are based on loose or truck cubic yards.

- Load/ Haul Overburden Volume: 0 yd^3
- Planning cost to Load/ Haul Overburden: $0
- Load/ Haul Borrow Soil Volume: 602 yd^3
- Planning cost to Load/ Haul Borrow Soil: $3,590
- Spread Backfill/Compaction Volume: 602 yd^3
- Planning cost to Spread Backfill/Compaction: $1,339
- Miscellaneous Clean up Duration: 6 weeks
- Planning cost for Miscellaneous Clean up: $2,396

Site Revegetation is part of Site Restoration. This work covers the seeding of native dry land grasses; planting sage brush and irrigation for four times during the spring and early summer months. The areas to be re-vegetated include the waste site, overburden stockpile, staging areas and access roads.

- Total area to be re-vegetated: 5 acres
- Planning cost for reseeding: $5,861
- Planning cost for planting sagebrush: $6,549
- Planning cost for Irrigation: $30,622

Soil Excavation:

- Excavation: The work activities covered by Excavation include stripping and stockpiling overburden soil, and excavation of contaminated soil. The contaminated soil is placed directly into the ERDF containers. The moving from of the containers from excavation site and processing of the containers is covered in the section Container Loading and Handling Process. Dust suppression is included in each activity. A description of how the work is performed is discussed in D3.3.1 General Assumptions. For this site one crew working one shift per day has been used to for the planned work. Overburden, and contaminated soil quantities are based on loose or truck cubic yards.
    - Overburden soil removed and stockpiled: 0 yd^3
    - Planning cost to remove overburden: $0
    - Excavation of contaminated soil: 602 yd^3
    - Planning cost to excavate contaminated soil: $3,161
    - RCT support for soil excavation: 8 hours
    - RCT Excavation support cost: $769
    - FH Industrial Safety support: 16 hours
    - FH Industrial Safety cost: $1,105
- Container Loading and Handling Process: This activity involves installing liners in containers, hauling the containers to a survey area, weighing, unloading at a temporary storage area. See D3.3.1 General Assumption for detail of how the work is performed. For this site one crew working one shift per day has been used to for the planned work.
    - Number of ERDF Containers hauled, weigh, processed: 47 containers
    - The planning cost for hauling and securing the containers is $4,376
    - The planning cost for preparing containers for loading is $725
    - The planning cost for weighing and storing containers: $1,507
    - RCT support for Queue operations survey: 8 hours
    - RCT support for Queue operations planning cost: $1,507
    - RCT support for container radiation surveying: 8 hours

  - RCT support for container radiation surveying planning cost: $1,539
- ERDF Transportation and Disposal: The planning cost for disposal and transportation is $882 per container without overhead charges. This cost includes the disposal fee, the transportation cost from the wastes site staging area to ERDF, and the replacement of the loaded container with an empty container at the staging area.
  - Total number of containers required: 47 containers
  - Cost of containers: $55,444

Construction Staff: The contactor will have a field staff to manage the work at the site. See D3.3.1 General Assumption for a description of the crew and trucks. The duration of this work is based on total project duration. Prepare Final D&D Report covers the cost of the contractor to turn over submittals required to close out the work. This activity is considered a lump sum cost to the project.

- Duration of project: 25 days
- Planning cost for Field management: $71,912
- Planning cost for Final D&D Report: $9,780

Fluor Hanford Project Management: FH will provide oversight for the duration of the construction activities (mobilization through demobilization). See D3.3.1 General Assumption for a description of the crew. Prepare Final D&D Report covers the cost of the as built documentation process for FH. This activity is considered lump sum cost to the project. The final site survey by FH survey team is part of the as built process and is based on the area of the waste site.

- Duration of project management: 25 days
- Project management cost: $46,338
- Planning cost for Final D&D Report: $2,342

Annual Cost: No annual costs are associated with Alternative 3. No site monitoring is required because all of the contaminated waste will be removed.

D3.4 ALTERNATIVE 4 – ENGINEERED BARRIER

ET Capillary Barriers will be constructed over the 216-A-29 and 216-S-10 Ditches. For planning purposes the side overlap for all types of barriers will be 20 feet for all exterior sides.

D3.4.1 General Assumptions

The general assumptions for Alternative 4 are as follows:

D3.4.1.1 The field work such as mobilization/demobilization, borrow site excavation, barrier fill, revegetation, and some for the post construction work will be contracted to a FP Contractor. The Project Management, RCT support, sampling, and Safety oversight will be performed by FH.

D3.4.1.2 Mobilization and Start Up include site training, mobilization of equipment and personnel, installing temporary construction fences, construction of access roads, setting up office, and storage trailers with utilities. Air sampling will be performed during the construction of the first layer of the barrier. A minimum of two samples will be taken per day. Planning cost per sample is $520 each. The sampling crew is made up of one sampler and RCT.

D3.4.1.3 Revegetation of the waste site barrier includes planting native dry land grass using tractors with seed drills and hand broadcasting, hand planting sage brush seedlings, and irrigation four times in the spring or early summer. All disturbed areas such as the around the barrier, stockpile, staging areas and access roads are to be replanted.

D3.4.1.4 The FH Project Management team is made up of a part time project manager, with a full time field supervisor, and part time engineering support. QA, Rad Con, and Safety also provide oversight along with other support for contract management, and project controls. Total hours for this staff are planned at 22.5 hours per day. The duration of this work is based on total project duration.

D3.4.1.5 The FP Contractor field supervisory team is made up of a full construction manager and field supervisor, along with part time QA, construction safety, and clerical support. Two pickup trucks are included in the cost. Total hours for this staff are planned at 21 hours per day. The duration of this work is based on total project duration.

D3.4.1.6 Demobilization shall include demobilization of equipment and personnel, removing temporary construction fences, access roads, and office/storage trailers.

D3.4.1.7 There are two on site sources for the fill materials to construct the three soil/fill layers. The source for engineered fill is located at Pit 30 approximately halfway between 200E and 200W. This pit is assumed to have the sufficient quantity for this project. The source for the silt required for Layers 1 and 2 is located at area C about two miles south of 200W.

D3.4.1.8 The sand, drainage gravel, gravel filter, crushed base course, fractured basalt, and the asphalt pavement will be supplied by off site vendors or from commercial gravel pits. These materials are delivered to the waste site by the vendor.

D3.4.1.9 All barrier sites are considered to have settled and are compacted enough to support construction of a barrier with out further settling. Dynamic Compaction is not used for group of barriers.

D3.4.1.10 Sites that will get an ET Barrier are considered level before the constructing the barrier. All sites will require pre-leveling before the start of construction of the barrier. The construction process is the same as the bottom layer of a barrier.

D.3.4.1.11 The ET/Capillary Barrier will be made up of four different layers.

- The bottom layer will be constructed of 20 inches of engineered fill. The construction of the engineered fill requires the excavation of suitable borrow from an on site pit source. The estimated time to complete the fill is based on the production rate of a of a 4-5 yd^3 loader excavating at the pit. All material is screened with a grizzly mounted on a surge bin to remove 4 inch or larger rocks. The six semi tractor trucks with 20 yd^3 bottom dump trailer trailers are needed to keep up with the loader. A 6000 gal water tanker provides dust control at the pit. The Production rate for this work is 185 yd^3/h. The spreading and compaction equipment used at the barrier is a 250-300-hp Dozer with a U-blade to spread fill and two 12 ton vib tandem rollers. Dust control is by a truck with a 6,000-gal water trailer.

- To produce a smooth surface to prevent low areas, the surface of engineered fill is fine graded. Work involves a motor grader, 4-5 yd^3 loader, two 12-ton vib single drum roller, and water tanker. The production rate is 5,000 yd^2/day for the engineered fill surface area. One labourer supports the grader operator as a grade checker. Two engineer technicians set up the grade and elevation control.
- The third layer will be constructed of 6 inches of sand covered with geotextile. Work covers the spreading, compacting and fine grading of the filter sand used for the third layer. The sand will come from an off site source. The sand will be delivered by haul truck spread on the engineered fill layer. The equipment used to construct this layer is a motor grader, two 12-ton vib tandem rollers and a truck with a 6,000-gal water trailer. Production Rate for this work is 208 yd^3/hr. Three equipment operators and one truck driver operates the equipment. One labourer supports the grader operator as a grade checker and to help unload trucks truck.
- Layer 3 will be fine graded to produce a smooth surface before placement of the geotextile. Work involves a motor grader, 4-5 yd^3 loader, one 12-ton vib single drum roller, and water tanker. The production rate is 2500 yd^2/h for the engineered fill surface area. One labourer supports the dozer operator and water truck. Two engineer technicians set up the grade and elevation control.
- A geotextile is placed on top of Layer 3. This item of work covers the placement of needle punched 120 mil polypropylene geotextile over the sand filter layer. The production rate is 150 yd^2/h. Three laborers place and splice the fabric.
- The second layer will be constructed of 20 inches of silt fill. The construction of this layer involves excavating and hauling the silt from the on site pit to the barrier. The production rate is based on a 4-5 yd^3 loader excavating and loading at the pit. There are six trucks that are 20 yd^3 bottom dump trailer and semi tractor combinations. The Production rate for this work is 185 yd^3/h based on the production of the loader. At the barrier the silt is spread with a 200-250 hp low ground pressure dozer. The silt is scarified to prevent over compaction. Dust control at the pit and the barrier uses trucks with a 6,000-gal water trailers.
- The top layer will be constructed of 20 inches of silt/pea gravel fill. The fill material is made up of silt with 15% pea gravel added by weight. The silt is excavated with a 4-5 yd^3 Loader and hauled from the site silt source by two dump trucks to a process area near the pit. Pea gravel from an off site source. It is hauled and stockpiled at the silt process area. A 4-5 yd^3 loader and a pug mill with belt loader are used to mix the silt and gravel. The hauling from the process area and the spreading of the material is the same as described for the second layer.
- The side slopes of the barrier will be covered with fractured basalt 1 foot deep and engineered fill 1 foot deep.
    - The side slopes of the barrier are graded before placing any ballast, gravel filter or fractured basalt. The work involves a 100-150-hp dozer with laser controls, 4-5 yd^3 loader, one 12-ton vib single drum roller, and water tanker. The

production rate is 2500 yd^2/h for the engineered fill surface area. One labourer supports the dozer operator and water truck. Two engineer technicians set up the grade and elevation control.

- o The construction of the ballast and the gravel filter for the side slope follows the grading of the side slope. A truck with a water trailer provides dust control. The Production rate for this work is 125 yd^3/h. The spreading and compaction equipment used at the barrier to spread fill is a 4-5 yd^3 loader, 100-150-hp dozer with laser controls, and one 12-ton vib single drum roller. One laborer supports the dozer operator and water truck. Both gravel layers are 6 inches deep. The ballast and the gravel filter will come from a commercial source and will be delivered and stockpiled at the construction site. The delivered cost for ballast is $19.98/ yd^3 and for gravel filter is $16.70/$yd^3$ based on vendor quotes.

- o The fractured basalt with silt layer is the last layer of the side slopes to be constructed. The fractured basalt will come from a commercial source and will be delivered and stockpiled at the construction site. The delivered cost of the rock is based on vendor quotes of $21.61/$yd^3$. The silt will come from the same source as Layer 2. The silt will be delivered and stockpiled at the barrier site when the silt for Layer 2 is being hauled. One loader and 300-hp dozer are used to place the basalt on the fill slope. One laborers support the work. The production rate is 70 yd^3/h. A quarter time water truck and driver are used for dust control.

D3.4.1.13 Instrumentation is not included for this series of barriers.

D3.4.1.14 After completion of the barrier construction work a 4-ft steel post with chain fence is to be built around the site. The fence location is at the toe of the barrier slope.

D.3.4.1.15 During the construction of the barrier compaction testing will be performed on the three layers of fill. The lower level will require that a minimum level of compaction has been reached. While the top two layers will be tested to ensure that the fill does not become over compacted.

D3.3.1.16 The yd^3 quantities listed below are based on loose or truck cubic yards. The swell factor used is 15%.

D3.4.2 Representative Site 216-A-29 Ditch

The site work is estimated to 112 working days based on the following breakdown. Time required for remedial engineering, proposal/bidding/selection process, and startup submittals/permits is in addition to the times shown. The construction process will use one crew to perform the work.

- Mobilization: 15 days to mobilize personnel, equipment, and materials, construction staging areas with roads, installing temporary trailers with utilities, setting up survey buildings and decontamination sites.
- Capping: 83 days
- Revegetation: 4 days
- Demobilize: 10 days

Total construction duration = 112 days = 22.4 weeks = 5.6 months

Site Description: The basis for the following information can be found on Table D-7):

- Area of waste site contamination: 2794 ft X 6 ft = 16,764 ft^2
- Area of waste site with 20-ft overlap: (2794+(20X2)) X (6+(20X2)) = 125,948 ft^2
- Type of Cap: ET Capillary
- Side Slope of Cap: 3:1
- Depth of pre leveling required: ~~0~~ 3 ft
- Depth Cap: ~~9~~ 5.5 ft
- Horizontal Side Slope Distance: 22.8 ft
- Cap foot print length: (2794+((20+22.8)X2)) = 2880 ft
- Cap foot print width: (6+((20+22.8)X2)) = 92 ft
- Area of Cap foot print: 2880 X 92 = 263960 sq ft

Mobilization and Demobilization: The activities involved in mobilizing and demobilizing personnel, equipment, and other startup work have been broken down in to several categories.

Typical heavy equipment mobilized to and demobilized from the site is:

- Large dozer
- two LPG dozers
- 2-3CY excavator
- two 4-5CY wheel loaders
- Soil Vib Rollers
- two off highway dump trucks
- Pug Mill with hoppers and belt loaders
- two farm tractors
- motor grader
- six semi tractors and 20CY bottom dump trailers
- two 4,000 to 6,000-gal water trucks
- flatbed truck
- revegetation equipment -seed drill, mulcher,& tiller

The cost of moving equipment 35 miles from a commercial storage yard to the waste site is planned at $25,649 to mobilize and to demobilize.

Contractor personnel are given training before the start of work at the site. The cost of training is planned at $9,581. The training will meet site requirements to work at a waste site.

The contractor will setup or construct a temporary staging area, office trailers, change trailer, and storage container, at a cost of $ 24,912. The rental cost of the trailers, and utilities are also included and are based on the duration of the work. Site access roads will also be constructed at a cost of $ 8,784. The staging area and roads will be scarified as part of demobilization and the planning costs is $699. The office trailers, storage containers will be removed by contractor or off site vender and are considered part to the rental cost.

A temporary fence is constructed around the waste site work area. It will be a steel post with orange mesh fabric. The planning cost for this site is $31,851 to construct and $4,967 to remove.

Before remediation work starts at the waste site, a boundary /topog /location survey is performed by the contractor. The planning cost for this work is $20,992 and is based on the area of the waste site.

Fluor Hanford Sampling and Crew Support: FH will perform all sampling required.

Air Sampling (Industrial and Environmental) See assumption for sampling rate.

- Industrial Air Samples: 33 samples
- Quarterly Environmental Permit Samples: 6 samples
- FH Sampling crew: 35 hours
- Air Sampling Cost: $ 28,874

Site Work:

- **Installation of Cap:** Site 216-A-29 Ditch requires an ET Capillary Barrier. The design, construction, and production rates for the barrier are discussed above in the General Assumptions. The yd^3 quantities are based on loose or truck cubic yard.

  These areas and volumes will be used for the cost estimates:
  - Area (footprint) of Barrier: 264,960 ft^2
  - Pre level Volume: 32,280 yd^3
  - Layer 4 - Volume of engineered fill: 15,035 yd^3
  - Layer 3 – Volume of Sand: 4,105 yd^3
  - Layer 3 – area of geotextile: 21,416 yd^2
  - Layer 2 – Volume of silt: 11,801 yd^3
  - Layer 1 – Volume of silt & pea gravel mixture: 9832 yd^3
  - Side Slope - Volume gravel filter: 2,184 yd^3
  - Side Slope - Volume Ballast: 2,184 yd^3
  - Side Slope – Volume fractured basalt and silt: 6,084 yd^3
- The planning costs for the layers are:
  - Pre Level: $340,692
  - Layer 4 Engineered Fill: $166,877
  - Layer 3 Sand: $208,055
  - Layer 2 Silt: $107,497

    - Layer 1 Silt & Pea gravel: $89,561
    - Side Slope: $712,141
    - Silt Pit Process Operations: $112,131
- Other items of work that are involved in the construction of the barrier are construction survey/ elevation control, soils compaction testing, site cleanup, construction of a site fence, and FH RCT support. Miscellaneous site cleanup covers the labor and equipment to cover a work area cleanup on a weekly basis.
    - Planning cost for Surveying: $ 69,072
    - Planning cost for Soils Compaction Testing: $39,369
    - Planning cost for Miscellaneous Clean up: $1,693
    - Planning cost for Site Fence: $29,843
    - RCT support for Construction cost: $35,135
- Site Revegetation is part of Site Work. This work covers the seeding of native dry land grasses; planting sagebrush and irrigation for four times during the spring and early summer months. The areas to be re-vegetated include the waste site cap, construction staging areas and temporary access roads.
    - Total area to be re-vegetated: 15 acres
    - Planning cost for reseeding: $10,600
    - Planning cost for planting sagebrush: $14,781
    - Planning cost for Irrigation: $75,438

Fix Price Contractor Field Management: The contactor will have a field staff to manage the work at the site. See D3.3.1 General Assumption for a description of the crew and trucks. The duration of this work is based on total project duration. Prepare Final D&D Report covers the cost of the contractor to turn over submittals required to close out the work. The activity is considered lump sum cost to the project.

- Duration of project: 112 days
- Planning cost for Field management: $405,721
- Planning cost for Final D&D Report: $10,986

Fluor Hanford Project Management: FH will provide oversight for the duration of the construction activities (mobilization through demobilization). See D3.4.1 General Assumption for a description of the crew. Prepare Final D&D Report covers the cost of the as built documentation process for FH. The activity is considered lump sum cost to the project.

- Duration of project management: 112 days
- Project management cost: $216,620
- Planning cost for Final D&D Report: $2,342

Surveillance and Cap Maintenance: The costs associated with surveillance and cap maintenance are operation and maintenance costs and are incurred annually. The activities performed during surveillance and cap maintenance are expected to be the same as those described for site inspection/surveillance and existing cover maintenance cost items under Alterative 2. Refer to the Alternative 2 assumptions for these cost items. The surveillance and cap maintenance costs are calculated as follows:

- Surveillance/inspections (footprint of cap system)

- Area of cap system	= 264,960 ft^2 =6.1 Acre
- Team hours to complete inspections	= 5.3 days (1 day for every 50,000 ft^2)
- Daily inspection rate (2 Techs)	= \$896/day (\$56/h/person)
- Barrier Cover Inspection of surface soil	= \$896 X 5.3 days
	= \$4,749/event
- Radiation surveys of surface soil	= \$1,000 for every 5,000 ft^2
	= \$52,992/event

- Cap maintenance (footprint of cap system)

- Area of cap system	=6.1 Acre
- Area requiring repair (10% of total area)	=2,952 yd^2
- Volume of cap repair (2 ft)	=1969 yd^3
- Oversight (soil placement 130 yd^3/h)	=1.9 days- Oversight (vegetation
5,000 yd^2/h) =0.4 day	

Oversight performed by one FH Engineer at \$60/h.

Monitoring: Monitoring includes collecting groundwater samples from down-gradient wells to evaluate the performance of the cap system. Refer to Section D3.1.4.

D3.4.3 Representative Site 216-S-10 Ditch

The site work is estimated to 78 working days based on the following breakdown. Time required for remedial engineering, proposal/bidding/selection process, and startup submittals/permits is in addition to the times shown. The construction process will use one crew to perform the work.

- Mobilization: 15 days to mobilize personnel, equipment, and materials, construction staging areas with roads, installing temporary trailers with utilities, setting up survey buildings and decontamination sites.
- Barrier Construction: 51 days
- Revegetation: 2 days
- Demobilize: 10 days

Total construction duration = 78 days = 15.6 weeks = 3.7 months

Site Description: The basis for the following information can be found on Table D-7):

- Area of waste site contamination: 958 ft X 6 ft = 4,590 ft^2
- Area of waste site with 20-ft overlap: (958+(20X2)) X (6+(20X2)) = 45,908 ft^2

- Type of Cap: ET Capillary
- Side Slope of Cap: 3:1
- Depth of pre leveling required: 9 ft
- Depth Cap: 5.5 ft
- Horizontal Side Slope Distance: 22.8 ft
- Cap foot print length: (958+((20+22.8)X2)) = 1044 ft
- Cap foot print width: (6+((20+22.8)X2)) = 92 ft
- Area of Cap foot print: 1044 X 92 = 96,048 ft^2

Mobilization and Demobilization: The activities involved in mobilizing and demobilizing personnel, equipment, and other startup work have been broken down in to several categories.

Typical heavy equipment mobilized to and demobilized from the site is:

- Large dozer
- two LPG dozers
- 2-3CY excavator
- two 4-5CY wheel loaders
- Soil Vib Rollers
- two off highway dump trucks
- Pug Mill with hoppers and belt loaders
- two farm tractors
- motor grader
- six semi tractors and 20CY bottom dump trailers
- two 4,000 to 6,000-gal water trucks
- flatbed truck
- revegetation equipment - seed drill, mulcher, and tiller.

The cost of moving equipment 35 miles from a commercial storage yard to the waste site is planned at $25,649 to mobilize and to demobilize.

Contractor personnel are given training before the start of work at the site. The cost of training is planned at $9,581. The training will meet site requirements to work at a waste site.

The contractor will setup or construct a temporary staging area, office trailers, change trailer, and storage container, at a cost of $17,247. The rental cost of the trailers, and utilities are also included and are based on the duration of the work. Site access roads will also be constructed at a cost of $8,784. The staging area and roads will be scarified as part of demobilization and the planning costs is $699. The office trailers, storage containers will be removed by contractor or off site vender and are considered part to the rental cost.

A temporary fence is constructed around the waste site work area. It will be a steel post with orange mesh fabric. The planning cost for this site is $13,412 to construct and $2,091 to remove.

Before remediation work starts at the waste site, a boundary /topog /location survey is performed by the contractor. The planning cost for this work is $9,142 and is based on the area of the waste site.

Fluor Hanford Sampling and Crew Support: FH will perform all sampling required.

Air Sampling (Industrial and Environmental) See assumption for sampling rate.

- Industrial Air Samples: 33 samples
- Quarterly Environmental Permit Samples: 6 samples
- FH Sampling crew: 39 hours
- Air Sampling Cost: $28,874

Site Work:

- **Installation of Cap:** Site 216-S-10 Ditch requires an ET Capillary Barrier. The design, construction and production rates for the barrier are discussed above in the General Assumptions.

  These areas and volumes will be used for the cost estimates:

- o Area (footprint) of Cap: 96,048 ft^2
- o Pre level Volume: 42,240 yd^3
- o Layer 4 - Volume of engineered fill: 5,390 yd^3
- o Layer 3 – Volume of Sand: 1,466 yd^3
- o Layer 3 – area of geotextile: 7,647 yd^2
- o Layer 2 – Volume of silt: 4,196 yd^3
- o Layer 1 – Volume of silt & pea gravel mixture: 3,474 yd^3
- o Side Slope - Volume gravel filter: 823 yd^3
- o Side Slope - Volume Ballast: 823 yd^3
- o Side Slope – Volume fractured basalt and silt: 2298 yd^3
- The planning costs for the layers are:
  - o Pre Level: $445,813
  - o Layer 4 Engineered Fill: $59,825
  - o Layer 3 Sand : $74,292
  - o Layer 2 Silt: $38,222
  - o Layer 1 Silt & Pea gravel: $31,645
  - o Side Slope: $176,807
  - o Silt Pit Process Operations: $39,623

- Other items of work that are involved in the construction of the barrier are construction survey/ elevation control, soils compaction testing, site cleanup, construction of a site fence, and FH RCT support. Miscellaneous site cleanup covers the labor and equipment to cover a work area cleanup on a weekly basis.
    - Planning cost for Surveying: $27,764
    - Planning cost for Soils Compaction Testing: $30,274
    - Planning cost for Miscellaneous Clean up: $1,69.
    - Planning cost for Site Fence: $11,403
    - RCT support for Construction cost: $35,408
- Site Revegetation is part of Site Work. This work covers the seeding of native dry land grasses; planting sagebrush and irrigation for four times during the spring and early summer months. The areas to be re-vegetated include the waste site cap, construction staging areas and temporary access roads.
    - Total area to be re-vegetated: 7 acres
    - Planning cost for reseeding: $4,947
    - Planning cost for planting sagebrush: $6,898
    - Planning cost for Irrigation: $35,204

Fix Price Contractor Field Management: The contactor will have a field staff to manage the work at the site. See D3.3.1 General Assumption for a description of the crew and trucks. The duration of this work is based on total project duration. Prepare Final D&D Report covers the cost of the contractor to turn over submittals required to close out the work. The activity is considered lump sum cost to the project.

- Duration of project: 78 days
- Planning cost for Field management: $282,555
- Planning cost for Final D&D Report: $10,986

Fluor Hanford Project Management: FH will provide oversight for the duration of the construction activities (mobilization through demobilization). See D3.4.1 General Assumption for a description of the crew. Prepare Final D&D Report covers the cost of the as built documentation process for FH. The activity is considered lump sum cost to the project.

- Duration of project management: 78 days
- Project management cost: $150,861
- Planning cost for Final D&D Report: $2,342

Surveillance and Cap Maintenance: The costs associated with surveillance and cap maintenance are operation and maintenance costs and are incurred annually. The activities performed during surveillance and cap maintenance are expected to be the same as those described for site inspection/surveillance and existing cover maintenance cost items under Alterative 2. Refer to the Alternative 2 assumptions for these cost items. The surveillance and cap maintenance costs are calculated as follows:

- Surveillance/inspections (footprint of cap system)
  - Area of cap system = 96,048 ft^2 = 2.2 Acre
  - Team hours to complete inspections = 1.9 days (1 day for every 50,000 ft^2)
  - Daily inspection rate (2 Techs) = \$896/day (\$56/h/person)
  - Barrier Cover Inspection of surface soil = \$896 X 1.9 days = \$1702/event
  - Radiation surveys of surface soil = \$1,000 for every 5,000 ft^2 = \$19,210/event
- Cap maintenance (footprint of cap system)
  - Area of cap system = 2.28 Acre
  - Area requiring repair (10% of total area) = 1,067 yd^2
  - Volume of cap repair (2 ft) = 715 yd^3
  - Oversight (soil placement 130 yd^3/h) = 0.7 day
  - Oversight (vegetation 5,000 yd^2/h) = 0.2 day

Oversight performed by one FH Engineer at \$60/h.

Monitoring: Monitoring includes collecting groundwater samples from down-gradient wells to evaluate the performance of the cap system. Refer to Section D3.1.4.

D4.0 REFERENCES

DE-AC06-96RL13200, 1996, *Contract Between the U.S. Department of Energy, Richland Operations Office, and Fluor Daniel Hanford, Inc.*, U.S. Department of Energy, Richland Operations Office, Richland, Washington, as amended.

EPA/540/R-00/002, 2000, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, OSWER 9355.0-75, U.S. Environmental Protection Agency, Washington, D.C.

OMB Circular No. A-94, 2002, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs,* Office of Management and Budget, Washington, D.C., as revised.

Means, R. S., 2001a, *ECHOS Environmental Remediation Cost Data – Unit Price*, 7th Annual Edition, Robert S. Means Company, Kingston, Massachusetts.

Means, R. S., 2004b, *Facility Construction Cost Data*, 19th Annual Edition, Robert S. Means Company, Kingston, Massachusetts.

Site Stabilization Agreement for All Construction Work for the U.S. Department of Energy at the Hanford Site, 1984, as amended, commonly known as the Hanford Site Stabilization Agreement (original title, *Site Stabilization Agreement, Hanford Site, between J. A. Jones Construction Services Company and Morrison-Knudsen Company, Inc., and the Building and Construction Trades Department of the AFL-CIO and its affiliated international unions, and the International Brotherhood of Teamsters, Chauffeurs, Warehousemen, and Helpers of America*).

Table D-1. 216-A-29 Ditch Alternative 2.

Item	**Item Cost**				**Notes**
	Annually	**Per 3 Years**	**Per 5 Years**	**Per 30 Years**	
Existing Cover Inspection	$781				Cost is based on a two-person crew (8 h/day. It is assumed to require 1 day to inspect sites up to 50,000 ft^2 in size. An additional day is required for each additional 50,000 ft^2. The site area -
Radiation Survey of Site Surface	$8,712				Cost is based on $1,000 for every 5,000 ft^2. The site area -
Existing Cover Maintenance	$5,723				Cost includes the purchase of soil to repair ruts and holes over 10% of the site area
Vadose Zone Monitoring Replacement			$3,473	$7,130	Replacement of vadose zone monitoring occurs once every 5 years. Bore hole replacement occurs once every 30 years
Prepare and Issue Sampling Reporting			$10,000		Obtain lab, prepare sampling plan, document sampling event and results
Site Reviews			$20,000		Prepare Site Condition Report every 5 years
Ground water monitoring well replacement			$9,818		Includes the installation, maintenance, and replacement of three monitoring wells
Groundwater sampling and analysis	$4,180				Represents the non-discounted cost of sampling and analysis in years 1-150

Table D-2. 216-S-10 Ditch Alternative 2.

Item	Item Cost				Notes
	Annually	Per 3 Years	Per 5 Years	Per 30 Years	
Existing Cover Inspection	$781				Cost is based on a two-person crew (8 h/day. It is assumed to require 1 day to inspect sites up to 50,000 ft2 in size. An additional day is required for each additional 50,000 ft^2. The site area -
Radiation Survey of Site Surface	$8,712				Cost is based on $1,000 for every 5,000 ft^2. The site area -
Existing Cover Maintenance	$5,723				Cost includes the purchase of soil to repair ruts and holes over 10% of the site area.
Vadose Zone Monitoring Replacement			$3,473	$7,130	Replacement of vadose zone monitoring occurs once every 5 years. Bore hole replacement occurs once every 30 years.
Prepare and Issue Sampling Reporting			$10,000		Obtain lab, prepare sampling plan, document sampling event and results.
Site Reviews			$20,000		Prepare Site Condition Report every 5 years.
Ground water monitoring well replacement			$9,818		Includes the installation, maintenance, and replacement of three monitoring wells.
Groundwater sampling and analysis	$4,180				Represents the non-discounted cost of sampling and analysis in years 1-150.

Table D-3. 216-A-29 North Ditch – Alternative 3 – Removal, Treatment, and Disposal. (4 Pages)

FLUOR HANFORD
DD / FH
TRENCH TEMPLATE
EST NO. CS29NT3C

200-CS-1 FEASIBILITY STUDY
216-A-29 North Ditch - Alt 3 RTD
FT_R02N - WORK BREAKDOWN STRUCTURE SUMMARY

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EST WBS	ESTIMATE WBS DESCRIPTION	ESTIMATE SUBTOTAL	TOTAL INDIRECTS	SUB TOTAL	ESCALATN TOTAL	ESCAL %	SUB TOTAL	CONT %	CONTGNCY TOTAL	TOTAL AMOUNT
1.03.02 MOBILIZATION / DEMOBILIZATION										
302010301	PERSONNEL TRAINING-BASIC	24,388	4,031	28,420	0	0.00	28,420	0	0	28,420
302020102	WASTE SITE SURVEY	6,863	1,134	7,997	0	0.00	7,997	0	0	7,997
302020203	MOB SITE WORK EQUIPMENT	5,106	844	5,950	0	0.00	5,950	0	0	5,950
302020301	INSTALL TEMP CONST BARRIER	17,117	2,829	19,946	0	0.00	19,946	0	0	19,946
302020302	TEMP OFFICE & FACILITIES	41,826	6,913	48,740	0	0.00	48,740	0	0	48,740
302020304	CONSTRUCT DECON AREA	40,499	6,694	47,194	0	0.00	47,194	0	0	47,194
302020305	TEMP SITE ROAD	7,203	1,190	8,393	0	0.00	8,393	0	0	8,393
302090101	REMOVE TEMP CONST BARRIER	3,414	564	3,979	0	0.00	3,979	0	0	3,979
302090102	REMOVE DECON AREA	18,411	3,043	21,454	0	0.00	21,454	0	0	21,454
302090103	REMOVE ROADS & PARKING	757	125	882	0	0.00	882	0	0	882
302090301	DEMOBILIZE CONSTRUCTION EQUIPMENT	14,543	2,404	16,947	0	0.00	16,947	0	0	16,947
302090304	FH DECON CONSTRUCTION EQUIPMENT SUPPORT	2,201	363	2,565	0	0.00	2,565	0	0	2,565
SUBTOTAL MOBILIZATION / DEMOBILIZATION		182,332	30,139	212,472	0	0.00	212,472	0	0	212,472
1.03.03 MONITORING /SAMPLING										
302030102	SITE AIR MONITORING	46,800	6,931	53,731	0	0.00	53,731	0	0	53,731
302030302	RAD SAMPLING,ANALYSIS-VEG/SEDM/SOIL	51,646	7,648	59,294	0	0.00	59,294	0	0	59,294
302030403	FH SAMPLE CREW	11,156	1,844	13,000	0	0.00	13,000	0	0	13,000
SUBTOTAL MONITORING /SAMPLING		109,602	16,423	126,026	0	0.00	126,026	0	0	126,026
1.03.04 SITE WORK										
302080101	LOAD/HAUL OVERBURDEN FROM STOCKPILE	42,011	6,944	48,956	0	0.00	48,956	0	0	48,956
302080102	LOAD/HAUL FROM BORROW SITE	7,114	1,176	8,290	0	0.00	8,290	0	0	8,290
302080201	BACKFILL & COMPACTION	45,844	7,578	53,422	0	0.00	53,422	0	0	53,422
302080301	MECH SEEDING GRASS	10,059	1,662	11,722	0	0.00	11,722	0	0	11,722
302080302	SHRUBS/TREES/GROUNDCOVER	11,240	1,858	13,098	0	0.00	13,098	0	0	13,098
302080303	IRRIGATION	52,558	8,687	61,245	0	0.00	61,245	0	0	61,245
302090104	MISC CLEANUP	5,484	906	6,390	0	0.00	6,390	0	0	6,390
SUBTOTAL SITE WORK		174,313	28,814	203,127	0	0.00	203,127	0	0	203,127
1.03.05 SOIL EXCAVATION										

Table D-3. 216-A-29 North Ditch – Alternative 3 – Removal, Treatment, and Disposal. (4 Pages)

EST WBS	ESTIMATE WBS DESCRIPTION	ESTIMATE SUBTOTAL	TOTAL INDIRECTS	SUB TOTAL	ESCALATN TOTAL	ESCAL %	SUB TOTAL	CONT %	CONTGNCY TOTAL	TOTAL AMOUNT
302040101	UNCONTAMINATED/OVERBURDEN SOIL	85,026	14,054	99,080	0	0.00	99,080	0	0	99,080
302040102	EXCAVATE CONTAMINATED SOIL W/DUST CONTR	6,264	1,035	7,299	0	0.00	7,299	0	0	7,299
302040106	RCT SUPPORT	14,365	2,374	16,740	0	0.00	16,740	0	0	16,740
302040107	INDUSTRIAL SAFETY TECH SUPPORT	12,112	1,708	13,820	0	0.00	13,820	0	0	13,820
302060403	LOAD/HAUL RAD CONT SOIL	8,683	1,435	10,119	0	0.00	10,119	0	0	10,119
302060501	QUEUE AREA OPERATIONS	14,793	2,445	17,238	0	0.00	17,238	0	0	17,238
302060502	FH QUEUE AREA OPERATIONS	522	86	609	0	0.00	609	0	0	609
302060601	LOW ACTIVITY CONTAINERS	4,433	732	5,166	0	0.00	5,166	0	0	5,166
302060603	FH DECONTAMINATE CONTAINERS	3,137	518	3,655	0	0.00	3,655	0	0	3,655
302060801	ERDF DISPOSAL COST	102,976	15,250	118,227	0	0.00	118,227	0	0	118,227
SUBTOTAL SOIL EXCAVATION		252,314	39,642	291,957	0	0.00	291,957	0	0	291,957
1.03.07 CONSTRUCTION STAFF										
302090201	PREPARE FINAL D&D REPORT	8,393	1,387	9,780	0	0.00	9,780	0	0	9,780
303020101	CONSTRUCTION FIELD STAFF-FP	160,451	26,522	186,973	0	0.00	186,973	0	0	186,973
SUBTOTAL CONSTRUCTION STAFF		168,844	27,909	196,754	0	0.00	196,754	0	0	196,754
1.03.08 PROJECT MANAGEMENT										
302090201	PREPARE FINAL D&D REPORT	2,010	332	2,342	0	0.00	2,342	0	0	2,342
302090203	FINAL SITE SURVEY -FH	3,043	491	3,535	0	0.00	3,535	0	0	3,535
303010101	PROJECT MANAGEMENT-FH-CPT	103,389	17,090	120,479	0	0.00	120,479	0	0	120,479
SUBTOTAL PROJECT MANAGEMENT		108,443	17,914	126,357	0	0.00	126,357	0	0	126,357
TOTALS		995,851	160,844	1,156,695	0	0.00	1,156,695	0	0	1,156,695

Table D-3. 216-A-29 South Ditch – Alternative 3 – Removal, Treatment, and Disposal. (4 Pages)

FLUOR HANFORD
DD / FH
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200-CS-1 FEASIBILITY STUDY
216-A-29 South Ditch - Alt 3 RTD
FT_R02N - WORK BREAKDOWN STRUCTURE SUMMARY

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EST WBS	ESTIMATE WBS DESCRIPTION	ESTIMATE SUBTOTAL	TOTAL INDIRECTS	SUB TOTAL	ESCALATN TOTAL	ESCAL %	SUB TOTAL	CONT %	CONTGNCY TOTAL	TOTAL AMOUNT
1.03.02 MOBILIZATION / DEMOBILIZATION										
302010301	PERSONNEL TRAINING-BASIC	24,388	4,031	28,420	0	0.00	28,420	0	0	28,420
302020102	WASTE SITE SURVEY	3,050	504	3,554	0	0.00	3,554	0	0	3,554
302020203	MOB SITE WORK EQUIPMENT	5,106	844	5,950	0	0.00	5,950	0	0	5,950
302020301	INSTALL TEMP CONST BARRIER	7,548	1,247	8,796	0	0.00	8,796	0	0	8,796
302020302	TEMP OFFICE & FACILITIES	37,523	6,202	43,726	0	0.00	43,726	0	0	43,726
302020304	CONSTRUCT DECON AREA	40,499	6,694	47,194	0	0.00	47,194	0	0	47,194
302020305	TEMP SITE ROAD	7,203	1,190	8,393	0	0.00	8,393	0	0	8,393
302090101	REMOVE TEMP CONST BARRIER	1,505	248	1,754	0	0.00	1,754	0	0	1,754
302090102	REMOVE DECON AREA	18,411	3,043	21,454	0	0.00	21,454	0	0	21,454
302090103	REMOVE ROADS & PARKING	757	125	882	0	0.00	882	0	0	882
302090301	DEMOBILIZE CONSTRUCTION EQUIPMENT	14,543	2,404	16,947	0	0.00	16,947	0	0	16,947
302090304	FH DECON CONSTRUCTION EQUIPMENT SUPPORT	2,201	363	2,565	0	0.00	2,565	0	0	2,565
SUBTOTAL MOBILIZATION / DEMOBILIZATION		**162,738**	**26,900**	**189,640**	**0**	**0.00**	**189,640**	**0**	**0**	**189,640**
1.03.03 MONITORING /SAMPLING										
302030102	SITE AIR MONITORING	23,920	3,542	27,462	0	0.00	27,462	0	0	27,462
302030302	RAD SAMPLING,ANALYSIS-VEG/SEDM/SOIL	39,010	5,777	44,787	0	0.00	44,787	0	0	44,787
302030403	FH SAMPLE CREW	6,396	1,057	7,454	0	0.00	7,454	0	0	7,454
SUBTOTAL MONITORING /SAMPLING		**69,326**	**10,377**	**79,704**	**0**	**0.00**	**79,704**	**0**	**0**	**79,704**
1.03.04 SITE WORK										
302080101	LOAD/HAUL OVERBURDEN FROM STOCKPILE	18,658	3,084	21,743	0	0.00	21,743	0	0	21,743
302080102	LOAD/HAUL FROM BORROW SITE	7,012	1,159	8,171	0	0.00	8,171	0	0	8,171
302080201	BACKFILL & COMPACTION	21,797	3,603	25,401	0	0.00	25,401	0	0	25,401
302080301	MECH SEEDING GRASS	6,035	997	7,033	0	0.00	7,033	0	0	7,033
302080302	SHRUBS/TREES/GROUNDCOVER	6,744	1,114	7,859	0	0.00	7,859	0	0	7,859
302080303	IRRIGATION	31,534	5,212	36,747	0	0.00	36,747	0	0	36,747
302090104	MISC CLEANUP	3,770	623	4,393	0	0.00	4,393	0	0	4,393
SUBTOTAL SITE WORK		**95,554**	**15,795**	**111,349**	**0**	**0.00**	**111,349**	**0**	**0**	**111,349**
1.03.05 SOIL EXCAVATION										

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Table D-3. 216-A-29 South Ditch – Alternative 3 – Removal, Treatment, and Disposal. (4 Pages)

FLUOR HANFORD
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200-CS-1 FEASIBILITY STUDY
216-A-29 South Ditch - Alt 3 RTD
FT_R02N - WORK BREAKDOWN STRUCTURE SUMMARY

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EST WBS	ESTIMATE WBS DESCRIPTION	ESTIMATE SUBTOTAL	TOTAL INDIRECTS	SUB TOTAL	ESCALATN TOTAL	ESCAL %	SUB TOTAL	CONT %	CONTGNCY TOTAL	TOTAL AMOUNT
302040101	UNCONTAMINATED/OVERBURDEN SOIL	37,763	6,242	44,005	0	0.00	44,005	0	0	44,005
302040102	EXCAVATE CONTAMINATED SOIL W/DUST CONTR	6,174	1,020	7,194	0	0.00	7,194	0	0	7,194
302040106	RCT SUPPORT	7,182	1,187	8,370	0	0.00	8,370	0	0	8,370
302040107	INDUSTRIAL SAFETY TECH SUPPORT	6,298	888	7,186	0	0.00	7,186	0	0	7,186
302060403	LOAD/HAUL RAD CONT SOIL	8,547	1,412	9,960	0	0.00	9,960	0	0	9,960
302060501	QUEUE AREA OPERATIONS	8,330	1,377	9,707	0	0.00	9,707	0	0	9,707
302060502	FH QUEUE AREA OPERATIONS	495	81	577	0	0.00	577	0	0	577
302060601	LOW ACTIVITY CONTAINERS	4,352	719	5,071	0	0.00	5,071	0	0	5,071
302060603	FH DECONTAMINATE CONTAINERS	2,972	491	3,463	0	0.00	3,463	0	0	3,463
302060801	ERDF DISPOSAL COST	101,212	14,989	116,201	0	0.00	116,201	0	0	116,201
SUBTOTAL SOIL EXCAVATION		183,329	28,410	211,738	0	0.00	211,739	0	0	211,739
1.03.07 CONSTRUCTION STAFF										
302090201	PREPARE FINAL D&D REPORT	8,393	1,387	9,780	0	0.00	9,780	0	0	9,780
303020101	CONSTRUCTION FIELD STAFF-FP	108,613	17,953	126,566	0	0.00	126,566	0	0	126,566
SUBTOTAL CONSTRUCTION STAFF		117,006	19,341	136,347	0	0.00	136,347	0	0	136,347
1.03.08 PROJECT MANAGEMENT										
302090201	PREPARE FINAL D&D REPORT	2,010	332	2,342	0	0.00	2,342	0	0	2,342
302090203	FINAL SITE SURVEY -FH	1,352	218	1,571	0	0.00	1,571	0	0	1,571
303010101	PROJECT MANAGEMENT-FH-CPT	69,986	11,568	81,555	0	0.00	81,555	0	0	81,555
SUBTOTAL PROJECT MANAGEMENT		73,349	12,119	85,469	0	0.00	85,469	0	0	85,469
TOTALS		701,306	112,944	814,250	0	0.00	814,250	0	0	814,250

Table D-4. 216-S-10 Ditch – Alternative 3 – Removal, Treatment, and Disposal. (2 Pages)

FLUOR HANFORD
DD / FH
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200-CS-1 FEASIBILITY STUDY
216-S-10 Ditch - Alt 3 RTD
FT_R02N - WORK BREAKDOWN STRUCTURE SUMMARY

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EST WBS	ESTIMATE WBS DESCRIPTION	ESTIMATE SUBTOTAL	TOTAL INDIRECTS	SUB TOTAL	ESCALATN TOTAL	ESCAL %	SUB TOTAL	CONT %	CONTGNCY TOTAL	TOTAL AMOUNT
1.03.02 MOBILIZATION / DEMOBILIZATION										
302010301	PERSONNEL TRAINING-BASIC	24,388	4,031	28,420	0	0.00	28,420	0	0	28,420
302020102	WASTE SITE SURVEY	3,050	504	3,554	0	0.00	3,554	0	0	3,554
302020203	MOB SITE WORK EQUIPMENT	5,106	844	5,950	0	0.00	5,950	0	0	5,950
302020301	INSTALL TEMP CONST BARRIER	7,681	1,269	8,951	0	0.00	8,951	0	0	8,951
302020302	TEMP OFFICE & FACILITIES	37,523	6,202	43,726	0	0.00	43,726	0	0	43,726
302020304	CONSTRUCT DECON AREA	40,499	6,694	47,194	0	0.00	47,194	0	0	47,194
302020305	TEMP SITE ROAD	7,203	1,190	8,393	0	0.00	8,393	0	0	8,393
302090101	REMOVE TEMP CONST BARRIER	1,532	253	1,785	0	0.00	1,785	0	0	1,785
302090102	REMOVE DECON AREA	18,411	3,043	21,454	0	0.00	21,454	0	0	21,454
302090103	REMOVE ROADS & PARKING	757	125	882	0	0.00	882	0	0	882
302090301	DEMOBILIZE CONSTRUCTION EQUIPMENT	14,543	2,404	16,947	0	0.00	16,947	0	0	16,947
302090304	FH DECON CONSTRUCTION EQUIPMENT SUPPORT	2,201	363	2,565	0	0.00	2,565	0	0	2,565
SUBTOTAL MOBILIZATION / DEMOBILIZATION		162,899	26,927	189,826	0	0.00	189,826	0	0	189,826
1.03.03 MONITORING /SAMPLING										
302030102	SITE AIR MONITORING	38,480	5,698	44,178	0	0.00	44,178	0	0	44,178
302030302	RAD SAMPLING,ANALYSIS-VEG/SEDM/SOIL	43,174	6,394	49,568	0	0.00	49,568	0	0	49,568
302030403	FH SAMPLE CREW	9,620	1,590	11,211	0	0.00	11,211	0	0	11,211
SUBTOTAL MONITORING /SAMPLING		91,274	13,683	104,958	0	0.00	104,958	0	0	104,958
1.03.04 SITE WORK										
302080101	LOAD/HAUL OVERBURDEN FROM STOCKPILE	26,904	4,447	31,352	0	0.00	31,352	0	0	31,352
302080102	LOAD/HAUL FROM BORROW SITE	19,219	3,177	22,396	0	0.00	22,396	0	0	22,396
302080201	BACKFILL & COMPACTION	34,828	5,757	40,585	0	0.00	40,585	0	0	40,585
302080301	MECH SEEDING GRASS	6,035	997	7,033	0	0.00	7,033	0	0	7,033
302080302	SHRUBS/TREES/GROUNDCOVER	6,744	1,114	7,859	0	0.00	7,859	0	0	7,859
302080303	IRRIGATION	31,534	5,212	36,747	0	0.00	36,747	0	0	36,747
302090104	MISC CLEANUP	4,798	793	5,592	0	0.00	5,592	0	0	5,592
SUBTOTAL SITE WORK		130,068	21,500	151,566	0	0.00	151,566	0	0	151,566
1.03.05 SOIL EXCAVATION										

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Table D-4. 216-S-10 Ditch – Alternative 3 – Removal, Treatment, and Disposal. (2 Pages)

FLUOR HANFORD
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200-CS-1 FEASIBILITY STUDY
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EST WBS	ESTIMATE WBS DESCRIPTION	ESTIMATE SUBTOTAL	TOTAL INDIRECTS	SUB TOTAL	ESCALATN TOTAL	ESCAL %	SUB TOTAL	CONT %	CONTGNCY TOTAL	TOTAL AMOUNT
302040101	UNCONTAMINATED/OVERBURDEN SOIL	54,451	9,000	63,452	0	0.00	63,452	0	0	63,452
302040102	EXCAVATE CONTAMINATED SOIL W/DUST CONTR	16,922	2,797	19,719	0	0.00	19,719	0	0	19,719
302040106	RCT SUPPORT	12,301	2,033	14,334	0	0.00	14,334	0	0	14,334
302040107	INDUSTRIAL SAFETY TECH SUPPORT	10,658	1,503	12,161	0	0.00	12,161	0	0	12,161
302060403	LOAD/HAUL RAD CONT SOIL	23,396	3,867	27,263	0	0.00	27,263	0	0	27,263
302060501	QUEUE AREA OPERATIONS	3,815	630	4,445	0	0.00	4,445	0	0	4,445
302060502	FH QUEUE AREA OPERATIONS	1,348	222	1,571	0	0.00	1,571	0	0	1,571
302060601	LOW ACTIVITY CONTAINERS	11,876	1,963	13,840	0	0.00	13,840	0	0	13,840
302060603	FH DECONTAMINATE CONTAINERS	8,090	1,337	9,428	0	0.00	9,428	0	0	9,428
302060801	ERDF DISPOSAL COST	264,382	39,155	303,537	0	0.00	303,537	0	0	303,537
SUBTOTAL SOIL EXCAVATION		**407,244**	**62,511**	**469,756**	**0**	**0.00**	**469,756**	**0**	**0**	**469,756**
1.03.07 CONSTRUCTION STAFF										
302090201	PREPARE FINAL D&D REPORT	8,393	1,387	9,780	0	0.00	9,780	0	0	9,780
303020101	CONSTRUCTION FIELD STAFF-FP	140,703	23,258	163,961	0	0.00	163,961	0	0	163,961
SUBTOTAL CONSTRUCTION STAFF		**149,096**	**24,645**	**173,742**	**0**	**0.00**	**173,742**	**0**	**0**	**173,742**
1.03.08 PROJECT MANAGEMENT										
302090201	PREPARE FINAL D&D REPORT	2,010	332	2,342	0	0.00	2,342	0	0	2,342
302090203	FINAL SITE SURVEY -FH	1,352	218	1,571	0	0.00	1,571	0	0	1,571
303010101	PROJECT MANAGEMENT-FH-CPT	90,664	14,986	105,651	0	0.00	105,651	0	0	105,651
SUBTOTAL PROJECT MANAGEMENT		**94,027**	**15,537**	**109,565**	**0**	**0.00**	**109,565**	**0**	**0**	**109,565**
TOTALS		**1,034,609**	**164,805**	**1,199,415**	**0**	**0.00**	**1,199,415**	**0**	**0**	**1,199,415**

Table D-5. 216-A-29 North Ditch – Alternative 4 – Engineered Barrier. (4 Pages)

FLUOR HANFORD
DD / FH
ET CAPILLARY/MONOFILL TEMPLATE
EST NO. CS29NB4B

200-CS-1 FEASIBILITY STUDY
216-A-29 North Ditch - Alt 4 ET Barrier
FT_R02N - WORK BREAKDOWN STRUCTURE SUMMARY

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EST WBS	ESTIMATE WBS DESCRIPTION	ESTIMATE SUBTOTAL	TOTAL INDIRECTS	SUB TOTAL	ESCALATN TOTAL	ESCAL %	SUB TOTAL	CONT %	CONTGNCY TOTAL	TOTAL AMOUNT
1.04.02 MOBILIZATION/DEMOBILIZATION										
302010301	PERSONNEL TRAINING-BASIC	8,222	1,359	9,581	0	0.00	9,581	0	0	9,581
302020102	WASTE SITE SURVEY	15,399	2,545	17,945	0	0.00	17,945	0	0	17,945
302020203	MOB SITE WORK EQUIPMENT	22,011	3,638	25,649	0	0.00	25,649	0	0	25,649
302020301	INSTALL TEMP CONST BARRIER	25,372	4,194	29,567	0	0.00	29,567	0	0	29,567
302020302	TEMP OFFICE & FACILITIES	21,378	3,533	24,912	0	0.00	24,912	0	0	24,912
302020305	TEMP SITE ROAD	7,538	1,246	8,784	0	0.00	8,784	0	0	8,784
302090101	REMOVE TEMP CONST BARRIER	3,957	654	4,611	0	0.00	4,611	0	0	4,611
302090103	REMOVE ROADS & PARKING	600	99	699	0	0.00	699	0	0	699
SUBTOTAL MOBILIZATION/DEMOBILIZATION		104,480	17,270	121,751	0	0.00	121,751	0	0	121,751
1.04.03 MONITORING/SAMPLING										
302030102	SITE AIR MONITORING - INDUSTRIAL	18,903	3,307	22,210	0	0.00	22,210	0	0	22,210
302030103	SITE AIR MONITORING - ENVIRONMENTAL	3,780	661	4,442	0	0.00	4,442	0	0	4,442
SUBTOTAL MONITORING/SAMPLING		22,684	3,968	26,652	0	0.00	26,652	0	0	26,652
1.04.04 SITE WORK										
302080301	MECH SEEDING GRASS	8,490	1,403	9,894	0	0.00	9,894	0	0	9,894
302080302	SHRUBS/TREES/GROUNDCOVER	11,839	1,956	13,796	0	0.00	13,796	0	0	13,796
302080303	IRRIGATION	60,421	9,987	70,408	0	0.00	70,408	0	0	70,408
SUBTOTAL SITE WORK		80,750	13,348	94,099	0	0.00	94,099	0	0	94,099
1.04.06 CAP-ET-CAPILLARY										
302080401	SITE LEVELING & COMPACTION	264,450	43,713	308,164	0	0.00	308,164	0	0	308,164
302080402	LAYER 8 CONTOUR FILL	138,709	22,928	161,638	0	0.00	161,638	0	0	161,638
302080407	LAYER 3 SAND FILTER	173,758	28,722	202,480	0	0.00	202,480	0	0	202,480
302080408	LAYER 2 TOP SOIL	122,422	20,236	142,658	0	0.00	142,658	0	0	142,658
302080409	LAYER 1 TOP SOIL W/ PEA GRAVEL	70,470	11,648	82,119	0	0.00	82,119	0	0	82,119
302080410	SIDE SLOPE - BERM	369,805	61,128	430,934	0	0.00	430,934	0	0	430,934
302080412	PIT C & PROCESS OPERATIONS	88,227	14,583	102,811	0	0.00	102,811	0	0	102,811
302080413	SURVEYING	53,463	8,837	62,301	0	0.00	62,301	0	0	62,301

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Table D-5. 216-A-29 North Ditch – Alternative 4 – Engineered Barrier. (4 Pages)

FLUOR HANFORD
DD / FH
ET CAPILLARY/MONOFILL TEMPLATE
EST NO. CS29NB4B

200-CS-1 FEASIBILITY STUDY
216-A-29 North Ditch - Alt 4 ET Barrier
FT_R02N - WORK BREAKDOWN STRUCTURE SUMMARY

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EST WBS	ESTIMATE WBS DESCRIPTION	ESTIMATE SUBTOTAL	TOTAL INDIRECTS	SUB TOTAL	ESCALATN TOTAL	ESCAL %	SUB TOTAL	CONT %	CONTGNCY TOTAL	TOTAL AMOUNT
302080414	TESTING	33,250	5,496	38,746	0	0.00	38,746	0	0	38,746
302080415	FH-RCT SUPPORT	28,088	4,312	32,401	0	0.00	32,401	0	0	32,401
302080416	MINOR WORK	23,575	3,897	27,473	0	0.00	27,473	0	0	27,473
302090104	MISC CLEANUP	1,453	240	1,693	0	0.00	1,693	0	0	1,693
SUBTOTAL CAP-ET-CAPILLARY		1,367,676	225,746	1,593,422	0	0.00	1,593,422	0	0	1,593,422
1.04.08 CONSTRUCTION STAFF										
302090201	PREPARE FINAL D&D REPORT	9,428	1,558	10,986	0	0.00	10,986	0	0	10,986
303020101	CONSTRUCTION FIELD STAFF-FP	338,843	56,010	394,853	0	0.00	394,853	0	0	394,853
SUBTOTAL CONSTRUCTION STAFF		348,271	57,569	405,840	0	0.00	405,840	0	0	405,840
1.04.09 PROJECT MANAGEMENT										
302090201	PREPARE FINAL D&D REPORT	2,010	332	2,342	0	0.00	2,342	0	0	2,342
303010101	PROJECT MANAGEMENT-FH-CPT	180,913	29,905	210,818	0	0.00	210,818	0	0	210,818
SUBTOTAL PROJECT MANAGEMENT		182,923	30,237	213,160	0	0.00	213,160	0	0	213,160
TOTALS		2,106,786	348,140	2,454,926	0	0.00	2,454,926	0	0	2,454,926

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Table D-5. 216-A-29 South Ditch – Alternative 4 – Engineered Barrier. (4 Pages)

FLUOR HANFORD
DD / FH
ET CAPILLARY/MONOFILL TEMPLATE
EST NO. CS29SB4B

200-CS-1 FEASIBILITY STUDY
216-A-29 South Ditch - Alt 4 ET Barrier
FT_R02N - WORK BREAKDOWN STRUCTURE SUMMARY

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EST WBS	ESTIMATE WBS DESCRIPTION	ESTIMATE SUBTOTAL	TOTAL INDIRECTS	SUB TOTAL	ESCALATN TOTAL	ESCAL %	SUB TOTAL	CONT %	CONTGNCY TOTAL	TOTAL AMOUNT
1.04.02 MOBILIZATION/DEMOBILIZATION										
302010301	PERSONNEL TRAINING-BASIC	8,222	1,359	9,581	0	0.00	9,581	0	0	9,581
302020102	WASTE SITE SURVEY	7,845	1,296	9,142	0	0.00	9,142	0	0	9,142
302020203	MOB SITE WORK EQUIPMENT	22,011	3,638	25,649	0	0.00	25,649	0	0	25,649
302020301	INSTALL TEMP CONST BARRIER	10,393	1,718	12,112	0	0.00	12,112	0	0	12,112
302020302	TEMP OFFICE & FACILITIES	11,511	1,902	13,414	0	0.00	13,414	0	0	13,414
302020305	TEMP SITE ROAD	7,538	1,246	8,784	0	0.00	8,784	0	0	8,784
302090101	REMOVE TEMP CONST BARRIER	1,822	301	2,124	0	0.00	2,124	0	0	2,124
302090103	REMOVE ROADS & PARKING	600	99	699	0	0.00	699	0	0	699
SUBTOTAL MOBILIZATION/DEMOBILIZATION		69,945	11,561	81,507	0	0.00	81,507	0	0	81,507
1.04.03 MONITORING/SAMPLING										
302030102	SITE AIR MONITORING - INDUSTRIAL	7,561	1,322	8,884	0	0.00	8,884	0	0	8,884
302030103	SITE AIR MONITORING - ENVIRONMENTAL	2,520	440	2,961	0	0.00	2,961	0	0	2,961
SUBTOTAL MONITORING/SAMPLING		10,081	1,763	11,845	0	0.00	11,845	0	0	11,845
1.04.04 SITE WORK										
302080301	MECH SEEDING GRASS	4,245	701	4,947	0	0.00	4,947	0	0	4,947
302080302	SHRUBS/TREES/GROUNDCOVER	5,919	978	6,898	0	0.00	6,898	0	0	6,898
302080303	IRRIGATION	30,210	4,993	35,204	0	0.00	35,204	0	0	35,204
SUBTOTAL SITE WORK		40,375	6,674	47,049	0	0.00	47,049	0	0	47,049
1.04.06 CAP-ET-CAPILLARY										
302080401	SITE LEVELING & COMPACTION	106,330	17,576	123,907	0	0.00	123,907	0	0	123,907
302080402	LAYER 8 CONTOUR FILL	54,958	9,084	64,042	0	0.00	64,042	0	0	64,042
302080407	LAYER 3 SAND FILTER	68,587	11,337	79,925	0	0.00	79,925	0	0	79,925
302080408	LAYER 2 TOP SOIL	48,082	7,948	56,030	0	0.00	56,030	0	0	56,030
302080409	LAYER 1 TOP SOIL W/ PEA GRAVEL	27,476	4,541	32,018	0	0.00	32,018	0	0	32,018
302080410	SIDE SLOPE - BERM	153,373	25,352	178,726	0	0.00	178,726	0	0	178,726
302080412	PIT C & PROCESS OPERATIONS	34,402	5,686	40,089	0	0.00	40,089	0	0	40,089
302080413	SURVEYING	24,407	4,034	28,441	0	0.00	28,441	0	0	28,441

Table D-5. 216-A-29 South Ditch – Alternative 4 – Engineered Barrier. (4 Pages)

FLUOR HANFORD
DD / FH
ET CAPILLARY/MONOFILL TEMPLATE
EST NO. CS29SB4B

200-CS-1 FEASIBILITY STUDY
216-A-29 South Ditch - Alt 4 ET Barrier
FT_R02N - WORK BREAKDOWN STRUCTURE SUMMARY

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EST WBS	ESTIMATE WBS DESCRIPTION	ESTIMATE SUBTOTAL	TOTAL INDIRECTS	SUB TOTAL	ESCALATN TOTAL	ESCAL %	SUB TOTAL	CONT %	CONTGNCY TOTAL	TOTAL AMOUNT
302080414	TESTING	13,685	2,262	15,947	0	0.00	15,947	0	0	15,947
302080415	FH-RCT SUPPORT	11,377	1,746	13,124	0	0.00	13,124	0	0	13,124
302080416	MINOR WORK	9,889	1,634	11,524	0	0.00	11,524	0	0	11,524
302090104	MISC CLEANUP	1,453	240	1,693	0	0.00	1,693	0	0	1,693
SUBTOTAL CAP-ET-CAPILLARY		554,026	91,446	645,472	0	0.00	645,472	0	0	645,472
1.04.08 CONSTRUCTION STAFF										
302090201	PREPARE FINAL D&D REPORT	9,428	1,558	10,986	0	0.00	10,986	0	0	10,986
303020101	CONSTRUCTION FIELD STAFF-FP	186,519	30,831	217,350	0	0.00	217,350	0	0	217,350
SUBTOTAL CONSTRUCTION STAFF		195,947	32,390	228,337	0	0.00	228,337	0	0	228,337
1.04.09 PROJECT MANAGEMENT										
302090201	PREPARE FINAL D&D REPORT	2,010	332	2,342	0	0.00	2,342	0	0	2,342
303010101	PROJECT MANAGEMENT-FH-CPT	99,585	16,461	116,046	0	0.00	116,046	0	0	116,046
SUBTOTAL PROJECT MANAGEMENT		101,595	18,793	118,389	0	0.00	118,389	0	0	118,389
TOTALS		971,971	160,630	1,132,601	0	0.00	1,132,601	0	0	1,132,601

Table D-6. 216-S-10 Ditch – Alternative 4 – Engineered Barrier. (2 Pages)

FLUOR HANFORD
DD / FH
ET CAPILLARY/MONOFILL TEMPLATE
EST NO. CSS10B4D

200-CS-1 FEASIBILITY STUDY
216-S-10 Ditch -Alt4 ET Barrier
FT_R02N - WORK BREAKDOWN STRUCTURE SUMMARY

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EST WBS	ESTIMATE WBS DESCRIPTION	ESTIMATE SUBTOTAL	TOTAL INDIRECTS	SUB TOTAL	ESCALATN TOTAL	ESCAL %	SUB TOTAL	CONT %	CONTGNCY TOTAL	TOTAL AMOUNT
1.04.02 MOBILIZATION/DEMOBILIZATION										
302010301	PERSONNEL TRAINING-BASIC	8,222	1,359	9,581	0	0.00	9,581	0	0	9,581
302020102	WASTE SITE SURVEY	7,845	1,296	9,142	0	0.00	9,142	0	0	9,142
302020203	MOB SITE WORK EQUIPMENT	22,011	3,638	25,649	0	0.00	25,649	0	0	25,649
302020301	INSTALL TEMP CONST BARRIER	11,703	1,934	13,638	0	0.00	13,638	0	0	13,638
302020302	TEMP OFFICE & FACILITIES	14,800	2,446	17,247	0	0.00	17,247	0	0	17,247
302020305	TEMP SITE ROAD	7,538	1,246	8,784	0	0.00	8,784	0	0	8,784
302090101	REMOVE TEMP CONST BARRIER	1,825	301	2,127	0	0.00	2,127	0	0	2,127
302090103	REMOVE ROADS & PARKING	600	99	699	0	0.00	699	0	0	699
SUBTOTAL MOBILIZATION/DEMOBILIZATION		74,546	12,322	86,868	0	0.00	86,869	0	0	86,869
1.04.03 MONITORING/SAMPLING										
302030102	SITE AIR MONITORING - INDUSTRIAL	21,424	3,748	25,172	0	0.00	25,172	0	0	25,172
302030103	SITE AIR MONITORING - ENVIRONMENTAL	3,780	661	4,442	0	0.00	4,442	0	0	4,442
SUBTOTAL MONITORING/SAMPLING		25,204	4,409	29,614	0	0.00	29,614	0	0	29,614
1.04.04 SITE WORK										
302080301	MECH SEEDING GRASS	4,245	701	4,947	0	0.00	4,947	0	0	4,947
302080302	SHRUBS/TREES/GROUNDCOVER	5,919	978	6,898	0	0.00	6,898	0	0	6,898
302080303	IRRIGATION	30,210	4,993	35,204	0	0.00	35,204	0	0	35,204
SUBTOTAL SITE WORK		40,375	6,674	47,049	0	0.00	47,049	0	0	47,049
1.04.06 CAP-ET-CAPILLARY										
302080401	SITE LEVELING & COMPACTION	393,388	65,027	458,415	0	0.00	458,415	0	0	458,415
302080402	LAYER 8 CONTOUR FILL	55,062	9,101	64,164	0	0.00	64,164	0	0	64,164
302080407	LAYER 3 SAND FILTER	68,719	11,359	80,078	0	0.00	80,078	0	0	80,078
302080408	LAYER 2 TOP SOIL	48,176	7,963	56,139	0	0.00	56,139	0	0	56,139
302080409	LAYER 1 TOP SOIL W/ PEA GRAVEL	27,531	4,550	32,082	0	0.00	32,082	0	0	32,082
302080410	SIDE SLOPE - BERM	153,664	25,400	179,064	0	0.00	179,064	0	0	179,064
302080412	PIT C & PROCESS OPERATIONS	34,474	5,698	40,172	0	0.00	40,172	0	0	40,172
302080413	SURVEYING	24,407	4,034	28,441	0	0.00	28,441	0	0	28,441

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Table D-6. 216-S-10 Ditch – Alternative 4 – Engineered Barrier. (2 Pages)

FLUOR HANFORD
DD / FH
ET CAPILLARY/MONOFILL TEMPLATE
EST NO. CSS10B4D

200-CS-1 FEASIBILITY STUDY
216-S-10 Ditch -Alt4 ET Barrier
FT_R02N - WORK BREAKDOWN STRUCTURE SUMMARY

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EST WBS	ESTIMATE WBS DESCRIPTION	ESTIMATE SUBTOTAL	TOTAL INDIRECTS	SUB TOTAL	ESCALATN TOTAL	ESCAL %	SUB TOTAL	CONT %	CONTGNCY TOTAL	TOTAL AMOUNT
302080414	TESTING	27,690	4,577	32,268	0	0.00	32,268	0	0	32,268
302080415	FH-RCT SUPPORT	31,644	4,858	36,502	0	0.00	36,502	0	0	36,502
302080416	MINOR WORK	9,906	1,637	11,544	0	0.00	11,544	0	0	11,544
302090104	MISC CLEANUP	1,453	240	1,693	0	0.00	1,693	0	0	1,693
SUBTOTAL CAP-ET-CAPILLARY		876,119	144,450	1,020,569	0	0.00	1,020,569	0	0	1,020,569
1.04.08 CONSTRUCTION STAFF										
302090201	PREPARE FINAL D&D REPORT	9,428	1,558	10,986	0	0.00	10,986	0	0	10,986
303020101	CONSTRUCTION FIELD STAFF-FP	251,800	41,622	293,423	0	0.00	293,423	0	0	293,423
SUBTOTAL CONSTRUCTION STAFF		261,228	43,181	304,410	0	0.00	304,410	0	0	304,410
1.04.09 PROJECT MANAGEMENT										
302090201	PREPARE FINAL D&D REPORT	2,010	332	2,342	0	0.00	2,342	0	0	2,342
303010101	PROJECT MANAGEMENT-FH-CPT	134,440	22,222	156,663	0	0.00	156,663	0	0	156,663
SUBTOTAL PROJECT MANAGEMENT		136,450	22,555	159,005	0	0.00	159,005	0	0	159,005
TOTALS		1,413,925	233,592	1,647,518	0	0.00	1,647,518	0	0	1,647,518

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Table D-7. 200-CS-1 Operable Unit Representative and Analogous Site Information.

Waste Site	**Site Dimensions (ft)**			**Overburden Depth (ft)**	**Excavation Dimensions (ft)**			**Contaminated Volume (yd^3)**	**Excavated Volume (yd^3)**	**Clean Soil Volume (yd^3)**	**Area of Barrier in Acres**
	Length	**Width**	**Depth**		**Length**	**Width**	**Depth**				
216-A-29 Ditch	4,000	6	2-15	6	3,594	37 to 45	10 to 13	2,399	30,811	28,412	8.1
216-S-10 Ditch	2,250	6	6	0	1025	51	15	3,625	15,865	0	2.3
					Total volume of soil to ERDF			6,024 yd^3			

Table D-8. 200-CS-1 Operable Unit Net Present Value and Non-Discounted Costs.

WASTE SITES	ALTERNATIVE 1: No Action	ALTERNATIVE 2: Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls	ALTERNATIVE 3: Removal, Treatment, and Disposal	ALTERNATIVE 4: Engineered Barrier
216-A-29 Ditch (Non-discounted cost)	N/A	$868,340 $4,031,232	$$2,759,317 $0	$3,587,527 $25,954,293
216-B-64 Trench (Non-discounted cost)	$0	N/A N/A	N/A N/A	N/A N/A
216-S-10 Ditch (Non-discounted cost)	N/A	$867,538 $4,077,514	$1,679,178 $0	$3,573,574 $8,456,185
216-S-10 Pond (Non-discounted cost)	$0	N/A N/A	N/A N/A	N/A N/A
216-S-11 Pond (Non-discounted cost	$0	N/A N/A	N/A N/A	N/A N/A

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APPENDIX E

CLOSURE PLAN FOR THE 216-A-29 DITCH

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CONTENTS

FIGURES

TABLES

TERMS

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
DQO	data quality objectives
Ecology	Washington State Department of Ecology
GW	groundwater
HEIS	*Hanford Environmental Information System* database
MCL	maximum contaminant level
N/A	not applicable
ND	not detected
OU	operable unit
PUREX	Plutonium-Uranium Extraction Plant
RCRA	*Resource Conservation and Recovery Act of 1976*
RI	remedial investigation
SMCL	secondary maximum contaminant level
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989a)
Tri-Party Agreement Action Plan	*Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al. 1989b)
TSD	treatment, storage, and disposal (unit)
U	undetected

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	Millimeters	millimeters	0.039	inches
inches	2.54	Centimeters	centimeters	0.394	inches
feet	0.305	Meters	meters	3.281	feet
yards	0.914	Meters	meters	1.094	yards
miles	1.609	Kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.0836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	Hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	Grams	grams	0.035	ounces
pounds	0.454	Kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	Milliliters	milliliters	0.033	fluid ounces
tablespoons	15	Milliliters	liters	2.1	pints
fluid ounces	30	Milliliters	liters	1.057	quarts
cups	0.24	Liters	liters	0.264	gallons
pints	0.47	Liters	cubic meters	35.315	cubic feet
quarts	0.95	Liters	cubic meters	1.308	cubic yards
gallons	3.8	Liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	Millibecquerel	millibecquerel	0.027	picocuries

APPENDIX E

CLOSURE PLAN FOR THE 216-A-29 DITCH

E1.0 INTRODUCTION

The original closure plan for the 216-A-29 Ditch (DOE/RL-93-74, *200-BP-11 Operable Unit RFI/CMS and 216-B-3 Main Pond, 216-B-63 Trench, and 216-A-29 Ditch Work/Closure Plan*) was submitted to the Washington State Department of Ecology (Ecology) pursuant to *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989a) milestone M-20-36 in June 1995. This closure plan has been rewritten to supersede the June 1995 closure plan. Documents and information sources mentioned in this closure plan are not intended for incorporation in WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8, for the Treatment, Storage, and Disposal of Dangerous Waste.*

The 216-A-29 Ditch Treatment, Storage, and/or Disposal (TSD) unit will be incorporated into the *Hanford Facility RCRA Permit*. When the permit modification to incorporate the TSD unit becomes effective, the provisions of *Hanford Facility RCRA Permit* Conditions II.Y.2.c will apply. Permit Condition II.Y.2.c establishes the corrective action status of the waste site following certification of closure. This closure plan is written to address only the dangerous waste constituents of concern relating to *Resource Conservation and Recovery Act of 1976* (RCRA) TSD unit operations (TSD unit constituents). Therefore, any other constituents of concern described in DOE/RL-2004-17, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit*, related to past-practice activities at this waste site will be addressed under past-practice authority, in accordance with Permit Condition II.Y.2.c.ii. Any physical activities necessary to complete remediation of non-TSD unit constituents is outside the scope of this closure plan and will be performed in conjunction with Tri-Party Agreement past-practice activities for the 200-CS-1 source operable unit (OU) and the 200-PO-1 Groundwater OU.

The development of this closure plan has been coordinated with the 200-CS-1 source OU in accordance with Tri-Party Agreement milestone M-15-39C. This coordinated approach was established in June 2002 following the completion of negotiations between the U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology (Ecology) on the modifications to 200 Areas waste site cleanup milestones through Tri-Party Agreement change requests M-13-02-01, M-15-02-01, M-16-02-01, and M-20-02-01. As a result, much of the text contained in this closure plan has been obtained from existing 200-CS-1 OU *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) documentation.

The proposed closure strategy for the 216-A-29 Ditch soils is clean closure following remediation of the soils and clean closure of the TSD unit pertaining to groundwater following approval of this closure plan. The soil strategy is based on analytical data summarized in DOE/RL-2004-17 and verification sampling activities in the soil to be completed following soil remediation as part of the 200-CS-1 OU activities. Groundwater data contained in the *Hanford Environmental Information System* (HEIS) database was used to show that the TSD unit has not impacted groundwater.

E2.0 UNIT DESCRIPTION

This chapter provides a physical description of the 216-A-29 Ditch and describes security related to the 216-A-29 Ditch.

E2.1 PHYSICAL DESCRIPTION AND OPERATIONS

The 216-A-29 Ditch is located to the east of the 200 East Area of the Hanford Facility (Figure E-1). The 216-A-29 Ditch received discharge from the Plutonium-Uranium Extraction (PUREX) Plant chemical sewer. The ditch was uncovered and unlined and followed the natural topography. The ditch originated from the southeast side of the A Tank Farm (east of the AP Tank Farm) outside the 200 East Area perimeter fence. The ditch was estimated to be 1,220 m (4,000 ft) long and 1.8 m (6 ft) wide and varied from 0.6 to 4.6 m (2 to 15 ft). The head end of the ditch was modified in 1983 to allow the construction of the AP Tank Farm. The end of the ditch connects to the 216-B-3-3 Ditch and finally to the 216-B-3 Pond.

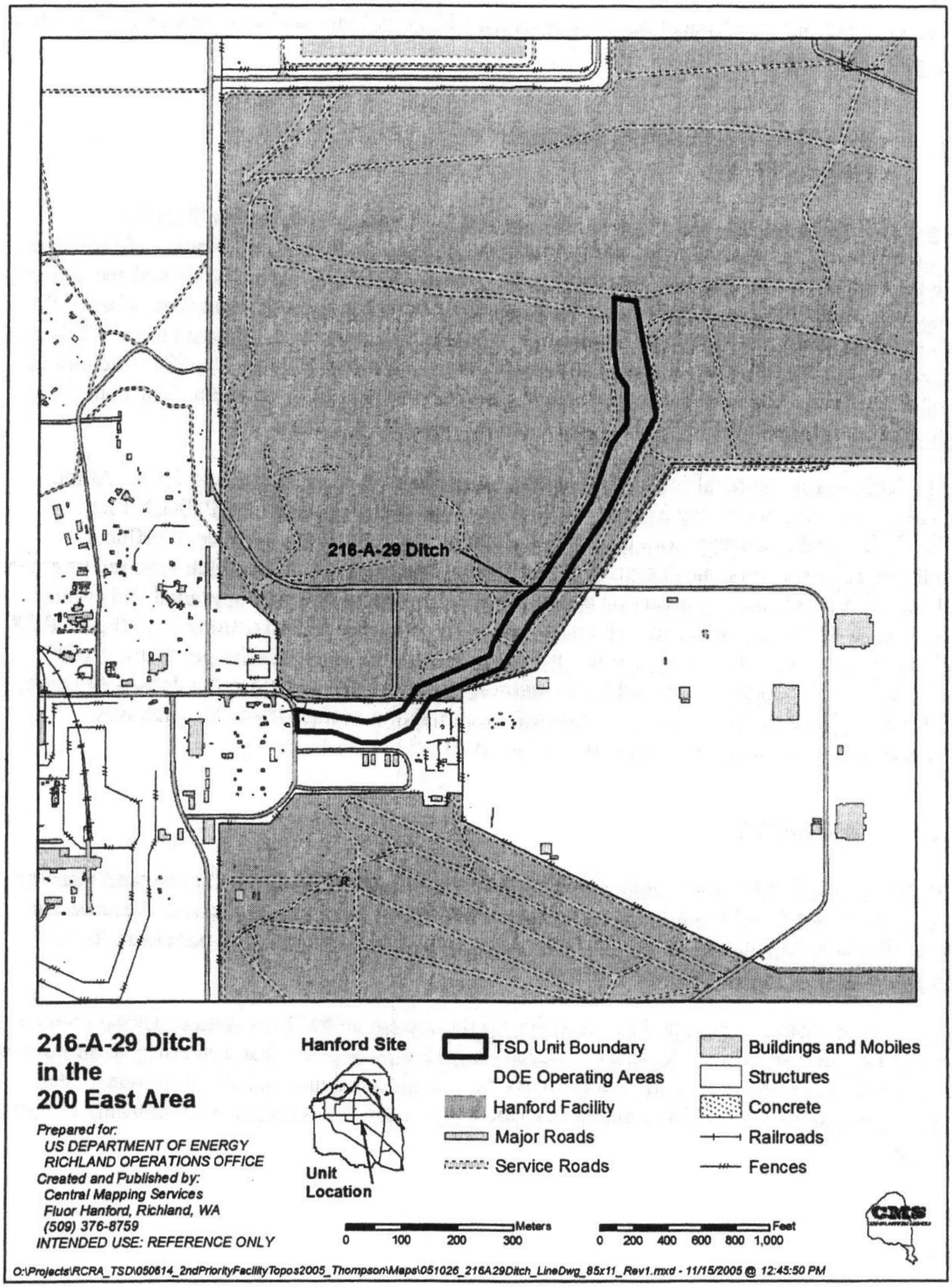
The PUREX Plant chemical sewer operated between November 1955 and July 1991. At the beginning of its operation, the 216-A-29 Ditch received discharge from the PUREX Plant cooling water and discharge from the chemical sewer. In early 1980, because of effluent monitoring requirements, the chemical sewer lines feeding the 216-A-29 Ditch required upgrades to allow for monitoring and diversion capabilities. A diversion box was upgraded and connected to the 216-A-42 Retention Basin. The basin received contaminated diversions from the PUREX Plant chemical sewer line, cooling water line, and steam condensate discharge. During 1990, plans were developed and approved to discontinue discharges to and close the 216-A-29 Ditch, and in 1991, all discharges were discontinued. Stabilization of the 216-A-29 Ditch was performed in three phases from July to October 1991.

E2.2 SECURITY

Security information for the Hanford Facility is discussed in DOE/RL-91-28, *Hanford Facility Dangerous Waste Permit Application*, Section 6.1, General Information Portion. Because the 216-A-29 Ditch is located near the 200 East Area, the security information pertaining to the 200 Areas applies to this TSD unit.

Changes to security are expected to occur during the course of 200 East Area deactivation and decommissioning activities. Security measures will remain in place that limit entry to authorized personnel and that preclude unknowing access by unauthorized individuals. Following clean-closure certification of this TSD unit as described in Section 7.8, security provisions no longer will apply.

Figure E-1. 216-A-29 Ditch Location and Site Plan.



E3.0 PROCESS INFORMATION

The following waste streams, which are summarized from the stream-specific, report (WHC-EP-0342, Addendum 2, *PUREX Plant Chemical Sewer Stream-Specific Report*), contributed to the 216-A-29 Ditch:

- Various floor drains: 202-A Canyon Building pipe and operations gallery; air compressor, process blower, and service blower rooms in 202-A; 211-A pump house; and 202-A Canyon Building instrument and maintenance shops
- 618-1 and 618-2 flash tanks containing heating coils, spray water, and steam condensate
- 206-A Vacuum Acid Fractionator Building condensers and reboiler cooling water and steam condensate
- Sink drain from the battery room, instrument shop, and maintenance shop in 202-A
- 202-A laboratory ventilation room; heating, ventilation, and air conditioning-related drainage
- 202-A laboratory nonradioactive clothing change room drains
- 202-A blower room condensate
- Overflow from various demineralized water storage tanks
- Overflow from the emergency water supply tank
- Raw water used to flush continuously the PUREX Plant chemical sewer line.

See Section 7.1 for additional information on physical isolation of the TSD unit.

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E4.0 WASTE CHARACTERISTICS

This chapter identifies the estimate of maximum inventory and the characteristics of the waste disposed at the 216-A-29 Ditch.

E4.1 ESTIMATE OF MAXIMUM INVENTORY OF WASTE

During operations, approximately 22,700,000 L/day (6,000,000 gal/day) of liquid wastewater reached the 216-A-29 Ditch. Accurate records are not available concerning the total volume of waste disposed. The ditch was equipped with a meter for measuring flow rate. Flow rates varied from approximately 378 to 5,290 L/min (100 to 1,400 gal/min), depending on the operating conditions of the PUREX Plant. The average flow was about 3,760 L/min (970 gal/min).

E4.2 WASTE CHARACTERISTICS

The dangerous waste received at the 216-A-29 Ditch includes nitric acid, sulfuric acid, sodium hydroxide, potassium hydroxide, hydrazine, hydroxylamine nitrate, cadmium nitrate, ammonium fluoride, and ammonium nitrate. Some of these chemicals are regulated under WAC 173-303, "Dangerous Waste Regulations," as a dangerous waste because they have a characteristic of corrosivity (D002). Cadmium nitrate is regulated because of the cadmium (D006). Hydrazine is regulated because it is in the listed waste code (U133). In addition, other constituents are regulated because it is mentioned in the state-only WT02 waste code. These TSD unit constituents are identified in WHC-EP-0342, Addendum 2; DOE/RL-89-28, *216-B-3 Expansion Pond Closure Plan*, Rev. 2 (Attachment 23 to Revision 6 of the *Hanford Facility RCRA Permit*); and DOE/RL-2004-17, Appendix B, Table B-2.

Based on the dangerous waste received at the 216-A-29 Ditch, the TSD unit constituents of concern for RCRA closure are sodium (from sodium hydroxide), potassium (from potassium hydroxide), sulfate (from sulfuric acid), nitrate (from nitric acid, hydroxylamine nitrate, cadmium nitrate, and ammonium nitrate), ammonia (from ammonium fluoride, and ammonium nitrate), fluoride (from ammonium fluoride), cadmium (from cadmium nitrate) and hydrazine. These constituents constitute the scope of the TSD unit RCRA closure activities (Table E-1). The pH ranges of the pond and ditch soils are reported as 6.5 to 9.5 and are well within the noncorrosive range from WAC 173-303-090(6), "Dangerous Waste Characteristics," "Characteristic of Corrosivity."

Table E-1. Comparison of 216-A-29 Ditch Remedial Investigation Data to Clean-Closure Levels. (2 Pages)

TSD Unit Constituent Related to Part A Waste Codes D002, D006, U133, and WT02	Maximum Concentration Shallow-Zone Soil (mg/kg)	Maximum Concentration Deep Zone Soil (mg/kg)	Hanford Site Soil Background (mg/kg) [1]	Environmental Protection Ecological Receptors for Shallow Zone Soils [2] (mg/kg)	Human Health Protection Soil Direct Contact [3] (mg/kg)		Soil Concentration Protective of Groundwater [4] (mg/kg)	Clean Closure Driver [5]	Meet Clean Closure Standard?
			90% Log Normal Distribution		Carcinogen	Non-carcinogen			
Sodium	873	Not in RI report table	690	N/A	N/A	N/A	N/A	Not regulated	Yes
Potassium	2,260	ND	2,440	N/A	N/A	N/A	N/A	Not regulated	Yes
Sulfate	2,970	46.2	237	N/A	N/A	N/A	1,030	Soil concentration protective of GW	No
Nitrate (as N)	210	76.4	11.7	N/A	N/A	5,600,000	83[6]	Soil concentration protective of GW	No
Ammonia	34.3	ND	9.23	N/A	N/A	N/A	N/A	Not regulated	Yes
Fluoride (using fluorine)	5.26	ND	100	N/A	N/A	210,000	24.1	Background	Yes
Cadmium	28	0.32	-	N/A	N/A	3,500[7]	N/A	Human health protection	Yes
Hydrazine	Not in RI, Table 4-1	Not in RI, Table 4-3	-	N/A	0.3333	N/A	Practical quantitation limit[8]	Practical quantitation limit	Yes[9]

[1] DOE/RL-92-24, Volume 1, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, Rev. 3.

[2] WAC 173-340-745(5)(b)(ii), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels," "Standard Method C Industrial Soil Cleanup Levels," "Environmental Protection.," Environmental protection ecological receptors are not clean up levels, based on WAC 173-340-7493(2)(a)(i), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Problem Formulation Step," "The Chemicals of Ecological Concern" WAC 173-340-745(3)(b)(ii), "Soil Cleanup Standards for Industrial Properties," "Method A Industrial Soil Cleanup Levels," "General Requirements," values are identical to WAC 173-340-740(3)(b)(ii), "Unrestricted Land Use Soil Cleanup Standards," "Method B Soil Cleanup Levels for Unrestricted Land Use," "Standard Method B Soil Cleanup Levels," "Environmental Protection," because they use the same approach.

[3] WAC 173-340-745(5)(b)(iii)(B)(I) and (II), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels," "Standard Method C Industrial Soil Cleanup Levels," "Human Health Protection," "Soil Direct Contact," "Noncarcinogens," and "Carcinogens." Equations are found in (I) (noncarcinogens) and (II) (carcinogens) for human health direct contact. Point of compliance is surface to 15 ft (WAC 173-340-740(6), "Unrestricted Land Use Soil Cleanup Standards," "Point of Compliance").

[4] WAC 173-340-745(5)(b)(iii)(A), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels," "Standard Method C Industrial Soil Cleanup Levels," "Human Health Protection," "Ground Water Protection." Point of compliance is soils throughout the site (WAC 173-340-740(6)). WAC 173-340-745(5)(b)(iii)(A) values are identical to WAC 173-340-740(3)(b)(iii)(A), "Unrestricted Land Use Soil Cleanup Standards," "Method B Soil Cleanup Levels for Unrestricted Land Use," "Standard Method B Soil Cleanup Levels," "Human Health Protection," "Ground Water Protection," because they use the same approach.

[5] Represents the most restrictive level after ensuring the most restrictive level is not less than natural background and for analytical considerations as indicated in WAC 173-340-700(6)(d), "Overview of Cleanup Standards," "Requirements for Setting Cleanup Levels," "Natural Background and Analytical Considerations."

[6] Alternate fate and transport model established pursuant to WAC 173-340-747(8), "Deriving Soil Concentrations for Ground Water Protection," "Alternative Fate and Transport Models." See DOE/RL-2005-63, *Feasibility Study for the 200-CS-1 Chemical Sewer Group Operable Unit* ,Table 3-1.

[7] Soils also meet WAC 173-340-740(3)(b)(iii)(B)(I), "Unrestricted Land Use Soil Cleanup Standards," "Method B Soil Cleanup Levels for Unrestricted Land Use," "Standard Method B Soil Cleanup Levels," "Human Health Protection," "Soil Direct Contact," "Noncarcinogens," noncarcinogen value of 80 mg/kg.

[8] The practical quantitation limit for hydrazine exceeds the soil concentration protective of groundwater standard of 0.0000625. Therefore, the practical quantitation limit is used for clean-closure determinations.

Table E-1. Comparison of 216-A-29 Ditch Remedial Investigation Data to Clean-Closure Levels. (2 Pages)

TSD Unit Constituent Related to Part A Waste Codes D002, D006, U133, and WT02	Maximum Concentration Shallow-Zone Soil (mg/kg)	Maximum Concentration Deep Zone Soil (mg/kg)	Hanford Site Soil Background (mg/kg)[1]	Environmental Protection Ecological Receptors for Shallow Zone Soils[2] (mg/kg)	Human Health Protection Soil Direct Contact[3] (mg/kg)		Soil Concentration Protective of Groundwater[4] (mg/kg)	Clean Closure Driver[5]	Meet Clean Closure Standard?
			90% Log Normal Distribution		Carcinogen	Non-carcinogen			

[9] Hydrazine was not identified as a constituent of concern during the 200-CS-1 Operable Unit data quality objectives process. Contained-in determinations for listed waste code U133 for hydrazine in soils have been approved by the Washington state Department of Ecology. Clean closure is based on the data quality objectives process and the contained-in determination.

GW = groundwater.
N/A = not applicable.
ND = not detected.
Part A = DOE 2002, *216-S-10 Pond and Trench Part A, Form 3 Dangerous Waste Permit Application*, Rev. 6.
RI = remedial investigation (DOE/RL-2004-17, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit*).
TSD = treatment, storage, and disposal (unit).

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E5.0 GROUNDWATER MONITORING

The 216-A-29 Ditch groundwater closure approach is clean closure. The closure approach is based on the data gathered to date from the monitoring network (PNNL-13047, *Groundwater Monitoring Plan for the 216-A-29 Ditch*), the groundwater data contained in the HEIS, and text provided in PNNL-15070, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*, Section 2.11.3.4, for the 216-A-29 Ditch. Groundwater monitoring also will continue, as appropriate, in the 200-PO-1 Groundwater OU for past-practice discharges. Table E-2 shows a comparison of the TSD unit constituent levels in groundwater to clean-closure levels. The clean-closure levels for groundwater are the calculated overall groundwater cleanup levels. Following approval of this closure plan, the TSD unit groundwater monitoring program for the 216-A-29 Ditch will be discontinued.

The current interim-status groundwater monitoring plan (as required by WAC 173-303-400,"Dangerous Waste Regulations," "Interim Status Facility Standards," and 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart F, "Ground-Water Monitoring") is contained in a separate document, PNNL-13047. This document contains further details regarding the geology, hydrology, and current groundwater monitoring programs for the RCRA TSD unit. Excerpts from PNNL-15070 are presented below that provide for more recent monitoring network and groundwater conditions.

The 216-A-29 Ditch unit continued to be monitored under an interim-status detection program (40 CFR 265.93(b), "Interim Status for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Preparation, Evaluation, and Response,") in fiscal year 2004. The groundwater beneath the 216-A-29 Ditch is monitored for evidence of dangerous waste migration, as required by interim-status RCRA regulations (40 CFR 265.93(b) as referenced by WAC 173-303-400). The groundwater monitoring network at this TSD unit is sampled twice annually for constituents that include contamination indicator parameters, annual groundwater quality parameters, and site-specific constituents. The well network is adequate for the current groundwater flow directions.

Except for specific conductance, indicator parameters in downgradient wells did not exceed critical mean values in fiscal year 2004. Specific conductance exceeded its critical mean value in three downgradient wells during fiscal year 2003 (wells 299-E26-13, 299-E25-48, and 299-E25-35) (Figure E-2). During fiscal year 2004, specific conductance did not exceed the critical mean in well 299-E26-13, although the other two wells still showed the exceedance. The reason for the exceedance at wells 299-E25-48 and 299-E25-35, which lie at the head end of the 216-A-29 Ditch, is the high sulfate concentrations in groundwater associated with discharges of sulfuric acid. The reason for the elevation of specific conductance in wells in other portions of the ditch is unknown.

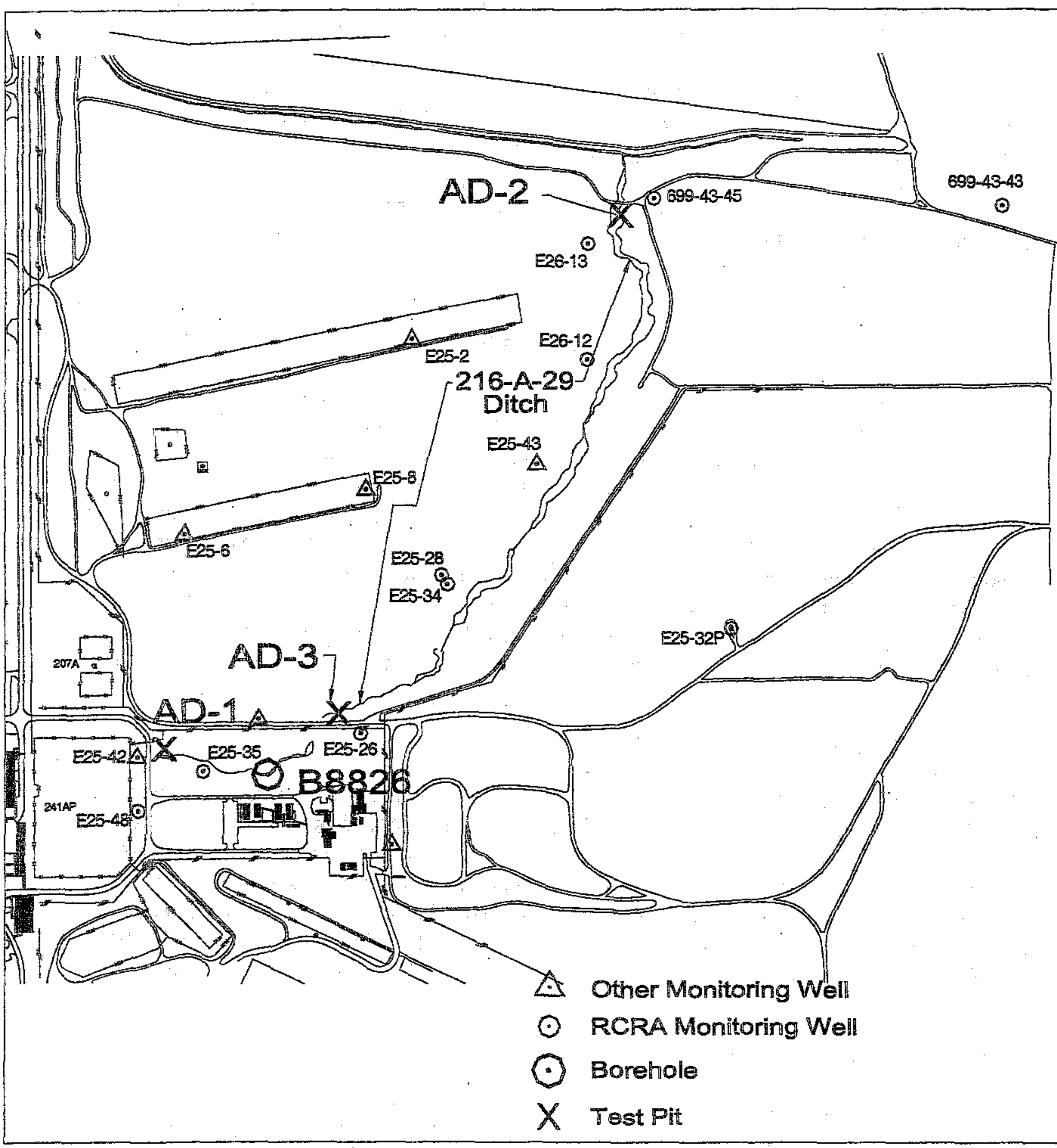
Table E-2. Comparison of 216-A-29 Ditch Groundwater Data to Clean-Closure Levels.

Dangerous Constituent Related to Part A Waste Codes D002, D006, U133, and WT02	Maximum Concentration in Groundwater from HEIS (µg/L)	Hanford Site Groundwater Background (µg/L)[1] (90 % Log Normal Distribution)	Overall Groundwater Cleanup Level (µg/L)	Clean Closure Driver [2]	Meet Clean Closure standard?
Sodium	48,500	26,998	N/A	Not regulated	Yes
Potassium	8,130	9,122	N/A	Not regulated	Yes
Sulfate	236,000[3]	47,014	250,000	SMCL	Yes
Nitrate (as N)	4,697[3]	6,067	10,000	MCL	Yes
Ammonia	Not analyzed	113	N/A	Not regulated	Yes
Fluoride (fluorine)	1,000	1,047	4,000	MCL	Yes
Cadmium	<5[5]	0.916	5	MCL	Yes
Hydrazine	1.6 U[6]	-	Practical quantitation limit[7]	Practical quantitation limit	Yes

[1] DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background.*
[2] Listed values represent the most restrictive level of the groundwater pathways after evaluation of this value to ensure that it is not less than natural background and for analytical considerations as indicated in WAC 173-340-700(6)(d), "Overview of Cleanup Standards," "Requirements for Setting Cleanup Levels," "Natural Background and Analytical Considerations."
[3] Trends for these constituents are currently increasing, but the contamination is from sources other than the 216-A-29 Ditch.
[4] All values reported as undetected with variable detection limits ranging from 1,000 µg/L to 36 µg/L.
[5] All values reported as undetected with variable detection limits ranging from 10 µg/L to 0.058 µg/L.
[6] All values reported as undetected with variable detection limits ranging from 3,000 µg/L to 1.6 µg/L.
[7] The clean up level of 0.0146 µg/l is below the practical quantitation limit. Clean closure is based on the practical quantitation limit.

HEIS = *Hanford Environmental Information System.*
MCL = maximum contaminant level.
N/A = not applicable.
Part A = DOE 2002, *216-S-10 Pond and Trench Part A, Form 3 Dangerous Waste Permit Application,* Rev. 6.
SMCL = secondary maximum contaminant level.
U = undetected.

Figure E-2. Borehole and Test Pit Location Map for the 216-A-29 Ditch.



G:\Maps\042999M.DWG

Two of the three wells that exceeded the critical mean for specific conductance in fiscal year 2003 continued to exhibit an increasing trend. The trend for the third well has reached a plateau. Elevated sulfate levels have been shown to increase specific conductance at the 216-A-29 Ditch in the past. Sulfate levels continued to rise in network wells – most of them with a concomitant rise in specific conductance. This association also has been reported near the Liquid Effluent Retention Facility, Low-Level Waste Management Area 2, and Waste Management Areas A-AX and C. All of these waste management areas are located at the west edge of the decommissioned B Pond. The direction of groundwater flow near the 216-A-29 Ditch generally is to the south-southwest, and the gradient is largely flat. The B Pond continues to create a small hydraulic barrier that contributes to now localized reversals of groundwater flow. The lower mud unit of the Ringold Formation inhibits flow to the east near the 216-A-29 Ditch and groundwater, therefore, is forced to the south. The resulting groundwater flow rate is low, not exceeding ~0.1 m/day.

E5.1 HISTORY OF RCRA GROUNDWATER MONITORING

The RCRA groundwater monitoring of the 216-A-29 Ditch began in November 1988 with an interim-status indicator parameter evaluation (detection-level) program (DOE/RL-92-03, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1991*). The wells were sampled quarterly for one year to establish background levels. Background sampling was completed in August 1989. The program was elevated to an assessment-level program in 1990 because of elevated specific conductance beyond the critical mean in one downgradient well. The results of the groundwater quality assessment, which concluded in 1995, are reported in WHC-SD-EN-EV-032, *Results of the Groundwater Quality Assessment Program at the 216-A-29 Ditch*. The program then reverted to indicator evaluation monitoring in October 1996.

E5.2 AQUIFER IDENTIFICATION

The uppermost or unconfined aquifer beneath the 216-A-29 Ditch is approximately 2 to 24 m (7 to 79 ft) thick and is contained within sediments of the Hanford formation and the Ringold Formation. The aquifer extends from the water table to the top of the basalt or, in some areas, the lower mud unit of the Ringold Formation. Groundwater flow is to the southwest because of the groundwater recharge from the 216-B-3 Pond system. The average groundwater flow velocities range from approximately 0.03 to 0.09 m/day (PNNL-13047). The water table beneath the ditch has declined significantly since the discharges to the 216-B-3 Pond system ceased.

E5.3 WELL LOCATION AND DESIGN

At the end of the assessment monitoring program, the monitoring well network reverted to a smaller group of 10 wells. There were two upgradient wells (699-43-43 and 699-43-45) and eight downgradient wells. Well 699-43-43 no longer produces representative groundwater samples and was removed from the sampling schedule in 2001. The downgradient wells (prefixed by 299-) are E25-26, E25-28, E25-32P, E25-34, E25-35, E25-48, E26-12, and E26-13 (Figure E-2). All of the wells are sampled semiannually with dedicated sampling pumps.

Construction of wells followed the RCRA standard well-construction specifications. The standards in WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," were used to set the basic design requirements. The interim-status groundwater monitoring network for the 216-A-29 Ditch includes 10 wells constructed from 1985 through 1992. Nine of the wells are constructed with screens at the water table, and the remaining well is screened above the top of the basalt. Construction summaries and details of drilling and design specifications for all wells in the interim-status groundwater monitoring system are contained in several reports and are available upon request. Two upgradient wells (699-43-43 and 699-43-45) were selected to determine the background groundwater chemistry.

E5.4 RESULTS OF RCRA INTERIM-STATUS GROUNDWATER MONITORING DATA

The RCRA indicator parameters are specific conductance, pH, total organic carbon, and total organic halides. Site-specific parameters include inductively coupled plasma metals, anions, alkalinity, and turbidity. These constituents, other than turbidity, are analyzed annually although the wells are sampled semiannually. Groundwater quality parameters are chloride, iron (filtered), manganese (filtered), phenols, sodium (filtered), and sulfate. The 216-A-29 Ditch was placed into an assessment-level groundwater monitoring program in 1990 because of elevated specific conductance beyond the critical mean in one downgradient well. From that time until 1995, comprehensive sampling and analysis were performed to determine the cause of this exceedance. The assessment report (WHC-SD-EN-EV-032) concluded that elevated specific conductance was caused by high concentrations of sulfate, sodium, and calcium in the groundwater beneath the 216-A-29 Ditch. The TSD unit reverted to an indicator parameter evaluation program. In fiscal year 2004, specific conductance increased slightly in nearly all of the network wells.

The groundwater near the 216-A-29 Ditch displays pH at levels above interim drinking water standards, but these are not considered attributable to the TSD unit. Unfiltered chromium and iron historically have exceeded drinking water standards in several wells, but filtered results have not exceeded the drinking water standard. These concentrations have been attributed to well construction and oxidizing conditions in the aquifer.

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E6.0 CLOSURE STRATEGY AND PERFORMANCE STANDARDS

This chapter identifies the 216-A-29 Ditch closure strategy and closure performance standards for soils. Groundwater is discussed in Section 5.0.

E6.1 CLOSURE STRATEGY

The standards for closure of Hanford Facility interim-status TSD units are contained in WAC 173-303-610, "Dangerous Waste Regulations," "Closure and Post-Closure," based on the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Tri-Party Agreement Action Plan) (Ecology et al. 1989b), Section 5.3. The possibility for clean closure for all TSD units at the Hanford Facility is described in the Tri-Party Agreement Action Plan, Section 6.3.1.

E6.2 CLOSURE PERFORMANCE STANDARDS

This section identifies general clean-closure performance standards and the specific closure standards for the soils.

E6.2.1 Treatment, Storage, and Disposal Unit Closure Performance Standards

The closure performance standards of WAC 173-303-610(2)(a)(i - iii), "Dangerous Waste Regulations," "Closure and Post-Closure," "Closure Performance Standard," require the owner or operator of a TSD facility to close the facility in a manner that: (1) "minimizes the need for further maintenance," (2) "controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, postclosure escape of dangerous waste, dangerous waste constituents, leachate, contaminated runoff, or dangerous waste decomposition products to the ground, surface water, groundwater, or the atmosphere" and, (3) "returns the land to the appearance and use of surrounding land areas to the degree possible given the nature of the previous dangerous waste activity." These standards can be met by the clean-closure removal or decontamination standard of WAC 173-303-610(2)(b) or by implementing the alternative closure requirements of WAC 173-303-610(1)(e), "Dangerous Waste Regulations," "Closure and Post-Closure," "Applicability."

Potential contaminant exposures and health impacts to humans are largely dependent on land use. The land use for the 200 Areas selected by The U.S. Department of Energy through 64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)," is industrial (exclusive). Industrial cleanup standards are identified in WAC 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels." Before the application of the WAC 173-340-745(5) standards, however, clean closure is evaluated based on the traditional application of WAC 173-340-740(3), "Unrestricted Land Use Soil Cleanup Standards," "Method B Soil Cleanup Levels for Unrestricted Land Use," as required by WAC 173-303-610(2)(b)(i).

The standards in WAC 173-340-745(5) can be imposed through the alternative closure requirements of WAC 173-303-610(1)(e).

The first approach to examine for TSD unit closure is clean closure. Clean closure will eliminate the need for future inspections and maintenance necessitated by TSD unit constituent contamination. Clean closure also will eliminate the need for future postclosure monitoring and maintenance of the soils. Clean closure using the WAC 173-340-740(3) values were examined first because if the DOE/RL-2004-17 data showed that the soils met WAC 173-340-740(3) values as is without further remediation, the TSD unit clean closure can occur independent of the OU remediation activities.

If the TSD unit constituents cannot meet the WAC 173-340-740(3) values, then the WAC 173-340-745(5) values are used to determine if the closure standard has been met. If the DOE/RL-2004-17 data showed that the soils met WAC 173-340-745(5) values as is without remediation, the alternative closure requirements of WAC 173-303-610(1)(e) would be used to implement closure.

To achieve clean closure following remediation of the soils, verification sampling and analysis must be used to demonstrate that TSD unit constituent concentrations meet the closure standard.

E6.2.2 Soil Closure Standards

The clean-closure requirements are established in WAC 173-303-610(2)(b) and the surface impoundment standards in WAC 173-303-650(6)(a), "Dangerous Waste Regulations," "Surface Impoundments," "Closure and Post-Closure Care," to remove or decontaminate unit soils contaminated above clean-closure standards. These soil clean-closure cleanup levels are the numeric levels identified in WAC 173-340-740(3) that are either: (1) levels calculated using the most restrictive WAC 173-340-740(3) formulas for unrestricted use, or (2) background levels (DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*) when the most restrictive WAC 173-340-740(3) formulas are more stringent than Hanford Site background concentrations.

WAC 173-340-740(3) contains the following potential clean-closure standards: Environmental protection related to ecological receptors, soil concentrations protective of groundwater, soil direct-contact carcinogens, soil direct-contact noncarcinogens, soil direct-contact petroleum vapors, and soil vapors. The 'environmental protection related to ecological receptors' values are not a clean-closure standard for TSD unit closure, based on WAC 173-340-7493(2)(a)(i), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Problem Formulation Step," "The Chemicals of Ecological Concern.") The 'soil concentration protective of groundwater,' 'soil direct-contact carcinogens,' and 'soil direct-contact noncarcinogens' are applicable and are identified in Table E-1. The 'soil concentrations protective of groundwater' value for nitrate was established using the alternative fate and transport provisions in WAC 173-340-747(8), "Deriving Soil Concentrations for Ground Water Protection," "Alternative Fate and Transport Models," as described in DOE/RL-2005-63, *Feasibility Study for the 200-CS-1 Chemical Sewer Group Operable Unit*, Section 2.13 and Table 3-1. The 'soil direct-contact petroleum vapors' and 'soil vapors' standards do not apply, because there are no petroleum compounds and no volatile organic compounds related to TSD unit closure, respectively.

WAC 173-340-745(5) contains the identical potential clean-closure standards as WAC 173-340-740(3)[1]. The applicability statements for the individual pathways stated above under WAC 173-340-740(3) also apply to the WAC 173-340-745(3), "Soil Cleanup Standards for Industrial Properties," "Method A Industrial Soil Cleanup Levels," standards. In addition, the following individual pathways and their methods to arrive at a standard are identical: environmental protection related to ecological receptors, soil concentrations protective of groundwater, and soil vapors. There is no difference in these standards when comparing WAC 173-340-740(3) to WAC 173-340-745(5). The only differences between WAC 173-340-740(3) and WAC 173-340-745(5) for applicable standards are: 'soil direct-contact carcinogens,' and 'soil direct-contact noncarcinogens.' See Table E-1 for additional information on the clean-closure standards.

Historical listed waste (U133) hydrazine discharges will not prevent clean closure of the 216-A-29 Ditch. Hydrazine was ruled out as a potential contaminant of concern during the data quality objectives (DQO) process for the 200-CS-1 OU. The DQO report (BHI-01276, *200-CS-1 Operable Unit DQO Summary Report*) states: "Hydrazine is a listed waste that was potentially discharged with the cooling waters. However, because hydrazine is extremely reactive and volatile, it no longer is present in any media associated with the 200-CS-1 OU." The practical quantitation limit for hydrazine exceeds the soil concentration protective of groundwater standard of 0.0000625. Therefore, the practical quantitation limit is used for clean-closure determinations. Furthermore, 216-A-29 Ditch hydrazine was subject to a contained-in determination by Ecology (letter 072750, "200 Area Hydrazine Contained-In Determination Strategy"; letter 02-RCA-0261, "216-A-29 Ditch Hydrazine Contained-in Determination (CID) Request"; Ecology 2002, "Letter, J. Hebdon, U.S. Department of Energy, to J. B. Price, Washington State Department of Ecology, 216-A-29 Ditch Hydrazine Contained-in Determination (CID) Request, DOE/RL 02-RCA-0261, dated April 4, 2004"). This contained-in determination addressed the 216-A-29 Ditch soils. Therefore, clean closure can be pursued for hydrazine at the 216-A-29 Ditch, and the U133 waste code no longer applies to 216-A-29 Ditch soils. Clean closure for hydrazine is based on the DQO process and the contained-in determinations.

[1] Clean closure using health based standards other than those prescribed by WAC 173-303-610(2)(b)(i) is described in two memos: (1) EPA, 1996, "Coordination Between RCRA Corrective Action and Closure and CERCLA Site Activities," and (2) EPA, 1998, "Risk Based Clean Closure."

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E7.0 CLOSURE ACTIVITIES

This chapter summarizes clean-closure activities for the 216-A-29 Ditch performed as part of the 200-CS-1 OU remediation process. Physical closure activities included TSD unit physical isolation, borehole and test pit drilling, sampling and analysis, removal of 216-A-29 Ditch soils, and verification sampling following soil removal. Administrative closure activities also are discussed (e.g., certification).

The unit soils are planned to be clean closed based on the results of DOE/RL-2004-17 and remediation of the 216-A-29 Ditch soils. Soil will be removed and generated as waste. The soil generated as a waste will require subsequent designation according to WAC 173-303-070(3), "Designation of Dangerous Waste," "Designation Procedures," and (5), "Additional Designation Required," and management as part of closure. Because soils are not expected to be designated as dangerous waste, treatment of the soils is not expected before they are disposed of at the Environmental Restoration Disposal Facility.

E7.1 TREATMENT, STORAGE, AND DISPOSAL UNIT PHYSICAL ISOLATION

To preclude any further discharges to the unit and in support of TSD unit closure, the 216-A-29 Ditch was physically isolated from receipt of the PUREX Plant chemical sewer effluent. Stabilization of the 216-A-29 Ditch was performed in three phases from July to October 1991. The trench no longer can accept dangerous waste.

E7.2 TREATMENT, STORAGE, AND DISPOSAL UNIT SAMPLING AND ANALYSIS

The following sections describe sampling and analyses activities that have been completed for the 216 A-29 Ditch.

E7.2.1 Soil Sampling and Analysis

As part of the 200-CS-1 OU remedial investigation, data were collected to characterize the nature and vertical extent of contamination and the physical conditions in the vadose zone underlying the 216-A-29 Ditch. Drilling, test pit excavation, surface and borehole geophysical surveys, and soil sampling and analysis were conducted during the field activities. Borehole and test pit locations are shown in Figure E-2.

Borehole B8826 was drilled and sampled in the 216-A-29 Ditch east of the AP Tank Farm in the 200 East Area. Test Pits AD-1 through AD-3 were excavated and sampled at the 216-A-29 Ditch in fiscal year 2002, and details are summarized in DOE/RL-2004-17. Data collected from Test Pit AD-3 was additional to the data required by DOE/RL-99-44, *200-CS-1 Operable Unit RI/FS Work Plan and RCRA TSD Unit Sampling Plan*, and was used to support the decision-making process for locating a proposed waste transfer line to the Waste Vitrification Plant.

Borehole B8826 was drilled and sampled during fiscal year 2003. The borehole was drilled through the 216 A-29 Ditch, from the ground surface to a depth of 83.2 m (273 ft). The borehole was logged using a high-resolution spectral gamma-ray logging system and a neutron-moisture logging system. The borehole was drilled to better define stratigraphy and to assess the nature and vertical extent of contamination, as well as to determine the physical properties of the soil beneath the TSD unit.

The test pit locations were prepared by removing 0.3 to 0.6 m (1 to 2 ft) of topsoil from the site. The test pits were excavated to a maximum depth of 7 m (25 ft) below ground surface using a track-hoe. Samples were obtained directly from the track-hoe bucket at intervals of approximately 0.7 m (2.5 ft). Before being placed in a sample jar, soil samples were screened in the field to assist in selecting sample points, to support worker health and safety, and to provide shipping information. Samples were analyzed for chemical and physical properties. The test pits were backfilled in the reverse order from which they were excavated, using the track hoe.

Soils from the boreholes and test pits were screened in the field both for indications of contamination and for assisting in determining the discrete sample locations or depths before the samples were collected. Soil samples were collected for analysis and determination of physical properties. The sampling approach generally required a greater sample frequency near the bottom of the TSD unit, which is the area of highest suspected contamination. Sample collection always was attempted at depths of 4.6 and 7.6 m (15 and 25 ft) below ground surface to define contamination profiles. Sample frequency generally was reduced to 6.1 to 15.2 m (20- to 50-ft) intervals below a depth of 7.6 m (25 ft) in the boreholes.

Soil samples were analyzed for the constituents of concerns from DOE/RL-2004-17. Samples were analyzed selectively for field bulk density and moisture content. In addition, ditch bottom samples from each of the test pits were analyzed for an expanded list of compounds, to satisfy waste-designation requirements. Soil descriptions were recorded to better define stratigraphic relationships in the OU. The results obtained from previous characterization activities also were evaluated as part of this remedial investigation.

E7.2.2 Soil Sample Results

Analytical results obtained from the remedial investigation were intended for RCRA closure decisions and are defensible for use in this closure plan. Table E-1 identifies the maximum concentration of TSD unit constituents in shallow soils and deep-zone soils from DOE/RL-2004-017, Tables 4-1 and 4-3. The maximum values are compared to the clean-closure levels described in Section 6.2.2.

After comparing the TSD unit constituent concentrations found in DOE/RL-2004-17, Tables 4-1 and 4-3, to the WAC 173-340-740(3) values, the TSD unit was not eligible for clean closure without remediation. The TSD unit constituent concentrations were then compared to the WAC 173-340-745(5) values with the same result. Not all constituents met the WAC 173-340-745(5) standard without remediation. Remediation of the 216-A-29 Ditch soils will prevent the need for barrier construction as part of the 200-CS-1 OU decision making. The WAC 173-340-745(5) standards still can be used to meet clean-closure standards.

Table E-1 shows that six of eight TSD unit constituents (sodium, potassium, ammonia, fluoride, cadmium, and hydrazine) meet the clean-closure standard, the constituent is not regulated, or, in the case of hydrazine, other provisions are used to demonstrate clean closure. Nitrate and sulfate are the TSD unit constituents that do not meet the clean-closure standard. To meet WAC 173-340-745(5) cleanup levels, 216-A-29 Ditch soils will require removal. Furthermore, because the 200-CS-1 OU is removing the 216-A-29 Ditch soils, the closure approach for the soils will be to remove the 216-A-29 Ditch soils and conduct verification sampling.

E7.3 OTHER ACTIVITIES REQUIRED FOR CLOSURE

The 200-CS-1 OU activities planned to support clean closure of the TSD unit include the removal of the 216-A-29 Ditch soils. This activity is expected to achieve clean closure for the TSD unit soils. In addition, a DQO action with follow-on verification sampling will be performed to determine if the clean-closure levels have been met, as part of the 200-CS-1 OU activities. After closure, appearance of the land will be consistent with future land-use determinations for adjacent portions of the 200 Areas as an industrial-exclusive portion of the Hanford Facility.

E7.4 INSPECTIONS

The TSD unit has been inspected to ensure that it meets interim-status requirements. Annual inspections are performed based on Ecology approval in 2003. Following closure certification as described in Section 7.8, inspections for the 216-A-29 Ditch will be discontinued.

E7.5 TRAINING

A dangerous waste training plan has been maintained for the TSD unit to meet interim-status requirements. The duties associated with dangerous waste management activities include performing inspections, notifying Ecology of any potential threats to human health and the environment, and performing groundwater monitoring. Following closure certification as described in Section 7.8, the dangerous waste training plan addressing the 216-A-29 Ditch waste management duties will be discontinued. Following approval of this closure plan, the dangerous waste training plan will be revised to remove the groundwater monitoring duties.

During the time that the remaining closure activities are performed, as described in Section 7.6, personnel training will be conducted in accordance with the CERCLA training requirements contained in 40 CFR 300.150, "National Oil and Hazardous Substances Pollution Contingency Plan," "Worker Health and Safety."

E7.6 SCHEDULE FOR CLOSURE

The remaining closure activities for this TSD unit include (1) removal of the 216-A-29 Ditch soils, (2) completion of a DQO process for verification sampling, and (3) verification sampling of the soils. These activities will be conducted as part of the 200-CS-1 OU activities. Following submittal of this closure plan to Ecology, Ecology's 90-day review period begins in accordance with the Tri-Party Agreement Action Plan, Figure 9-2.

E7.7 AMENDMENT OF CLOSURE PLAN

As required by WAC 173-303-610(3)(b), "Dangerous Waste Regulations," "Closure and Post-Closure," "Closure Plan; Amendment of Plan," the closure plan will be amended if changes to closure activities require a modification of the approved closure plan. Modifications to this plan could occur as a result of the activities identified in Section 7.6.

E7.8 CERTIFICATION OF CLOSURE

Upon removal of the 216-A-29 Ditch soils, verification sampling must be performed to determine if the closure activities meet the clean-closure standard. When verification sampling results have been evaluated, closure activities under this closure plan are planned to have been completed.

In accordance with WAC 173-303-610(6), "Dangerous Waste Regulations," "Closure and Post-Closure," "Certification of Closure," within 60 days of completion of TSD unit closure, the U.S. Department of Energy will submit to the lead regulatory agency (Ecology) a certification of closure. Both DOE and the Co-Operator identified on the current Part A Permit Application (DOE 2002, *216-A-29 Ditch Part A, Dangerous Waste Permit Application*, Rev. 6) will sign the certification of closure, and an independent Registered Professional Engineer will state that the unit has been closed in accordance with the approved closure plan. The certification will be submitted by registered mail or an equivalent delivery service. Documentation supporting the independent Registered Professional Engineer's certification will be placed in the Administrative Record.

E8.0 POSTCLOSURE PLAN

The closure strategy for the 216-A-29 Ditch is clean closure with regard to TSD unit constituents for soils and groundwater. Therefore, no postclosure plan is required. If the verification sampling following removal of the 216-A-29 Ditch soils does not demonstrate clean closure, a postclosure plan will be prepared for the 216-A-29 Ditch. The postclosure plan will be submitted to Ecology within 180 days following certification of closure or as otherwise agreed to by Ecology, based on 200-CS-1 OU schedules.

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APPENDIX F

SEASONAL SOIL COMPARTMENT MODEL

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CONTENTS

FIGURES

TABLES

TERMS

AGTEHM	Agricultural Terrestrial Ecosystem Hydrology Model
AP	airport
COPC	contaminant of potential concern
EPA	U.S. Environmental Protection Agency
K_d	chemical-specific distribution coefficient
K_{oc}	soil organic carbon-water partition coefficient
NWS	National Weather Service
OTS	U.S. Environmental Protection Agency, Office of Water and Toxic Substances
OU	operable unit
SESOIL	Seasonal Soil Compartment Model
WAC	*Washington Administrative Code*

APPENDIX F

SEASONAL SOIL COMPARTMENT MODEL

F1.0 BASIS FOR SEASONAL SOIL COMPARTMENT MODEL AS AN ALTERNATIVE TRANSPORT AND FATE MODEL

The extended risk analysis uses as a vadose zone to groundwater alternative transport and fate model in accordance with the requirements in *Washington Administrative Code* (WAC) 173-340-747(8), "Deriving Soil Concentrations for Ground Water Protection," "Alternative Fate and Transport Models," in order to help clarify uncertainties in the understanding of the threats posed by shallow (0 to 15 ft [0 to 4.6 m]) soil contamination. The uncertainties stem from initial use of Equation 747-1 from WAC 173-340-747(8) to evaluate vadose zone soil contamination impacts on groundwater. Equation 747-1 is a screening tool that does not account for the significant depth to groundwater, typically 270 ft (94 m), or the deficiency of net infiltration typical of the Hanford Site. WAC 173-340-747(8) specifies procedures and requirements for establishing soil concentrations that are protective of groundwater using fate and transport models other than Equation 747-1.

The alternative fate and transport model used to evaluate soil to groundwater impacts is the Seasonal Soil Compartment Model (SESOIL). SESOIL was developed originally by the U.S. Environmental Protection Agency's Office of Water and Toxic Substances. The Oak Ridge National Laboratory has upgraded the model several times, including a major effort in 1995. General Sciences Corporation (GSC 1998, *SESOIL*) currently licenses the model. SESOIL is widely used in the hazardous waste industry to assess soil-to-groundwater impacts at *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* and *Resource Conservation and Recovery Act of 1976* sites such as those found at the 200-CS-1 Operable Unit (OU) waste sites. Various states, including Colorado and Kansas, use SESOIL to evaluate the impacts that contaminants in soils may have on groundwater. A detailed discussion of SESOIL can be found in Section F2.0.

SESOIL is a compartment model that computes the mass movement of constituents from overlying strata to the underlying strata using advective moisture movement from infiltration, water balance, and constituent-partitioning algorithms. SESOIL helps clarify the groundwater impacts assessment, over the use of Equation 747-1 from WAC 173-340-747(8), by:

- Using local climatological data to drive the moisture flux
- Incorporating the significant depth to groundwater that is intrinsic to the Hanford Site
- Integrating constituent-specific migration and attenuation characteristics over time.

The constituent partitioning and depth of penetration aspects of SESOIL are governed by (1) the distribution coefficient (e.g., K_d) in a method that is essentially similar to that used by Equation 747-1, and (2) the vertical moisture velocity computed by the model using site-specific meteorological (i.e., Pasco National Weather Service data).

A comparison of requirements for the use of alternative fate and transport models, as set forth in WAC 173-340-740, with SESOIL, as configured for the 200-CS-1 OU waste sites, is provided in Table F-1.

Examination of Table F-1 indicates that the use of SESOIL as an alternative fate and transport model to clarify uncertainties in the refined risk analysis has been accomplished in accordance with WAC 173-340-747(8). The uncertainties arise from the use of Equation 747-1, which does not account for the significant depth to groundwater, typically 270 ft (94 m), nor does the equation account for the scarcity of net infiltration typical of the arid Hanford Site. SESOIL modeling results, detailed in Sections 2-12 and 2-13 are credible and consistent with observed monitoring data.

F2.0 DETAILED DESCRIPTION OF THE SESOIL MODEL

F2.1 SESOIL OVERVIEW

SESOIL is a one-dimensional vertical transport software code for the unsaturated soil zone (Figure F-1).[1] SESOIL is a unique model, both in its structure and its mathematics. An integrated screening-level soil compartment model, SESOIL is designed to simultaneously model water transport, sediment transport, and pollutant fate. However, for applications at the 200-CS-1 OU waste sites, sediment transport was not used.

SESOIL was developed for the U.S. Environmental Protection Agency (EPA) Office of Water and the Office of Toxic Substances in 1981 by Arthur D. Little, Inc., Cambridge, Massachusetts (Bonazountas and Wagner 1981, *SESOIL: A Seasonal Compartment Model*) as part of the EPA Risk Analysis Program. The model was updated in 1984 to include a fourth soil compartment (the original model included up to three layers) and soil erosion algorithms (Bonazountas and Wagner 1984, "Modeling Mobilization and Fate of Leachate Below Uncontrolled Hazardous Waste Sites"). Following a comprehensive evaluation of SESOIL (Watson and Brown 1985, *Testing and Evaluation of the SESOIL Model*), SESOIL was enhanced at the Oak Ridge National Laboratory (Hetrick et al. 1986, "Model Predictions of Watershed Hydrologic Components: Comparison and Verification"; Hetrick et al. 1988, "Model Predictions of Watershed Erosion Components"; ORNL/TM-10672, *Qualitative Validation of Pollutant Transport Components of an Unsaturated Soil Zone Model [SESOIL]*).

SESOIL was developed as a screening-level model, using less soil, chemical, and meteorological values as input than most other similar models. Output of the SESOIL model includes time-varying pollutant concentrations at various soil depths and pollutant loss from the unsaturated zone in terms of surface runoff, percolation to the groundwater, volatilization, and degradation.

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[1] Much of this section was excerpted nearly verbatim from Chapter 7.0 in Bonazountas et al. 1997, *SESOIL in Environmental Fate and Risk Modeling*.

SESOIL accepts time-varying pollutant loading. It can simulate chemical releases to soil from a variety of sources, including landfill disposal, accidental leaks, agricultural applications, leaking underground storage tanks, or deposition from the atmosphere. Applications of SESOIL include long-term leaching studies from waste disposal sites, pesticide and sediment transport in watersheds, studies of hydrological cycles and water balances in soil compartments, and pre-calibration runs for other simulation models. The model can be used to estimate the effects of various site management or design strategies on pollutant distributions and concentrations in the environment.

The soil column in SESOIL is a user-defined compartment extending from the surface through the unsaturated zone to the groundwater table. Typically, SESOIL is used to estimate the migration rate of chemicals through soils and the concentration of the chemicals in soil layers following a chemical release to the soil environment. SESOIL simulation of chemical persistence considers mobility, volatility, and degradation. This is consistent with its applications at the 200-CS-1 OU waste sites. The SESOIL model requires several chemical and site-specific parameters to estimate the concentration of the chemical in the soil, its rate of leaching toward groundwater, and its impact on other environmental pathways. The user is required to provide chemical properties and release rate, and soil and climate data.

F2.2 SESOIL THEORY

F2.2.1 Model Description

SESOIL is a one-dimensional vertical transport model for the unsaturated soil zone. The model is based on mass balance and equilibrium partitioning of the chemical between different phases (i.e., dissolved, sorbed, vapor, and pure). SESOIL was designed to perform *long-term* simulations of chemical transport and transformations in the soil. The model employs theoretically derived equations to represent water transport, sediment transport on the land surface, pollutant transformation, and migration of the pollutant to the atmosphere and groundwater. Climatic data, compartment geometry, and soil and chemical property data are the major components used in the equations.

Processes modeled by SESOIL are categorized into three cycles: hydrology, sediment (not used for the 200-CS-1 OU waste sites), and pollutant transport. Each cycle is a separate submodel within the SESOIL code. Most mathematical environmental simulation models may be categorized as stochastic (i.e., statistical) or deterministic models; both models are theoretically derived. Stochastic models incorporate the concept of probability or some other measure of uncertainty, while deterministic models describe the system in terms of cause-effect relationships. SESOIL employs a stochastic approach for the hydrologic cycle and a deterministic approach for the pollutant transport cycle.

F2.2.2 Soil Compartment

In SESOIL, the soil compartment (or column) is a cell extending from the surface through the unsaturated zone to the upper level of the saturated soil zone (aquifer or groundwater table). While SESOIL estimates the pollutant mass added to the groundwater, the saturated zone is not modeled. The output from SESOIL can be used for generating input values for groundwater transport models. In the version used for the 200-CS-1 OU waste sites, a simple groundwater-mixing model (Summers model) takes the SESOIL output and estimates groundwater concentrations. The Summers model is an integrated feature of the modeling system provided in RISKPRO Version 3.0 (GSC 1998).

SESOIL performs simulation for three separate cycles within the soil compartment. The cycles and the processes included in each cycle are as follows:

- Hydrologic cycle, which includes rainfall, infiltration, groundwater runoff (i.e., recharge), surface runoff, capillary rise, evapotranspiration, and soil moisture retention (storage)
- Sediment cycle, which includes sediment wash load (erosion due to storms), which was not simulated for the 200-CS-1 OU waste sites
- Pollutant fate cycle, which includes the processes of advection, diffusion (e.g., air phase) volatilization, sorption, cation exchange, hydrolysis, wash load, surface runoff, groundwater runoff (i.e., recharge), metal complexation, and chemical degradation/decay. For the 200-CS-1 OU waste sites, advection, sorption, and groundwater runoff were the principal processes simulated. Chemical degradation/decay was simulated to address benzene contamination at the 216-B-63 Trench.

F2.2.3 Hydrologic Cycle

The hydrologic cycle, illustrated in Figure F-2, is one-dimensional submodel that considers vertical movement only and focuses on the role of soil moisture (or interstitial pore water) in the soil compartment. The hydrologic cycle submodel calculates results for the hydrology of a site and transfers these results to the sediment wash load cycle and the pollutant fate cycle. The hydrologic cycle used in SESOIL is an adaptation of the water balance dynamics theory of Eagleson 1978, "Climate, Soil, and Vegetation." The theory can be described as a dimensionless analytical representation of an annual water balance. It is itself a model based on interacting hydrological processes, which include parameters governing climate, soil, and vegetation of a basin. These processes are coupled through statistical algorithms.

It is beyond the scope of this discussion to present the detailed physics and mathematical expressions used. The hydrologic cycle is thoroughly described by Eagleson (1978) and summarized by Bonazountas and Wagner (1984). It is based on the water balance equations (see Equations 1 and 2). All of these parameters are expected or mean annual values, and in SESOIL they are expressed in centimeters:

$$P - E - MR = S + G = Y \qquad \text{Eq 1}$$

$$I = P - S \qquad \text{Eq 2}$$

where

- P = precipitation
- E = evapotranspiration
- MR = moisture retention
- S = surface runoff
- I = infiltration
- Y = yield
- G = groundwater runoff or recharge (includes term for capillary rise).

Precipitation is represented by Poisson arrivals of rectangular gamma-distributed intensity pulses that have random depth and duration. Infiltration is described by the Philip equation, which assumes the medium to be effectively semi-infinite, and the internal soil moisture content at the beginning of each storm and interstorm period to be uniform at its long-term average. Percolation to the groundwater is assumed to be steady throughout each time step of simulation, at a rate determined by the long-term average soil moisture content. Capillary rise from the water table is assumed to be steady throughout the time period and to take place to a dry surface. Surface runoff is derived from the distribution of rainfall intensity and duration, and by use of the Philip infiltration equation. The effects of moisture storage are included in the monthly option in SESOIL, based on the work of Eagleson as modified by Bonazountas and Wagner (1984).

Eagleson's theory assumes a one-dimensional vertical analysis in which all processes are stationary at the long-term average. Eagleson's approach assumes that soils are homogeneous and that the soil column is semi-infinite in relation to the surface processes. Thus, in the hydrologic cycle of SESOIL, the entire unsaturated soil zone is conceptualized as a single layer (or compartment), and the prediction for soil water content is an average value for the entire unsaturated zone.

While the user can provide different permeability values as input for each of the four major soil layers for SESOIL's pollutant cycle, the hydrologic cycle will compute and use the depth-weighted average permeability according to the formula shown in Equation 3:

Eq 3

$$Kz = \frac{d}{\sum_{i=1}^{n} \frac{d_i}{K_i}}$$

where

- K_z = vertically averaged permeability (cm^2)
- K_i = permeability for layer i (cm^2)
- d = depth from surface to groundwater (cm)
- d_i = thickness of layer i (cm).

There is no explicit consideration of snow and ice, which are entered as precipitation. The model assumes that the water table elevation is constant, with no change in groundwater storage from year to year. Bonazountas et al. (1984) adopted this theory for annual and monthly simulations.

Each process in Equations 1 and 2 is written in terms of the soil moisture content. Solution of the equations is accomplished by iterating on soil moisture until the calculated value for precipitation is within 1 percent of the measured value input by the user. When this iteration is completed, components such as infiltration and evapotranspiration in Equations 1 and 2 are known. SESOIL uses this procedure in the annual and monthly routines. The monthly routine is an extension of the annual routine. The monthly routine, used for the 200-CS-1 OU waste sites, is discussed below.

Monthly Hydrologic Cycle

The monthly water balance routine is based on the same theory as the annual routine, with modifications made to the details of moisture transfer from month to month (handling of moisture storage) and to the radiation effects. The initial value for soil moisture content is calculated in SESOIL by summing the appropriate monthly climatic input data (for the first year) to obtain annual values and using the annual cycle algorithm. Then, for each month, the monthly input values for precipitation, mean storm number, and mean length of the rain season are multiplied by 12 to again obtain annual values. Equations 1 and 2 then are solved to compute the soil moisture content, and the results for the components (e.g., infiltration, evapotranspiration) are divided by 12 to attain average monthly values.

The monthly cycle in SESOIL accounts for the change in moisture storage from month to month, incorporating the work of Metzger and Eagleson 1980, "The Effects of Annual Storage and Random Potential Evapotranspiration on the One-Dimensional Annual Water Balance"). The SESOIL evapotranspiration algorithm has been modified from the original work of Eagleson (1978) to include seasonal changes in average monthly radiation (radiation was a constant function of latitude before). Hetrick 1984, "Simulation of the Hydrologic Cycle for Watersheds," observed that hydrology predictions of the original SESOIL model were insensitive to seasonal changes in meteorological data. To model the hydrology more realistically, an algorithm from the Agricultural Terrestrial Ecosystem Hydrology Model (AGTEHM) model (ORNL/TM-7856, *AGTEHM: Documentation of Modifications to the Terrestrial Ecosystem Hydrology Model (TEHM) for Agricultural Applications*) is now used. The AGTEHM algorithm computes daily potential radiation (incoming radiation for cloudless skies) for a given latitude and Julian date (December 31= 365). The middle day of the month is used in the algorithm and the effect of cloud cover is calculated with the expression (Hetrick et al. 1986) shown in Equation 4:

$$S_{avg} = S[\,(i-C) + k\,.\,C] \qquad \text{Eq 4}$$

where

S_{avg}	=	the average monthly solar radiation
S	=	the potential radiation
C	=	the fraction of sky covered by clouds
k	=	the transmission factor of cloud cover.

The value for k used in SESOIL is 0.32 as suggested by ORNL/TM-7856. Because latitude and monthly cloud cover are required input for SESOIL (e.g., Pasco National Weather Service Station for the 200-CS-1 waste sites), no new input data are needed to support this modification.

SESOIL model predictions (using the monthly option) of watershed hydrologic components have been compared to those of (1) the more data-intensive terrestrial ecosystem hydrology model AGTEHM (ORNL/TM-7856), and (2) empirical measurements at a deciduous forest watershed and a grassland watershed (Hetrick et al. 1986). Although there were some differences in monthly results between the two models, good agreement was obtained between model predictions for annual values of infiltration, evapotranspiration, surface runoff, and groundwater runoff (recharge). In addition, SESOIL model predictions compared well with the empirical measurements at the forest stand and the grassland watersheds.

Figure F-3 illustrates how the SESOIL layer and sub-layer system typically were configured for the 200-CS-1 OU waste sites.

Hydrologic Calibration

Calibration of unsaturated soil zone models can be uncertain and difficult because climate, soil moisture, soil infiltration, and percolation are strongly interrelated parameters that are difficult and expensive to measure in the field. If possible, input parameters for any unsaturated soil zone model should be calibrated so that hydrologic predictions agree with observations.

In SESOIL, all input parameters required for the hydrologic cycle can be estimated from field studies with the exception of the pore disconnectedness index, "c." This parameter is defined as the exponent relating the "wetting" or "drying" time-dependent permeability of a soil to its saturated permeability (Eagleson 1978; Eagleson and Tellers 1982, "Ecological Optimality in Water-Limited Natural Soil-Vegetation Systems, 2. Tests and Applications"). Brooks and Corey 1966, "Properties of Porous Media Affecting Fluid Flow," presented the relationship shown in Equation 5:

$$K(S) = K(I) * S^{c} \quad \text{Eq 5}$$

where

K(I) = saturated hydraulic conductivity (cm/s)
K(S) = hydraulic conductivity at S (cm/s)
S = percent saturation
c = pore disconnectedness index.

This parameter is not commonly found in the literature. Default values for "c" proposed by Eagleson (1978) and Bonazountas and Wagner (1981, 1984) are clay, 12; silty clay loam, 10; clay loam, 7.5; sandy loam, 6; silt loam, 5.5; sandy clay loam, 4; and sand, 3.7.

F2.2.4 Pollutant Fate Cycle

The pollutant fate cycle focuses on the various chemical transport and transformation processes that may occur in the soil. These processes were summarized in Section 2.2.2, and are discussed in more detail below. The pollutant fate cycle uses calculated results from the hydrologic cycle that are automatically provided to the pollutant fate cycle.

In SESOIL, the ultimate fate and distribution of the pollutant are controlled by the processes interrelated by the mass balance equation (Equation 6). The processes are selectively employed and combined by the pollutant fate cycle based on the chemical properties and the simulation scenario specified by the user. The actual quantity or mass of pollutant taking part in any one process depends on the competition among all the processes for available pollutant mass. Pollutant availability for participation in these processes and pollutant rate of migration to the groundwater depend on its partitioning in the soil between the gas (soil air), dissolved (soil moisture), and solid (adsorbed to soil) phases.

Pollutant Cycle Foundation

In SESOIL, any layer or sub-layer can receive pollutant, store it, and export it to other subcompartments. Downward movement of pollutant occurs only with the soil moisture, while upward movement can occur only by vapor phase diffusion. Like the hydrologic cycle, the pollutant fate cycle is based on a mass balance equation that tracks the pollutant as it moves in the soil moisture between subcompartments. Upon reaching and entering a layer or sub-layer, the model assumes instantaneous uniform distribution of the pollutant throughout that layer or sub-layer. The mass balance equation (Equation 6) is:

$$O(t-1) + I(t) = T(t) + R(t) + M(t) \qquad \text{Eq 6}$$

where

O(t-1) = the amount of pollutant originally in the soil compartment at time t-1 (flg/cm^2)
I(t) = the amount of pollutant entering the soil compartment during a time step (flg/cm^2)
T(t) = the amount of pollutant transformed within the soil compartment during the time step (flg/cm^2)
R(t) = the amount of pollutant remaining in the soil compartment at time t (flg/cm^2)
M(t) = the amount of pollutant migrating out of the soil compartment during the time step (flg/cm^2).

The fate of the pollutant in the soil column includes both transport and transformation processes, which depend on the chemical's partitioning among the three phases: soil air, soil moisture, and soil solids. The three phases are assumed to be in equilibrium with each other at all times, and the partitioning is a function of chemical-specific partition coefficients and rate constants supplied by the user.

Once the concentration in one phase is known, the concentrations in the other phases can be calculated. The pollutant cycle of SESOIL is based on the chemical concentration in the soil water. That is, all processes are written in terms of the pollutant concentration in soil water, and the model iterates on the soil moisture concentration until the system defined by Equation 6 balances.

The concentration in the soil air is calculated via the modified Henry's law constant (see Equation 7):

$$c_{sa} = \frac{c * H}{R * (T + 273)} \qquad \text{Eq 7}$$

where

c_{sa}	=	pollutant concentration in soil air (μg/mL)
c	=	pollutant concentration in soil water (μg/mL)
H	=	Henry's law constant (m^3atm/mol)
R	=	gas constant [8.2*10-5 m^3atm/(mol ^{o}K)]
T	=	soil temperature (^{o}C).

The concentration adsorbed to the soil is calculated using the Freundlich isotherm (note that a cation exchange option, discussed later, is available in SESOIL) (see Equation 8):

$$s = K_d c^{\frac{1}{n}} \qquad \text{Eq 8}$$

where

S	=	pollutant-adsorbed concentration (μg/g soil)
K_d	=	pollutant-partitioning coefficient (μg/g soil)/(μg/mL)
c	=	pollutant concentration in soil water (μg/mL)
n	=	Freundlich constant.

The total concentration of the pollutant in the soil is computed as shown in Equation 9:

$$c_o = f_a * c_{sa} * \theta * c + \rho_b n \qquad \text{Eq 9}$$

where

c_o	=	overall (total) pollutant concentration (μg/cm^3)
f_a	=	$n-\theta$ = the air-filled porosity (mL/mL)
n	=	soil (total) porosity (mL/mL)
θ	=	soil moisture (water) content (mL/mL)
ρ_b	=	soil bulk density (g/cm^3).

In SESOIL, each soil layer or sub-layer has a set volume, and the total soil column is treated as a series of interconnected layers. Each layer or sub-layer has its own mass balance equation (Equation 6) and can receive and release pollutant to and from adjacent layers or sub-layers. The individual fate processes that compose the SESOIL mass balance equations (e.g., volatilization, degradation) are functions of the pollutant concentration in the soil water of each zone and a variety of first-order rate constants, partitioning coefficients, and other constants.

The pollutant cycle equations are formulated on a monthly basis and results are given for each month simulated. However, to account for the dynamic processes in the model more accurately, an explicit time step of 1 day is used in the equations. The monthly output represents the summation of results from each day.

In the event that the dissolved concentration exceeds the aqueous solubility of the pollutant, the dissolved concentration is assumed to equal the aqueous solubility. That is, if during solution of the mass balance equation for any one layer, the dissolved concentration exceeds the solubility of the chemical, the iteration is stopped for that time step, and the solubility is used as the dissolved concentration. The adsorbed and soil air concentrations are calculated using the chemical partitioning equations as before (Equations 7 and 8).

To maintain the mass balance, the remaining pollutant is assumed to remain in a pure phase (undissolved). Transport of the pure phase is not considered, but the mass of the chemical in the pure phase is used as input to that same layer in the next time step. Simulation continues until the pure phase eventually disappears.

Pollutant Depth Algorithm

This section introduces the user to the major algorithms and processes simulated in the pollutant cycle of SESOIL, which is based on the pollutant concentration in soil moisture. In theory, a nonreactive dissolved pollutant originating in any unsaturated soil layer will travel to another soil layer or to the groundwater at the same speed as the moisture mass originating in the same soil layer. The movement of a reactive pollutant, however, will be retarded in relation to the movement of the bulk moisture mass because of vapor phase partitioning and the adsorption of the pollutant onto the soil particles. If it is assumed that no adsorption occurs, and that the vapor phase is negligible, the pollutant will move at the same rate as water through the soil.

Originally, only the advective velocity was used in SESOIL to determine the depth the pollutant reached during a time step. The depth (D) was calculated as shown in Equation 10:

$$D = \frac{J_w t_c}{\theta} \qquad \text{Eq 10}$$

where

J_w = water velocity (cm/s)
t_c = advection time (s)
θ = soil water content (cm^3/cm^3).

Using this approach, all chemicals reach the groundwater at the same time, irrespective of their chemical sorption characteristics. To account for retardation, SESOIL uses Equation 11 to calculate the depth reached by a chemical with a linear equilibrium partitioning between its vapor, liquid, and adsorbed phases (Jury et al. 1984, "Behavior Assessment Model for Trace Organics in Soil: II. Chemical Classification and Parameter Sensitivity"):

$$D = \frac{J_w t_c}{\theta + \rho_b {}^* Kd + \dfrac{f_a H}{R(T+273)}} \qquad \text{Eq 11}$$

All terms previously were defined.

SESOIL calculates the flux J_w (see below) for each layer using the infiltration rate and groundwater runoff (recharge) rate computed by the hydrologic cycle, and the depths and permeabilities input by the user. It must be noted that a different permeability can be input for each of the four major soil layers. While the hydrologic cycle will use the weighted mean average of layer permeabilities according to Equation 3, the pollutant cycle does take into account the separate permeability for each layer in computing J_w at the layer boundaries according to Equation 12:

$$J_{w,z} = \left[G + (I - G)\left(\frac{d_j}{d}\right)\right]\left(\frac{k_i}{K_z}\right) \qquad \text{Eq 12}$$

where

- $J_{w,z}$ = infiltration rate at depth z, which will be the boundary between two major layers (cm/s)
- G = groundwater runoff (recharge) (cm/s)
- I = infiltration at surface (cm/s)
- d_j = depth of soil column below depth z (cm)
- d = depth of soil column from surface to groundwater table (cm)
- K_z = intrinsic permeability defined by Equation 3 (cm^2)
- k_i = vertically averaged permeability for layer i (cm^2); computed using Equation 3, except d in the numerator of Equation 3 is the sum of the layer depths above depth z and the summation in the denominator is from layer 1 to layer i.

The user is allowed three options for pollutant loading: (1) a spill loading, where all of the pollutant is entered at the soil surface in the first time step of the month the loading occurs; or (2) a steady application, where the pollutant load is distributed evenly for each time step during the month the loading is specified; or (3) initial concentrations for any sub-layer can be input. However, Option (3) allows the user to input initial concentrations into any sub-layer, allowing a specific initial concentration distribution for the entire soil column. Option (3) was used for assessing the 200-CS-1 OU waste sites.

Equation 11 is used to compute the depth of the pollutant front from that point. If initial concentrations are input, the depth of the front begins at the middle of the lowest layer that has a concentration. Subsequently, the pollutant is not allowed to enter a layer or sub-layer until the depth of the pollutant front has reached the top of that layer or sub-layer. When the pollutant depth reaches the groundwater table, the pollutant leaves the unsaturated zone by simply multiplying the groundwater runoff (recharge) rate by the concentration in the soil moisture.

Volatilization/Diffusion

In SESOIL, volatilization/diffusion includes movement of the pollutant from the soil surface to the atmosphere and from lower soil layers to upper ones. The vapor phase diffusion in SESOIL operates in the upward direction only. The rate of diffusion for a chemical is determined by the properties of the chemical, the soil properties, and environmental conditions. The volatilization/diffusion model in SESOIL is based on the model of Farmer et al. 1980, "Hexachlorobenzene: Its Vapor Pressure and Vapor Phase Diffusion," and is a discretized version of Fick's first law over space, assuming vapor phase diffusion as the rate-controlling process. That is, the same equation is used for volatilization to the atmosphere as is used for diffusion from lower layers to upper ones. The vapor phase diffusion flux through the soil J_s, ($\mu g/cm^2 s$) is described as shown in Equation 13:

$$J_a = -D_a\left(\frac{f_a^{\frac{10}{3}}}{f^2}\right)\frac{dc_{sa}}{d_z} \qquad \text{Eq 13}$$

where

D_a = the vapor diffusion coefficient of the compound in air (cm^2/s)
c^{sa} = comes from Equation 7 and f_a and f. are as defined previously.

The pollutant can volatilize directly to the atmosphere from the surface layer, but if the chemical is in the second or lower layer, and the concentration in that layer is greater than the layer above it, then the chemical will diffuse into the upper layer rather than volatilize directly into the atmosphere.

Sorption: Adsorption/Desorption and Cation Exchange

SESOIL includes two partitioning processes for movement of pollutant from soil moisture or soil air to soil solids: (1) the sorption process, and (2) the cation-exchange mechanism. The cation-exchange process was not used to evaluate the 200-CS-1 OU waste sites and information relative to that process contained in the author's publication (Bonazountas et al. 1997, *SESOIL in Environmental Fate and Risk Modeling*) is omitted from this presentation. Simulation of adsorption for metal contaminants of potential concern (e.g., silver) used distribution coefficients.

The sorption process may be defined as the adhesion of pollutant molecules or ions to the surface of soil solids. Most sorption processes are reversible; adsorption describing the movement of pollutant onto soil solids, and desorption being the partitioning of the chemical from solid into the liquid or gas phase (Lyman et al. 1982, *Handbook of Chemical Property Estimation Methods*). Adsorption and desorption are usually assumed to be occurring in equilibrium and are therefore modeled as a single process. Adsorption is assumed to occur rapidly relative to the migration of the pollutant in soil moisture; and it can drastically retard pollutant migration through the soil column.

SESOIL employs the general Freundlich equation (Equation 8) to model soil sorption processes. The equation correlates adsorbed concentration with the dissolved concentration of the pollutant by means of an adsorption coefficient and the Freundlich parameter. This equation has been found to most nearly approximate the adsorption of many pollutants, especially organic chemicals, and a large amount of data has been generated and is available in the literature.

For most organic chemicals, adsorption occurs mainly on the organic carbon particles within the soil (Lyman et al. 1982). The organic carbon partition coefficient (K) for organic chemicals can be measured or estimated. The soil organic carbon-water partition coefficient (K_{oc}) is converted to the partition coefficient (K_d) by multiplying by the fraction of organic carbon in the soil.

Values for the Freundlich exponent can be found in the literature. They generally range between 0.7 and 1.1, although values can be found as low as 0.3 and as high as 1.7. In the absence of data, a value of 1.0 is recommended, because no estimation techniques for this parameter have yet been developed. Note that using 1.0 for the Freundlich exponent assumes a linear model for sorption (Equation 8).

Degradation: Biodegradation and Hydrolysis

The pollutant cycle of SESOIL contains two transformation routines that can be used to estimate pollutant degradation in the soil. Biodegradation is the biological breakdown of organic chemicals, most often by microorganisms. Hydrolysis is the chemical reaction of the pollutant with water. Both processes result in the loss of the original pollutant and the creation of new chemicals. The SESOIL model accounts for the mass of original pollutant lost through degradation, but does not keep track of any degradation products. The user is responsible for knowing what the degradation products will be and their potential significance.

The biodegradation process usually is a significant loss mechanism in soil systems, because soil environments have a diverse microbial population and a large variety of food sources and habitats (Hamaker 1972, "Decomposition: Quantitative Aspects"). Many environmental factors affect the rate of biodegradation in soil, including pH, moisture content of the soil, temperature, redox potential, availability of nutrients, oxygen content of the soil air, concentration of the chemical, presence of appropriate microorganisms, and presence of other compounds that may be preferred substrates. However, SESOIL does not consider these factors.

Biodegradation in SESOIL is handled as primary degradation, defined as any structural transformation in the parent compound that results in a change in the chemical's identity. Biodegradation is estimated using the chemical's rate of decay in both the dissolved and adsorbed phases according to the first-order rate equation (Equation 14):

$$P_d = \left(C*\theta*K_{dl} + s*\rho_b*k_{ds}\right)*A*d_s*\Delta t \qquad \text{Eq 14}$$

where

P_d = decayed pollutant mass during time step Δt
k_{dl} = biodegradation rate of the compound in the liquid phase (per day)
k_{ds} = biodegradation rate of the compound in the solid phase (per day)
A = area of pollutant application (cm^2)
d_s = depth of the soil sub-layer (cm)
Δt = time step (day).

C, θ, s, and ρ_b are as defined for Equations 8 and 9.

The parameters C, θ, s are functions of time in the SESOIL model.

The use of a first-order rate equation is typical for fate and transport models and generally is an adequate representation of biodegradation for many chemicals. However, because of the many factors affecting biodegradation, in some cases, a first-order rate may not be applicable to the site field conditions; a zero-order or a second- or higher-order rate might be more appropriate. The biodegradation algorithm in SESOIL described by Equation 14 cannot handle these cases.

The SESOIL hydrolysis algorithm allows the simulation of neutral, acid-, or base-catalyzed reactions and assumes that both dissolved and adsorbed pollutant are susceptible to hydrolysis (Lyman et al. 1982). Hydrolysis was not simulated in evaluation of the 200-CS-1 OU waste sites and it will not be discussed in this section.

Pollutant Cycle Evaluation

Several approaches, such as verification, calibration, sensitivity analysis, uncertainty analysis, and validation, are used to evaluate the reliability and usefulness of an environmental model.

Verification establishes that results from each of the algorithms of the model are correct. Calibration is the process of adjusting selected model parameters within an accepted range until the differences between model predictions and field observations are within selected criteria of performance (Donnigan and Dean 1985, *Environmental Exposures from Chemicals*). Sensitivity analysis focuses on the relative impact that each parameter or term has on the model output, in order to determine the effect of data quality on output reliability. Uncertainty analysis seeks to quantify the uncertainty in the model output as a function of uncertainty in both model input and model operations. Validation also compares measured with predicted results, but includes analysis of the theoretical foundations of the model, focusing on the model's performance in simulating actual behavior of the chemical in the environment under study. Validation often has been broadly used to mean a variety of things, including all five of the techniques reported earlier.

A number of calibration, validation, and sensitivity studies have been performed on SESOIL. Extensive testing using extreme ranges of input data have verified the model. Studies of the hydrologic cycle were discussed above. The following discusses the kinds of evaluations that have been performed on the pollutant cycle of the SESOIL model. Note that model validation is a continuing process; no model is ever completely validated.

To assess SESOIL's predictive capabilities for pollutant movement, a pollutant transport and validation study was performed by Arthur D. Little, Inc., under contract to the EPA (Bonazountas et al. 1982, *Evaluation of Seasonal Soil Groundwater Pollutant Pathways*). The application/validation study was conducted on two field sites, one in Kansas and one in Montana. SESOIL results were compared to data for the metals chromium, copper, nickel, and sodium at the Kansas site, and to the organics naphthalene and anthracene at the Montana site. Results showed reasonable agreement between predictions and measurements, although the concentrations of the metals were consistently underestimated, and the rate of metal movement at the Kansas site was consistently overestimated; and at the Montana site, the concentrations of the organics were overestimated by SESOIL. Bonazountas et al. (1982) state that the overestimations for the organics probably occurred because biodegradation was not considered in the simulations. NOTE: This study was undertaken with the original SESOIL model, not the modified model described herein.

Hetrick et al. (1989) compared predictions of the improved version of SESOIL with empirical data from a laboratory study involving six organic chemicals (Melancon et al. 1986, "Evaluation of SESOIL, PRZM, and PESTAN in a Laboratory Column Leaching Experiment"); from three different field studies involving the application of aldicarb to two field plots (Hornsby et al. 1983, "Fate of Aldicarb in Florida Citrus Soils: Field and Laboratory Studies"; Jones 1983, "Fate of Aldicarb in Florida Citrus Soil: 2. Model Evaluation"; Jones 1985, "Field, Laboratory, and Modeling Studies on the Degradation and Transport of Aldicarb Residues in Soil and Groundwater"); and atrazine to a single-field watershed (EPA/600/3-78/056, *Transport of Agricultural Chemicals from Small Upland Piedmont Watersheds*). Results for several measures of pollutant transport were compared, including the location of chemical peak versus time, the time-dependent amount of pollutant leached to groundwater, the depth distribution of the pollutant at various times, the mass of the chemical degraded, and the amount of pollutant in surface runoff. This study showed that SESOIL predictions were in good agreement with observed data for both the laboratory study and the field studies.

SESOIL does a good job in predicting the leading edge of the chemical profile (Hetrick et al. 1989), due mainly to the improvement of the pollutant depth algorithm to include the chemical sorption characteristics (see the pollutant depth algorithm section). In addition, when a split-sample calibration/validation procedure was used on 3 years of data from the single-field watershed, SESOIL did a good job of predicting the amount of chemical in the runoff. The model was less effective in predicting actual concentration profiles; the simulated concentrations near the soil surface underestimated the measurements in most cases. One explanation is that SESOIL does not consider the potential upward movement of the chemical with the upward movement of water due to soil evaporation losses.

SESOIL is a very useful screening-level chemical migration and fate model. The model is relatively easy to use, the input data are straightforward to compile, and most of the model parameters can be readily estimated or obtained. Sensitivity analysis studies with SESOIL can be done efficiently.

SESOIL can be applied to generic environmental scenarios to evaluate the general behavior of chemicals. Care should be taken when applying SESOIL to sites with large vertical variations in soil properties, because the hydrologic cycle assumes a homogeneous soil profile. Only one value for the soil moisture content is computed for the entire soil column. If different permeabilities are input for each soil layer, the soil moisture content calculated in the hydrologic cycle using the vertically averaged permeability (Equation 3) may not be valid for the entire soil column. Thus, the user is warned that even though the model can accept different permeabilities for each layer, it does not fully account for the effects of variable permeability.

F3.0 SESOIL MODEL INPUT PARAMETERS

Section F2.0 provides a detailed explanation of the SESOIL model, and Sections F2.7.5 and F2.8.5 discuss the applications of the SESOIL model for evaluating the impacts from vadose zone soil contamination on underlying groundwater. This section presents the input parameters used in the SESOIL model and the long-term average results of the hydrologic cycle obtained by the model from Equations 1 and 2. Site-specific soil column and chemical-specific parameters are discussed in Sections F2.7.5 and F2.8.5. Model input parameters and hydrologic cycle results are found in Tables F-2 through F-6.

F4.0 REFERENCES

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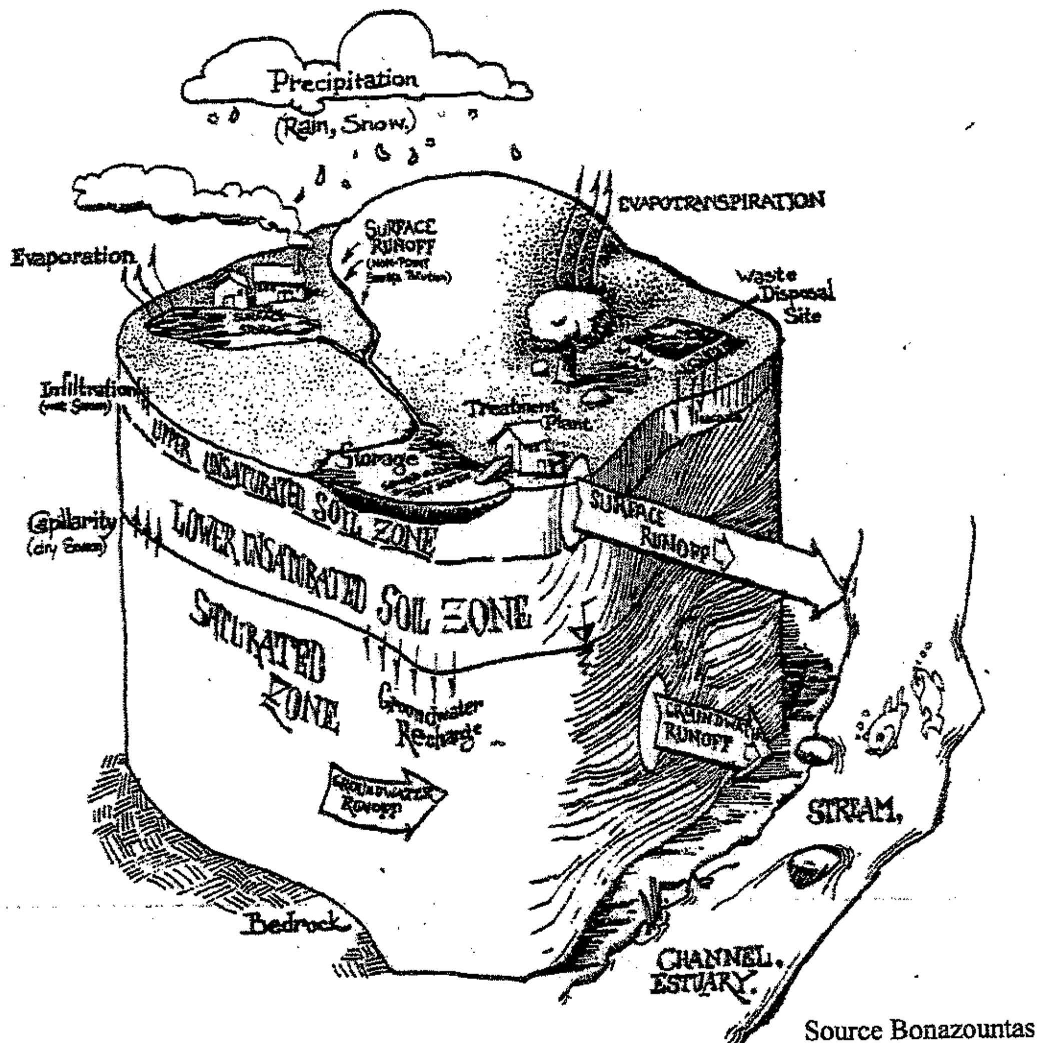
Figure F-1. SESOIL General Conceptualization.



Source Bonazountas et al., 1997

Figure F-2. Schematic of the Monthly Hydrologic Cycle.

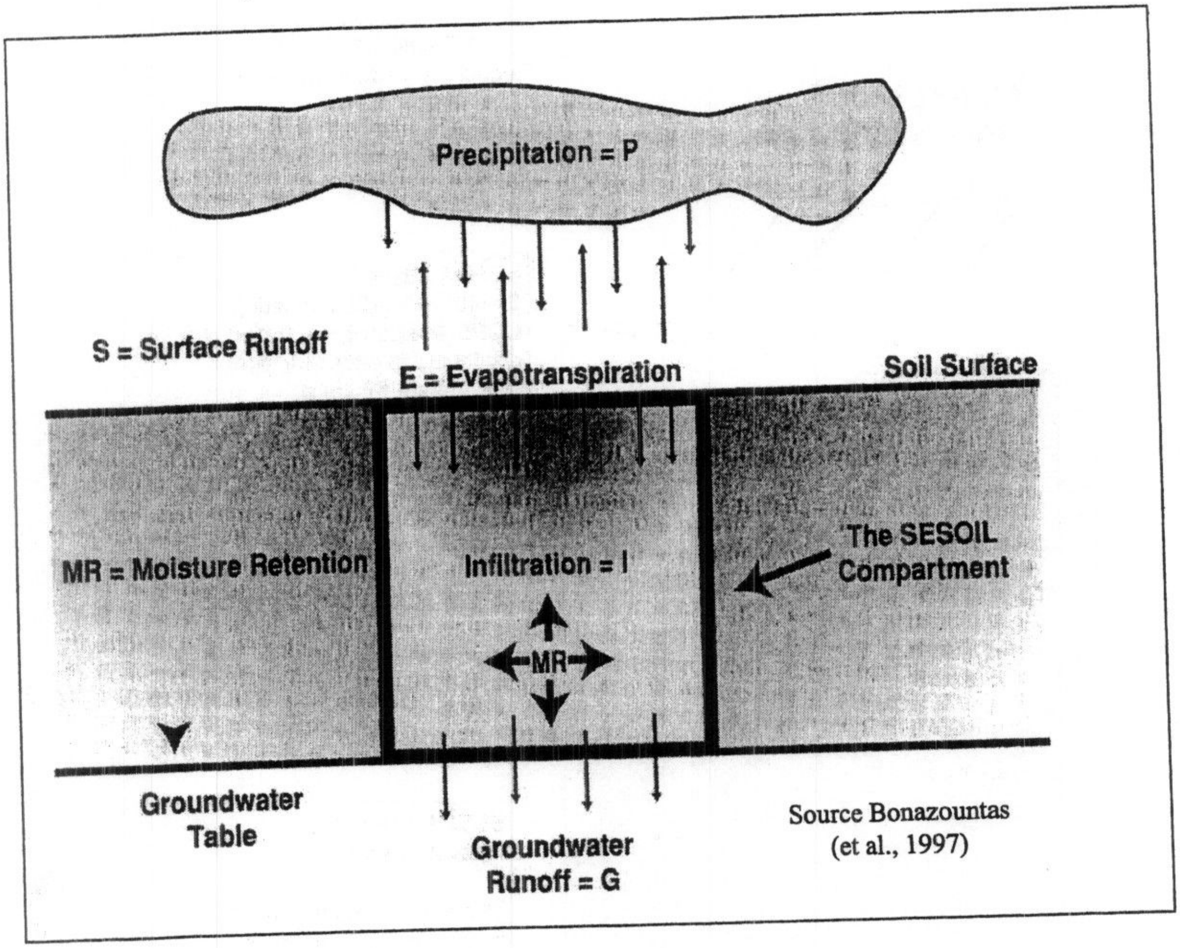
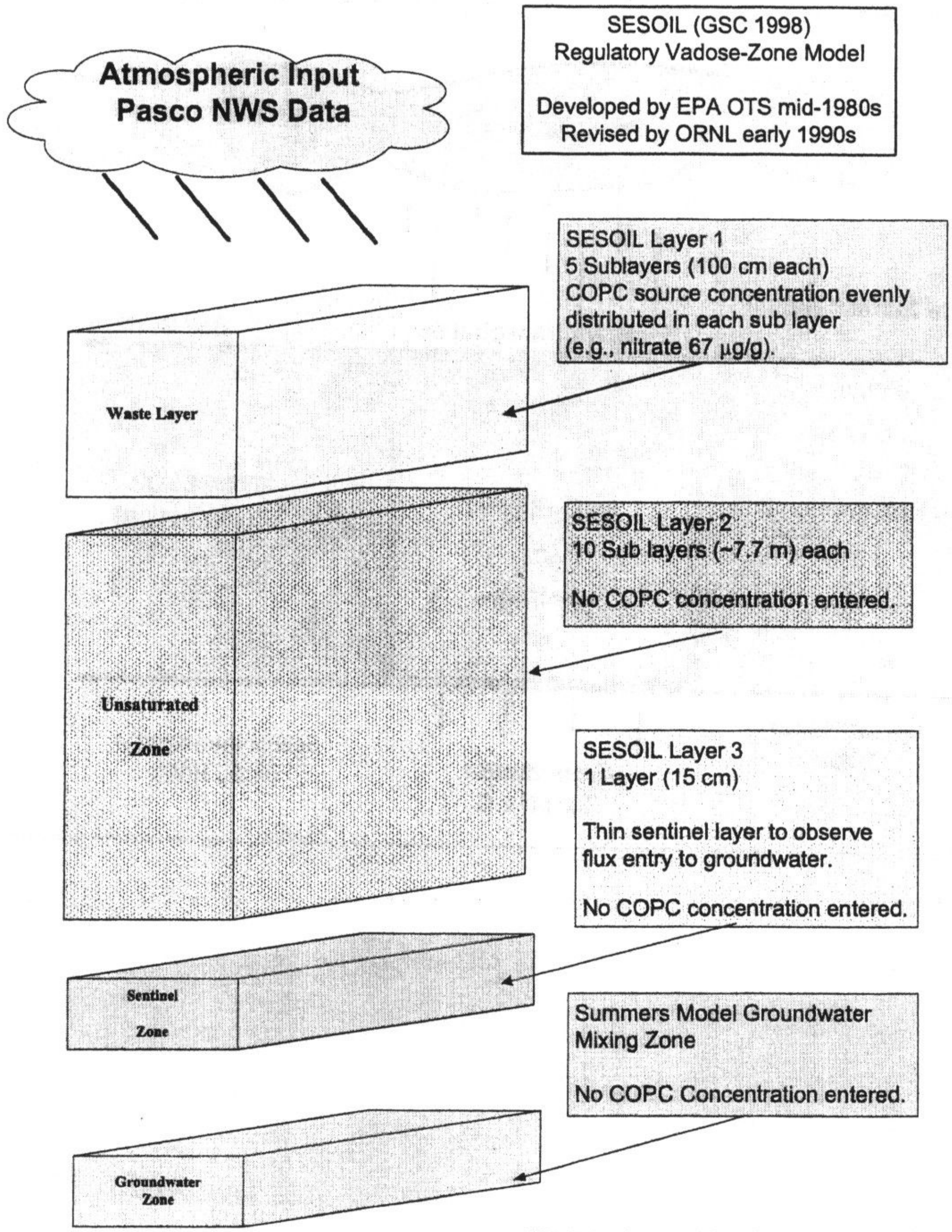


Figure F-3. Illustration of SESOIL Layer and Sub-Layer General Configuration for the 200-CS-1 Operable Unit Waste Sites.



SESOIL = Seasonal Soil Compartment Model
COPC = Chemical of Potential Concern
EPA = Environmental Protection Agency
OTS = Office of Toxic Substances
ORNL = Oak Ridge National Laboratory
GSC = General Sciences Corporation

Table F-1. Comparison of WAC 173-340-747(8) Requirements and SESOIL as Configured for 200-CS-1 Operable Unit Waste Sites. (2 Pages)

Section of WAC 173-340-747(8) Requirement	SESOIL as Configured for 200-CS-1 Operable Unit Waste Sites
(8)(a) Utilize site-specific data.	Uses local (Pasco National Weather Service Station) climatological data, local soil property data (Burbank soils are common on the Central Plateau), site-specific depths to groundwater (typically 270 ft [94 m] below ground surface), and site-specific soil constituent concentrations.
8(b) Chemical partitioning and advective flow and other processes may be used to predict fate and transport.	SESOIL simulates one-dimensional (vertical) advective flow and chemical partitioning. With one exception, advective flow and partitioning were the sole processes used by SESOIL to predict fate and transport. SESOIL can simulate other processes (e.g., volatilization and degradation), and benzene biodegradation at the 216-B-65 Trench was investigated to clarify uncertainties.
8(b)(i) Sorption values must be derived in accordance with §(4)(c) or §(5)(b). §(4)(c) specifies the use of default K_d values; §(5)(b) addresses requirements for petroleum fractions and it is not applicable.	Sorption (partitioning) was simulated with default K_ds obtained from the Washington State Department of Ecology (Ecology 2003). Default K_ds were not available for nitrate, nitrite, and sulfate. For these constituents, a K_d for nitrate, developed using site-specific data published by PNNL-13895 was used. NOTE: SESOIL also uses aqueous solubility in its algorithms to ensure that partitioning does not result in concentrations exceeding solubility limits. Aqueous solubilities were obtained from reliable public domain sources and are documented in the report.
8(b)(ii) Sets forth requirements for assessing vapor phase partitioning; they are not applicable.	Vapor phase partitioning, as discussed in WAC 173-340-747(8)(b)(ii), was not simulated.
8(b)(iii) States that rates of natural degradation must be derived from site-specific measurements.	Natural degradation was not simulated, with the exception of benzene biodegradation, at the 216-B-65 Trench. In the case of benzene, a conservative degradation constant, obtained from a reliable public domain source, was used to help investigate the potential for benzene degradation. Documentation is provided in the report.
8(b)(iv) Requires that estimates of dispersion be derived from site-specific measurements or literature values.	SESOIL is a one-dimensional (vertical) compartment model that does not simulate dispersion as discussed in §8(b)(iv).
8(b)(v) Permits the use of algorithms that account for decay over time.	Decay, as discussed in §8(b)(v), was not simulated.
8(b)(vi) States that dilution should be estimated from site-specific measurements or estimated using site-specific characteristics.	Dilution is estimated using site-specific characteristics by virtue of the use of the Burbank soil and typical groundwater characteristics. Dilution is computed in the soil column through sequential mass balance algorithms. Constituent mass entering a compartment is mixed with the existing mass in the compartment. Dilution is computed in the groundwater by means of a simple mixing equation that uses typical site-specific gradient and hydraulic conductivity data.

Table F-1. Comparison of WAC 173-340-747(8) Requirements and SESOIL as Configured for 200-CS-1 Operable Unit Waste Sites. (2 Pages)

Section of WAC 173-340-747(8) Requirement	SESOIL as Configured for 200-CS-1 Operable Unit Waste Sites
8(b)(vii) states that infiltration must be derived in accordance with §(5)(f)(ii)(A) or §(5)(f)(ii)(B). §(5)(f)(ii)(A) specifies a geographic locale consideration when using a default infiltration rate; this requirement is not applicable. §(5)(f)(ii)(B) requires that when a site-specific infiltration measurement or estimate is used, no cap or similar impeding structure can be assumed.	No cap or infiltration impeding structure was assumed.
8(c) Sets forth department evaluation criteria based on WAC 173-340-702(14),(15), and (16). WAC 173-340-702(14) places the burden of proof that *Washington Administrative Code* protectiveness requirements have been met on the respondent when deviations from default values are used. WAC 173-340-702(15) establishes a process for the department to consider new scientific information; this section is not applicable. WAC 173-340-702(16) establishes department "quality of information criteria," including considerations such as acceptance in the scientific community, relevance, rationale, and propensity to err on the side of safety.	The SESOIL model meets all requirements specified in WAC 173-340-747(8), which stresses the use of site-specific date. SESOIL was developed under U.S. Environmental Protection Agency direction and is widely accepted in the regulatory community. The use of SESOIL to clarify uncertainties in potential impacts to groundwater at the 200-CS-1 OU waste sites is consistent with the developer's intent. Significant errors on the side of safety, including conscious and considerable overestimation of the source mass in the vadose zone, ensure that the results will be conservative and protective.

Ecology 2003, *Cleanup Levels and Risk Calculations (CLARC) Database*, https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx .
PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide.*
WAC 173-340-702(14), "General Policies," "Burden of Proof."
WAC 173-340-702(15), "General Policies," "New Scientific Information."
WAC 173-340-702(16), "General Policies," "Criteria for Quality of Information."
WAC 173-340-747(8), "Deriving Soil Concentrations for Ground Water Protection," "Alternative Fate and Transport Models."

K_d = chemical-specific distribution coefficient.
OU = operable unit.
SESOIL = Seasonal Soil Compartment Model.
WAC = *Washington Administrative Code.*

Table F-2. SESOIL Statistical Climate Parameters from Pasco, Washington, National Weather Service Station.

Month	Air Temp °C	Cloud Cover (Fraction)	Relative Humidity	Albedo	Precipitation (cm)	No. of Storms	Duration (days)
Oct.	10.94	0.6	0.65	0.16	1.48	1.77	0.234583
Nov.	4.22	0.8	0.8	0.23	2.22	2.91	0.3275
Dec.	0.39	0.8	0.8	0.36	2.93	3.39	0.355833
Jan.	-1.61	0.8	0.8	0.4	2.81	3.47	0.422917
Feb.	2.56	0.8	0.8	0.26	1.75	2.44	0.340833
Mar.	6.06	0.7	0.6	0.21	1.4	2.11	0.307083
Apr.	10.44	0.65	0.55	0.16	0.97	1.27	0.224583
May	15	0.6	0.5	0.15	1.48	1.69	0.332917
Jun.	18.72	0.6	0.5	0.15	1.29	1.74	0.239583
Jul.	22.61	0.3	0.4	0.15	0.41	0.49	0.111667
Aug.	21.61	0.4	0.4	0.16	0.82	0.92	0.185833
Sep.	17.5	0.4	0.5	0.23	0.86	1	0.175833

SESOIL = Seasonal Soil Compartment Model.

Table F-3. SESOIL Soil Parameters.

Variable	Parameter	Remark
Soil series	Burbank	The Burbank series consists of very deep, excessively drained, very slow to medium runoff; rapid permeability soils formed in basaltic glacial outwash or alluvium (WSU 2005). Burbank soils are commonly found in the 200-CS-1 Operable Unit sites.
Bulk density	1.569 g/cm^3	Burbank series (GSC 1998).
Intrinsic permeability	1x10^{-6} cm^2	High end of the range (1 x 10^{-10} to 1 x 10^{-6} cm$^{2)}$ for silty sand soils (EPA 1986) and Freeze and Cherry (1979).
Pore disconnectedness index	3.9	Relates the wetting/drying time-dependant permeability of a soil to its saturated permeability (GSC 1998). See Equation 5 in this appendix. Values suggested in GSC (1998) include silt loam, 5.5; sandy loam, 6; sandy clay loam, 4; and sand, 3.7.
Effective porosity	0.28	Burbank series (GSC 1998).
Organic carbon content	0.1%	Default value (Ecology 2003).
Freundlich equation exponent	1.0	Default (GSC 1998). Freundlich equation not used in the assessment.

Ecology 2003, *Cleanup Levels and Risk Calculations (CLARC) Database*, https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx .

EPA/800/6-85/002b, *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Groundwater – Part II.*

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WSU, 2005, *Soils of Washington.*

SESOIL = Seasonal Soil Compartment Model.

Table F-4. SESOIL Chemical Parameters for Nitrate and Nitrate/Nitrite.

Variable	Parameter	Remark
Solubility	990,000 mg/L	Assume essentially miscible (99% aqueous solubility).
Diffusion coefficient	0.0 cm^2/s	No diffusion assumed.
Henry's constant	0.0 m^3-atm/mole	No volatilization assumed.
Adsorption coefficient (K_d)	1.17	Average of three Hanford Site measurements from gravely sands (82.5% gravel, 15.6% sand, 1.2% silt, 0.7% clay) (PNNL-13895).
Molecular weight	62 g/mole	Nitrate (NO_3)
Hydrolysis, biodegradation, complexation	Various	These processes not simulated.

NOTE: See tables in individual sections of Chapter 2.0 of the main text for other chemicals.

PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide.*

SESOIL = Seasonal Soil Compartment Model.

Table F-5. SESOIL Summers Groundwater Mixing Model.

Variable	Parameter	Remark
Saturated hydraulic conductivity	0.86 cm/day	Typical of deep groundwater system.
Horizontal gradient	0.02 cm/cm	2% grade typical of deep groundwater system.
Thickness of groundwater mixing zone	500 cm	Nominal 5 m mixing zone is conservative.
Width of contaminated zone	800 cm	Nominal 8 m width perpendicular to groundwater flow generally corresponding to ditch/trench width.

Summers Mixing Model (GSC 1998):

$$C_{gw} = \frac{(Q_p * C_p) - (Q_a * C_a)}{Q_p + Q_a}$$

where

C_{gw} = groundwater concentration (μg/mL).

Q_p = volumetric flow rate of soil water (cm^3/day).

Q_a = volumetric flow rate of groundwater beneath contaminated area (cm^3/day).

C_p = contaminant concentration in pore water entering groundwater (μg/mL).

Ca = existing contaminant concentration in pore water in groundwater (μg/mL).

GSC, 1998, *SESOIL*.

SESOIL = Seasonal Soil Compartment Model.

Table F-6. SESOIL Long-term Average Hydrologic Cycle Components Obtained from Model Results.

Hydrologic Parameter	Result
Average soil moisture Zone 1 (waste layer)	1.337%
Average soil moisture below zone (unsaturated zone)	1.337%
Total precipitation	20.318 cm
Total infiltration	20.318 cm
Total evapotranspiration	3.508 cm
Total surface runoff	0.000 cm
Total groundwater runoff (recharge)	16.810 cm
Total moisture retention	0.000 cm
Total yield	16.810 cm
See Equations 1 and 2 in the text	

SESOIL = Seasonal Soil Compartment Model.

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STATE ENVIRONMENTAL POLICY ACT ENVIRONMENTAL CHECKLIST

FOR THE

HANFORD FACILITY, 216-A-29 DITCH CLOSURE

REVISION 0

March 2006

WASHINGTON ADMINISTRATIVE CODE ENVIRONMENTAL CHECKLIST [WAC 197-11-960]

2006-03-06

A. BACKGROUND

1. Name of proposed project, if applicable:

This *State Environmental Policy Act* (SEPA) *of 1971* Environmental Checklist is being submitted for closure of the Hanford Facility, 216-A-29 Ditch. This area will be closed with respect to dangerous waste contamination that resulted from treatment operations as a *Resource Conservation and Recovery Act* (RCRA) *of 1976* treatment, storage, and/or disposal (TSD) unit.

2. Name of applicants:

U.S. Department of Energy, Richland Operations Office (DOE-RL).

3. Address and phone number of applicants and contact persons:

U.S. Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

Contact:

Keith A. Klein, Manager
Richland Operations Office
(509) 376-7395

4. Date checklist prepared:

March 2006.

5. Agency requesting the checklist:

Washington State Department of Ecology
P.O. Box 47600
Olympia, Washington 98504-7600

6. Proposed timing or schedule: (including phasing, if applicable):

This SEPA Environmental Checklist is being submitted concurrently with a closure plan prepared in accordance with Washington Administrative Code (WAC) 173-303 Dangerous Waste Regulations. The closure plan will be submitted to the Washington State Department of Ecology by March 2006.

7. Do you have any plans for future additions, expansion, or further activity related to or connected with this proposal? If yes, explain.

No. The 216-A-29 Ditch closure plan is being submitted in conjunction with 216-S-10 Pond and Ditch closure plan and the 216-B-63 Trench closure plan. The 216-S-10 Pond and Ditch closure plan submittal is required by March 31, 2006 in accordance with Tri-Party Agreement (Ecology et al) Milestone

M-20-39. The 216-A-29 Ditch, 216-B-63 Trench, and the 216-S-10 Pond and Ditch TSD units are all within the 200-CS-1 source Operable Unit.

8. List any environmental information you know about that has been prepared, or will be prepared, directly related to this proposal.

The original closure plan for the 216-A-29 Ditch was submitted to the State of Washington Department of Ecology (Ecology) pursuant to Tri-Party Agreement milestone M-20-36 in June 1995. An updated closure plan is being prepared.

This SEPA Environmental Checklist is being submitted to Ecology to address the 216-A-29 Ditch closure activities. Environmental information that has been prepared directly related to this proposal is contained in DOE/RL-2004-017, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit* and groundwater data contained in the Hanford Environmental Information System (HEIS). Environmental information that will be prepared directly related to this proposal will be contained in the document(s) prepared to describe (1) the soil removal necessary to achieve clean closure, and (2) the data quality objectives and verification sampling implemented following soil removal. Any other information related to the 216-A-29 Ditch after closure of the TSD unit will be performed in conjunction with Tri-Party Agreement past practice activities for the 200-CS-1 source operable unit and 200-PO-1 groundwater operable unit.

General information concerning the Hanford Facility environment can be found in the *Hanford Site National Environmental Policy Act (NEPA) Characterization*, PNL-6415, Revision 17, September 2005. This document is updated annually by Pacific Northwest National Laboratory (PNNL), and provides current information concerning climate and meteorology, ecology, history and archeology, socioeconomic, land use and noise levels, and geology and hydrology. These baseline data for the Hanford Site and past activities are useful for evaluating proposed activities and their potential environmental impacts.

9. Do you know whether applications are pending for government approvals of other proposals directly affecting the property covered by your proposal? If yes, explain.

No other applications are pending. However, see response to A8 regarding physical activities necessary to complete remediation of non-TSD unit constituents.

10. List any government approvals or permits that will be needed for your proposal, if known.

DOE-RL forwards the aforementioned 216-A-29 Ditch closure plan to Ecology for approval.

11. Give brief, complete description of your proposal, including the proposed uses and the size of the project and site. There are several questions later in this checklist that ask you to describe certain aspects of your proposal. You do not need to repeat those answers on this page.

The proposed DOE-RL closure strategy for the 216-A-29 Ditch soils is clean closure following remediation of the soils and clean closure of the TSD unit pertaining to groundwater following approval of the closure plan.

The PUREX Plant chemical sewer operated between November 1955 and July 1991. At the beginning of its operation, the 216-A-29 Ditch received discharge from the PUREX Plant cooling water and discharge from the chemical sewer. In early 1980, because of effluent monitoring requirements, the chemical sewer lines feeding the 216-A-29 Ditch required upgrades to allow for monitoring and diversion capabilities. A diversion box was upgraded and connected to the 216-A-42 Retention Basin. The basin received contaminated diversions from the PUREX Plant chemical sewer line, cooling water line, and steam condensate discharge. During 1990, plans were developed and approved to discontinue discharges to and close the 216-A-29 Ditch, and in 1991, all discharges were discontinued. Stabilization of the 216-A-29 Ditch was performed in three phases from July to October 1991. The trench can no longer accept dangerous waste.

Current data show that six of eight TSD unit constituents (sodium, potassium, ammonia, fluoride, cadmium, and hydrazine) either meet the clean closure standard, the constituent is not regulated, or in the case of hydrazine, other provisions are used to demonstrate clean closure. Nitrate and sulfate are the TSD unit constituents not meeting the clean closure standard. To meet WAC 173-340-745(5) cleanup levels, 216-A-29 Ditch soils will require removal. Furthermore, since the 200-CS-1 Operable Unit is removing 216-A-29 Ditch soils, the closure approach for the soils will be to remove the 216-A-29 Ditch soils and conduct verification sampling.

No other physical activities are required for closure. After closure, appearance of the land will be consistent with land use determinations of the Hanford Facility.

12. Location of the proposal. Give sufficient information for a person to understand the precise location of your proposed project, including a street address, if any, and section, township, and range, if known. If a proposal would occur over a range of area, provide the range or boundaries of the site(s). Provide a legal description, site plan, vicinity map, and topographic map, if reasonably available. While you should submit any plans required by the agency, you are not required to duplicate maps or detailed plans submitted with any permit applications related to this checklist.

The 216-A-29 Ditch is located to the east of the 200 East Area of the Hanford Facility. The 216-A-29 Ditch received discharge from the PUREX Plant chemical sewer. The ditch was uncovered and unlined and followed the natural topography. The ditch originated from the southeastern side of the A Tank Farm (east of the AP Tank Farm) outside the 200 East Area perimeter fence. The ditch was estimated to be 1,220 m (4,000 ft) long and 1.8 m (6 ft) wide and varied from 0.6 m to 4.6 m (2 to 15 ft). The head end of the ditch was modified in 1983 to allow the construction of the AP Tank Farm. The end of the ditch connects to the 216-B-3-3 Ditch and finally to the 216-B-3 Pond.

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B. ENVIRONMENTAL ELEMENTS

1. Earth

a. General description of the site (circle one): Flat, rolling, hilly, steep slopes, mountainous, other___________.

The southern portion of the 216-A-29 Ditch is flat, however a fair amount of the ditch is on a steep slope.

b. What is the steepest slope on the site (approximate percent slope)?

The approximate slope of the southern portion of the 216-A-29 Ditch is less than 2 percent. For the northern portion, the elevation change drops from approximately 205 meters down to approximately 180 meters.

c. What general types of soils are found on the site? (for example, clay, sandy gravel, peat, muck)? If you know the classification of agricultural soils, specify them and note any prime farmland.

Soil types consist mainly of eolian and fluvial sands and gravel. More detailed information concerning specific soil classifications can be found in the *Hanford Site National Environmental Policy Act (NEPA) Characterization*, PNL-6415, Revision 17, September 2005. Farming is not permitted on the Hanford Facility.

d. Are there surface indications or history of unstable soils in the immediate vicinity? If so, describe.

No.

e. Describe the purpose, type, and approximate quantities of any filling or grading proposed. Indicate source of fill.

Removed, contaminated soil would be replaced with clean fill from existing Hanford Site borrow areas. Additional information regarding Hanford Site borrow material may be found in DOE/EA-1403, *Use of Existing Borrow Areas, Hanford Site, Richland, Washington.*

f. Could erosion occur as a result of clearing, construction, or use? If so, generally describe.

Erosion might only occur during soil removal activities, depending on the time of the year the activity is performed.

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g. About what percent of the site will be covered with impervious surfaces after project construction (for example, asphalt or buildings)?

Not applicable. No construction is proposed as part of this project.

h. Proposed measures to reduce or control erosion, or other impacts to the earth, if any:

None.

2. Air

a. What types of emissions to the air would result from the proposal (i.e., dust, automobile, odors, industrial wood smoke) during construction and when the project is completed? If any, generally describe and give approximate quantities, if known.

Routine closure activities would generate dust.

An airborne radiological release could occur as a result of upset conditions. Such a release would not exceed immediately dangerous to life and health concentrations outside the immediate area of the spill/release because of the small quantity of material that is available for release.

b. Are there any off-site sources of emissions or odors that may affect your proposal? If so, generally describe.

No.

c. Proposed measures to reduce or control emissions or other impacts to the air, if any?

Good engineering practices [e.g., applying the principle of As Low As Reasonably Achievable (ALARA)] would be followed, and actions would comply with onsite procedures designed to protect the environment and personnel safety and health.

3. Water

a. Surface

1) Is there any surface water body on or in the immediate vicinity of the site (including year-round and seasonal

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streams, saltwater, lakes, ponds, wetlands)? If yes, describe type and provide names. If appropriate, state what stream or river it flows into.

No. The 216-A-29 Ditch are over 7 kilometers from the Columbia River.

2) **Will the project require any work over, in, or adjacent to (within 200 feet) the described waters? If yes, please describe and attach available plans.**

The work would not require any activity in or near the described waters and drainage.

3) **Estimate the amount of fill and dredge material that would be placed in or removed from surface water or wetlands and indicate the area of the site that would be affected. Indicate the source of fill material.**

There would be no dredging or filling from or to surface water or wetlands.

4) **Will the proposal require surface water withdrawals or diversions? Give general description, purpose, and approximate quantities if known.**

No surface water withdrawal or diversion would be required.

5) **Does the proposal lie within a 100-year floodplain? If so, note location on the site plan.**

The 216-A-29 Ditch are not within the 100-year or 500-year floodplain [*Hanford Site National Environmental Policy Act (NEPA) Characterization*, PNL-6415, Revision 17, September 2005].

6) **Does the proposal involve any discharges of waste materials to surface waters? If so, describe the type of waste and anticipated volume of discharge.**

No.

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b. Ground

1) Will ground water be withdrawn, or will water be discharged to ground water? Give general description, purpose, and approximate quantities if known.

No.

2) Describe waste material that will be discharged into the ground from septic tanks or other sources, if any (for example: Domestic sewage; industrial, containing the following chemicals...; agricultural; etc.). Describe the general size of the system, the number of such systems, the number of houses to be served (if applicable), or the number of animals or humans the system(s) are expected to serve.

None.

c. Water Run-off (including storm water)

1) Describe the source of run-off (including storm water) and method of collection and disposal, if any (include quantities, if known). Where will this water flow? Will this water flow into other waters? If so, describe.

The Hanford Facility receives only 15.2 to 17.8 centimeters of annual precipitation. Precipitation runs off the existing buildings and seeps into the soil on and near the buildings. This precipitation does not reach the groundwater or surface waters.

2) Could waste materials enter ground or surface waters? If so, generally describe.

Engineering controls during closure activities, such as using dry decontamination methods, visually checking the liners for breaches before using decontamination solutions (and minimizing the use of liquid solutions), etc., will prevent dangerous waste materials from entering ground or surface waters. All waste materials would be contained.

d. Proposed measures to reduce or control surface, ground, and run-off water impacts, if any:

Measures would include visually checking for breaches or cracks, and sealing any found (or containing solutions in a catch pan),

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before using decontamination solutions; and using dry decontamination methods and minimizing the use of liquids.

4. Plants

a. Check or circle the types of vegetation found on the site.

- ☐ deciduous tree: alder, maple, aspen, other
- ☐ evergreen tree: fir, cedar, pine, other
- ☒ shrubs
- ☒ grass
- ☐ pasture
- ☐ crop or grain
- ☐ wet soil plants: cattail, buttercup, bulrush, skunk cabbage, other
- ☐ water plants: water lily, eelgrass, milfoil, other
- ☐ other types of vegetation

The most common vegetation community in the 200 East Area is sagebrush/cheatgrass or Sandberg's bluegrass. Native vegetation resides in the immediate vicinity of the 216-A-29 Ditch.

b. What kind and amount of vegetation will be removed or altered?

Vegetation existing where the soil will be removed will also be removed during 216-A-29 Ditch closure activities.

c. List threatened or endangered species known to be on or near the site.

No known threatened or endangered species are known to be on or near the 216-A-29 Ditch. Additional information on species can be found in *Hanford Site National Environmental Policy Act (NEPA) Characterization*, PNL-6415 (Revision 17, September 2005).

d. Proposed landscaping, use of native plants, or other measures to preserve or enhance vegetation on the site, if any:

None.

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5. Animals

a. Indicate (by underlining) any birds and animals which have been observed on or near the site or are known to be on or near the site:

birds: <u>Raptors (burrowing owls, ferruginous, redtail, and Swainson's hawks) eagles, songbirds,</u>
animals: <u>deer, elk, coyotes, rabbits, rodents</u>.

Additional information on animals can be found in *Hanford Site National Environmental Policy Act (NEPA) Characterization*, PNL-6415 (Revision 17, September 2005).

b. List any threatened or endangered species known to be on or near the site.

One federal and state listed threatened or endangered species has been identified on the 1,517 square kilometer Hanford Site along the Columbia River (the bald eagle) and three in the Columbia River (steelhead, spring-run Chinook salmon, and bull trout). In addition, the state listed white pelican, sandhill crane, and ferruginous hawk also occur on or migrate through the Hanford Site.

c. Is the site part of a migration route? If so, explain.

The Hanford Site is a part of the broad Pacific Flyway. However, the 216-A-29 Ditch location is not known as a haven for migratory birds.

d. Proposed measures to preserve or enhance wildlife, if any:

This project contains no specific measures to preserve or enhance wildlife.

6. Energy and Natural Resources

a. What kinds of energy (electric, natural gas, oil, wood stove, solar) will be used to meet the completed project's energy needs? Describe whether it will be used for heating, manufacturing, etc.

None.

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b. Would your project affect the potential use of solar energy by adjacent properties? If so, generally describe.

No.

c. What kinds of energy conservation features are included in the plans of this proposal? List other proposed measures to reduce or control energy impacts, if any:

None.

7. Environmental Health

a. Are there any environmental health hazards, including exposure to toxic chemicals, risk of fire and explosion, spill, or hazardous waste that could occur as a result of this proposal? If so, describe.

No.

1) Describe special emergency services that might be required.

No special emergency services are known to be required.

2) Proposed measures to reduce or control environmental health hazards, if any:

None.

b. Noise

1) What type of noise exists in the area which may affect your project (for example: traffic, equipment, operation, other)?

None is anticipated.

2) What types and levels of noise would be created by or associated with the project on a short-term or a long-term basis (for example: traffic, construction, operation, other)? Indicate what hours noise would come from the site.

None is anticipated.

3) Proposed measures to reduce or control noise impacts, if any:

None.

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8. Land and Shoreline Use

a. What is the current use of the site and adjacent properties?

The 216-A-29 Ditch site is not in use. Adjacent properties are industrial/research.

b. Has the site been used for agriculture? If so, describe.

No portion of the 200 East Area has been used for agricultural purposes since 1943.

c. Describe any structures on the site.

There are no structures at the 216-A-29 Ditch site.

d. Will any structures be demolished? If so, what?

Not applicable. There are no structures on the site (refer to Section B.8.c).

e. What is the current zoning classification of the site?

Does not apply. The site is located on Federal lands and as such is not subject to the Growth Management Act (State of Washington land use authority). However, for completeness, the Hanford Site is currently included in the Benton County Comprehensive Plan (June 22, 1998) as the undesignated "Hanford Sub-Area".

f. What is the current comprehensive plan designation of the site?

The Federal land management decision process has determined through NEPA [*Hanford Comprehensive Land-Use Plan Environmental Impact Statement Record of Decision* (64 FR 61615, November 12, 1999)] that the 200 East Area geographic area, which includes the 216-A-29 Ditch, is designated Industrial-Exclusive.

g. If applicable, what is the current shoreline master program designation of the site?

Does not apply.

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h. Has any part of the site been classified as an "environmentally sensitive" area? If so, specify.

No.

i. Approximately how many people would reside or work in the completed project?

None after the closure activity is performed.

j. Approximately how many people would the completed project displace?

None.

k. Proposed measures to avoid or reduce displacement impacts, if any:

Does not apply.

l. Proposed measures to ensure the proposal is compatible with existing and projected land uses and plans, if any:

Does not apply (refer to Section B.8.f.).

9. Housing

a. Approximately how many units would be `provided, if any? Indicate whether high, middle, or low-income housing.

None.

b. Approximately how many units, if any, would be eliminated? Indicate whether high, middle, or low-income housing.

None.

c. Proposed measures to reduce or control housing impacts, if any:

Does not apply.

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10. Aesthetics

a. What is the tallest height of any proposed structure(s), not including antennas; what is the principal exterior building material(s) proposed?

No new structures are being proposed.

b. What views in the immediate vicinity would be altered or obstructed?

None.

c. Proposed measures to reduce or control aesthetic impacts, if any:

None.

11. Light and Glare

a. What type of light or glare will the proposal produce? What time of day would it mainly occur?

None.

b. Could light or glare from the finished project be a safety hazard or interfere with views?

No.

c. What existing off-site sources of light or glare may affect your proposal?

None.

d. Proposed measures to reduce or control light and glare impacts, if any:

None.

12. Recreation

a. What designated and informal recreational opportunities are in the immediate vicinity?

None.

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b. Would the proposed project displace any existing recreational uses? If so, describe.

No.

c. Proposed measures to reduce or control impacts on recreation, including recreation opportunities to be provided by the project or applicant, if any?

None.

13. Historic and Cultural Preservation

a. Are there any places or objects listed on, or proposed for, national, state, or local preservation registers known to be on or next to the site? If so, generally describe.

No places or objects listed on, or proposed for, national, state, or local preservation registers are known to be on or next to the 216-A-29 Ditch.

b. Generally describe any landmarks or evidence of historic, archaeological, scientific, or cultural importance known to be on or next to the site.

There are no known archaeological, historical, or Native American religious sites on or near the 216-A-29 Ditch.

c. Proposed measures to reduce or control impacts, if any:

None.

14. Transportation

a. Identify public streets and highways serving the site, and describe proposed access to the existing street system. Show on site plans, if any.

Does not apply.

b. Is site currently served by public transit? If not, what is the approximate distance to the nearest transit stop?

No. The distance to the nearest public transit stop is approximately 50 kilometers, located at Washington State University Tri-Cities.

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c. How many parking spaces would the completed project have? How many would the project eliminate?

Not applicable.

d. Will the proposal require any new roads or streets, or improvements to existing roads or streets, not including driveways? If so, generally describe (indicate whether public or private).

No.

e. Will the project use (or occur in the immediate vicinity of) water, rail, or air transportation? If so, generally describe.

No.

f. How many vehicular trips per day would be generated by the completed project? If known, indicate when peak volumes would occur.

Additional vehicular trips would be required to remove contaminated soils. Peak traffic volumes would occur during the daytime.

g. Proposed measures to reduce or control transportation impacts, if any:

None.

15. Public Services

a. Would the project result in an increased need for public services (for example: fire protection, police protection, health care, schools, other)? If so, generally describe.

No.

b. Proposed measures to reduce or control direct impacts on public services, if any:

Does not apply.

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16. Utilities

a. Circle utilities currently available at the site: electricity, natural gas, water, refuse service, telephone, sanitary sewer, septic system, other:

No utilities currently are available at the 216-A-29 Ditch.

b. Describe the utilities that are proposed for the project, the utility providing the service, and the general construction activities on the site or in the immediate vicinity which might be needed.

No utilities are planned for the proposed activity. If necessary, to support contaminated soil removal, portable electrical generators could be provided on a temporary basis.

SIGNATURES

The above answers are true and complete to the best of my knowledge. I understand that the lead agency is relying on them to make its decision.

______________________________ ____________________

Keith A. Klein, Manager   Date
U.S. Department of Energy
Richland Operations Office